CHAPTER 4 FORECAST OF FUTURE TRAFFIC DEMAND

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Generally, the demand for transport services is qualitative and differentiated. There is a whole range of specific demands for transport which are differentiated by time of day, day of week, trip purpose, type of cargo, importance of speed and frequency, and so on. A transport service without the attributes matching this differentiated demand may be useless. This characteristic makes it more difficult to analyze and forecast the demand for transport services: tonnage and passenger kilometers are extremely coarse units of performance hiding a massive range of requirements and services.

4.1 Methodology for Traffic Demand Forecast

4.1.1 Conventional Four-Stage Sequential Model

In this study, conventional four-stage sequential model (FSM) is applied, although ordinal (domestic) and international traffic demands are estimated separately. Basic FSM procedure is shown in Fig. 4-1-1.

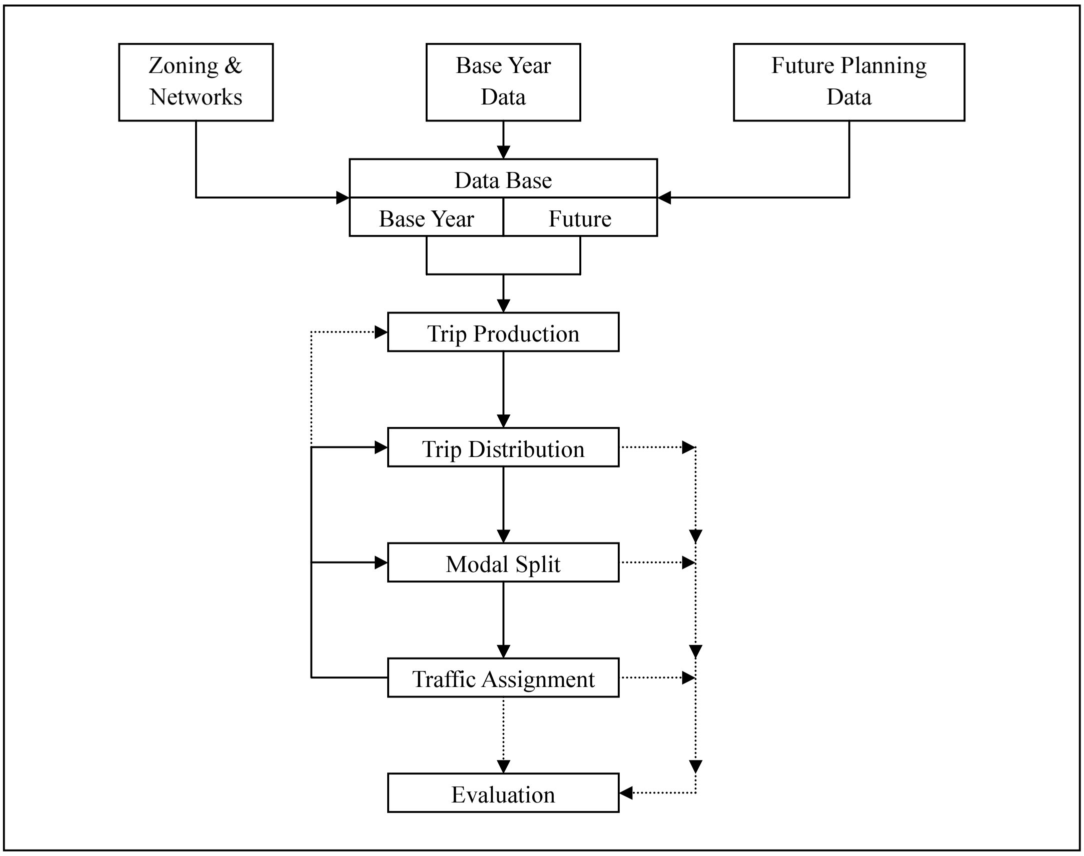


Fig. 4-1-1 Conventional Four-Stage Sequential Model (FSM)

The approach starts by considering a zoning and network system, collecting and coding of existing plans and present conditions, and calibration and validation those data. These data would include base-year levels for population in each zone of the study area as well as levels of economic activity, such as employment and/or land use pattern. These data are then utilized to estimate a model of total number of trips generated and attracted by each zone of the study area (trip generation). The next step is the allocation of these trips to particular destinations, in other words their distribution over space, thus producing a trip matrix (trip distribution). The following stage normally involves modeling the choice of mode and this results in modal split, i.e. the allocation of trips in the matrix to different modes (modal split). Finally, the last stage in the FSM requires the assignment of the trips by each mode to their corresponding networks: typically private and public transport, and/or passenger and cargo transport (traffic assignment).

Once the model has been calibrated and validated for base-year conditions, it must be applied to one or more planning horizons. In order to step forward, it is necessary to develop scenarios and plans describing the relevant characteristics of the transport system and planning variables under alternative future conditions. The preparation of realistic and reliable scenarios is not a simple task as it is very easy to fall into the trap of constructing futures which will not be financially viable nor realistic in the context of the possibly evolution of land use and activities in the study area.

Having prepared realistic scenarios and plans for testing, the same sequence of models has to be run again to simulate their performance. A comparison is then made between the costs and benefits, however measured, of different schemes under different scenarios. The objective of the demand forecast is to choose the most attractive programme of projects and transport policies, which satisfies the demand for movement of persons and goods in the study area.

4.1.2 Applied Procedure for Traffic Demand Forecast

Considering the overall objective of the project and primary role of NR-1 within the southeast region of Cambodia and its international requirement as an “Asian Highway No. A-1”, ordinal domestic traffic and international traffic demand shall be estimated separately for long-range target year of 2015, with short- and middle-range target years of 2005 and 2010.

(1) Data Base

Result of traffic survey and interview as well as socio-economic characteristics described in previous chapters shall be arranged for JICA STRADA (System for Traffic Demand Analysis) format.

(2) Present OD Matrix

Based on the roadside OD interview, cargo movement survey, public transport survey, as well as roadside traffic volume counts, present OD matrix shall be formulated.

(3) Ordinal Traffic Demand Estimation and Forecast

- <u>Trip Generation & Attraction</u>: by using present OD matrix with socio-economic and demographic data, most reliable trip generation and attraction models shall be formulated.
- <u>Trip Distribution</u>: by applying future socio-economic framework and improvement effect of accessibility to said trip generation and attraction models, most adequate trip distribution model shall be formulated.

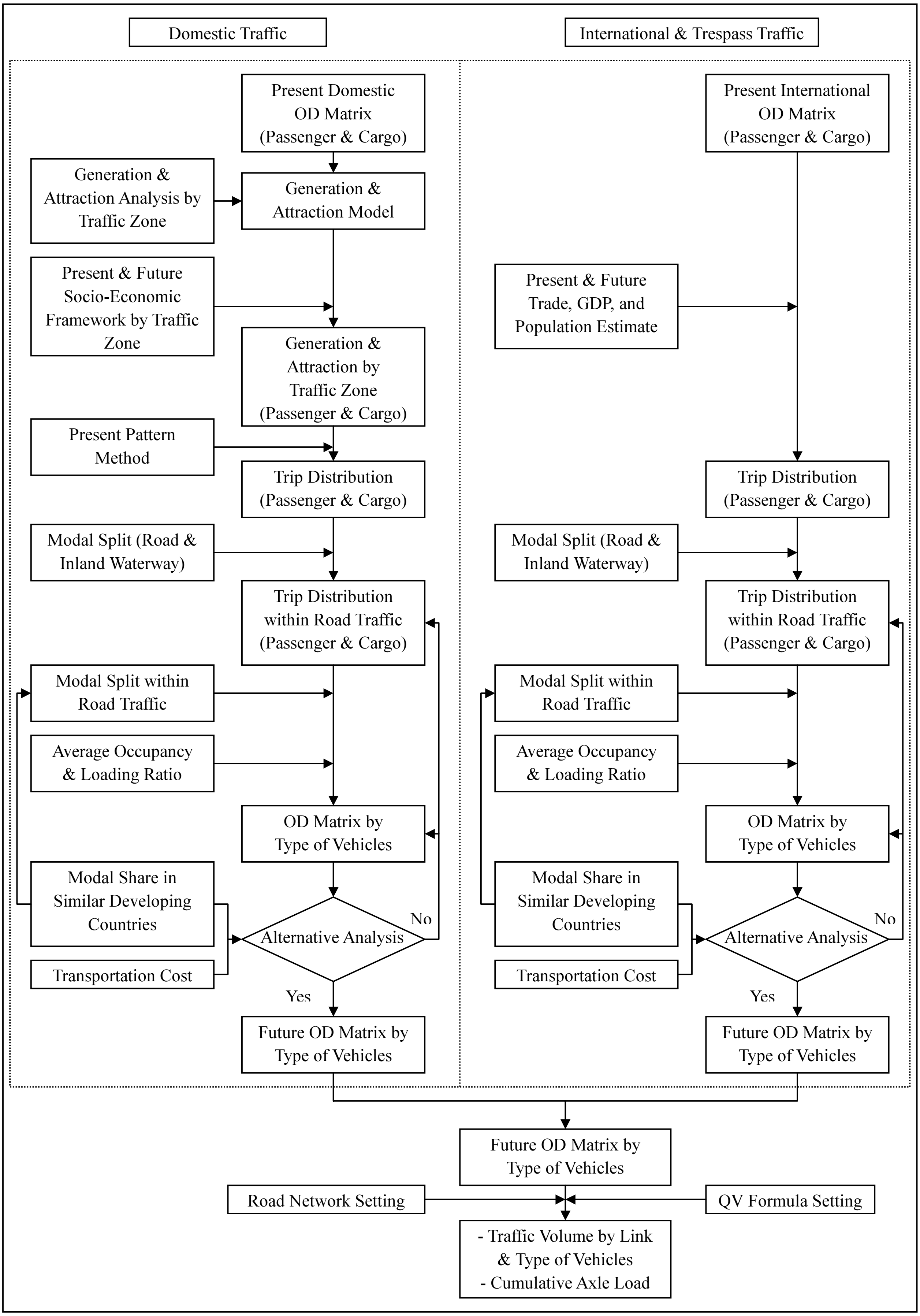


Fig. 4-1-2 Methodology for Traffic Demand Forecast

- Modal Share: based on the current modal share, present passenger and cargo OD matrix shall be formulated. In addition, modal shift in similar developing counties shall be utilized for estimating future passenger and cargo OD matrix.
- Vehicle OD: vehicle OD matrix shall be converted from passenger and cargo OD matrix by applying average occupancy and loading rates.

(4) International & Trespass Traffic Demand Estimation and Forecast

Instead of using trip generation and attraction model in domestic traffic demand forecast, international trade volume with Vietnam[1] shall be considered as induced cargo traffic.

(5) Traffic Assignment

Virtual road networks shall be formulated into the analytical tool (JICA-STRADA) based on the existing and proposed road networks and their conditions, such as capacity and free flow speed. In addition, NR-1, NR-2, NR-6, and NR-7 with its present and future condition shall be compared for analysis of alternative route selection between Phnom Penh and Ho Chi Minh Cities.

4.2 Trip Production and Distribution

Obtained data from cordon line surveys are not able to cover all intra-zonal movements and/or several inter-zonal movements, that is not crossing these survey lines, due to too scattered survey stations were set up to cover all National Roads networks in southeastern region of Cambodia. Therefore, OD (origin and destination) matrixes by mode and/or purpose made by these field survey data were not perfect, in other word; they were containing a lot of OD pairs with "Zero" value. To deal with these omitted OD pairs, following preparation works were necessary for further analysis;

1. Initial trip generation and attraction (GA) data was formulated by using formula provided by "Transport Master Plan of Phnom Penh Metropolitan Area" (hereinafter referred to as "TMP-PPMA") with present and future socio-economic framework
2. Initial zonal impedance data was also formulated by using virtual road network data
3. Initial OD matrix was formulated by Frater Method with above mentioned GA and Impedance data
4. Adjusted OD matrix was formulated by comparing initial incremental assignment result and observed traffic volume data

(1) Trip Production

Trip production rate obtained from TMP-PPMA (= 2.35~2.50 trips per day per person) was utilized to set up the control total of initial trip generation and attraction of the Study Area. As shown in Table 4-2-1 and Fig. 4-2-1, total trip production from adjacent districts along NR-1 C-1 section will be increased from 718 thousand in 2002 to 981 thousand trips per day in 2015 (2015/2002 = 1.37) along the lines of its population growth (2015/2002 = 1.28).

[1] Other international traffic with Thailand and Laos will be not affecting NR-1's future volume with large magnitude, because most of that traffic is assumed to be terminating the trips at Phnom Penh. And, if these trips continued up to Vietnam or other destinations in the Study Area, these are recognized as Phnom Penh origin and/or destination trips.

Table 4-2-1 Projected Populations and Trip Productions by Large Traffic Zone

Population (Unit: 1,000 Persons)

Year	2002	2005	2010	2015
PP	1,233	1,387	1,657	1,932
KD-1	306	325	359	392
KD-2	417	444	490	536
KD-3	88	93	103	112
KD-4	102	108	119	131
KD-5	109	116	128	140
KD-6	209	222	246	268
PV	1,060	1,110	1,192	1,263
SR	541	570	620	667
KCM	1,837	1,952	2,146	2,333
NR-2	896	945	1,030	1,114
NR-3	636	675	742	813
NR-4	1,070	1,177	1,369	1,576
NR-5	1,920	2,059	2,313	2,588
NR-6	2,445	2,651	3,019	3,411
NR-7	566	619	714	815
TTL	13,434	14,454	16,245	18,091

Trip Production (Unit: 1,000 Person Trips per Day)

Year	2002	2005	2010	2015
PP	3,478	3,995	4,871	5,795
KD-1	718	780	879	981
KD-2	1,012	1,099	1,239	1,382
KD-3	206	224	252	281
KD-4	239	260	293	326
KD-5	256	278	313	349
KD-6	492	534	602	671
PV	2,491	2,664	2,920	3,157
SR	1,271	1,369	1,519	1,666
KCM	4,317	4,685	5,257	5,832
NR-2	2,107	2,269	2,523	2,786
NR-3	1,495	1,619	1,819	2,033
NR-4	2,514	2,825	3,355	3,941
NR-5	4,511	4,942	5,666	6,471
NR-6	5,747	6,363	7,396	8,528
NR-7	1,329	1,486	1,749	2,038
TTL	32,181	35,391	40,651	46,237

Legend:

PP: Phnom Penh KD-1~6: Kandal along NR-1~6 PV: Prey Veng

SR: Svay Rieng KCM: Kampong Cham NR-2~7: Provinces along NR-2~7

Trip Production Rate: 2002 = 2.35, 2005 = 2.40, 2010 = 2.45, 2015 = 2.50 Adjustment Rate: Urban = 1.20, Rural = 1.00

(2) Trip Generation and Attraction Model

As shown in Table 4-2-2, following GA model was formulated by using socio-economic and vehicle trip production data of Phnom Penh Metropolitan Area obtained from TMP-PPMA in 2000, that explain the relation between socio-economic indicators, such as population, number of employment and student, and trip generation or attraction to/from each traffic zone by different transport mode.

Table 4-2-2 Parameters of Explanatory Variables

Parameters of Explanatory Variables

	Constant	Population	Employment	Student	Urban-D	Market-D	Land Port-D	R^2
MC-G	-649.0	0.177	0.151	0.663	2,718	3,433		0.777
		2.102	1.854	4.363	2.489	2.722		
MC-A	-434.1	0.308	0.083	0.357	2,509	2,436		0.801
		4.289	1.201	2.764	2.701	2.270		
LV-G	-45.82	0.005	0.004	0.031	238.4	158.0		0.727
		1.128	1.002	3.829	4.039	2.318		
LV-A	-34.54	0.009	0.002	0.022	251.8	88.1		0.721
		2.077	0.461	2.851	4.542	1.376		
HV-G	-1.202	-0.000	0.001	0.002	14.49	5.23	576.94	0.926
		-0.014	1.978	2.067	2.015	0.634	17.982	
HV-A	0.178	-0.000	0.001	0.002	13.59	7.33	578.23	0.930
		-0.376	2.153	2.416	1.953	0.920	18.631	
CY-G	591.1	0.032	0.040	0.048	-922.1	185.9		0.803
		2.843	3.727	2.385	-6.403	1.118		
CY-A	504.6	0.036	0.036	0.006	-675.4	505.6		0.781
		3.474	3.570	0.342	-5.023	3.256		

Note: Upper: Parameter Lower: t-value R^2: Multiple Correlation Coefficient

MC: Motorcycles LV: Light Vehicles HV: Heavy Vehicles CY: Pedal-cycles

(3) Vehicle Trip

As shown in Table 4-2-3 and Fig. 4-2-2, following vehicle trips are obtained from pre-described GA model.

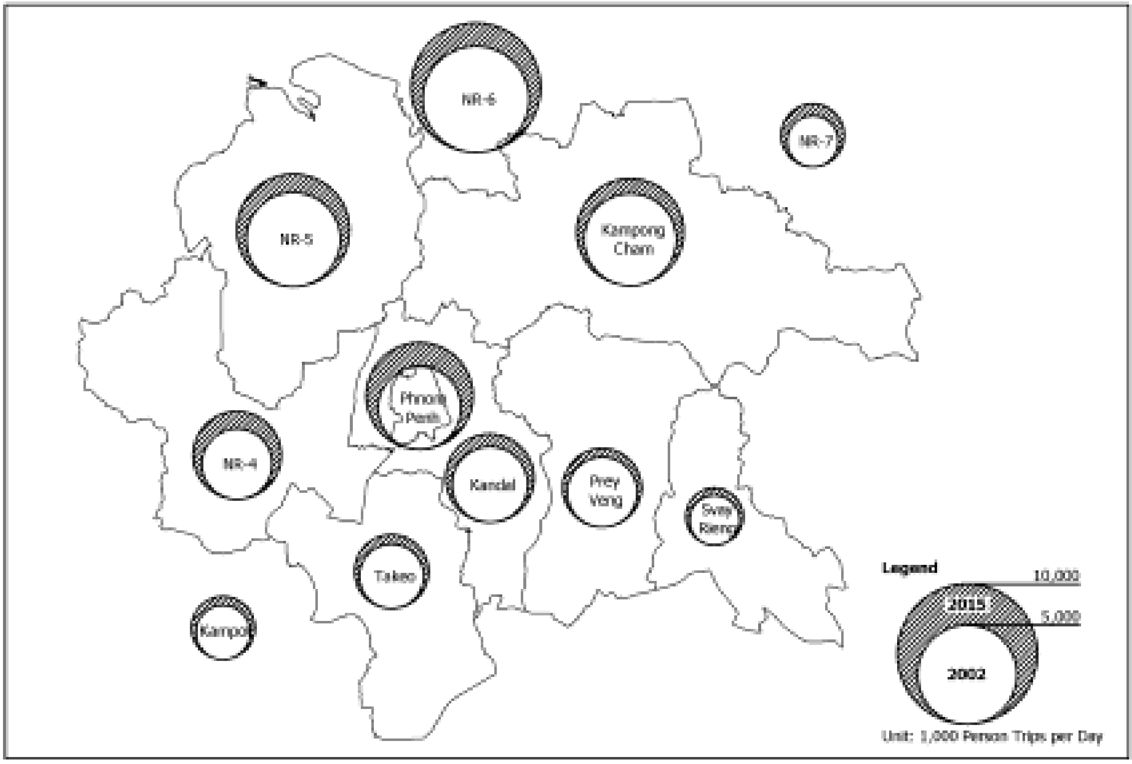


Fig. 4-2-1 Person Trip Productions by Large Zone (Regional Base)

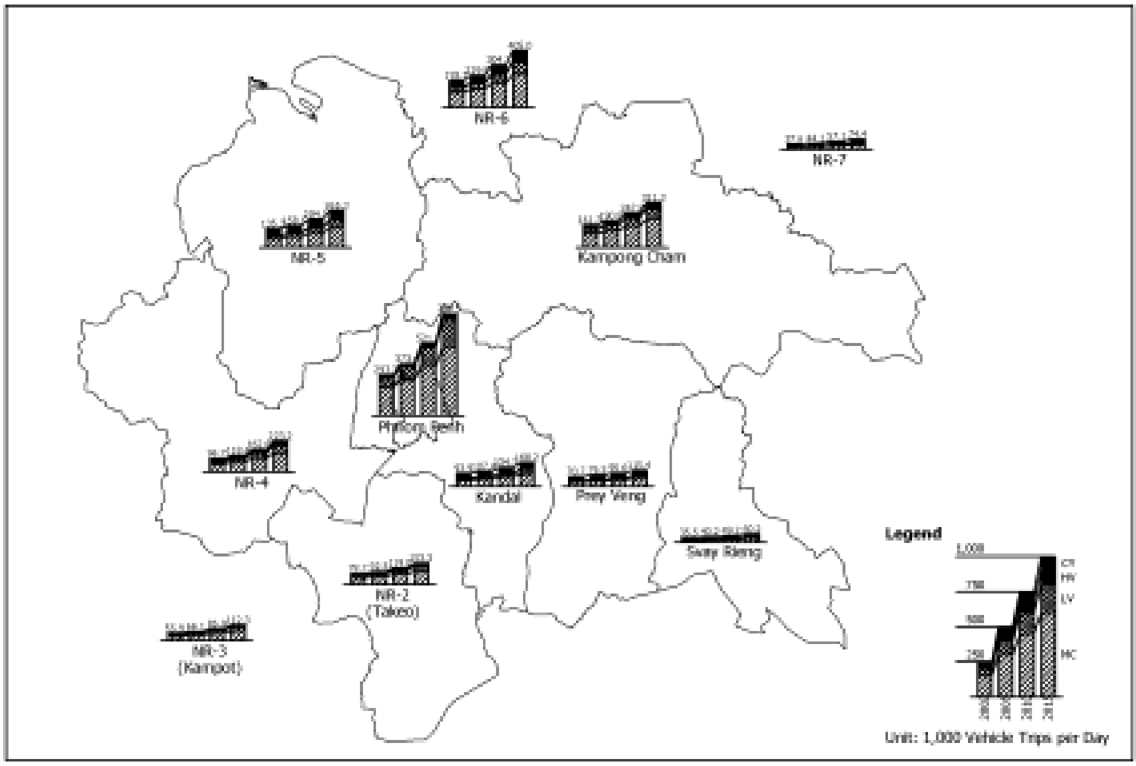
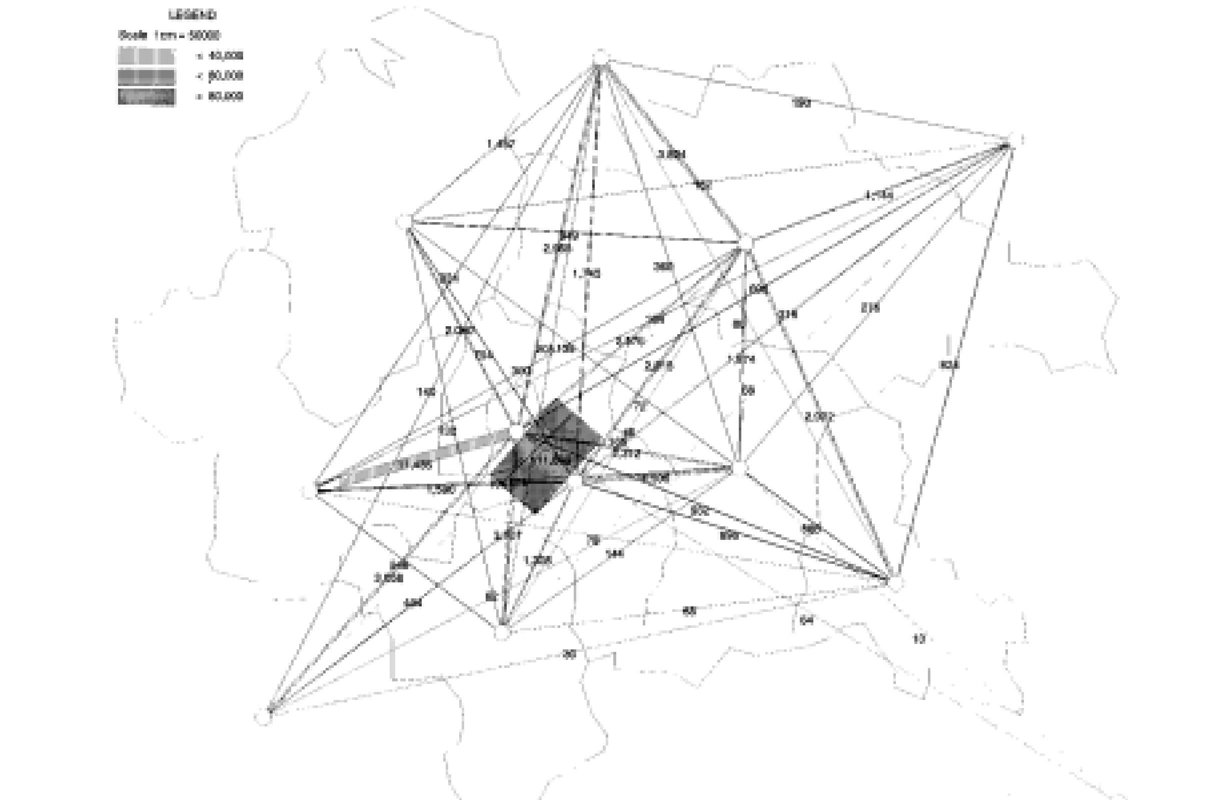
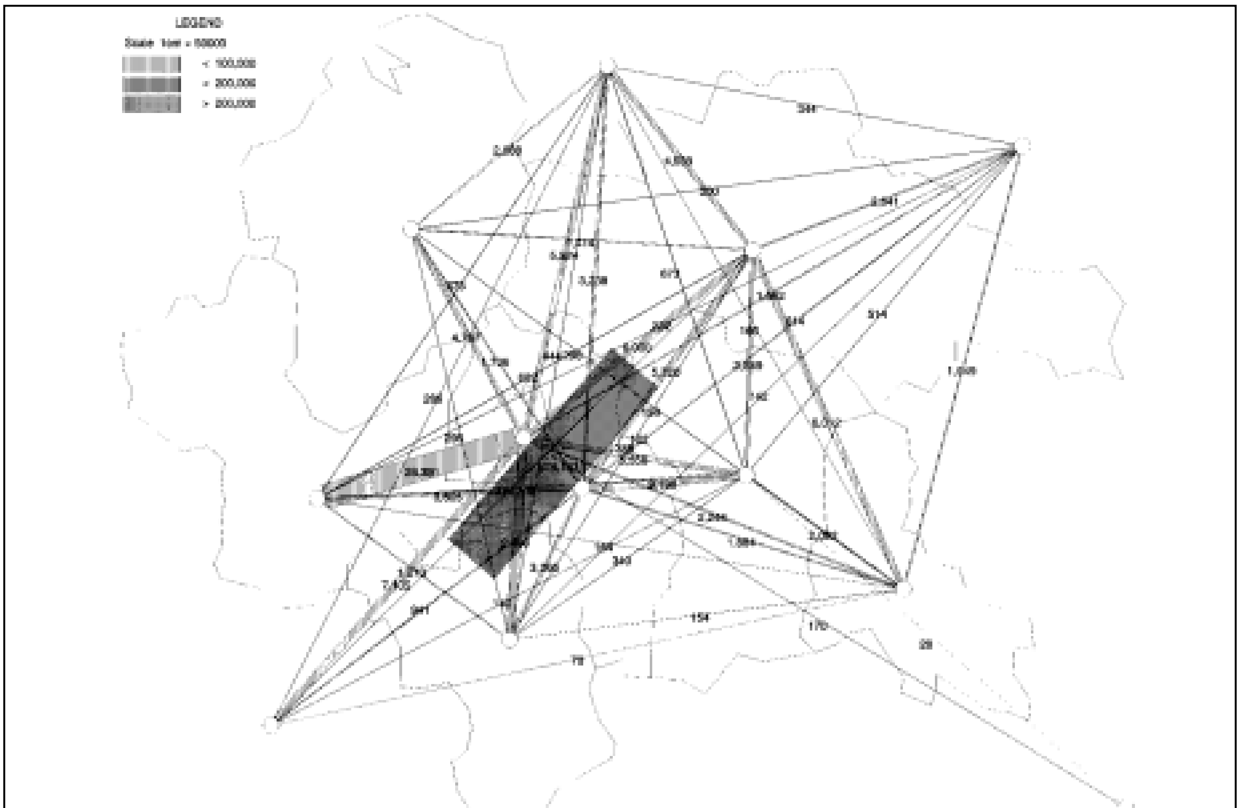


Fig. 4-2-2 Vehicle Trip Productions by Large Zone (Regional Base)



Unit: Vehicle per Day, not including Intra-Zonal Movements

Fig. 4-2-3 (1/2) Desired Line by Large Zone (Regional Base) in 2002



Unit: Vehicle per Day, not including Intra-Zonal Movements

Fig. 4-2-3 (2/2) Desired Line by Large Zone (Regional Base) in 2015

These figures are then adjusted by the estimated number of vehicles and trip production rate by mode by year, with adjustment factors by each traffic zone.

GA-2002 (Unit: 1,000 Vehicle Trips per Day)

Categories	MC	LV	HV	CY	TTL
PP	203.4	70.0	11.8	8.1	293.3
KD-1	10.3	2.9	0.4	11.7	25.3
KD-2	13.6	4.4	0.5	12.2	30.7
KD-3	2.3	0.7	0.1	2.8	5.9
KD-4	5.4	1.7	0.2	1.6	8.9
KD-5	4.9	1.5	0.2	2.4	9.0
KD-6	5.6	1.7	0.2	6.6	14.1
PV	29.0	9.0	1.1	31.6	70.7
SR	14.6	4.5	0.5	15.9	35.5
KCM	99.8	31.3	3.6	26.6	161.3
NR-2	48.7	15.3	1.8	12.9	78.7
NR-3	34.6	10.9	1.3	9.1	55.9
NR-4	58.1	18.3	4.8	15.5	96.7
NR-5	64.8	20.2	2.3	48.0	135.3
NR-6	106.4	33.6	3.8	48.9	192.7
NR-7	15.2	4.7	0.5	17.2	37.6
TTL	716.7	230.7	33.1	271.1	1,251.6

GA-2005 (Unit: 1,000 Vehicle Trips per Day)

Categories	MC	LV	HV	CY	TTL
PP	256.1	93.4	14.9	9.0	373.4
KD-1	12.3	3.7	0.5	12.1	28.6
KD-2	16.2	5.5	0.6	12.8	35.1
KD-3	2.8	0.9	0.1	2.9	6.7
KD-4	6.5	2.1	0.2	1.7	10.5
KD-5	5.8	1.9	0.2	2.6	10.5
KD-6	6.6	2.2	0.3	6.9	16.0
PV	34.0	11.2	1.3	32.8	79.3
SR	17.2	5.7	0.6	16.7	40.2
KCM	118.8	39.4	4.5	28.1	190.8
NR-2	57.6	19.2	2.2	13.5	92.5
NR-3	41.1	13.8	1.6	9.6	66.1
NR-4	71.7	23.9	5.9	16.9	118.4
NR-5	78.1	25.7	2.9	51.4	158.1
NR-6	129.0	43.0	4.8	53.0	229.8
NR-7	18.6	6.1	0.7	18.7	44.1
TTL	872.4	297.7	41.3	288.7	1,500.1

GA-2010 (Unit: 1,000 Vehicle Trips per Day)

Categories	MC	LV	HV	CY	TTL
PP	353.3	136.8	20.4	10.6	521.1
KD-1	16.2	5.3	0.7	13.0	35.2
KD-2	21.2	7.7	0.9	14.0	43.8
KD-3	3.7	1.3	0.1	3.2	8.3
KD-4	8.5	3.0	0.3	1.8	13.6
KD-5	7.7	2.7	0.3	2.8	13.5
KD-6	8.7	3.1	0.3	7.6	19.7
PV	43.4	15.4	1.7	35.1	95.6
SR	22.3	7.9	0.9	18.1	49.2
KCM	155.4	55.3	6.2	30.9	247.8
NR-2	74.6	26.7	3.0	14.7	119.0
NR-3	53.8	19.3	2.2	10.6	85.9
NR-4	99.3	35.5	8.0	19.8	162.6
NR-5	104.8	37.1	4.1	58.1	204.1
NR-6	174.4	62.3	6.9	61.1	304.7
NR-7	25.6	9.0	1.0	21.5	57.1
TTL	1,172.9	428.4	57.0	322.9	1,981.2

GA-2015 (Unit: 1,000 Vehicle Trips per Day)

Categories	MC	LV	HV	CY	TTL
PP	488.4	199.4	28.1	12.6	728.5
KD-1	21.2	7.4	0.9	13.9	43.4
KD-2	27.7	10.7	1.2	15.3	54.9
KD-3	4.8	1.8	0.2	3.5	10.3
KD-4	11.2	4.1	0.5	2.0	17.8
KD-5	10.1	3.7	0.4	3.0	17.2
KD-6	11.5	4.3	0.5	8.3	24.6
PV	55.1	20.7	2.3	37.3	115.4
SR	28.7	10.8	1.2	19.5	60.2
KCM	202.6	76.4	8.4	33.9	321.3
NR-2	96.7	36.6	4.0	16.0	153.3
NR-3	70.7	26.9	3.0	11.7	112.3
NR-4	137.5	51.9	10.8	23.0	223.2
NR-5	141.0	52.9	5.8	65.6	265.3
NR-6	235.8	89.2	9.8	70.2	405.0
NR-7	35.2	13.1	1.4	24.7	74.4
TTL	1,578.2	609.9	78.5	360.5	2,627.1

Legend:
PP: Phnom Penh KD-1~6: Kandal along NR-1~6 PV: Prey Veng
SR: Svay Rieng KCM: Kampong Cham NR-2~7: Provinces along NR-2~7

Number of Vehicles

Categories	MC	LV	HV	CY	TTL
2002	294,915	77,746	16,529	134,340	523,530
2005	355,901	99,301	20,681	144,540	620,422
2010	475,695	142,310	28,839	162,450	809,294
2015	635,901	201,541	39,756	180,910	1,058,108

Note: Number of CY is assumed to be 1% of Population

Trip Production Rate by Mode

Categories	MC	LV	HV	CY	TTL
2002	2.43	2.97	2.00	2.02	2.39
2005	2.45	3.00	2.00	2.00	2.42
2010	2.47	3.01	1.98	1.99	2.45
2015	2.48	3.03	1.97	1.99	2.48

Table 4-2-3 Trip Generation & Attraction by Each Transport Mode

(3) Trip Distribution

As described in previous section, GA data was distributed in accordance with the present OD pair by using each pair's impedance file, which is obtained from virtual road network file in analytical tools. Final loaded OD data by mode by year is attached in the Appendix.

4.3 Modal Share

(1) General Condition

The results of cordon line survey at major national roads proved that distribution of modal share is almost matching with logarithmic normal distribution of user's travel time. For example, the traveler made short time trip, hence shorter distance trip, is mainly using 2-wheel vehicles, such as bicycle and motorcycle, or just walk. And, traveler made long time trip, hence longer distance trip, is mainly using 4-wheel vehicles, such as sedan, pick-up, and mini-bus, or scheduled commercial bus, although major travel mode in this county is still motorcycles.

(2) Trip Time

The major mode of trip is varied from walk and bicycle, to motorcycle and 4 wheel vehicles, according to the desired trip time, therefore trip distance. For example, average trip time by each mode is 0.69 hr (varied from 0.44 hr for 25 percentile to 1.04 hr for 75 percentile) for bicycles (CY), 1.08 hr (0.75~1.66 hr) for motorcycles (MC), 2.39 hr (1.59~3.80 hr) for light vehicles (LV), and 2.79 hr (1.71~5.22 hr) for heavy vehicles (HV). The observed distribution of modal share is shown in Fig. 4-3-1.

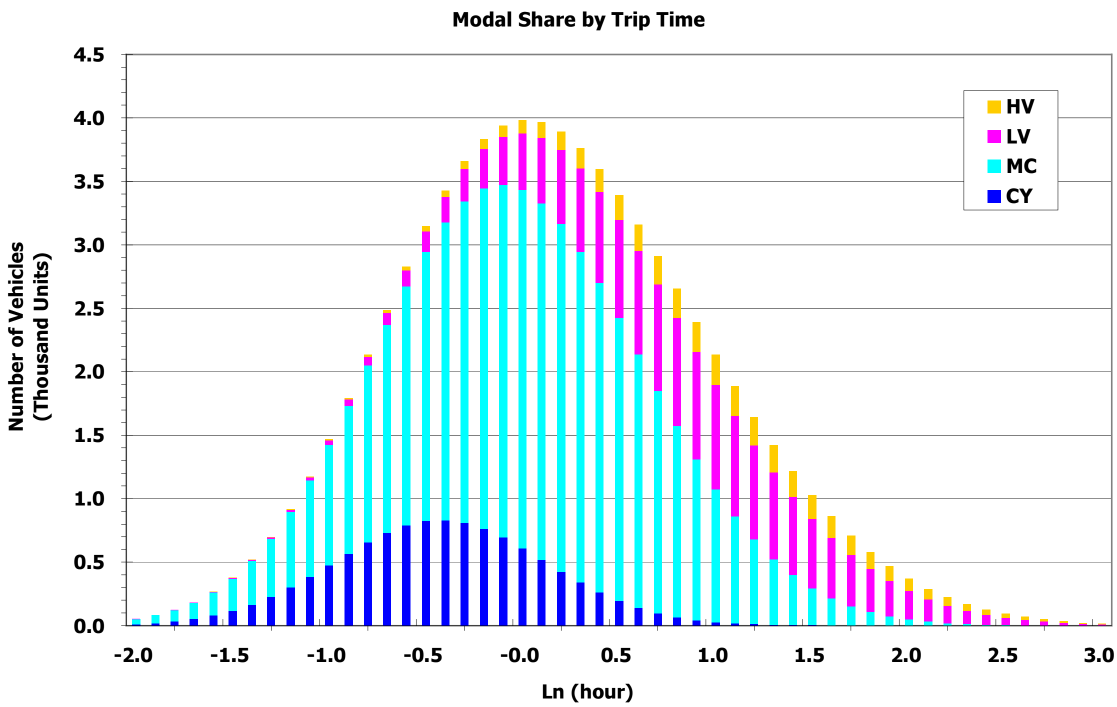


Fig. 4-3-1 Distribution of Modal Share by Trip Time

(3) Modal Share by Trip Time and Distance

As described in previous section, modal share will be varied in line with the desired trip time or distance. According to the observed data and analysis, in the case of one-hour trip, modal share befalls 15.3% for CY, 70.9% for MC, 11.2% for LV, and 2.7% for HV. The shorter trip time or distance, the larger share of 2-wheel vehicles. On the other hand, the longer trip time or distance, the larger share of 4-wheel vehicles, as shown in Table 4-3-1 and Fig. 4-3-2. And these figures were also considered, when trip distribution was calculated.

(4) Modal Shift

As described in previous chapter, modal shift, such as bicycle to motorcycle, motorcycle to light vehicles or public transport, will occur in line with the motorization, hence socioeconomic growth of this country. Although, the pace of modal shift may be varied from slower level to faster level based on the regional and/or local socio-economical potentials. Therefore, we have set up following assumptions to expand present traffic demand for the target year's traffic demand.

i. Total traffic demand will increase as same rate of motorization (therefore, it is not necessarily to bring in additional explanatory variables, such as GDP and/or GDP per Capita, because motorization itself already contains these factors)
ii. Modal shift will occur in line with motorization (therefore, it is not necessarily to bring in additional explanatory variables, such as household income and/or user's preference, because motorization itself already contains this modal shift tendency)
iii. Localized traffic demand will follow the regional socioeconomic magnitudes (therefore, it is necessarily to bring in additional adjustment factor, such as growth index of GRDP, to explain the growth potential of each OD pair)

Table 4-3-1 Estimated Modal Shares by Trip Time

Categories		2W		4W	
		CY	MC	LV	HV
Observed Trip Time (hr)					
	Average	0.69	1.08	2.39	2.79
	Std. Deviation	1.72	2.00	2.05	2.17
	Variance	1.34	1.61	1.68	1.82
	Kurtosis	2.75	4.99	3.94	3.07
	Skewness	0.32	-0.59	-0.54	-0.48
	Median	0.64	1.10	2.59	2.85
	25 Percentile	0.44	0.75	1.59	1.71
	75 Percentile	1.04	1.66	3.80	5.22
Estimated Modal Share					
	30 min	0.294	0.660	0.037	0.009
	60 min	0.153	0.709	0.112	0.027
	90 min	0.072	0.678	0.200	0.050
	120 min	0.033	0.602	0.289	0.076
	180 min	0.008	0.448	0.420	0.123

Categories		2W		4W	
		CY	MC	LV	HV
Estimated Trip Distance (km)					
	Average	6.85	21.36	94.12	83.56
	Std. Deviation	1.72	1.99	2.07	2.17
	Variance	1.34	1.61	1.70	1.82
	Kurtosis	2.79	4.49	3.85	3.07
	Skewness	0.34	-0.50	-0.54	-0.49
	Median	6.40	21.40	104.63	85.29
	25 Percentile	4.37	14.99	58.71	51.16
	75 Percentile	10.37	33.32	153.20	156.41
Travel Speed (km/hr)					
	Assumed	10.0	20.0	40.0	30.0
Number					
	Sampled	252	2,268	1,592	557
	Observed	11,299	49,085	15,400	4,571
	Rate	2.2%	4.6%	10.3%	12.2%

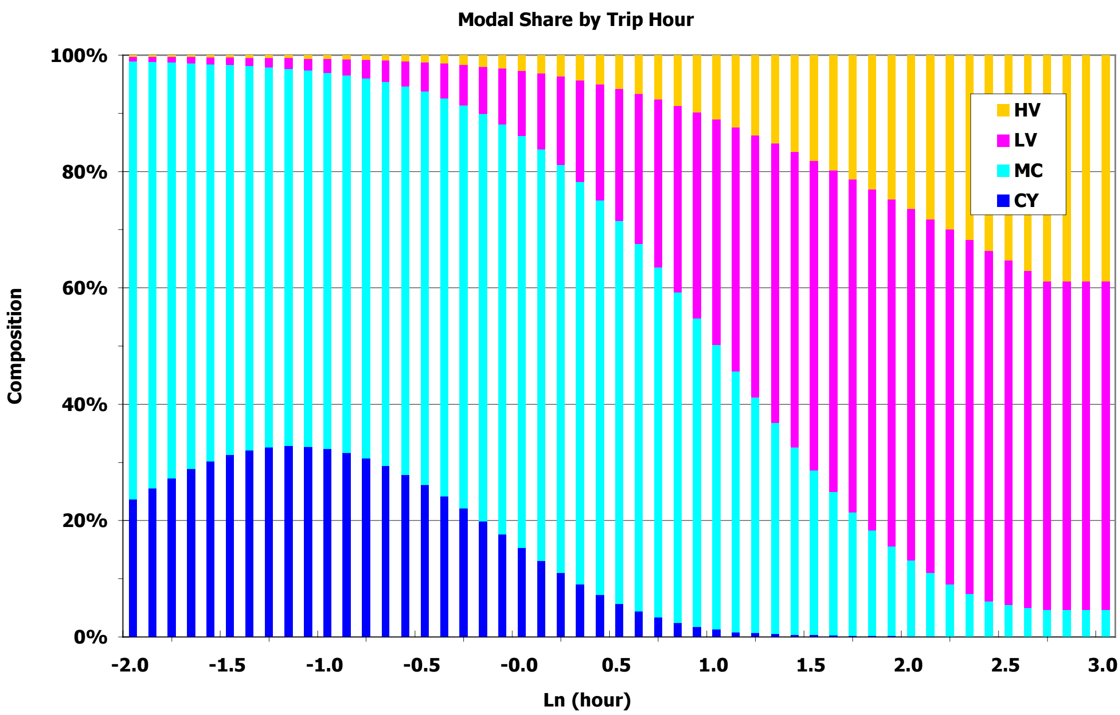


Fig. 4-3-2 Estimated Modal Shares by Trip Time

(5) Expanding and Adjustment Factors

Under above-described assumptions, as shown in Table 4-3-2 and Table 4-3-3, following indexes are utilized for estimating future OD matrixes.

Table 4-3-2 Expanding Factors for Future Traffic Demand Forecast by Mode

Categories	2005	2010	2015
MC	1.21	1.61	2.16
LV	1.28	1.83	2.59
HV	1.25	1.75	2.41
CY	1.08	1.21	1.35
GDP	1.21	1.61	2.15
GDP per Capita	1.12	1.33	1.61

Legend: MC: Motorcycles, LV: Light Vehicles, HV: Heavy Vehicles, CY: Pedal-cycles
Note: All index: 2002 = 1.00, and using High Growth Motorization (Case-II, Linear Function) Scenario, CY is assumed to be expanding in line with population growth

Table 4-3-3 Adjustment Factors for Future Traffic Demand Forecast by Region

Destination / Origin	Plain	Tonle Sap	Coastal	Plateau & Mountain
Plains	1.130	0.991	1.021	0.984
Tonle Sap	0.991	0.869	0.895	0.863
Coastal	1.021	0.895	0.922	0.889
Plateau & Mountain	0.984	0.863	0.889	0.857

Note: All Indexes are based on Future GRDP Indexes (Medium Growth Scenario)

4.4 International & Trespass Traffic Demand Estimation and Forecast[2]

(1) General Condition

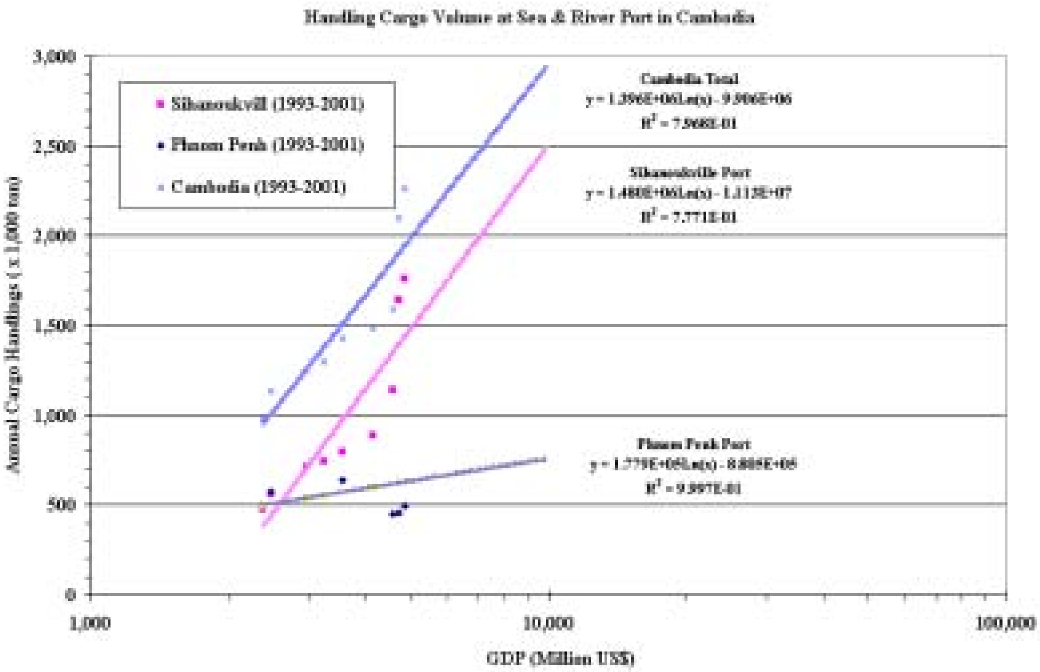
We assumed that some goods presently handled by Sihanouk Ville Port via NR-4 route, or by Phnom Penh Port via Mekong River route, will be converting to land transport via NR-1 route when all section of NR-1 would be improved, and if border of Cambodia and Vietnam would be opened freely. Then, this induced traffic volume to/from Ho Chi Minh City or the other parts of southern Vietnam, such as Kantoh, are assumed to be increasing in line with coutrie's economic scale, in other word, magnitude of gross domestic products (GDP) of the country.

(2) Basic Demands

Past trend and future forecast of handling cargo volume at Sihanoukville Port (SVP) and Phnom Penh Port (PPP) are shown in Fig. 4.4-1.

[2] Border points between Cambodia and Vietnam are not opened officially at present, although only two officially licensed micro-buses are operating between Phnom Penh and Ho Chi Minh City with three times per week or once a day, and carrying around 30 passengers each per day for both direction along NR-1. On the other hand, other trade activities between two countries are very limited at any border points along NR-1, NR-2, and NR-72, and only local people are able to cross border within limited hours, for minor trading, according to the Study Team's on-site surveillance. Another information obtained from official visit by JICA's delegation and Study Team at NR-1's border control station in September 2002, also proved that this station handled 29,419 passenger and 2,622-ton goods in 2000. This is equal to 81 (=29,419/365) passenger and 8.4-ton (=2,622/52/6) goods per day. These demands of passengers and goods would be able to be handled by only 3-microbuses (as same as presently operated scheduled bus) and 1-hevy truck or 2-medium trucks per day. Especially cargo demand is too small to utilize for the future demand forecast. Therefore, induced cross-border demands shall be estimated from convertible demands from these marine-land and inland waterway transport to land transport via NR-1.

Fig. 4-4-1 Past and Future Cargo Volume handled by Ports in Cambodia



According to the past trend, we observed that cargo volume handled by both ports have been increasing in line with counrie's GDP level, and it will be increasing as same manner in the future. Based on this assumption, presently around 960-thousand ton (excluding fuel) and 620-thousand ton (including fuel) of goods are handled by SVP and PPP in 2000, and will be reaching around 2,800-thousand ton and 780-thousand ton per annum correspondigly, if country's GDP will be reaching over 10 billion US dollars level in 2015. Within these volume, some goods will be transferable by land transport via NR-1. Therefore, we also estimate the volume of this transferable goods by port, by item, by share[3].

(3) Estimation

According to this estimation, around 110 thousand ton per annum of cargo would be transferable from marine-land and inland-waterway transport to land transport in 2000, and it will be increasing gradually in line with both countries' economic scale, and might be reaching around 160 thousand ton per annum in 2015. These volume are equivalent of 30-articulated trucks with 20-ton capacity in 2000, and 42 in 2015 per day. As same as ADB's report, we also assumed that a half of these volume will be handled by articulated truck with 20-ton capacity, and remaining half will be handled by heavy truck and middium truck with 10-ton and 5-ton capacities, correspondigly. Therfore, total daily induced cargo truck volume will be 64 (=16+16+32) in 2005, 72 (=18+18+36) in

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[3] In Phnom Penh Port, all item handle by this port are assumed to be to/from southern part of Vietnam, such as HCM and Canto. Although, fuel and other heavy and bulk cargo, such as log & timber, and construction material, will not be transferable to land due to transportation cost and/or regulations that might be applied to those items. On the other hand, in Sihanouk Ville Port, items handled by this port contains not only the goods to/from southern part of Vietnam, but also to/from northern parts of Vietnam and other countries, such as Thailand, Singapore, Taiwan, Australia, and United States. According to the statistics data obtained from ADB's handbook, trading share between Vietnam and Cambodia has been almost constant level with only 10% of all export and import. Therefore, we assumed this share will be constant in the future, and share of southern part of Vietnam is just a half of them. In addition, all containers handle by this port is assumed to be not transferable to land via NR-1, because this port is and will be the only one sea port with advanced container-handling system in this county

2010, and 84 (=21+21+42) in 2015. In our traffic demand forecast, three-quarters of these induced cargos are assumed to be coming from and/or going to Ho Chi Minh City, and remaining one-quarter is assumed to be coming from and/or going to Canto in southern Vietnam.

Table 4-4-1 Induced Cargo Traffic Estimation

Transferable Cargo Volume Estimate on Phnom Penh - Ho Chi Minh Route

	GDP	SV	PP	SV-T	PP-T	TTL-T	ICV	AT	HT	MT
unit	Million US$	x 1,000 ton per annual					unit per day			
2000	4,708	963	624	24	88	112	30	15	15	30
2005	6,229	1,382	674	35	87	121	32	16	16	32
2010	8,336	1,974	726	49	87	137	36	18	18	36
2015	11,155	2,802	777	70	89	159	42	21	21	42

Source: SV: JBIC Report on Review of Feasibility Study of the Sihanouk Ville Port Urgent Rehabilitation Project (PCI)
PP: Study Team estimate based on the Statistics Data provided by Port Authority of Phnom Penh (PCI-KEI)

Legend: SV: Sihanouk Ville Port (excluding Fuel)
PP: Phnom Penh Port (including Fuel)
SV-T: Transferable Cargo from Sihanouk Ville Port
PP-T: Transferable Cargo from Phnom Penh Port
TTL-T: Transferable Cargo Total
ICV: Induced Cargo Volume by AT Equivalent
AT: Articulated Truck (20t)
HT: Heavy Truck (10t)
MT: Medium Truck (5t)

Remarks: Transfer from SV (SV-T) is calculated from following formula: SV-T = 0.025 x SV
0.025 = 0.10 (Vietnam's Share) x 0.50 (Ho Chi Minh's Share) x [1-0.50] (Except Container)
(0.10 = Average Share calculated from Export & Import Figures obtained from ADB Statistics Book 2001)
Transfer from PP (PP-T) is assumed to be All General Cargo,
except Heavy & Bulk Cargo, such as Log & Timber, Construction Material, and Fuel (= Almost Constant)
Induced Cargo Volume (ICV) is calculated from following formula:
ICV = TTL-T x 1/52 (week) x 1/6 (weekday) x 1/20 (AT equivalent) x 1/[1-0.40] (Empty Cargo Ratio)
We also assume ICV will be distributed by AT, HT, and MT as following rates, correspondingly:
AT = 50% HT = 25% MT = 25%

4.5 Traffic Assignment

(1) General Condition

Based on the peak hour traffic volume observed on Monivong Bridge, we have found that 2-lane non-separated road with wide shoulder can handle around 1,500 units of 4-wheel vehicles and 12,500 units of 2-wheel vehicles per hour. Considering mixed traffic with 4-wheel and 2-wheel vehicles, or light and heavy vehicles in 4-wheel vehicles, or motorcycle, bicycle, and motorcycle-trailer (Motorumok) in 2-wheel vehicles, modified passenger car unit (pcu) equivalents are applied for each type of vehicles. Then, free flow speed and capacities of each links are decided according to the present and proposed conditions of corresponding road, by its number of lane, width of shoulder, surface condition, and presence of median (separated or non-separated).

(2) Passenger Car Units (PCU)

Following modified passenger car unit (pcu) equivalents shall be applied for further demand forecast.

Table 4-5-1 Modified Passenger Car Unit (PCU) Equivalents

Classification	LV	HV	MC	CY
Modified PCU Equivalents	1.25	3.75	0.25	0.25

Note: LV: Light Vehicles, HV: heavy vehicles, MC: Motorcycles, CY: Pedal-cycles, PCU: Passenger Car Unit, (Considering mixed traffic by larger and/or slower type of vehicles within the same vehicle categories)

(3) Basic Capacity on Road Networks

Following basic capacities are estimated according to the observed peak hour traffic volume, average peak hour ratio (= 0.15 against 12-hr traffic), and average 24/12-hr ratio (= 1.25).

Table 4-5-2 Basic Capacities of Typical Road Links

Section	Lane	4W	2W	Total
Non-Separated Section	2-lane for 4W & 2-lane for 2W	1,800~2,400 (15,000~20,000)	2,400~3,600 (20,000~30,000)	4,200~6,000 (35,000~50,000)
	4-lane for 4W & 2-lane for 2W	3,600~4,800 (30,000~40,000)		6,000~8,400 (50,000~70,000)
Separated Section	2-lane for 4W & 2-lane for 2W	2,400~3,600 (20,000~30,000)	2,400~3,600 (20,000~30,000)	4,8000~7,200 (40,000~60,000)
	4-lane for 4W & 2-lane for 2W	4,800~7,200 (40,000~60,000)		7,200~10,800 (60,000~90,000)

Unit: Upper: PCU per hour, Lower: PCU per day

(4) Applied Capacity and Free Flow Speed

Following capacities and free flow speed shall be applied for further demand forecast, considering number of lanes, surface condition, and width of shoulder. In addition, relation between traffic volume and travel speed in analytical tool (JICA-STRADA) is described in Fig. 4-5-1.

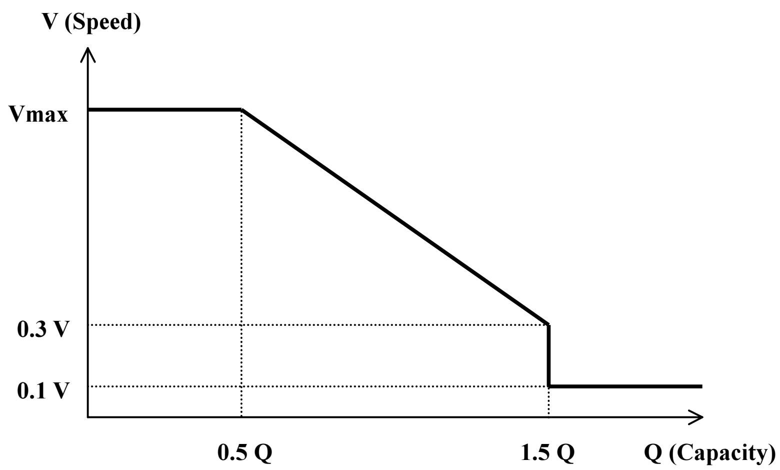

Fig. 4-5-1 QV Curve (Relation between Traffic Volume and Travel Speed)

Table 4-5-3 (a) Free Flow Speed and Capacity Setting for Traffic Assignment (2002~2005)

No.of Lane	Separation	Shoulder	Surface	Free Speed (km/hr)	Capacity (pcu per day)	Applied Section (Km)
4	Yes	Wide	Fair	40	90,000	0.0 ~ 0.6
2	No	Wide	Fair	40	45,000	0.6 ~ 3.5
2	No	Narrow	Fair	40	30,000	3.5 ~ 7.0
2	No	Narrow	Fair	40	30,000	7.0 ~ 14.0
2	No	None	Poor	30	20,000	14.0 ~ 55.4

Note: Shoulder Width; Wide > 1.5m, Narrow < 1.5m

Table 4-5-3 (b) Free Flow Speed and Capacity Setting for Traffic Assignment (2006~2015)

No.of Lane	Separation	Shoulder	Surface	Free Speed (km/hr)	Capacity (pcu per day)	Applied Section (Km)
4	Yes	Wide	Good	40	90,000	0.0 ~ 0.6
4	Yes	Wide	Good	40	90,000	0.6 ~ 3.5
2	Yes	Wide	Good	50	60,000	3.5 ~ 7.0
2	No	Normal	Good	60	45,000	7.0 ~ 14.0
2	No	Normal	Good	60	45,000	14.0 ~ 55.4

Note: Shoulder Width; Wide: = 2.5m, Normal: = 1.5m

(5) Results of Traffic Assignment

After several trial runs with different link settings and OD data adjustments by the incremental assignment programme, we have estimated following traffic demands on C-1 section of National Road No.1, on target year of 2015, as well as mid year of 2005 and 2010.

According to these results, in the “Without Project” case, average travel speed will be gradually declined from 34.4 km/hr in 2002 to 32.9 km/hr in 2015 (2015/2002 = 0.96) in line with the increase of traffic demand from 7.3 thousand in 2002 to 16.2 thousand pcu per day in 2015 (2015/2002 = 2.22), and total vehicle-time will be increasing significantly from 11.8 thousand in 2002 to 27.3 thousand pcu-hr in 2015 (2015/2002 = 2.32).

On the other hand, in the “With Project” case, average travel speed will be kept at level of around 50 km/hr in 2015 (2015/2002 = 1.43), even traffic demand in 2015 might be slightly higher than “Without Project” case by 16.7 thousand pcu per day (2015/2002 = 2.28), and total vehicle time also will be kept at adequate level of 18.7 thousand pcu-hr in 2015 (2015/2002 = 1.59).

Therefore total time saving by the Project will be reaching around 8.6 (= 27.3 - 18.7) thousand pcu-hr per day and this is equivalent with annual time saving by over 3 million pcu-hr in 2015.

Table 4-5-4 Results of Traffic Demand Forecast by Type of Vehicles (With Project Case)

Average Daily & Annual Traffic Volume Estimate 2002-2015 (MC)

Strada	from		to	Length	Average Daily Traffic Volume (Veh/Day)				Average Annual Traffic Volume ('000 Veh/Yr)				Ave. Annual Growth	
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	05-10	10-15
A	0.0	~	3.5	3.5	56,568	68,752	91,148	112,844	20,647	25,094	33,269	41,188	1.058	1.044
B	3.5	~	7.0	3.5	18,240	21,856	28,828	40,148	6,658	7,977	10,522	14,654	1.057	1.068
C	7.0	~	14.1	7.1	11,409	13,511	17,961	23,436	4,164	4,931	6,556	8,554	1.059	1.055
D	14.1	~	25.2	11.1	5,860	6,830	9,289	11,847	2,139	2,493	3,391	4,324	1.063	1.050
E	25.2	~	36.3	11.1	5,182	6,071	8,231	10,476	1,892	2,216	3,004	3,824	1.063	1.049
F	36.3	~	46.8	10.5	4,800	5,656	7,692	9,776	1,752	2,064	2,808	3,568	1.063	1.049
G	46.8	~	55.4	8.6	4,722	5,576	7,512	9,588	1,724	2,035	2,742	3,500	1.061	1.050
Total & Average				55.4	10,037	11,971	16,006	20,470	3,664	4,369	5,842	7,471	1.060	1.050
Index (2002=1.00)					1.00	1.19	1.59	2.04	1.00	1.19	1.59	2.04		
Composition					0.75	0.75	0.73	0.73	0.75	0.75	0.73	0.73		

Average Daily & Annual Traffic Volume Estimate 2002-2015 (LV)

Strada	from		to	Length	Average Daily Traffic Volume (Veh/Day)				Average Annual Traffic Volume ('000 Veh/Yr)				Ave. Annual Growth	
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	05-10	10-15
A	0.0	~	3.5	3.5	8,824	11,234	16,501	21,756	3,221	4,100	6,023	7,941	1.080	1.057
B	3.5	~	7.0	3.5	4,446	5,530	8,350	10,271	1,623	2,018	3,048	3,749	1.086	1.042
C	7.0	~	14.1	7.1	2,967	3,613	5,632	7,406	1,083	1,319	2,056	2,703	1.093	1.056
D	14.1	~	25.2	11.1	1,744	2,080	3,353	4,293	637	759	1,224	1,567	1.100	1.051
E	25.2	~	36.3	11.1	1,574	1,875	2,998	3,845	575	685	1,094	1,403	1.098	1.051
F	36.3	~	46.8	10.5	1,450	1,722	2,742	3,526	529	628	1,001	1,287	1.098	1.052
G	46.8	~	55.4	8.6	1,431	1,691	2,656	3,430	522	617	970	1,252	1.095	1.052
Total & Average				55.4	2,379	2,901	4,493	5,800	868	1,059	1,640	2,117	1.091	1.052
Index (2002=1.00)					1.00	1.22	1.89	2.44	1.00	1.22	1.89	2.44		
Composition					0.18	0.18	0.20	0.21	0.18	0.18	0.20	0.21		

Average Daily & Annual Traffic Volume Estimate 2002-2015 (HV)

Strada	from		to	Length	Average Daily Traffic Volume (Veh/Day)				Average Annual Traffic Volume ('000 Veh/Yr)				Ave. Annual Growth	
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	05-10	10-15
A	0.0	~	3.5	3.5	959	1,197	1,741	2,162	350	437	635	789	1.078	1.044
B	3.5	~	7.0	3.5	785	969	1,425	1,724	287	354	520	629	1.080	1.039
C	7.0	~	14.1	7.1	610	739	1,111	1,407	223	270	405	514	1.085	1.049
D	14.1	~	25.2	11.1	401	482	732	912	146	176	267	333	1.087	1.045
E	25.2	~	36.3	11.1	363	439	662	826	132	160	242	302	1.085	1.045
F	36.3	~	46.8	10.5	327	399	598	750	120	146	218	274	1.084	1.046
G	46.8	~	55.4	8.6	317	389	578	728	116	142	211	266	1.083	1.047
Total & Average				55.4	452	552	824	1,029	165	201	301	375	1.084	1.045
Index (2002=1.00)					1.00	1.22	1.82	2.27	1.00	1.22	1.82	2.27		
Composition					0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04		

Average Daily & Annual Traffic Volume Estimate 2002-2015 (CY)

Strada	from		to	Length	Average Daily Traffic Volume (Veh/Day)				Average Annual Traffic Volume ('000 Veh/Yr)				Ave. Annual Growth	
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	05-10	10-15
A	0.0	~	3.5	3.5	1,000	1,120	1,330	1,610	365	409	485	588	1.035	1.039
B	3.5	~	7.0	3.5	296	332	394	477	108	121	144	174	1.035	1.039
C	7.0	~	14.1	7.1	246	275	327	396	90	100	119	144	1.035	1.039
D	14.1	~	25.2	11.1	385	431	512	620	140	157	187	226	1.035	1.039
E	25.2	~	36.3	11.1	444	497	590	714	162	181	215	261	1.035	1.039
F	36.3	~	46.8	10.5	528	591	702	850	193	216	256	310	1.035	1.039
G	46.8	~	55.4	8.6	679	760	903	1,093	248	278	330	399	1.035	1.039
Total & Average				55.4	485	544	646	782	177	198	236	285	1.035	1.039
Index (2002=1.00)					1.00	1.12	1.33	1.61	1.00	1.12	1.33	1.61		
Composition					0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03		

Average Daily & Annual Traffic Volume Estimate 2002-2015 (ALL)

Strada	from		to	Length	Average Daily Traffic Volume (Veh/Day)				Average Annual Traffic Volume ('000 Veh/Yr)				Ave. Annual Growth	
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	05-10	10-15
A	0.0	~	3.5	3.5	67,351	82,303	110,720	138,372	24,583	30,041	40,413	50,506	1.061	1.046
B	3.5	~	7.0	3.5	23,767	28,686	38,997	52,619	8,675	10,470	14,234	19,206	1.063	1.062
C	7.0	~	14.1	7.1	15,232	18,138	25,031	32,644	5,560	6,620	9,136	11,915	1.067	1.055
D	14.1	~	25.2	11.1	8,390	9,823	13,886	17,671	3,062	3,585	5,069	6,450	1.072	1.049
E	25.2	~	36.3	11.1	7,563	8,882	12,481	15,862	2,761	3,242	4,556	5,790	1.070	1.049
F	36.3	~	46.8	10.5	7,105	8,368	11,735	14,902	2,593	3,054	4,283	5,439	1.070	1.049
G	46.8	~	55.4	8.6	7,149	8,416	11,650	14,840	2,610	3,072	4,252	5,417	1.067	1.050
Total & Average				55.4	13,354	15,968	21,969	28,080	4,874	5,828	8,019	10,249	1.066	1.050
Index (2002=1.00)					1.00	1.20	1.65	2.10	1.00	1.20	1.65	2.10		
Composition					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		

Table 4-5-5 Comparison of Traffic Demand Forecast (With and Without Project Case)

- Daily Traffic Volume, Average Speed, and Average Volume-Capacity Ratio (VCR) -

With Project Case

Strada	from		to	Length	Daily Traffic Volume (pcu)				Average Speed (km/hr)				Average VCR			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	29,024	36,046	50,427	64,140	39.7	39.0	39.9	39.1	0.48	0.59	0.56	0.71
B	3.5	~	7.0	3.5	13,142	16,100	23,157	29,646	40.0	40.0	50.0	40.0	0.44	0.54	0.39	0.49
C	7.0	~	14.1	7.1	8,917	10,739	15,847	20,676	40.0	40.0	50.0	50.0	0.30	0.36	0.35	0.46
D	14.1	~	25.2	11.1	5,252	6,243	9,496	12,142	30.0	40.0	60.0	60.0	0.26	0.21	0.21	0.27
E	25.2	~	36.3	11.1	4,740	5,668	8,559	10,964	30.0	40.0	60.0	60.0	0.24	0.19	0.19	0.24
F	36.3	~	46.8	10.5	4,378	5,254	7,917	10,167	30.0	40.0	60.0	60.0	0.22	0.18	0.18	0.23
G	46.8	~	55.4	8.6	4,335	5,207	7,752	9,996	30.0	40.0	60.0	60.0	0.22	0.17	0.17	0.22
Total & Average				55.4	7,307	8,856	12,993	16,672	34.4	39.7	51.0	49.3	0.30	0.28	0.27	0.34
Index (2002=1.00)					1.00	1.21	1.78	2.28	1.00	1.15	1.48	1.43	1.00	0.93	0.89	1.15

Without Project Case

Strada	from		to	Length	Daily Traffic Volume (pcu)				Average Speed (km/hr)				Average VCR			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	29,024	35,950	50,189	63,726	39.7	39.0	36.9	34.3	0.48	0.59	0.82	1.04
B	3.5	~	7.0	3.5	13,142	16,004	22,919	29,424	40.0	40.0	38.7	36.7	0.44	0.53	0.76	0.98
C	7.0	~	14.1	7.1	8,917	10,643	15,608	20,364	40.0	40.0	39.9	39.3	0.30	0.35	0.52	0.68
D	14.1	~	25.2	11.1	5,252	6,147	9,141	11,678	30.0	30.0	30.0	29.9	0.26	0.31	0.46	0.58
E	25.2	~	36.3	11.1	4,740	5,556	8,179	10,473	30.0	30.0	30.0	30.0	0.24	0.28	0.41	0.52
F	36.3	~	46.8	10.5	4,378	5,142	7,523	9,662	30.0	30.0	30.0	30.0	0.22	0.26	0.38	0.48
G	46.8	~	55.4	8.6	4,335	5,095	7,367	9,499	30.0	30.0	30.0	30.0	0.22	0.25	0.37	0.47
Total & Average				55.4	7,307	8,751	12,651	16,228	34.4	34.4	33.8	32.9	0.30	0.36	0.52	0.66
Index (2002=1.00)					1.00	1.20	1.73	2.22	1.00	1.00	0.98	0.96	1.00	1.20	1.73	2.22

Index (With/Without)

Strada	from		to	Length	Daily Traffic Volume (pcu)				Average Speed (km/hr)				Average VCR			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	1.00	1.00	1.00	1.01	1.00	1.00	1.08	1.14	1.00	1.00	0.68	0.68
B	3.5	~	7.0	3.5	1.00	1.01	1.01	1.01	1.00	1.00	1.29	1.09	1.00	1.01	0.51	0.50
C	7.0	~	14.1	7.1	1.00	1.01	1.02	1.02	1.00	1.00	1.25	1.27	1.00	1.01	0.68	0.68
D	14.1	~	25.2	11.1	1.00	1.02	1.04	1.04	1.00	1.33	2.00	2.01	1.00	0.68	0.46	0.46
E	25.2	~	36.3	11.1	1.00	1.02	1.05	1.05	1.00	1.33	2.00	2.00	1.00	0.68	0.47	0.47
F	36.3	~	46.8	10.5	1.00	1.02	1.05	1.05	1.00	1.33	2.00	2.00	1.00	0.68	0.47	0.47
G	46.8	~	55.4	8.6	1.00	1.02	1.05	1.05	1.00	1.33	2.00	2.00	1.00	0.68	0.47	0.47
Total & Average				55.4	1.00	1.01	1.03	1.03	1.00	1.16	1.51	1.50	1.00	0.78	0.52	0.52
Index (2002=1.00)					1.00	1.01	1.03	1.03	1.00	1.16	1.51	1.50	1.00	0.78	0.52	0.52

PCU: Passenger Car Unit Equivalents VCR: Volume Capacity Ratio

- Capacity-Length, Vehicle-Length, and Vehicle-Time -

With Project Case

Strada	from		to	Length	Capacity-Length (pcu-km)				Vehicle-Length (pcu-km)				Vehicle-Time (pcu-hr)			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	213,750	213,750	315,000	315,000	101,584	126,161	176,495	224,490	2,560	3,237	4,423	5,741
B	3.5	~	7.0	3.5	105,000	105,000	210,000	210,000	45,997	56,350	81,050	103,761	1,150	1,409	1,621	2,594
C	7.0	~	14.1	7.1	211,500	211,500	317,250	317,250	62,865	75,710	111,722	145,764	1,572	1,893	2,234	2,915
D	14.1	~	25.2	11.1	222,000	333,000	499,500	499,500	58,301	69,301	105,401	134,772	1,943	1,733	1,757	2,246
E	25.2	~	36.3	11.1	221,000	331,500	497,250	497,250	52,379	62,627	94,575	121,151	1,746	1,566	1,576	2,019
F	36.3	~	46.8	10.5	210,000	315,000	472,500	472,500	45,969	55,167	83,129	106,754	1,532	1,379	1,385	1,779
G	46.8	~	55.4	8.6	174,000	261,000	391,500	391,500	37,717	45,298	67,445	86,963	1,257	1,132	1,124	1,449
Total & Average				55.4	1,357,250	1,770,750	2,703,000	2,703,000	404,812	490,614	719,815	923,654	11,761	12,349	14,121	18,745
Index (2002=1.00)					1.00	1.30	1.99	1.99	1.00	1.21	1.78	2.28	1.00	1.05	1.20	1.59

Without Project Case

Strada	from		to	Length	Capacity-Length (pcu-km)				Vehicle-Length (pcu-km)				Vehicle-Time (pcu-hr)			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	213,750	213,750	213,750	213,750	101,584	125,825	175,662	223,041	2,560	3,229	4,763	6,495
B	3.5	~	7.0	3.5	105,000	105,000	105,000	105,000	45,997	56,014	80,217	102,984	1,150	1,400	2,073	2,806
C	7.0	~	14.1	7.1	211,500	211,500	211,500	211,500	62,865	75,033	110,036	143,567	1,572	1,876	2,756	3,653
D	14.1	~	25.2	11.1	222,000	222,000	222,000	222,000	58,301	68,236	101,467	129,627	1,943	2,275	3,382	4,342
E	25.2	~	36.3	11.1	221,000	221,000	221,000	221,000	52,379	61,389	90,378	115,727	1,746	2,046	3,013	3,858
F	36.3	~	46.8	10.5	210,000	210,000	210,000	210,000	45,969	53,991	78,992	101,451	1,532	1,800	2,633	3,382
G	46.8	~	55.4	8.6	174,000	174,000	174,000	174,000	37,717	44,324	64,089	82,642	1,257	1,477	2,136	2,755
Total & Average				55.4	1,357,250	1,357,250	1,357,250	1,357,250	404,812	484,812	700,839	899,039	11,761	14,103	20,756	27,290
Index (2002=1.00)					1.00	1.00	1.00	1.00	1.00	1.20	1.73	2.22	1.00	1.20	1.76	2.32

Index (With/Without)

Strada	from		to	Length	Capacity-Length (pcu-km)				Vehicle-Length (pcu-km)				Vehicle-Time (pcu-hr)			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	1.00	1.00	1.47	1.47	1.00	1.00	1.00	1.01	1.00	1.00	0.93	0.88
B	3.5	~	7.0	3.5	1.00	1.00	2.00	2.00	1.00	1.01	1.01	1.01	1.00	1.01	0.78	0.92
C	7.0	~	14.1	7.1	1.00	1.00	1.50	1.50	1.00	1.01	1.02	1.02	1.00	1.01	0.81	0.80
D	14.1	~	25.2	11.1	1.00	1.50	2.25	2.25	1.00	1.02	1.04	1.04	1.00	0.76	0.52	0.52
E	25.2	~	36.3	11.1	1.00	1.50	2.25	2.25	1.00	1.02	1.05	1.05	1.00	0.77	0.52	0.52
F	36.3	~	46.8	10.5	1.00	1.50	2.25	2.25	1.00	1.02	1.05	1.05	1.00	0.77	0.53	0.53
G	46.8	~	55.4	8.6	1.00	1.50	2.25	2.25	1.00	1.02	1.05	1.05	1.00	0.77	0.53	0.53
Total & Average				55.4	1.00	1.30	1.99	1.99	1.00	1.01	1.03	1.03	1.00	0.88	0.68	0.69
Index (2002=1.00)					1.00	1.30	1.99	1.99	1.00	1.01	1.03	1.03	1.00	0.88	0.68	0.69

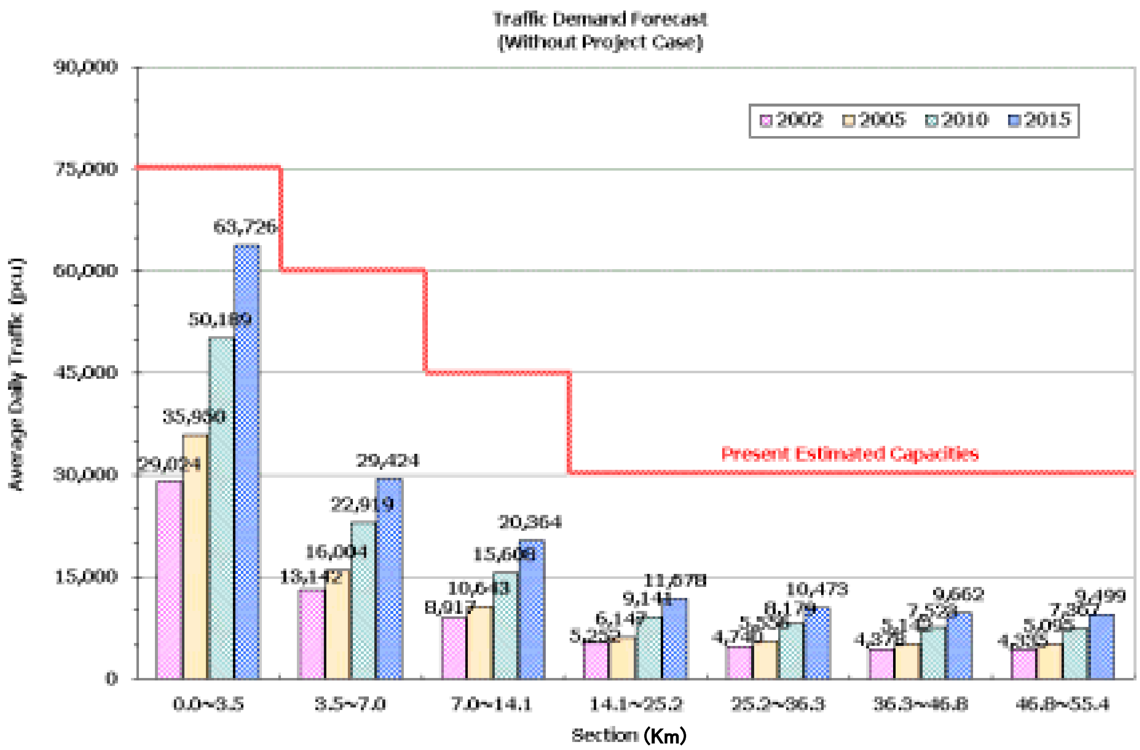

Fig. 4-5-2 (1/2) Results of Traffic Demand Forecast (Without Project Case)

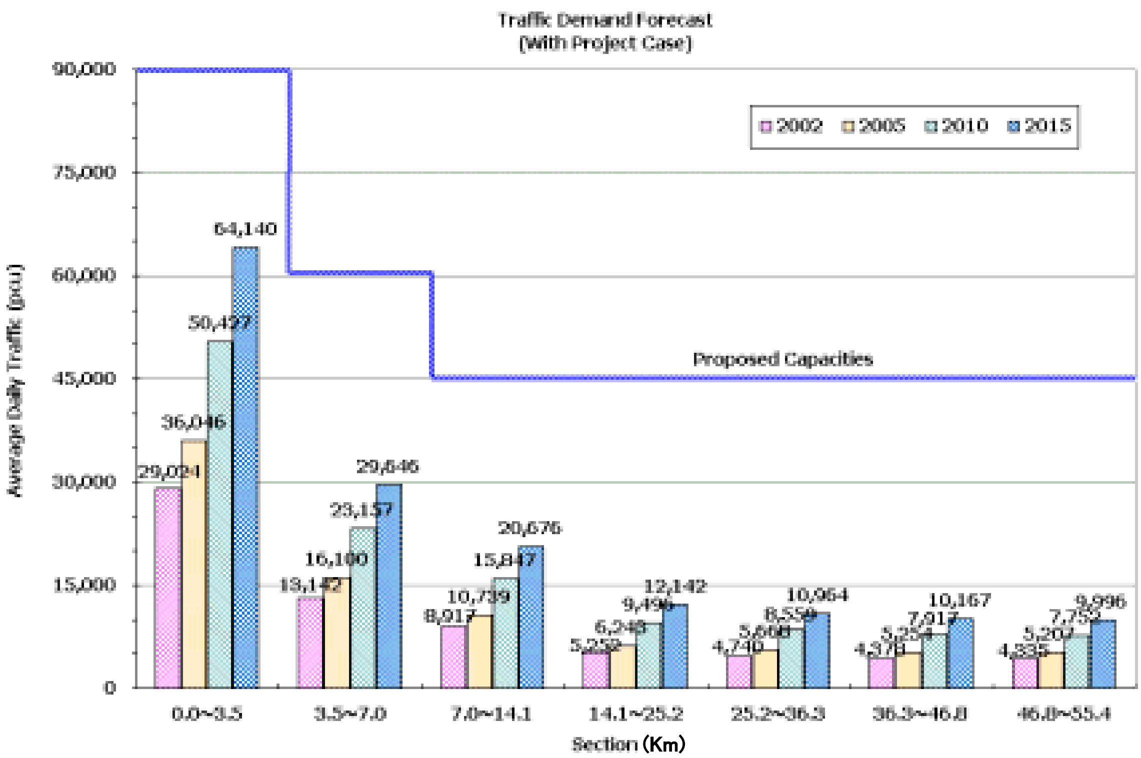

Fig. 4-5-2 (2/2) Results of Traffic Demand Forecast (With Project Case)

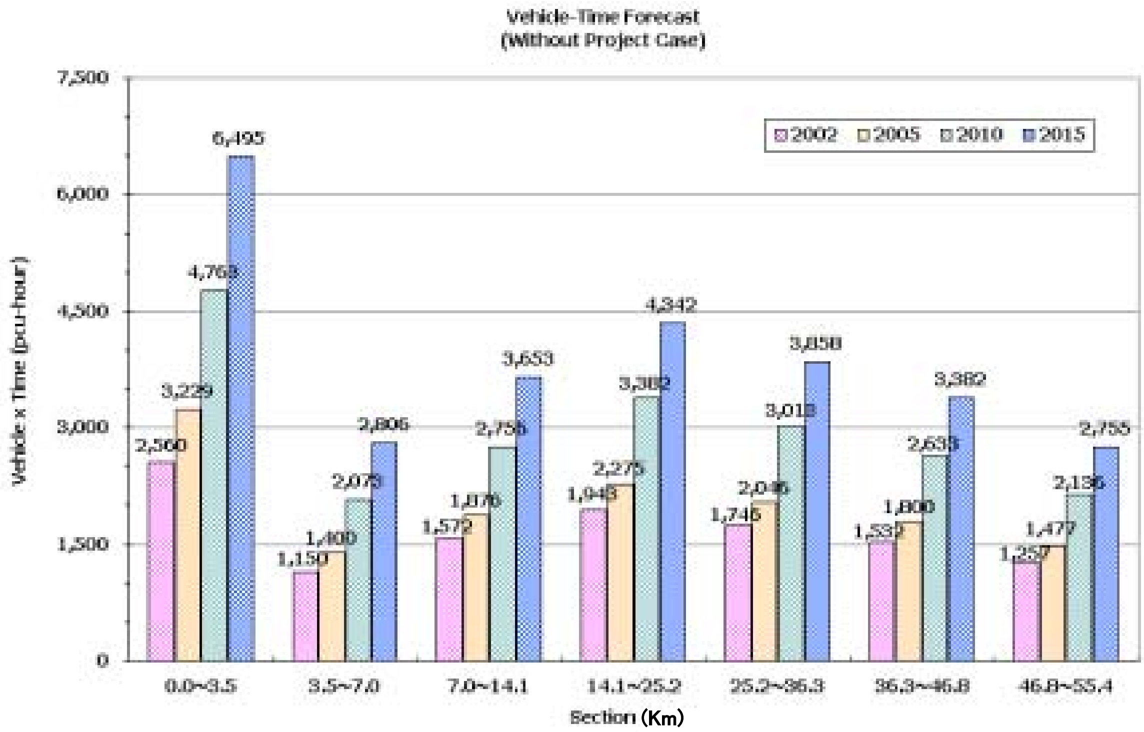

Fig. 4-5-3 (1/2) Results of Vehicle Time Forecast (Without Project Case)

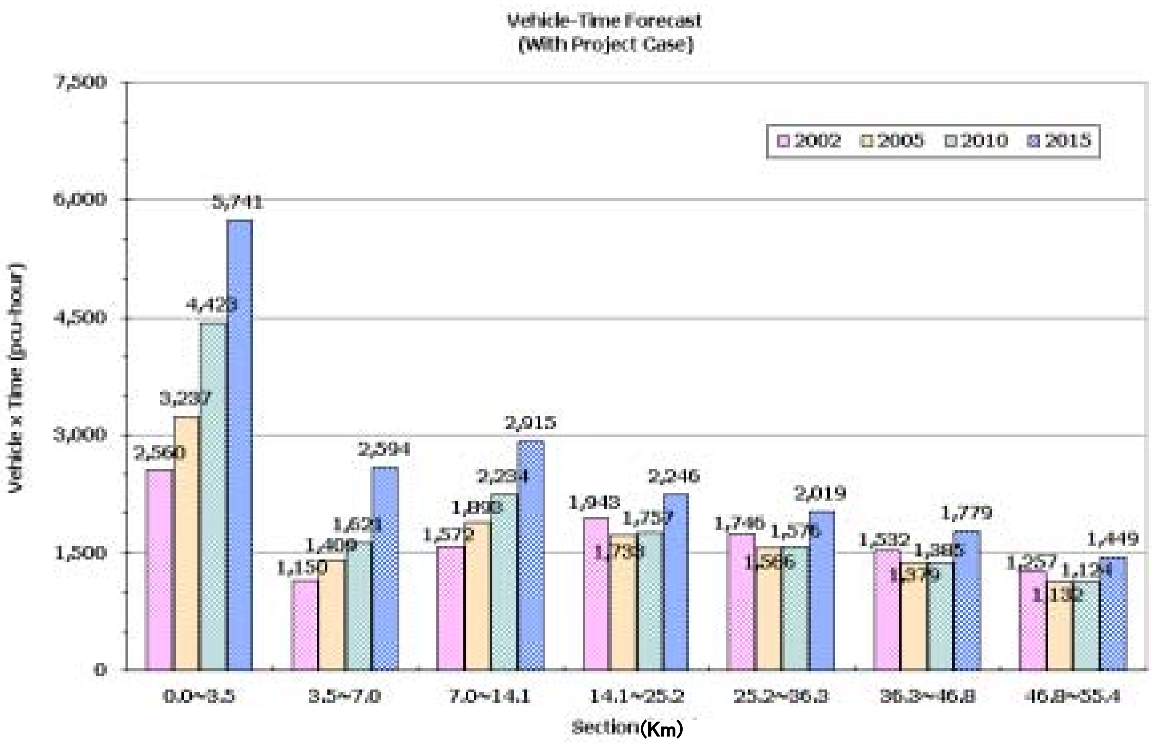

Fig. 4-5-3 (2/2) Results of Vehicle Time Forecast (With Project Case)

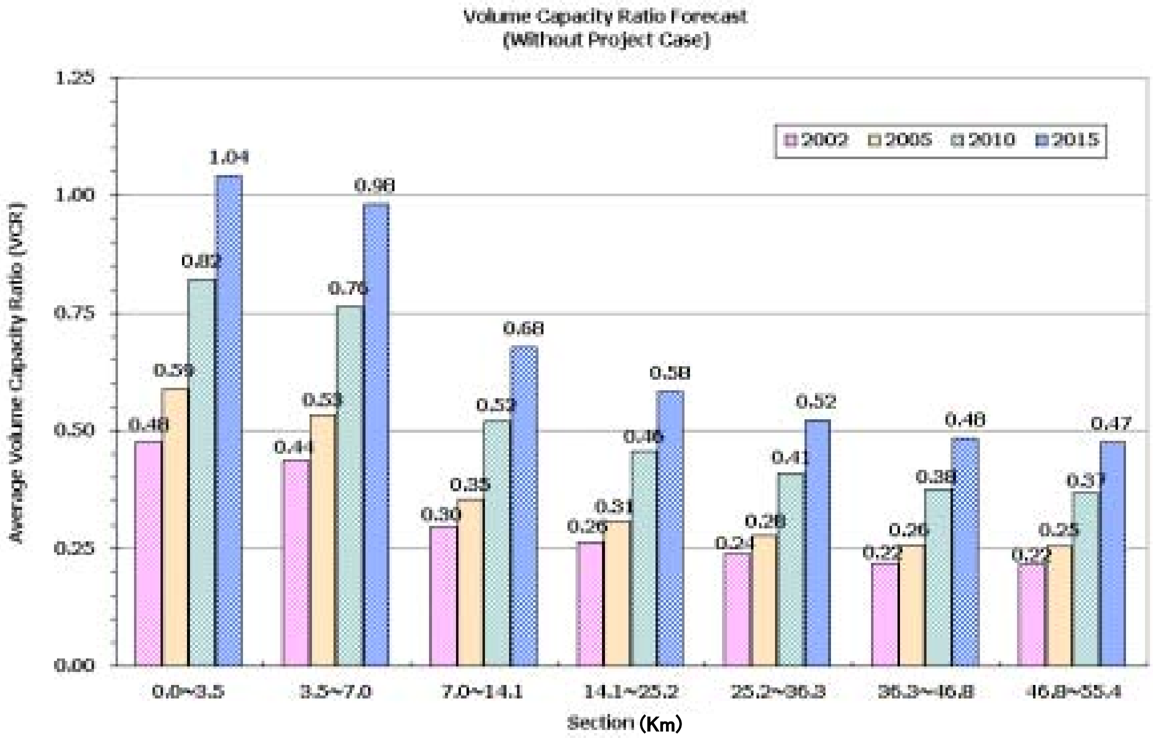

Fig. 4-5-4 (1/2) Results of VCR Forecast (Without Project Case)

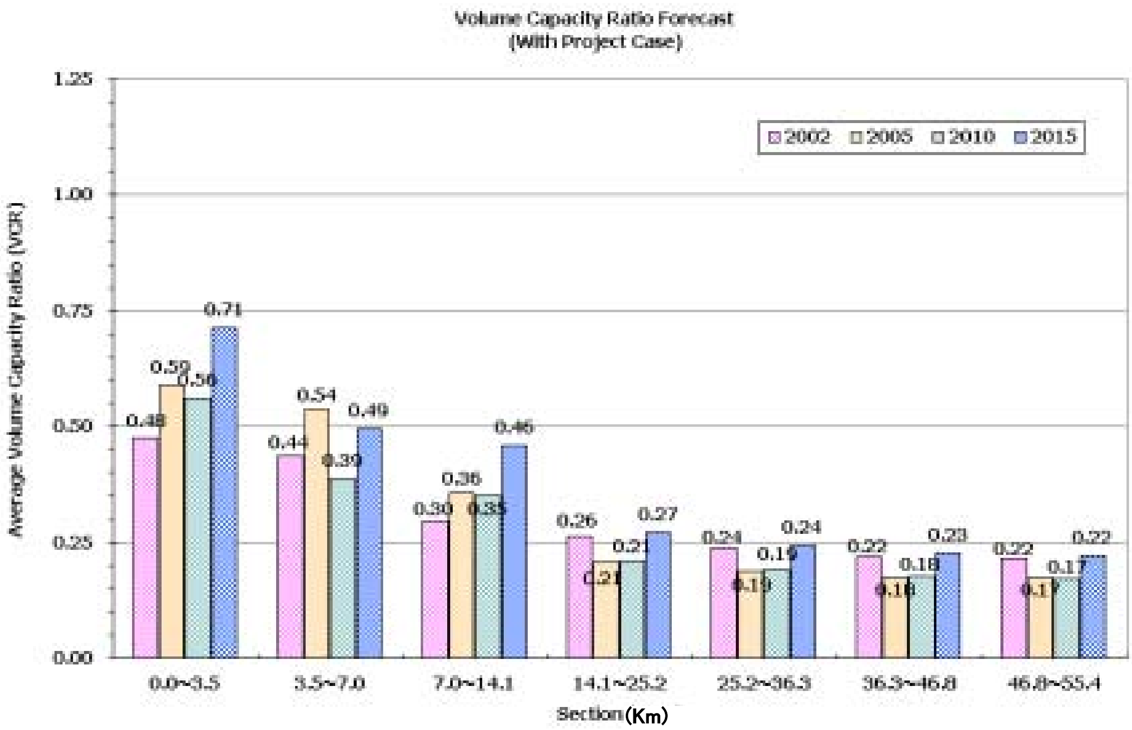

Fig. 4-5-4 (2/2) Results of VCR Forecast (With Project Case)

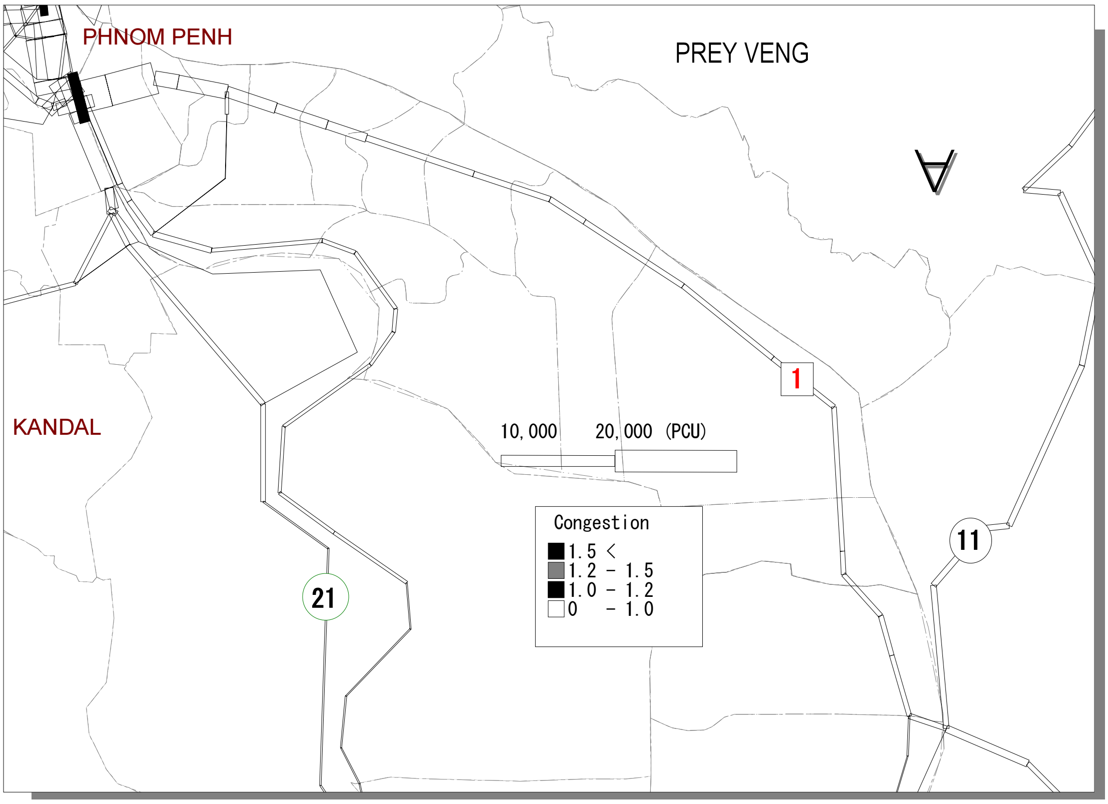

Fig. 4-5-5 (1/4) Traffic Assignment – 2002

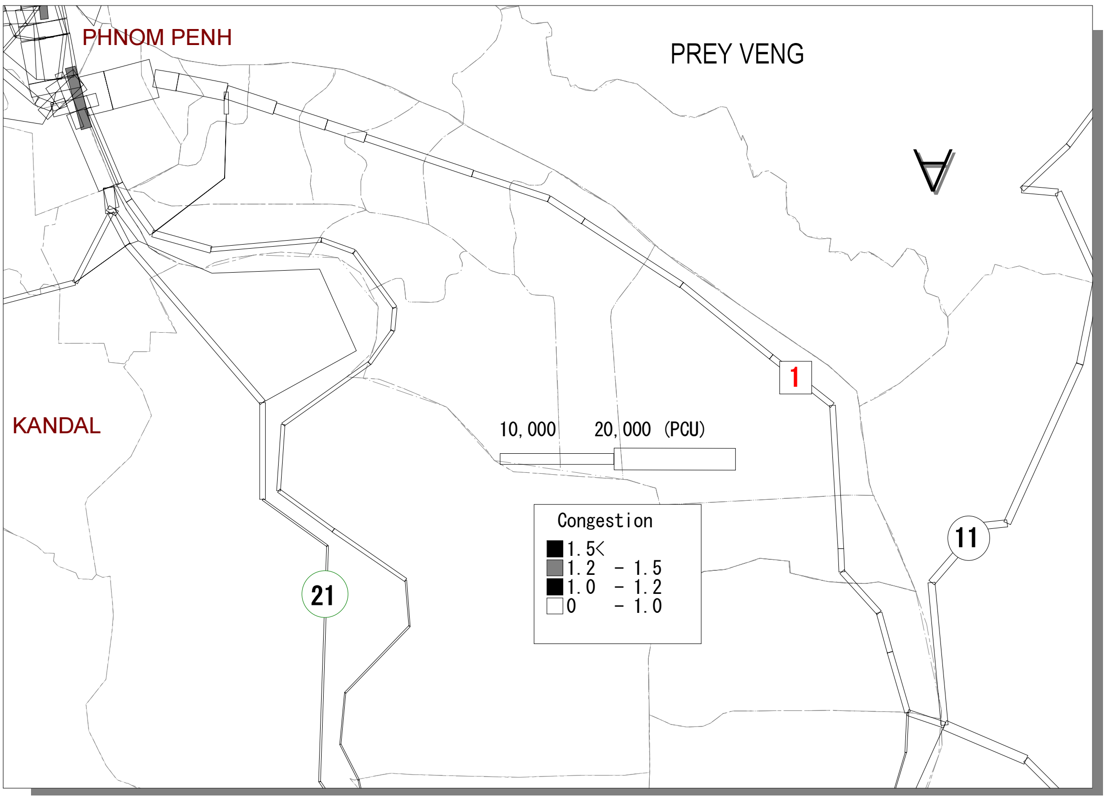

Fig. 4-5-5 (2/4) Traffic Assignment – 2005

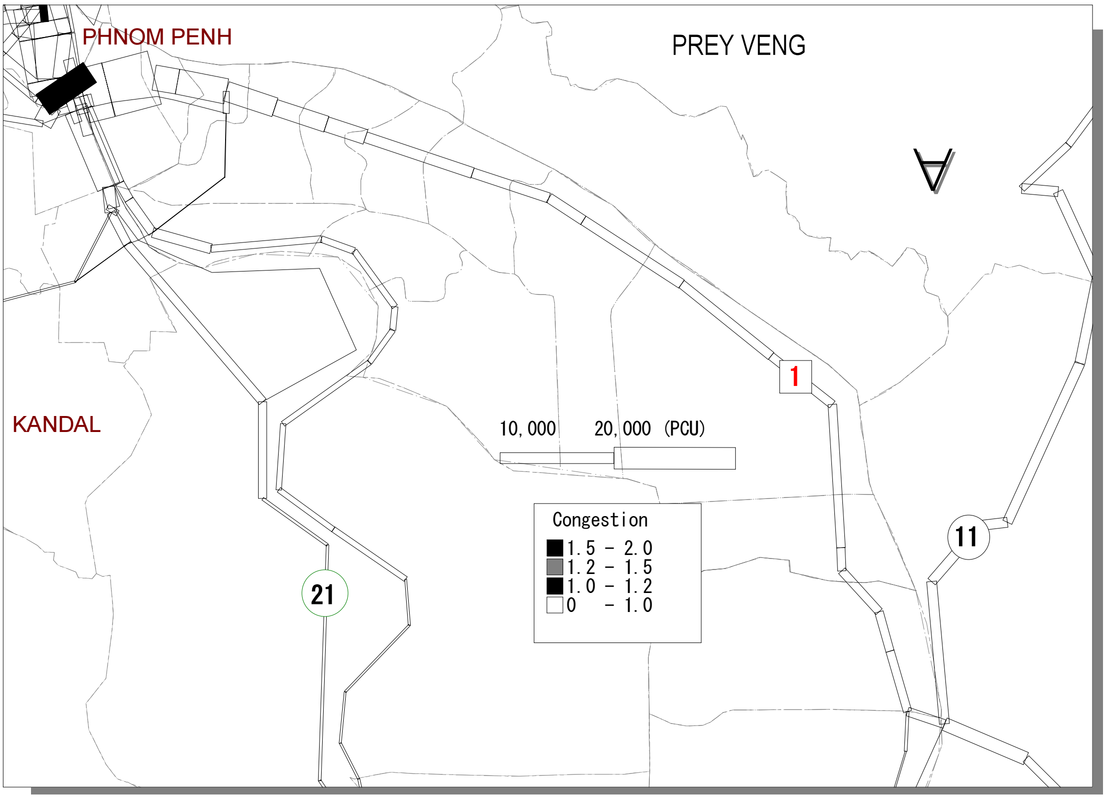

Fig. 4-5-5 (3/4) Traffic Assignment – 2010

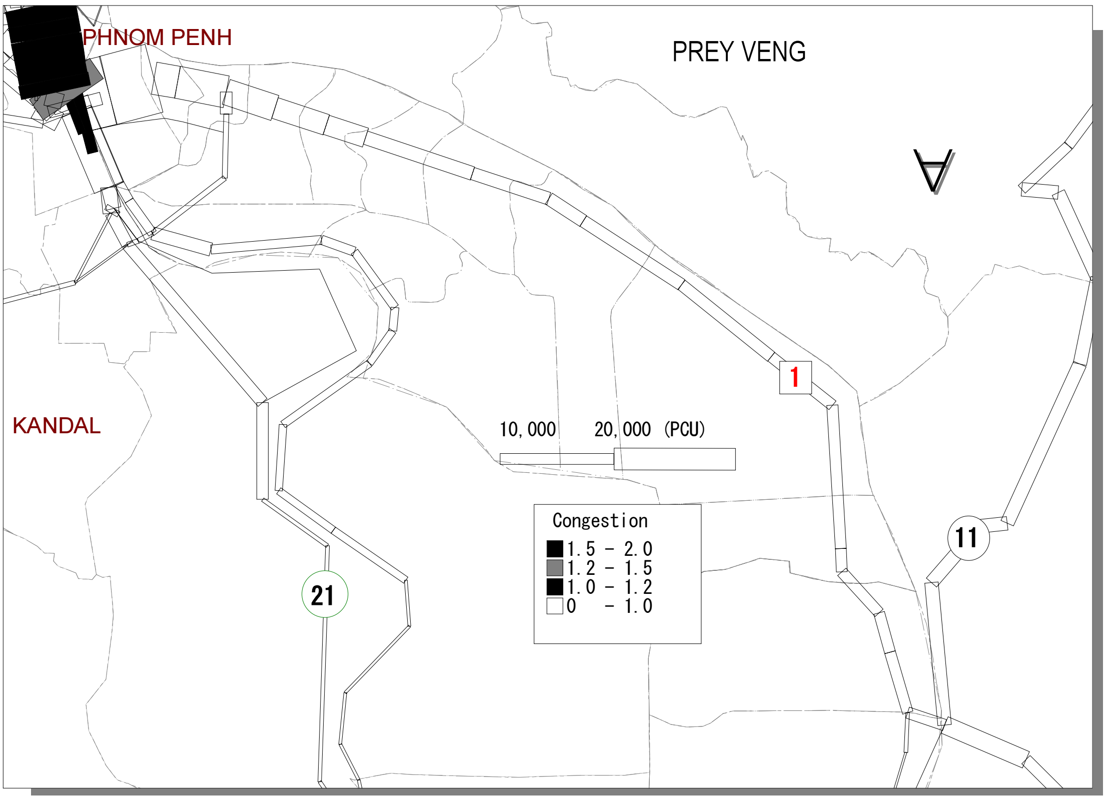

Fig. 4-5-5 (4/4) Traffic Assignment – 2015

CHAPTER 5 EXISTING CONDITIONS OF BRIDGES AND STRUCTURES

CHAPTER 5 EXISTING CONDITIONS OF BRIDGES AND STRUCTURES

5.1 Outline of Existing Conditions of Bridges and Structures

The project road is a part of National Road No.1 (NR-1), this is one of major arterial road as well as the Asian Highway No.A-1.

The current conditions of road structures (bridges and culverts) located in the project road (C-1 Section, length of 56km) of NR-1 were investigated by the Study Team in association with Local Consultant.

The project road is the stretch of NR-1 along the Mekong River between the eastern edge of the Monivong Bridge in Phnom Penh and the west terminal of Neak Loueng ferry crossing. During the rainy season, this road embankment is subject to serious damage by floods.

There were 14 structures on the project road including demolished and/or did not find out of four structures according to interview from local residents.

Finally, total existing structures are ten, comprising six water gates, two temporary bailey bridges and two pipe culverts. The station number, name and type of structures on the project road are shown in Fig. 5-1-1 and Table 5-1-1.

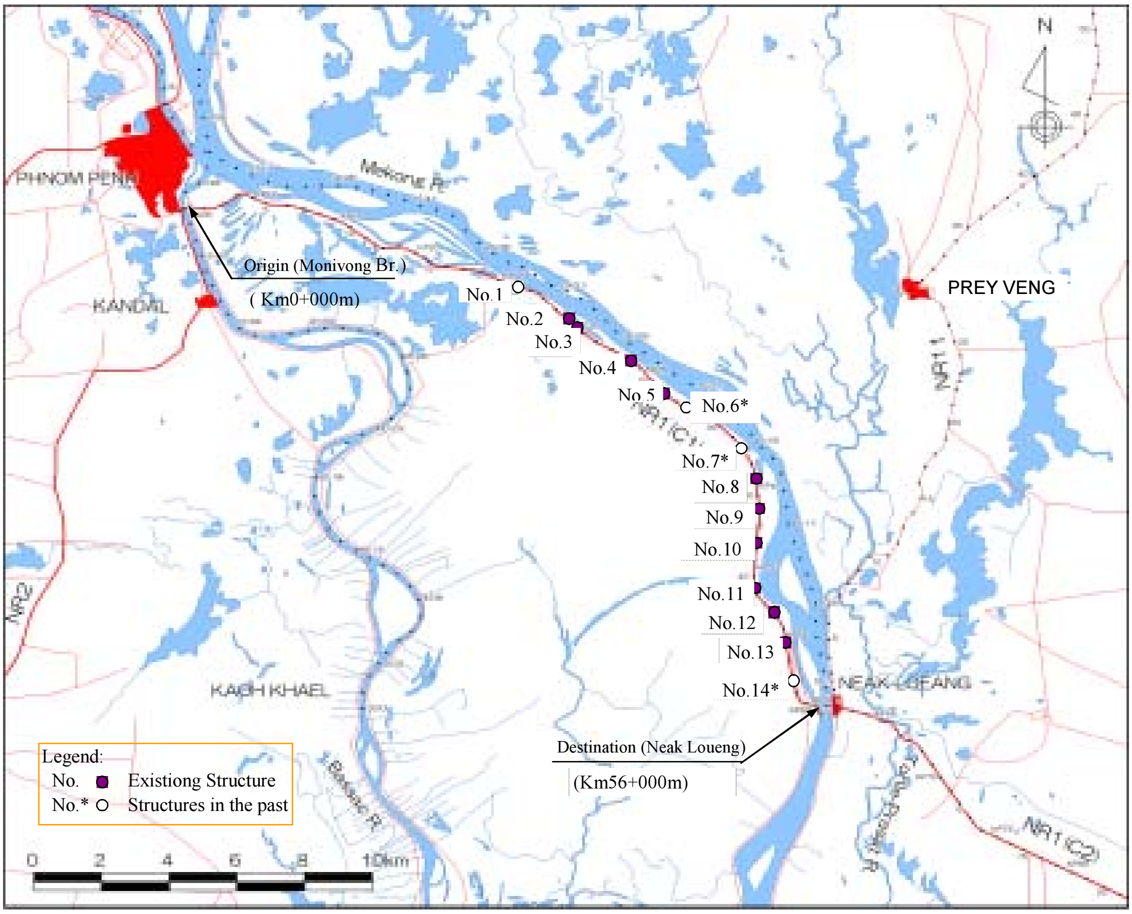

Fig. 5-1-1 Location of Structures on the Project Road

Table 5-1-1 List of Existing Structures on the Project Road

No	Station (Km)	Structure Name	Dimension		Type (span arrangement, number of gate)
			Section in Road-way parallel Length(m)	Section in Crossing Direction width(m)	
1*	20+640	Sdau Kanlang	Interview only		There was pipe culvert in the past.
2	24+000	Prek Loueng Culvert	0.50	10.50	1 0.5m (Steel)
3	24+840	Rohat Kchal Culvert	1.00	12.50	1 1.0m (RC)
4	28+450	Prek Pol Water Gate	10.10	20.00	3 Gates (by Japan's grant aid)
5	31+120	Prek Yourn Water Gate	10.10	23.50	3 Gates (by Japan's grant aid)
6*	32+800	Prek Ta Kaev	Interview only		There was pipe culvert in the past.
7*	36+900	Spean Dek	Interview only		There was steel bridge in the past.
8	38+923	Prek Chrey Water gate	10.10	23.50	3 Gates (by Japan's grant aid)
9	41+040	Prek Samrong Thom Water Gate	7.80	8.50 (6.50)	2 Gates
10	42+830	Pou Miev Bridge	99.00	5.70 (4.00)	3 Spans
11	45+776	Kokir Thom Water Gate	10.00	20.00	3 Gates (by Japan's grant aid)
12	47+967	Khbal Chrouy Bridge	66.00	5.50 (3.80)	2 Spans
13	50+040	Kampong Phnom Water Gate	7.70	8.50 (5.60)	3 Gates
14*	52+100	Spean Wat	Interview only		There was steel bridge, pipe culverts in the past.

*: Structure locations from interview results, but not found

Regarding the above two bridges, Pou Miev Bridge and Khbal Chrouy Bridge were temporarily constructed for urgent repair after collapsed the embankment by year 2000 floods. They are of bailey type with a potential lifespan of a few years. These sites of bridges have been scoured due to heavy rain and flood. The improvement works of bridges such as river bed protection and reinforcement of piers are currently carrying out on site.

The four water gates were constructed for colmatage and irrigation system with assistance of Japan's grant aid in the completion year 2002. The carriage-way width of 13.5 m at these water gates is satisfactory to the Asian Highway standard. Current conditions of the structures are also very well.

Other two old water gates and two pipe culverts were constructed under the Pol Pot and/or Sihanouk Regime. They might have incurred serious abrasion due to water flow or poor construction according to the chipped concrete members and the exposure of aggregates on surfaces. Moreover, a lot of scale, spall, honeycomb and cracks are visible on the whole of structures.

For other four locations, there were culverts and/or bridges at project road in the past time, from interview of residents.

5.2 Inventory Survey of Existing Bridges and Structures

5.2.1 Scope of Work

The following items are to be surveyed to establish inventory of existing structures related project road.

- To measure structural dimensions and summarize as a sketch (plan, profile, cross section etc.,)
- To take photograph for structures regarding damages/defects, and summarize in a sheet
- To compile all the data above as "Inventory of Facility"

5.2.2 Results of Inventory Survey

The inventory survey was conducted on the following points. The results were examined as shown in Table 5-1-1 and Table 5-2-1, and in attached photographs of existing conditions, and separate volume "Inventory Survey Report".

1)	Structure name	2)	Kilo Post	3)	Crossing object
4)	Structure type	5)	Dimension	6)	Composition of lane
7)	Completion year	8)	Load limit	9)	Design standard
10)	Pavement type	11)	Barrier type	12)	Handrail type
13)	Foundation type	14)	Bearing type	15)	Expansion type
16)	Slope protection type and dimension	17)	River bank protection type and dimension	18)	River bed protection type and dimension
19)	Approach road				

The results of the current conditions for each structure are shown in Table 5-2-1.

Table 5-2-1 Results of Inventory Survey for Structures

No	Structure Name	Outline
(1)	(Km 20+640) Sdau Kanlang	Interview only: There was pipe culvert crossing road in the past from interview and/or terrain around site. Pipe culvert did not find out currently.
(2)	Prek Loueng Culvert Constructed Sihanouk Regime 1965	Small functioning for discharge capacity in flood seasons as drainage pipe. Steel pipe ϕ 0.5m, mud inside. Highest water level is 1.5m above the road surface. Position of steel pipe is settled, and scoured around in/out let.
(3)	Rohat Kchal Culvert Constructed Pol Pot Regime 1979	Small functioning for discharge capacity in flood seasons as drainage pipe. Concrete pipe ϕ 1.0m with wing wall is over age, and quality of concrete is not good, cracked, etc. Highest water level is 0.5m below the road surface.
(4)	Prek Pol Water Gate Constructed 2002	This was newly constructed in 2002. Highest water level is 1.5m below the road surface. Functioning very well.
(5)	Prek Yourn Water Gate Constructed 2002	This was newly constructed in 2002. Highest water level is 2.7m below the road surface. Functioning very well.
(6)	(Km 32+800) Prek Ta Kaev	Interview only: There was pipe culvert (1.0m) before 1979, and collapsed by floods. Then, detour road was constructed by Vietnam Soldier. Culvert did not find out.
(7)	(Km 36+900) Spean Dek	Interview only: There was steel bridge (10-15m length) in past, and demolished in 1994. Now, embankment. (There is detour road at up-stream side)
(8)	Prek Chrey Water Gate Constructed 2002	This was newly constructed in 2002. Highest water level is 1.55m below the road surface. Functioning very well.
(9)	Prek Samrong Thom Water Gate Constructed Pol Pot Regime 1977	This was constructed under Pol Pot regime in 1977. This is seriously damaged with many cracks, spalling of concrete members, lime-water leaking and re-bar exposed. Settled approach road. Now, small functioning for water gate, because upstream of channel was filled with embankment for factory.
(10)	Pou Miev Bridge Temporary constructed 2000	River bed and H-steel piers are under repair work due to heavy scour. Slope was seriously eroded and is under repair work. No abutments are present. This is subject to load limit of 16 ton and narrow width with 4.0m.
(11)	Kokir Thom Water Gate Constructed 2002	This was newly constructed in 2002. Highest water level is 3.2m below the road surface. Functioning very well.
(12)	Khbal Chrouy Bridge Temporary constructed 2000	River bed and H steel piers are under repair work due to heavy scour. Slope was seriously eroded and is under repair work. No abutments are present. This is subject to load limit of 16 ton and narrow width with 4.0m.
(13)	Kampong Phnom Water Gate Constructed Pol Pot Regime 1976	Slab was fallen out and covered by steel plates on surface and filled in concrete to slab. Lots of scale and spalling are visible. Many cracks occurred and exposed re-bar. Exposure of aggregate on whole concrete structural surface. No gate is present. Approach road at both side settled. Functioning only in flood seasons.
(14)	(Km 52+100) Spean Wat	Interview only: There was steel bridge (10-15m length), and demolished in 1986. And pipe culverts were installed. However, due to constructed housing land, culverts were demolished, and embanked in 1999.

5.3 Stability of Existing Structures

The outline of structural study for the project road is to be evaluated the existing structures, and to be considered the location/type/scale of applicable new structures in viewpoints of structural characteristics, geographical and hydrological study, environment, and whole cost/benefit, etc. The method/procedure of structural study for the project road is shown in Fig. 5-3-1.

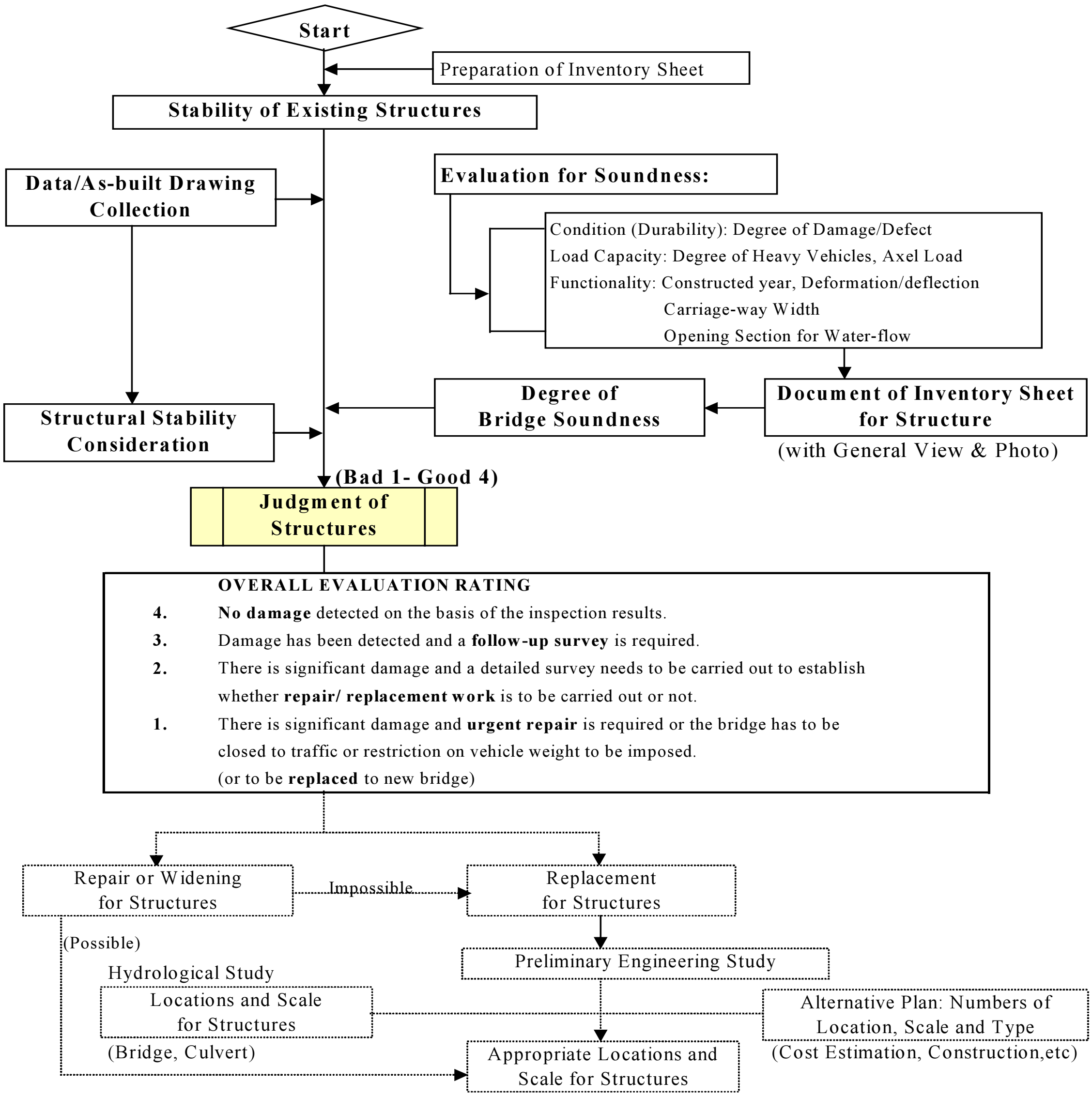

Fig. 5-3-1 Structural Study for the Project

As shown in the above flowchart, the stability of the existing structures was examined by the following two methods for evaluation as shown in Fig. 5-3-2.

(a) Soundness evaluation by site inspection/observation and data collection

(b) Consideration of structural aspects as stability/strength

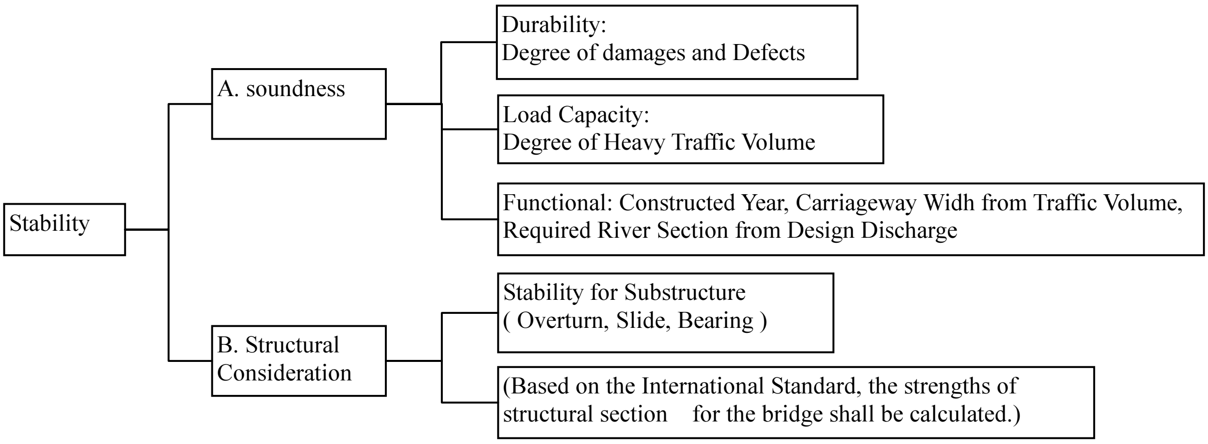

Fig. 5-3-2 Overall Evaluation Factor

5.3.1 Soundness Evaluation

Based on the inventory survey, the soundness evaluation in terms of present conditions, traffic level and functionality is to be carried out to identify the current damages and defects, the necessity of repair or replacement on the existing structures.

The evaluation method as shown in Table 5-3-1 is adapted to this project. On the basis of the evaluation results for each item, total rating on each structure is to be calculated.

Table 5-3-1 Rating for Existing Structures

Condition (Durability)	Load Capacity	Functionality	Evaluation point
No damage/defects	Heavy vehicle truck load more than 20 ton	No deformation/deflection Sufficient carriageway width Sufficient opening width for water flow	**4 (A)**
Inspection is required due to a few damage/defects	-	Functioning satisfactorily with a small deformation/deflection	**3 (B)**
Detailed inspection is required due to a lot of damage/defects	-	Big deformation/deflection Other functioning with small insufficient	**2 (C)**
Urgent repair work and/or Replacement work is required due to a lot of damage/defects	Heavy vehicle truck load less than 20 ton	Big deformation/deflection Insufficient carriageway width Insufficient opening width for water flow	**1 (D)**

The current **conditions of durability** are evaluated from the results of inventory survey (damage and defects) as separate volume “Inventory Survey Report”.

Traffic level is evaluated for load capacity such as surface, slab and beam according to the proportion of heavy vehicles on structures. The assumed 20 ton truck is according to Japanese specification, live loading system of “TL-20”.

Functionality is evaluated in terms of carriageway width for traffic, opening section for flood flow and deformation/deflection for vehicle passage.

5.3.2 Consideration of Structural Stability/ Strength for Existing Structures

There are no as-built drawings in the past year 1970s, except new four water gates constructed by Japan's Grant Aid in 2002.

Therefore, in this project, structural stability for the over-age structures is assumed from judging by damages/defects conditions, degree of deflection/vibration passing heavy traffic, and scouring conditions around structures, etc.

Two old water gates and two pipe culverts constructed in year 1960s- 1970s are not stable in viewpoints of the above judging items.

Also, the strengths of slab for old water gate were roughly calculated as shown in Table 5-3-2, applying reinforcing bars with diameter of 14mm and interval of 150mm from field inventory and below photograph 5-3-1.

Table 5-3-2 Result of Slab Strength for Old Water Gate

Part	Result				Remarks
Slab (Beam)	M=9.46tfm/m				t = 30cm, Re-bar: ϕ 14mm-150mm ctc
Material	Working Stress		Allowable Stress	Result	Remarks
Re-bar	σ s= 4,091kgf/cm2	>	σ sa=1,600kgf/cm2	over	"T-20" Load System, Japanese Standard
Concrete	σ c=114kgf/cm2	>	σ ca=70kgf/cm2	over	

As shown above results by ordinal live loading system, the working strengths of slab for existing water gate are exceeded against allowable strengths.

For example, small functionality of old two pipe culverts and critical defected slabs of over aged two old gates are shown in below Photograph 5-3-1.

(2) Km 24+000 Prek Loueng Culvert

(3) Km 24+840 Rohat Kchal Culvert

(9) Km 41+040 Prek Samroang Thom Water Gate (13) Km 50+040 Kampong Phnom Water Gate

Photograph 5-3-1 Defected Slabs of Two Old Water Gates

On the other hand, two bailey bridges is constructed using steel girder for emergency repair in caused flood year 2000. These bridges are only temporary facilities because of load limitation with 16 ton truck, carriage-way width with 4m, and temporary steel H beam piers, and embankment without abutments.

The existing conditions of temporary two bailey bridges are shown in Photograph 5-3-2.

(10) Km 42+830 Pou Miev Bridge L=99m under Repair (12) Km 47+967 khbal Chrouy Bridge L=66m Width-4m

Photograph 5-3-2 Conditions of Temporary Bailey Bridges (Cut-off: year 2000)

From below Reference of traffic survey, heavy vehicles are passing in the rage of 30.9% over 20 ton trucks on the project road NR-1.

Thus, due to heavy traffic transportation, durability of the existing structures might be caused serious defects/damages in near future.

Reference:

The results of conditions of heavy vehicles on project road NR-1 are shown in below:

- Ratio of heavy vehicle was 13.9% (PCU)
- Ratio of over 20 ton truck was 30.9% (over 25 ton was 19.1%)
- Measured vehicle weight including axle load on NR-1: referred in below Table 5-3-3. (Maximum axle load for measured truck weight 18.3 ton)

Table 5-3-3 Measured Vehicles Weight over 20 ton Trucks on NR-1

No.	Axle 1	Axle 2	Axle 3	Total (t)
12	7.3	18.3	-	25.6
20	6.3	15.1	14.9	36.3
25	4.6	12.1	12.1	28.8
26	4.8	8.2	7.9	20.9
27	8.7	10.5	10.6	29.8
28	8.6	10.7	10.4	29.7
29	7.3	7.8	9.3	24.4
30	7.7	9.4	10.2	27.3
31	7.1	13.7	-	20.8
32	5.9	9.0	9.5	24.4
33	4.5	10.4	9.6	24.5
34	7.8	10.8	10.4	29.0
35	5.3	11.7	10.0	27.0
37	6.2	12.3	11.2	29.7
40	5.4	9.1	8.8	23.3
44	7.7	10.5	10.5	28.7
47	4.9	13.8	13.6	32.3
51	5.9	9.7	9.2	24.8
56	6.4	10.5	7.7	24.6
65	4.8	14.3	13.2	32.3
71	7.3	15.9	-	23.2
72	8.8	15.1	-	23.9
74	4.4	11.8	11.5	27.7
77	5.6	8.4	8.3	22.3
82	5.5	15.2	-	20.7
83	6.5	9.1	8.7	24.3
84	7.6	10.2	10.9	28.7
86	4.5	8.4	7.9	20.8
91	4.7	11.0	10.9	26.6

Note: There were 29 vehicles are over 20t. It was measured 94 vehicles in total

5.3.3 Results of Overall Evaluation

The results of overall soundness evaluation for project structures are summarized in Table 5-3-4 referring field inventory sheet (separate volume).

Table 5-3-4 Overall Soundness Evaluation for Project Structure

Evaluation Item			Rating	Structure Number													
			4 3 2 1 Good → Bad	**1***	**2**	**3**	**4**	**5**	**6***	**7***	**8**	**9**	**10**	**11**	**12**	**13**	**14***
Durability	Degree of damages & defects of structure		4 3 2 1		2	2	4	4			4	1	2	4	2	1	
Load Capacity	Heavy vehicle axle load more than 20 ton		4				4	4			4			4			
	Heavy vehicle axle load less than 20 ton		1		1	1						1	1		1	1	
Function	Deformation/deflection		4 3 2 1		4	4	4	4			4	3	2	4	2	3	
	Carriageway width	Sufficient for future traffic	4				4	4			4			4			
		Insufficient for future traffic	1		1	1						1	1		1	1	
	Opening width	Sufficient for flood flow	4				4	4			4			4			
		Insufficient for flood flow	1		1	1						1	1		1	1	
Total Evaluation Point					9	9	20	20			20	7	7	20	7	7	
Overall Evaluation		A: Sound	(17-20 point)														
		B: Fairy Sound	(13-16 point)														
		C: Unsound	(9-12 point)														
		D: Dangerous	(5-8 point)														

Note: Structures number 1*, 6*, 7* and 14* used to exist in the past.

From the results of above Table 5-3-2 and Table-5-3-4, two pipe culverts (No.2, 3), two old water gates (No.9, 13), and two temporary bailey bridges (No.10, 12) shall be replaced and/or repaired urgently.

The problems for existing old structures are as follows;

Existing old water gates (No.9, 13)

It is over aged (constructed in 1970s). Quality of concrete is very poor. There are critical damages on concrete slab and shortage of loading capacity. Carriage-way width is too narrow for present and future traffic demand.

Existing pipe culverts (No.2, 3)

It is over aged (constructed in 1960s- 1970s). There are shortage of discharge capacity and carriageway width for future traffic demand.

Temporary steel bailey bridges (No.10, 12)

It is temporary bridge and durability is not sufficient. Loading capacity is very low at 16t and carriageway is only 4m wide.

However, the widening/repair of the existing structures is difficult and shall be replaced with new structure from below reasons;

Existing old water gates (No.9, 13)

It is difficult to connect between new and over-age concrete in widening/ reinforcement. It shall be replaced with new water gate type

Existing pipe culverts (No.2, 3)

There is insufficient opening section. It shall be replaced with new pipe/box culvert type

Temporary steel bailey bridges (No.10, 12)

There is insufficient width (4m) and loading Capacity. There is 16-ton loading limitation. Furthermore it is a temporary bridge. Permanent bridges should supersede these two bailey bridges.

Therefore, six existing structures (No.2, 3, 9, 10, 12 and 13) shall be replaced with new structures. The main items to be considered for planning and designing the new openings would be as follows;

Hydrological Aspects:	flood condition, opening section, discharge capacity and location
Structural Aspects:	stability, loading capacity, material availability, ease of construction and maintenance and construction cost
Transportation Aspects:	carriageway width, network functionality for NR-1/Asian Highway
Others:	topographic, geological, socio-economic and aesthetic conditions, etc.

Four other locations (No.1, 6, 7, 14) had opening structures in the past. The information was gained by interviewing local inhabitants by the study team. It is necessity to study the necessity of openings to meet inflow capasity.

5.3.4 Consideration of Monivong Bridge

The eastern end of Monivong Bridge is a origin point for the project road (The bridge itself is out of the study area). This bridge spans Bassac River and form a part of National Road No.1 (NR-1) in Kingdom of Cambodia. NR-1 connects Phnom Penh to Neak Loueng, Svay Rieng and even to Vietnam. It is also a part of Asian Highway No. A-1.

Future traffic demand requires two traffic lanes in each direction. The existing Monivong Bridge has only one lane in each direction and it would be the bottleneck of traffic on NR-1 in near future. It is important to know the soundness and durability of the existing bridge to solve this problem.

The bridge is supposed to be constructed in 1950s or 1960s by French contractor. The construction year cannot be secured because neither the official information nor as-built drawings are available. The details were obtained by inventory survey. Results are as follows;

(1) Dimension of the Bridge

Estimated dimension of Monivong Bridge is as follows;

- Bridge Length: 270m (75+120+75m)
- Width: 13.4m (Side-walk 2@1.2m, Carriage-way 11m with 2 lanes)
- Super Structural Type: Pre-stressed Concrete 2-Box Girder,
  3-Span Continuous Girder
  (Assumed tensioning method: Freyssinet)
- Foundation Type: Steel Pipe Piles

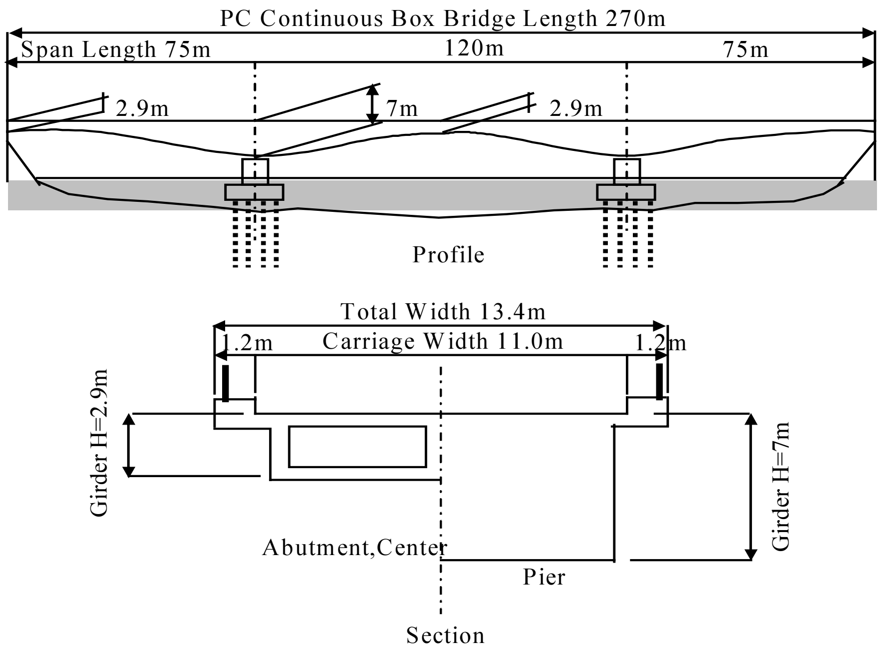

Fig. 5-3-3 Estimated Dimension of Monivong Bridge

(2) Existing Conditions of the Bridge

- Approach Embankment: Safe at both revetments of the bridge, but erosion is ongoing.
- Scouring in River Section: Unidentified (Under the water could not be seen)
- Pavement & Accessories: Functional (no critical defects were found) (Joints, Handrail, Shoe, etc.)
- Structure[1]:

Rigidity:	No deflection/ vibration on the bridge
Girder Concrete Strength:	Concrete strength was assumed as 57 Pa by Schmidt hammer, enough strength for pre-stressed concrete
Slab:	Lateral reinforced bars into slab were assumed for distribution of stress
Live Load Limitation:	No limitation (16 ton in the past)
Foundation for Substructure:	Steel pipe piles with large size

- Ratio of Girder Height/ Span Length

The average ratio of Monivong Bridge is 1/ 18.2

(3) Evaluation for Monivong Bridge

In viewpoints of visual inspection, above mentioned study and past report, the entire Monivong Bridge is expected to stabilize against international loading system.

Similarity of ratio girder height/ span length could give estimation of sufficient stability of existing Monivong Bridge. Similar pre-stressed concrete girders had been constructed in Japan. Followings are two examples of the ratio which has same girder type as Monivong Bridge. Japan International Loading System is applied to these bridges;

- Case 1- Length 84+120+84m Girder height 3.0, 8.0m (average ratio 1/17.5)
- Case 2- Length 80+104+80m Girder height 2.5, 5.5m (average ratio 1/22.0)

However, degrees of scouring due to floods around abutments, revetments and piers shall be surveyed/ recorded, and identified every year. Whole hydrological characteristics of Bassac, Tonle Sap, and Mekong River shall be investigated for safety/ stability for Monivong Bridge.

The detailed investigation/ study for Monivong Bridge will be required such as structural stability/ safety to secure for new international loading system. The followings should be taken into account; as-built drawings, applied design criteria, hydrological and geographical analysis, etc. as no records of design and/or construction are available in this study.

5.4 Review of Recent Bridge and Structure Construction Project

The bridges and other structures in Cambodia have been implemented themselves to emergency repair, rehabilitation and construction during 1980 and 1991.

[1] Source: Transport Master Plan of Phnom Penh Metropolitan Area Report Nov. 2000

After Peace Agreement, Rehabilitation Projects of Cambodian Road Network was started with assistances of various foreign countries after 1992.

Recent bridges and other structures on Trunk Road Networks in Cambodia are rehabilitated/ constructed funding by the Asian Development Bank (ADB), World Bank (WB), Australian Aid, French Aid and Japanese Aid, etc. These Design Standards are variously applied. However, based on the Australian Standard, Cambodian Standards for roads and bridge structures were published in year 1999.

Main recent and ongoing bridges/structures construction projects in Cambodia are shown in Table 5-4-1 including water gates on National Road No.1.

Table 5-4-1 Main Recent and Ongoing Bridge/Structure Projects

year	Assist Country/Organization	Location	Scope of Project
1993-1994	Japan	Chrouy Changvar Bridge	Reconstruction of 3 Spans Continuous Bridge
1993-1996	ADB	570km of NR-1,2,3,5,6,11	Procurement Steel Panel Bridges
1995-1996	Aus-Aid	NR-5, NR-6	Procurement 17 Bridges, Construction 12 Bridge
1996-1999	Japan	NR-6, NR-7	Reconstruction 13 Bridge, New construction 3 Bridges 110km Road Improvement
1996-2003	Japan	Mekong, Kampong Cham	Kizuna Bridge, New Bridge 1360m
1999-2003	ADB	NR-1(C-2)	105km Road and 3 Bridges Rehabilitation
2000-2003	WB	NR-6, NR-3	Reconstruction of Some Bridges
2000-	France	NR-11	Emergency Rehabilitation of 3 Bridges
2000-2002	Japan	NR-6A	Reconstruction of 3 Bridges
2000-2002	Japan	NR-1(C-1)	Construction of 4 Colmatage Water Gates
2000-2003	ADB	NR-5, NR-6, NR-7	Reconstruction of Some Bridges
2001-2003	Japan	NR-7, Kampong Cham	Reconstruction 1 Bridge 210m
2001-	South Korea	NR-3	Reconstruction of 9 Bridges

CHAPTER 6 EXISTING CONDITION OF THE PROJECT ROAD

CHAPTER 6 EXISTING CONDITION OF THE PROJECT ROAD

6.1 Review of Road Structure for Recent Road Improvement/ Rehabilitation Projects

Poor road condition of Cambodia has drawn attention of many donors including World Bank (WB), Asian Development Bank (ADB) and the Government of Japan (GOJ), and there have been many projects of road improvement/rehabilitation. Table 6-1-1 lists the major improvement/rehabilitation projects of principal National Roads.

Table 6-1-1 Major Improvement/Rehabilitation Project of Principal National Roads

NR No.	Section	Length (km)	Year of Implementation	Fund Source*	Remarks
1	(i) Neak Loueng ~ Vietnam Border	105	1999 ~ 2003	ADB	-
	(ii)Phnom Penh ~ Neak Loueng	55	-	-	Under study
2	Takeo Center ~ Vietnam Border	52		GOJ**	D/D on-going
3	Rtrapeang Ropov ~ Veal Rinh	21.5	2001 ~ 2003	WB	-
	Rtrapeang Ropov ~ Kampot	32.8	-	GOK	Loan processing
4	(Sihanouk Ville) ~ Phnom Penh	(220)	1994 ~ 1995	USAid	-
5	(i) Poipet ~ Sisophon	48.5	-	(ADB)	Loan processing
	(ii) Sisophon ~ Battambang	83	2001 ~ 2003	ADB	Loan No. 1824
	(iii) Battambang ~ Svay Doun Keo	50	2000 ~ 2003	ADB	Loan No. 1697
	(iv) Svay Doun Keo ~ Krakor	80	2000 ~ 2003	ADB	Loan No. 1697
	(v) Krakor ~ Kampong Chhnang	50	2001 ~ 2003	ADB	Loan No. 1824
	(vi) Kampong Chhnang~ Phnom Penh	50	-	RGC	-
6	(i) Siem Reap ~ Sisophon	100	-	(ADB)	Loan processing
	(ii) Siem Reap ~ Roluos	17.5	2000 ~ 2002	GOJ	-
	(iii) Roluos ~ Prey Romeas	61.1	2001 ~ 2004	WB	-
	(iv) Prey Romeas ~ Kampong Thom	70	2000 ~ 2003	ADB	Loan No. 1697
	(v) Kampong Thom ~ Skun	88	2001 ~ 2003	ADB	Loan No. 1824
	(vi) Chueng Chhnok ~ Skun	29	1998 ~ 1999	GOJ	Together with NR-7
	(vii) Phnom Penh ~ Chueng Chhnok	44	1994 ~ 1995	GOJ	(Skun-Kampong Cham)
	(viii) Phnom Penh ~ Skun	73	2000 ~ 2003	ADB	Emergency repair
7	Skun ~ Kampong Cham	49	1998 ~ 1999	GOJ	-
	Mekong (Kizuna) Bridge	3.34	1999 ~ 2002	GOJ	Bridge: 1,360 m
	Kizuna Bridge ~ Thnal Totueng	12	2000 ~ 2003	GOJ	-
	Thnal Totueng ~ Memot	72	2000 ~ 2003	ADB	Loan No. 1697
	Memot ~ Snuol	45	2001 ~ 2003	ADB***	Loan No. 1824
	Snuol ~ Kratie	83	2000 ~ 2003	ADB	Loan No. 1697
	Kratie ~ Laos Border	?	-	(China)	Under Negotiations

* Fund Source ADB: Asian Development Bank WB: World Bank
GOJ: Government of Japan GOK: Government of Korea
RGC: Royal Government of Cambodia

** Counterpart Fund for Non-Project Grant Aid by GOJ

*** OPEC Fund extended through ADB

Among those projects listed above, several projects of which design reports have been available to the Study Team have been reviewed as reference for planning and designing of the Study Road.

6.1.1 Review of Road Projects Under Grant Aid of GOJ

After completion of Chrouy Changvar Bridge (Japan-Cambodia Friendship Bridge) in 1993, there have been four road projects financed under the grant aid program of GOJ, as listed above. In addition, Tumpun Dike Road located in the southwest suburbs of Phnom Penh is to be improved as a part of the project for "Drainage Improvement and Flood Control in the Municipality of Phnom Penh" under Grant Aid Program of GOJ. Furthermore, detailed design is on-going for improvement of National Road No. 2 which is being financed by the "Counterpart Fund for the Non-Project Grant of GOJ".

The major factors of design of Japan's Grant Aid projects are summarized in the table below:

Table 6-1-2 Summary of Design Factors of Road Projects under Grant Aid of GOJ

<table>
<tr><th>NR No.</th><th>NR-6A</th><th>NR-6 & 7</th><th>NR-7</th><th>Access of Kizuna Br.</th></tr>
<tr><td>Design Speed</td><td colspan="3">60 km/hr</td><td>80 km/hr</td></tr>
<tr><td>Carriageway Width</td><td colspan="3">@3.50 x 2 = 7.0 m</td><td>7.0 m</td></tr>
<tr><td>Shoulder Width</td><td>1.5 m</td><td>1.5 m-2.0 m</td><td>1.0 m</td><td>1.5 m (Paved)</td></tr>
<tr><td>Thick. of Surface Course (AC)</td><td>5 cm</td><td>5cm</td><td>7-5 cm</td><td>5cm</td></tr>
<tr><td>Thickness of Base Course</td><td>10 cm</td><td>10-20 cm</td><td>25-30 cm</td><td>20 cm</td></tr>
<tr><td>Thick. of Subbase Course</td><td>15 cm</td><td>15-25 cm</td><td>50 cm</td><td>25 cm</td></tr>
<tr><td>Design CBR of Subgrade</td><td>6</td><td>6-20</td><td>2-3</td><td>Selected Material</td></tr>
<tr><td rowspan="2">NR No.</td><td colspan="3">NR-6 Siem Reap Section</td><td rowspan="2">Tumpun Dike Road
(Municipal Rd.)</td></tr>
<tr><td>Urban Section</td><td colspan="2">Rural Section</td></tr>
<tr><td>Design Speed</td><td colspan="3">60 km/hr</td><td>60 km/hr (?)</td></tr>
<tr><td>Carriageway Width</td><td colspan="3">7.0 m</td><td>7.0 m</td></tr>
<tr><td>Shoulder Width</td><td>0.5 – 2.50 m (Paved)</td><td colspan="2">2.0 m (Paved)</td><td></td></tr>
<tr><td>Thick. of Surface Course (AC)</td><td>7 – 8 cm</td><td colspan="2">7 cm</td><td>5 cm</td></tr>
<tr><td>Thickness of Base Course</td><td>15 cm</td><td colspan="2">10 cm</td><td>15 cm</td></tr>
<tr><td>Thick. of Subbase Course</td><td>25 cm</td><td colspan="2">20 cm</td><td>25 cm</td></tr>
<tr><td>Design CBR of Subgrade</td><td>8</td><td colspan="2">6</td><td>6</td></tr>
</table>

6.1.2 ADB Projects

Currently three road projects financed by ADB loan are being implemented and one more loan for a project of improvement of NR-5 (Poipet ~ Sisophon) and NR-6 (Sisophon ~ Siem Reap) is being processed. Loan No. 1697: Primary Road Restoration Projects and Loan and Loan No. 1824: Flood Emergency Relief Project is to improve/ rehabilitate the following road sections.

Table 6-1-3 Road Sections Improved/Rehabilitated under ADB Loans No. 1697 and No. 1824

Loan No.		NR No. and Section	Remarks*
1697:	Primary Road Restoration Project	NR-5: Battambang ~ Svay Doun Keo	5C
		Svay Doun Keo ~ Krakor	5B
		NR-6: Kampong Thom ~ Prey Romeas	6B
		NR-7: Thnal Keng ~ Memot	7A
		Memot ~ Snuol	7B, 7C, 7D
		Snuol ~ Kratie	7E
1824:	Flood Emergency Relief Project	NR-5: Sisophon ~ Battambang	5B
		Krakor ~ Kampong Chhnang	5A
		NR-6: Phnom Penh ~ Skun	Repair works
		Skun ~ Kampong Thom	6AF2

*5A, 6B etc: Contract package No.

Followings are the summary of the major design factors of ADB projects.

Table 6-1-4 Summary of Design Factors of ADB Project (Loan No. 1697)

Package No.	5B	5C	6B	7A	7E
Design Speed	60 km/hr				
Carriageway Width	7.0 m				
Shoulder Width	@1.50 m x 2 (bitumen sealed) + @0.5 m x 2 (laterite)				
Pavement Type	DBST (12 mm + 19 mm seal)				
Thickness of Base Course	20 cm	20 cm	15 cm	20 cm	15 cm
Thick. of Subbase Course	20 cm	27 cm	22 cm	25 cm	22 cm
Thick. of Selected Subgrade	10 cm	10 cm	10 cm	10 cm	10 cm

ADB is also financing, under Loan No. 1659-CAM, the improvement of Neak Loueng – Vietnam Border Section (C2 Section) of NR-1 which is adjacent to the Study Road. The summary of the major design factors of C2 section are as shown in the table below.

Table 6-1-5 Summary of Design Factors of C-2 Section

Sub-Section	Mekong Riv. – Km 85	Km 85 – Km 124	Km 124 – VN Border
Design Speed	100 km / hr		
Pavement Width	(3.75+1.50) x 2 = 12.5 m		
Shoulder Width	@0.50 m x 2		
Pavement Type	DBST		
Thickness of Base Course*	19 cm	18 cm	18 cm
Thickness of Subbase Course	12 cm	12 cm	12
Thickness of Selected Subgrade	35 cm	35 cm	25 cm
Design CBR of Subgrade	3.5	3.5	6

* Includes 2 cm of DBST seal

6.1.3 World Bank Projects

World Bank is financing two projects of principal national roads; NR-3 (Rtrapeang Ropov ~ Veal Rinh) and NR-6 (Roluos ~ Prey Romeas & Airport Access Road). Design factors are same for the two projects as summarized in the table below.

Table 6-1-6 Summary of Design Factors of World Bank Projects

Project	NR-3 (Rtrapeang Ropo~Vial Renh)	NR-6 (Roluos~Prey Romeas & Airport Access)
Design Speed	(Existing alignment)	
Pavement Width	10.0 m	
Shoulder Width	@0.50 m x 2	
Pavement Type	DBST	
Thickness of Base Course	15 cm	15 – 20 cm
Thick. of Subbase Course	24 – 44 cm	18 – 33 cm
Design CBR of Subgrade	4 - 10	7 - 10

6.1.4 MPWT Road Construction Projects

Data of reconstruction of NR-6 (Pk 76 – Pk 106) were available to the Study Team. The contract of this project was singed in May 1995. Outline of this project is as follows:

Table 6-1-7 Design Factors of Rehabilitation of NR-6 by MPWT

Design Speed	Not Available
Pavement Width	6.0 m
Shoulder Width	@1.50 m x 2
Pavement Type	DBST
Thickness of Base Course	15 cm
Thickness of Subbase Course	30cm

6.1.5 Comparison of Pavement Structures

Pavement design of other projects is compared in Table 6-1-8.

As for the surface, both asphalt concrete (AC) and DBST are widely used. In case of AC surface, thickness of surface course is 5 cm in many cases, and 8 cm in one case. Total thickness of pavement varies from 30 cm to 87 cm, depending on the type of pavement (AC or DBST), estimated traffic (ESAL), CBR of subgrade.

Table 6-1-8 Comparison of Pavement Design

Project				CBR of Subgrade	Pavement Thickness (cm)				Design ESAL/Year
Road	Section	Length	Desgn Yr		Subbase	Base	Surface	Total	
NR 1 (ADB Design)	C1 (Phnom Penh ~ Neak Loeung)	55 km	1997	3.5 (Select 36 cm)	27, 34	18	AC: 5	45~52	27, 46 mil/ 10 yr
	C2 (Neak Loeung ~ Vietnam Border)	105 km		3.5, 6 (Select 12 cm)	12 (Stablzd Latrite)	16~18	Macdm 2 cm seal	30	4.4~5.1 mil/ 10 yr
NR 2	Takeo Center ~ Vietnam Border	52 km	2002	18	20 (Laterite)	20	AC: 5	45	1.6 mil/12 yr
NR 3	Trapeang Pau ~ Veal Rinh	21.5 km	1998	4 5 7 10	44 39 31 24	15	DBST	39 54 46 39	0.231 mil/ 10 yr
NR 6A	Phnom Penh ~ Chun Chunok	44 km	1993	6	15	10	AC: 5	30	0.0347 mil/ 5 yr
NR 6, 7	Thnol Keng ~Kompong Cham	73 km	1997	6 10	25 15	20 10	AC: 5 AC: 5	50 30	0.357 mil/ 5 yr
NR 6	Siem Riap ~ Roluos (WB)		1998	10~15	18~30	15~20	DBST	38~45	0.328~1.235 mil/ 10 yr
	Ditto (JICA)	17.5 km	1999	5.9, 7.9	20, 25	10	AC: 7, 8	37~48	0.4~3.38 mil/ 5 yr
NR 7	Kizuna Bridge ~Tunoul Tontoeng	11.5 km	2001	2 3	50 50	30 25	AC: 7 AC: 5	87 80	1.21 mil/ 5 yr
NR 7	Mekong (Kizuna) Bridge (Access)	3.6 km	1997	Selected Material 50 cm	25	20	AC: 5	50	
NR 5	Contract Package 5B (ADB)		1998	Selected Material 10cm	20	20	DBST	40	
	Contract Package 5C				27	20		47	
NR 6	Contract Package 6B				22	15		37	
NR 7	Contract Package 7A				25	20		45	
	Contract Package 7E				22	15		37	

6.2 Review of Pavement Materials in Each Project

Types of pavement materials used, or assumed to be used in the design, for the projects listed the previous section are compared in the table below.

Table 6-2-1 Comparison of Pavement Materials

Project		Base Course		Subbase Course		Subgrade	
NR No.	Section	Material*	CBR	Material*	CBR	Material*	CBR
1	Neak Loueng ~ Vietnam Border	C/S		Stb Lat		Select	
2	Takeo Center ~ Vietnam Border	C/S	>80	Lat	20		18
6A	Phnom Penh ~ Chueng Chhnok	C/S	>80	C/R	>30		6 - 10
6,7	Thnal Keng ~ Kampong Cham	McSt C/S	>80	C/R	>30		
6	Siem Reap ~ Roluos (JICA)	C/S		C/R			6 - 8
7	Kizuna Br. ~ Thnal Totueng	McSt C/S	>80	C/R	>30		2-3
5,6,7	Contract Pack. 5B, 5C, 6B, 7A, 7E (ADB)	C/S		(1)**		Select	

*C/S: Crushed stone C/R: Crusher run Lat: Laterite Stb: Stabilized McSt: Mechanically stbilized
**Laterite mixed with existing macadam material

Base course material is crushed stone in all the projects. Crusher run is most widely used as subbase material, while laterite or mechanically stabilized laterite is used in some projects. Interesting case of subbase material is mixture of laterite and existing macadam material adopted in ADB projects of NR-5, 6 and 7.

It should be noted that the quarries are located within relatively short distances from the project sites in the cases of the above listed projects, while in case of the Study Road, quarries are located substantially distant from the project site.

6.3 Evaluation of Existing Road Conditions

6.3.1 Inventory Survey

To know the present condition of the Study Road and compile the information to be referred later, Road Inventory Survey was conducted. Main items surveyed and recorded are as follows:

i) Type and condition of pavement
ii) Widths of pavement and shoulder
iii) Location of electric poles, telecommunication cable and other utilities
iv) Approximate embankment height (Accurate embankment height was measured in the Cross Section Survey.)
v) Drainage
vi) Roadside land use
vii) Traffic signs, pavement markings, traffic signals other traffic control/safety facilities
viii) Possibility of flooding
ix) Soft ground

Table 6-3-1 shows the field record format of the Road Inventory Survey

Table 6-3-1 Format of Field Record of Road Inventory Survey

ROAD INVENTORY : FIELD SURVEY FORMAT (ROAD STRUCTURE & PAVEMENT)

ROAD NAME : NATIONAL ROAD NO.1
SECTION : ____________ (Sta. ____________ to ____________)
SECTION LENGTH : ____________ km

Survey Date: ____________
Engineer: ____________

Sub-Section No.	Sub-Section Length (km)	Pavement			Shoulder			Side Ditch (C)	Terrain (D)	Roadside Land Use (E)	Soft Soil Layer		Flood Section (Yes or No)	Parallel Irrigation Canal		Remarks (Note on accidents, environmental problems, slope protection, retaining wall etc)
		Width (m)	Type	Condition (A)	Width (m)	Type	Condition (A)				Yes or No	Settlement		Width (m)	Depth (m)	

(A) Condition
1. Good
2. Fair
3. Bad
4. Very Bad

(B) Type of Cross Section
1. Flat
2. Cut
3. Embankment
4. Cut/Embankment

(C) Type of Side Ditch
1. None
2. Earth
3. Riprap
4. Concrete

(D) Terrain
1. Flat
2. Rolling
3. Mountainous

(E) Roadside Land Use
1. Residential
2. Commercial
3. Rice Field
4. Plowed Field
5. Forest
6. Waste (Idle) Land

Condition of pavement was judged according to the following criteria:

Good: Smooth ride; with no structural defection

Fair: Ride is in an acceptable range and vehicles can travel at the seed higher than approximately 50 km/hr; there is no serious structural defection or structural defection has been properly repaired.

Bad: Substantial cracks or other defections are observed; occasional potholes may exist; travel speed may be lowered to approximately 30 – 40 km/hr.

Very Bad: Pavement is severely damaged to the extent that rehabilitation/reconstruction is urgently needed. Substantial number and area of potholes are observed. In the most severe case, pavement is completely destroyed and bituminous layer has been lost. Vehicles have to slow down to a peed lower than 30 km/hr.

Embankment height was judged by the engineer's eye-inspection. (Embankment height was more accurately surveyed in the Topographic Survey which was conducted separately from the Road Inventory Survey.)

(4) Road Surface Drainage Facility

i) Road surface drainage facility is practically non-existent even in the urbanized sections. Water logging on the shoulder is observed at urbanized sections where embankment height is nil.

(5) Bridge, Culvert and Watergate

i) There are Bailey bridges near Km 42+800 and Km 48+000 where the road embankment was excavated to release the water of Mekong River during the Flood of Year 2000.
ii) There are four newly reconstructed Colmatage water gates at Km 28+450, Km 31+120, Km 38+923 and Km 45+776.
iii) There are old water gates at Km 41+040 and Km 50+015.
iv) There are pipe culverts at Km 24+000 and Km 24+840.

(6) Traffic Control/Safety Facilities (Pavement Marking, Traffic Sign, Traffic Signal, Guardrail and Others)

i) Pavement markings are not seen on the Study Road.
ii) There is no traffic signal between Phnom Penh and Neak Loueng.
iii) There are 27 units of traffic signs between Phnom Penh and Neak Loueng. They are mainly signs to indicate school zones.
iv) There is no guardrail, even at high-embankment sections, endangering the vehicles running out of the road by accident.

(7) Utilities

i) Telecommunication cable (optic fiber) is located approximately 6.5 meters from the centerline on the right side and approximately 60 cm from the ground surface along the entire section.
ii) There are electric poles from Km 0+100 to Km 20+400. They are generally located along the edge of the shoulder, either on the both sides or one side of the road.

(8) Roadside Land Use

i) Roadside from Km 0+100 to Km 1+100 is very densely populated.
ii) In addition to the above, roadside from Km5+600 to Km 5+800 (Preak Aeng Market) and from Km 13+600 to Km 13+900 (Kokir Market) is densely populated.
iii) Except the sections stated in (ii) above, roadside of the section from Km 7+000 are sparsely populated and become more sparsely populated towards Neak Loueng.
iv) At the locations stated in (i) and (ii) above, there are many moto-remorks and moto-dops waiting passengers on carriageway. They are sometimes occupying some part of travel lanes and hider smooth and safe passage of other vehicles.

Tables 6-3-2 are the summary of the result of the road inventory survey.

Table 6-3-2 Summary of Road Inventory Survey (1/4)

Km	Pavement			Road W.					Embank. H.					Land Use							Remarks
	Fair	Bad	Very Bad	<8 m	8-11 m	11-13 m	13-15 m	>15 m	Flat	H<1 m	H=1-3 m	H=3-5 m	H>5 m	Industrial	Commercial	Rsidential	Paddy	Agricultural	Wasted	Swamp	
0+000																					
0+500		■						■	■						■						
1+000		■				■					■				■						
1+500		■			■							■				■					
2+000		■			■						■					■					
2+500		■			■								■			■					
3+000		■			■								■			▒				▒	
3+500		■			■								■			▒				▒	
4+000		■				■							■			■					
4+500		■			■							■				■					
5+000		■			■						■					■					
5+500		■			■							■				■					
6+000		■			■						■				■						
6+500		■			■						■					■					
7+000		■			■						■					■					Tiger Beer Road
7+500		■			■						■					■					
8+000		■			■								■			■					
8+500		■			■						■					■					
9+000		■			■						■					■					
9+500		■			■						■					■					
10+000	■				■						■					■					
10+500	■				■						■					■					
11+000	■				■						■					■					
11+500	■				■						■					■					
12+000		■			■							■				■					
12+500		■			■							■				■					
13+000			■		■								■			■					
13+500		■			■						■				■						
14+000		■			■					■					■						Kokir Market W=16 m
14+500		■			■					■						■					
15+000		■			■						■					■					

Table 6-3-2 Summary of Road Inventory Survey (2/4)

Km	Pavement			Road W.					Embank. H.					Land Use							Remarks
	Fair	Bad	Very Bad	<8 m	8-11 m	11-13 m	13-15 m	>15 m	Flat	H<1 m	H=1-3 m	H=3-5 m	H>5 m	Industrial	Commercial	Rsidential	Paddy	Agricultural	Wasted	Swamp	
15+000																					
15+500			■		■					■						■					
16+000		■			■					■						■					
16+500		■			■					■						■					
17+000		■			■						■					■					
17+500		■			■						■					■					Km 17+400-600 Pav VB
18+000		■			■						■					■					
18+500		■			■							■				■					
19+000			■		■							■							■		
19+500			■		■							■							■		
20+000			■		■					■						■					
20+500		■			■						■					■					
21+000		■			■						■					■					
21+500		■			■						■					■					
22+000		■			■						■					■					
22+500		■			■							■				■					
23+000		■			■							■				■					
23+500		■			■							■				■					
24+000		■			■							■				■					
24+500		■			■						■					■					
25+000		■			■						■					■					
25+500		■			■						■					■					
26+000		■			■						■					■					
26+500		■			■						■					■					
27+000		■			■						■					■					
27+500		■			■						■					■					
28+000		■			■							■				■					
28+500		■			■							■				▒		▒			
29+000		■			■							■				▒		▒			
29+500		■			■							■				▒		▒			
30+000		■			■						■					▒		▒			

Pav: Pavement VB: Very Bad

Table 6-3-2 Summary of Road Inventory Survey (3/4)

Km	Pavement			Road W.					Embank. H.					Land Use							Remarks
	Fair	Bad	Very Bad	<8 m	8-11 m	11-13 m	13-15 m	>15 m	Flat	H<1 m	H=1-3 m	H=3-5 m	H>5 m	Industrial	Commercial	Rsidential	Paddy	Agricultural	Wasted	Swamp	
30+000																					
30+500		■			■						■								■		
31+000		■			■						■					▒		▒			
31+500		■			■						■					▒		▒			
32+000		■			■						■					▒		▒			
32+500		■			■						■					▒		▒			
33+000			■		■								■			▒			▒		
33+500		■			■							■				■					
34+000		■			■							■				■					
34+500		■			■							■				▒			▒		
35+000			■		■							■				■					
35+500		■			■							■				■					
36+000		■			■							■				■					Km 35+600-800 Commercial
36+500		■			■							■				■			▒		
37+000		■			■							■				▒			■		
37+500		■			■							■		▒		■					
38+000		■			■							■				■					
38+500		■			■							■				■					
39+000		■			■							■				■					Km38+800-39+100 Pav = VB
39+500		■			■							■				■					
40+000			■		■							■				■					
40+500		■			■							■				■					
41+000		■			■							■		▒		■					
41+500			■		■							■						■			
42+000		■			■							■						■			Km 42+800 – 900: Bridge
42+500			■		■							■						■			
43+000		■			■							■							■		
43+500		■			■							■						■			
44+000		■			■							■				▒			▒		Km 44+280 - Pav = VB
44+500			■		■							■				■			▒		
45+000		■			■							■				■					

Pav: Pavement VB: Very Bad

Table 6-3-2 Summary of Road Inventory Survey (4/4)

Km	Pavement			Road W.					Embank. H.					Land Use							Remarks
	Fair	Bad	Very Bad	<8 m	8-11 m	11-13 m	13-15 m	>15 m	Flat	H<1 m	H=1-3 m	H=3-5 m	H>5 m	Industrial	Commercial	Rsidential	Paddy	Agricultural	Wasted	Swamp	
45+000																					
45+500			■		■						■					■					
46+000			■		■						■				■						
46+500		■			■						■					■					
47+000		■			■							■				■					
47+500			■		■							■				■					
48+000		■			■							■				■					Km 47+967-48+025 Bridge
48+500		■			■							■							■		
49+000		■			■							■				■					
49+500		■			■							■				■					
50+000		■			■						■					■					
50+500		■			■							■				■					
51+000		■			■						■					■					
51+500		■			■						■					■					
52+000		■			■						■					■					
52+500	■				■							■				■					
53+000	■				■						■					■					Km 52+110-53+200 Pav = Fair
53+500		■			■						■					■					
54+000	■				■						■					■					
54+500	■				■							■				■					Km 54+340- Flat
55+000		■			■				■							■					
55+500			■		■				■						■						
Ferry Terminal																					
55+500			■		■				■						■						Branch line
56+000			■		■				■						■						

6.3.2 Embankment

From the result of the field survey and the Inventory Survey following problems are identified:

(1) Low embankment height

Embankment height (road elevation) is lower than flood water level at several locations, as described in Section 7.3 "Topographic Survey". This causes decrease in bearing capacity of pavement structure and subgrade due to seepage of water into the materials, resulting in premature failure of the pavement. More directly, the embankment height lower than flood water level allows the flood water overtopping the road surface and disrupt the traffic.

Narrow road width

(2) Insufficient width of embankment at the top

Widths of the top of embankment at some locations are less than 9.0 m, which is considered to be minimum for an opposed 2-lane road (7.0 m-wide carriageway plus 1.0 m-wide shoulder on the both sides). Width of embankment at the top is narrower than 9 m, and as the result, road width is narrow at many locations. At these locations, vehicles have to slow down when they pass by with each other. This is typically seen from Km 30 towards Neak Loueng.

Embankment slope protected by vegetation

(3) Steep embankment slope

The existing slopes are usually well protected by vegetation and intact. However, the result of cross section survey seems to indicate that the angles slopes at several sections used be milder (say 1:2.0) than the present ones (say 1:1.5). This suspected because the slopes are steeper near the shoulder and gradually become milder towards the existing toe the slopes. These slopes may have been gradually eroded by flood water or water running down the slope from the road surface. (Further investigation is needed before confirming this observation.) Due attention need be paid in designing slope protection.

6.3.3 Pavement

The condition of existing pavement is summarized as following:

(1) Poor pavement condition

Pavement condition of the majority portion of the Study Road is judged to be "**Bad**". There is no section where pavement condition was judged to be "Good". Only 3 % is judged as "Fair". The rest was judged as either "Bad" or "Very Bad", indicating urgent repair works are needed. Often, surface condition of the pavement was acceptable with regard to the smoothness of the ride and travel speed. (Travel at 50 km/hr or more is sometimes possible.) However, substantial cracks were observed and, thus, the pavement condition was judged as “Bad”. Pavement condition becomes worse, in general, from Km 30+000 towards Neak Loueng.

According to the report of ADB, the structure of the existing pavement is basically macadam type with thickness varying from 15 cm to 30 cm. Often it is observed that there is thin layer(s) of overlay. Compared to the volume and axle load of the heavy vehicles passing on the road, the strength of the existing pavement is estimated to be insufficient. This is one of the causes of the present poor condition of the pavement.


Crack are developing


Destroyed pavement at Km 18～Km 19


Previously repaired pothole


Another case of damaged pavement

(2) Unfavorable soil properties of subgrade/embankment

On top of the pavement structure with insufficient strength, the bearing capacity of subgrade/embankment is often very low as described in Section 7.4 “Soil Investigation and Material Test”. In addition, it is suspected that the bearing capacity of subgrade is decreased due to seepage of water into subgrade material during flood season. This is suspected to be another major cause of premature failure of the pavement.

(3) Insufficient width

Width of pavement, except in the section near the Monivong Bridge (Chbar Ampov Market), is generally 5 to 6 meters. This pavement width is considered to be insufficient for opposed 2-lane highway. Four-wheel vehicles often have to slow down when they pass by each other. Slow-going vehicles, such as motorcycles and moto-remorks hinder smooth passage of fast-going vehicles such as passenger cars.

6.4 Route Alignment

This Section is to describe the route alignment of the Project Road on the basis of the detailed investigation made by the study team, road inventory survey along the Project Road section, and review of feasibility study and detailed design of the ADB Project.[1)]

The Project Road is defined as the section from Phnom Penh to Neak Loueng of the National Road No.1 and its length is of 56 km. For all the length the Project Road follows the alignment of the existing road. The National Road No.1, which forms as very important road network in the Greater Mekong Subregion and a part of the Asian Highway A-1 Route, starts at Phnom Penh, runs through the eastern part of Kandal Province, Prey Veng and Savey Rieng Provinces and terminates at the Vietnam boarder. The total length of this National Road No.1 is about 165 km. This Road is further extended to Ho Chi Minh City in Vietnam.

For the entire stretch of National Road No.1 (NR-1), Asian Development Bank (ADB) has carried out feasibility and detailed engineering study between 1996 and 1997 as a line of "the Greater Mekong Infrastructure Improvement Project". After completion of the study, it has been implemented to improve the road section between Neak Loueng and the border of Vietnam in Cambodia and the section in Vietnam under financial assistance of ADB. However, the section between Phnom Penh and Neak Loueng has not been implemented yet.

6.4.1 Route Description

The starting point of the Project Road is at the eastern end of the Monivong Bridge in Phnom Penh and the ending point is the gate at the ferry terminal west of Mekong in Neak Loueng. This point is Km 55+344 in case of east bound road and Km 55+415 in case of west bound road. (See Fig. 6-4-1)

The Project Road can be generally divided into 6 sections on the basis of the traffic movement mentioned in the Chapter 2, land use along the Project Road, and the existing road condition. Each of the road section is described below:

[1)] Greater Mekong Sub-region Infrastructure Improvement T.A. No. 5649. REG Ho Chi Minh City to Phnom Penh Highway Improvement Project Final Report, November 1997

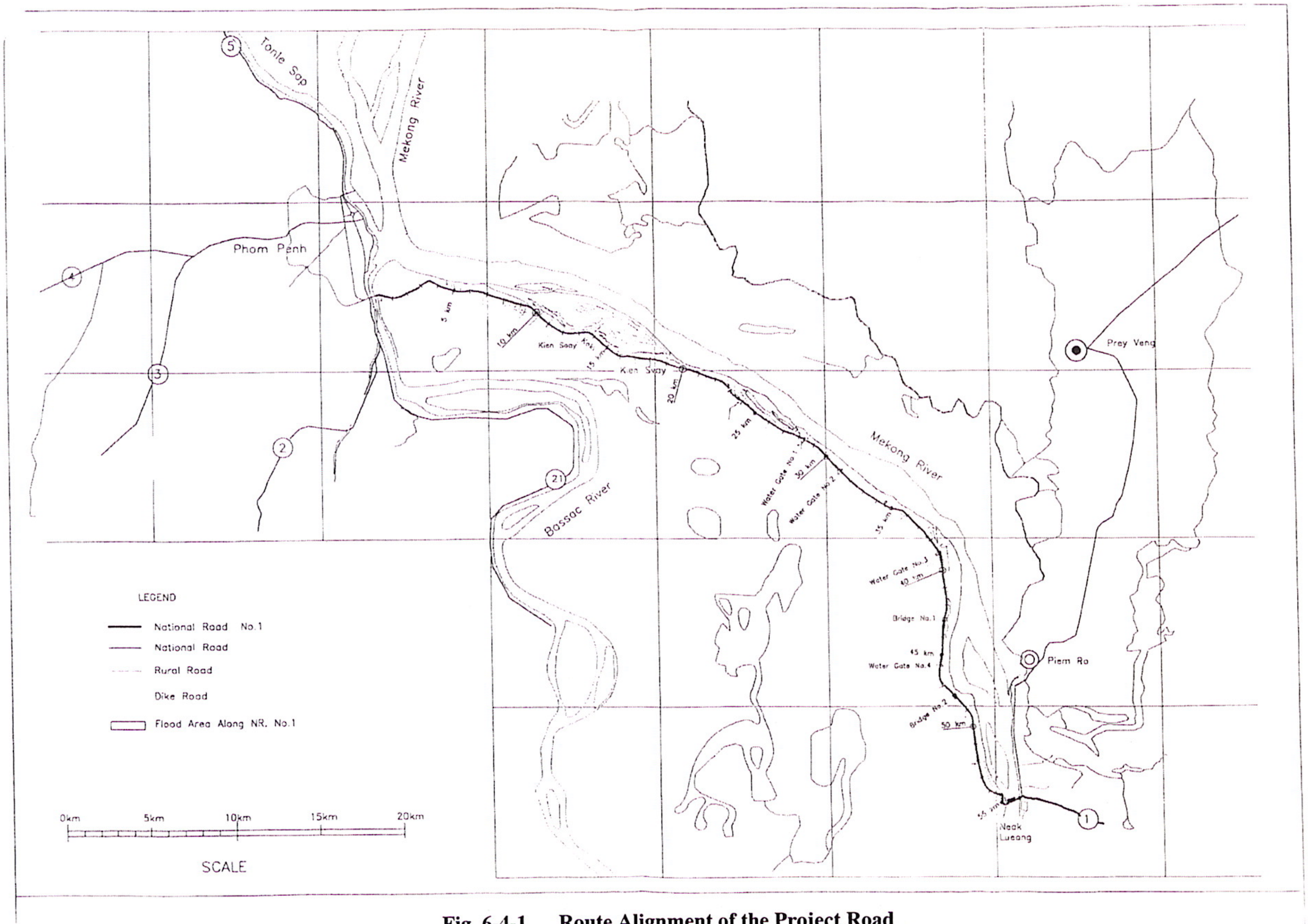

Fig. 6-4-1 Route Alignment of the Project Road

(1) Section 1 (Monivong Bridge Km 0+000 – Km 0+300)

At the starting point of the Project Road, a complex intersection is formed. This is due to the centerlines of Monivong Bridge and the Project Road being alternately. In addition, this road intersects with the district distributor road of Street No. 368 at Chbar Ampov. A lot of moto-dops, moto-remorks and other modes of transportation are waiting and parking at the small plazas within this intersection.

Although there are some traffic management problems, the existing road of the Section 1 from Monivong Bridge to Km 0+242 has already been developed as a dual carriageway, 4-lane road from Km 0+000 to Km 0+242 and its right-of-way (ROW) width is 28 meters. After the end of dual carriageway, it becomes a single carriageway via some transitional section.

The land use along this section is heavily developed as commercial areas. There is big Chbar Ampov Market in the north of this road. And along the Project Road, there are located a lot of retailed and wholesale shops and institutional buildings.

From the derivation of the vivid economic activities, the traffic volume on this section is very heavy, accounting for 88,913 vehicles/12 hours at Km 0+000 and 61,226 vehicles/12 hours at Km 0+100 in 2002. The majority of vehicle type is motorcycles and its share is about 87 %.

For improvement of the road section 1, there are 2 major issues identified in this study as follows;

1) How to treat disorderly traffic movement at Monivong intersection and in this section
2) How to acquire the ROW

(2) Section 2 (Km 0+300 to Km 7+000)

Following the existing NR-1, the Section 2 runs to eastern direction and then turns to south-eastern direction along the Mekong River and reaches at an intersecting point of road to Tiger Beer Factory (Km 7+000).

In the Section 2, the land use along the road section between Chbar Ampov and Km 1+500 has generally been developed as urbanized and populated areas. There are located many retailed shops, residential houses, schools, religious facilities, small factories alongside this road. The land use from Km 1+500 to Km 3+500 of the Section 2 is swampy land at the both side of the Project Road. That from Km 3+500 and Km 7+000 has partially developed as urbanized areas with some agricultural uses. To improve the Project Road, it would be necessary to acquire some of lands including houses.

The present traffic volume on this section amounts to 14,890 vehicles/12-hours at Km 7+000 and the share of the motor-cycles is a little less than the previous section and is about 71 %.

There are three key issues to improve this road section:

1) How to consider the motorcycle traffic
2) How to acquire the land and relocate houses along the Project Road

3) In future, it may be necessary to disperse traffic from NR-1 to alternate road

(3) Section 3 (Km 7+000 to Km 13+800)

The Section 3 starts at the intersecting point of Tiger Beer Road, and follows continuously the existing road to the south-eastern direction and reaches at Km 13+800.

As the land use along this Section 3, it becomes gradually sparsely populated area and the garden crop and agricultural lands appears. There is a small market located in the community center at Km 13+600-800.

Reflecting the sparsely populated areas and less economic activities, the traffic volume on this Section 3 gradually decreases and amounts to 13,304/12-hour in 2002. The share of motorcycle is still high and is about 72 %.

In general, this Section 3 has fewer problems than the Sections 1 and 2.

(4) Section 4 (Km 13+800 to Km 15+600)

The Section 4 follows continuously the existing road to the south-eastern direction, passes through the regional center of Kien Svay and Kokir Market and reaches at Km 15+600. Along this Section, there are located the district office of Kien Svay and the Kokir Market near the district office.

Since many persons are concentrating to this office and Kokir Market, the traffic volume in this section is bigger than that on the following Sections 5. In addition, the moto-dops and moto-remorks are waiting and parking alongside this road for transporting passengers and cargoes.

At around the Kokir Market, the ROW is wide enough to improve the Project Road, but it is necessary to consider parking of the moto-dop and moto-remork.

There will be two key issues to improve this road section:

1) How to treat moto-dops and moto-remorks parking problem at around Kokir Market on the Project Road
2) How to treat motor-cycle traffic on this section 4.

(5) Section 5 (Km 15+600 to Km 54+800)

The Section 5 follows continuously the existing road to the south-eastern and southern direction from Km 15+600 and reaches at Km 54+800.

The majority of the land use along this Section 5 is extensively agricultural areas, but there are located some industrial factories such as oil depots, logging manufacturing factories and small community centers in some places.

Since this section of the Project Road runs along the Mekong River, the Project Road was badly affected by the flooding of the Mekong River in year 2000. There are two temporary Bailey bridges at Km 42+800 and Km 47+967.

There are two major issues to improve the road.

1) To reconstruct the two temporary bridges taking into account hydrological consideration,

2) Height of the road surface is particularly low in relation to flood water level

(6) Section 6 (Km 54+800 to Km 55+344 or Km 55+415)

This Section 6 follows the existing NR-1 and reaches at the gate of Neak Loueng Ferry Terminal. This road is located within Neak Loueng town. The existing road is employed as one way system due to rather narrow existing road.

There are two major issues to improve the road.

1) Whether employ the existing one way system or not.
2) To reconstruct existing approach and exit roads from ferry terminal.

6.4.2 Review of Detailed Design of ADB Project

This section is to review alignment of Project Road made by the Asian Development Bank (ADB) and considerations of the possible alternative route.

In 1977, ADB implemented a study, including detailed design, for improvement of the National Road No. 1 and its extension in Vietnam with a title of "Ho Chi Minh City to Phnom Penh Highway Improvement Project"(hereinafter referred to as "ADB Project) As the title implies, the project covered the entire section from Phnom Penh to Ho Chi Minh in Vietnam. In this section, it is to carry out review of the Project Road in Cambodia

(1) Design Standards and Criteria

The principal technical standard adopted for the highway alignment was "A policy on Geometric Design of Highways and Street" by AASHTO. The following design standards and criteria were applied:

Design Speed	100 km per hour (km/h)
Horizontal alignment	
Minimum radius (desirable)	725 m
Minimum radius (absolute)	500 m
Vertical alignment	
Minimum hog radius (desirable)	10,000 m
Minimum hog radius (absolute)	5,500 m
Minimum sag radius (absolute)	5,500 m
Sight distance	
Minimum stopping sight distance (desirable)	210 m
Minimum stopping sight distance (absolute)	5,500 m
Cross Section Design	
Typical carriageway crossfall	3 %
Maximum superelevation (at minimum radius)	5.5 %
Typical shoulder crossfall	6 %
Maximum differential slope (carriageway to shoulder)	8 %
Typical embankment slope	1 in 1.5
Maximum relative profile slope (edge to center)	1 in 222

(2) Cross-Section

According to the ADB Project report, the typical cross-sections have been changed at several times due to problems related to financing. Finally, the typical cross-section proposed is illustrated as the following figure. In most areas, where non-motorized vehicle traffic volume is high, the design includes provision of non motorized traffic.

Typical Cross Section proposed in ADB Project is shown in Figure 6-4-2

(3) Project Road Alignments

Improvement made to the preliminary alignments include as follows:

1) minor change to some curve radii and approach transitions;
2) lifting of the vertical alignment between Phnom Penh and Neak Loueng to accommodate the increased depths of the pavement construction;
3) increase of road width between Kokir Market and Neak Loueng from 11.5 m to 13.5 m, with minor knock-on effect on the horizontal and vertical profiles;

In addition, the ADB Project proposed following design criteria used in fixing vertical alignment.

4) Hydrological Evaluation

The 1 in 10 year flood levels were used to fix the bottom of subgrade/top of embankment fill level in order to ensure the new pavement structure being kept dry during most periods of flooding. However, it is impossible to meet the flood levels accorded in 2000 and 2001, by the proposed embankment level. It is necessary to study for flood level.

5) Pavement Evaluation

Pavement alternative 1 was used in conjunction with the 1 in 10 year flood level to fix the final pavement level.

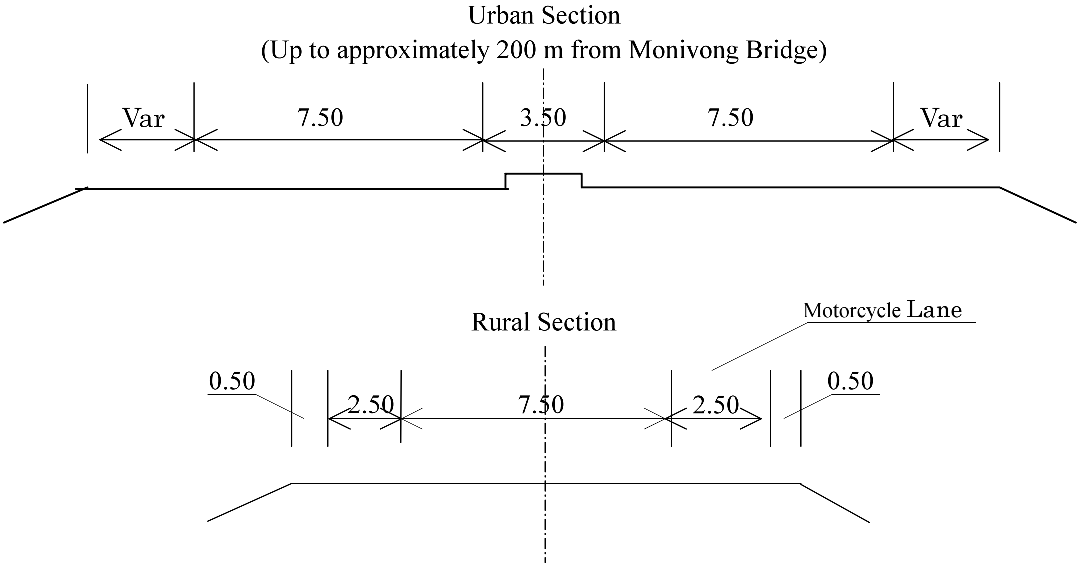

Fig. 6-4-2 Proposed Typical Cross Section

(4) Traffic Study

According to the ADB Project report, traffic on the National Road No.1 forecasted separately as 1) normal traffic, 2) diversified traffic and 3) generated traffic.

1) Normal Traffic

For forecasting normal traffic, the following steps were employed;

- apply elasticity with regard to GDP forecasts, determine annual growth rates and forecast traffic from present traffic figures
- assume shifts from medium to heavy trucks, and from heavy to articulated trucks, at a rate of 0.5 %

2) Divertible Traffic

According to the ADB Project report, with the opening of the Cambodia-Vietnam border and the upgrading of the Project Road, international traffic is expected to be modal shifts that by diversion to NR-1 as follows; -

- Sihanouk Ville port and Sihanouk Ville-Phnom Penh road
- Mekong River
- HCMC ports and HCMC-Phnom Penh Road

In total, a maximum of 155,000 tons of cargo may shift to the Project Road from the existing routes. Number of traffic volume is expected to be 10 articulated trucks, 10 heavy trucks and 20 medium trucks per day.

3) Generated Traffic

The generated traffic was considered to be a result of transport cost reduction due to the upgrading of the Project Road. VOC would decrease by about 4~6 % (for buses) to 14~18 % (for trucks) as a result of road surface condition betterment. The elasticity of VOC is around 1.0 for passenger transport and 0.5 for goods transport.

4) Summary and Review of Traffic Forecast

Table 6-4-1 shows the result of traffic forecasts following the above-mentioned process. From 2000 to 2010, annual growth rate of 4-wheel vehicle would be 10~20 % per year and that of 2-wheel vehicle is around 6~9 %.

However, it is necessary to review the traffic forecast made in the ADB Project because traffic growth rate is high and the forecast of divertible traffic forecast to NR-1 is based on rough assumptions.

Table 6-4-1 Traffic Forecasts in 2010

	1996			2010			Growth Rate (%)		
	2W Veh	4W Veh	Total	2W Veh	4W Veh	Total	2W Veh	4W Veh	Total
Section 1 0+000~0+300	82,524	8,918	91,442	180,612	35,991	216,602	219	404	237
Section 2 0+300~7+000	-	-	-	63,784	25,629	89,413	-	-	-
Section 3~6 7+000~55+415	6,688	2,800	9,488	21,316	13,930	35,246	319	498	371

Source: ADB Study

(5) Other Issues

1) Monivong Roundabout

The location of the proposed roundabout adjacent to the east end of Monivong Bridge is proposed to construct by the buildings opposite the end of the bridge, and the bridge itself.

The proposed layout plan is shown in Fig. 6-4-3.

2) Monivong Dualling

It was proposed that the 150 meters of the existing dual carriageway on the approach to the proposed Monivong roundabout will be reconstructed as necessary and new road marking placed. As shown in Fig. 6-4-3.

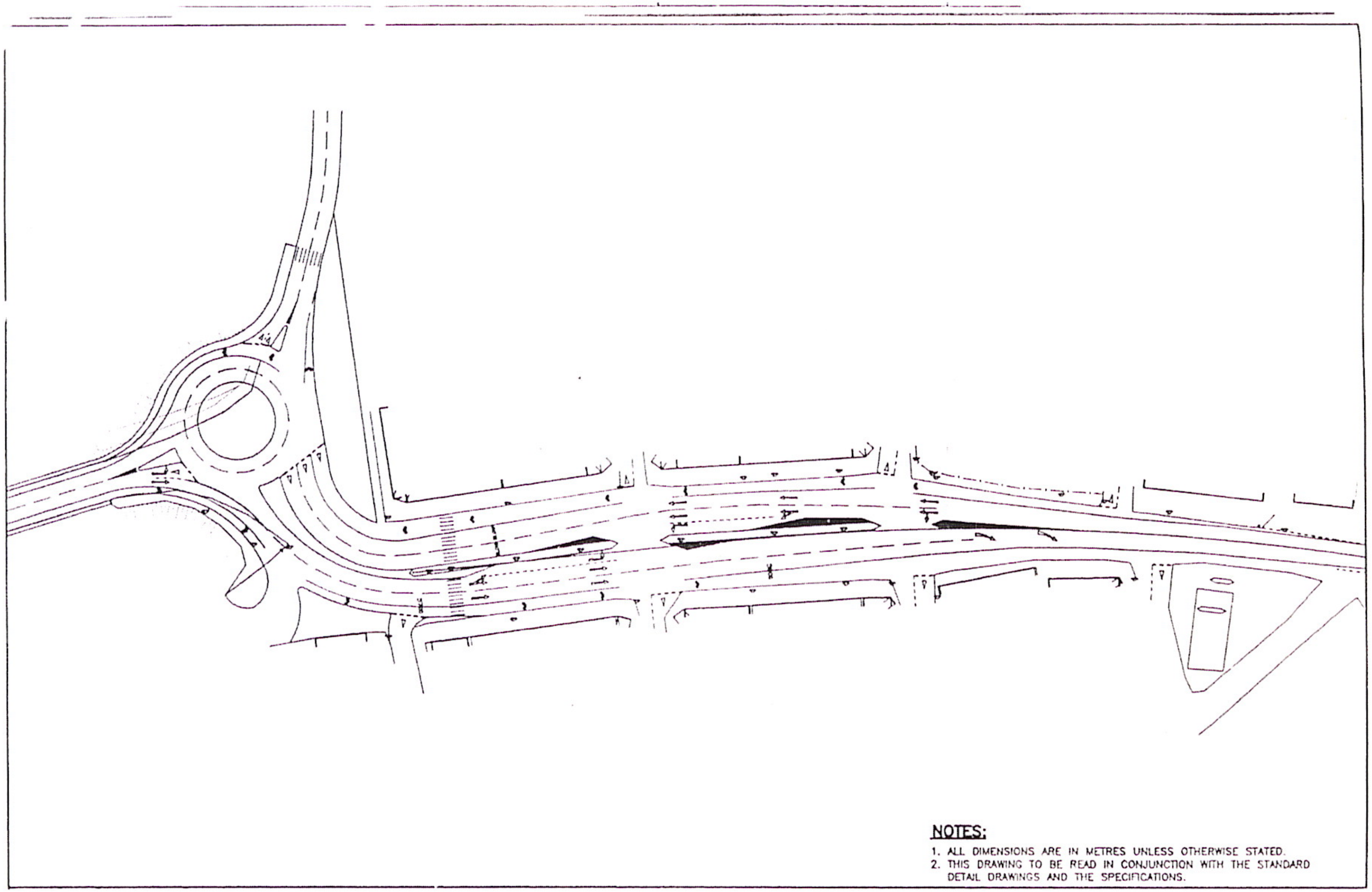

Fig. 6-4-3 Proposed Improvement Plan of the Monivong Roundabout

3) Ferry Terminal Junctions

On the basis of conclusions that the previous reports have shown that the ferries will be viable for the period in excess of ten years, the design in the ADB Project study includes improvement to the areas of the two ferry terminals, as regards Neak Loueng ferry facilities;

Terminal Point West of Mekong River

It was proposed that the existing approach and exit roads from ferry terminal will be reconstructed as necessary, and road markings placed to indicate lanes for motorized and non-motorized vehicles, as shown in Fig. 6-4-4.

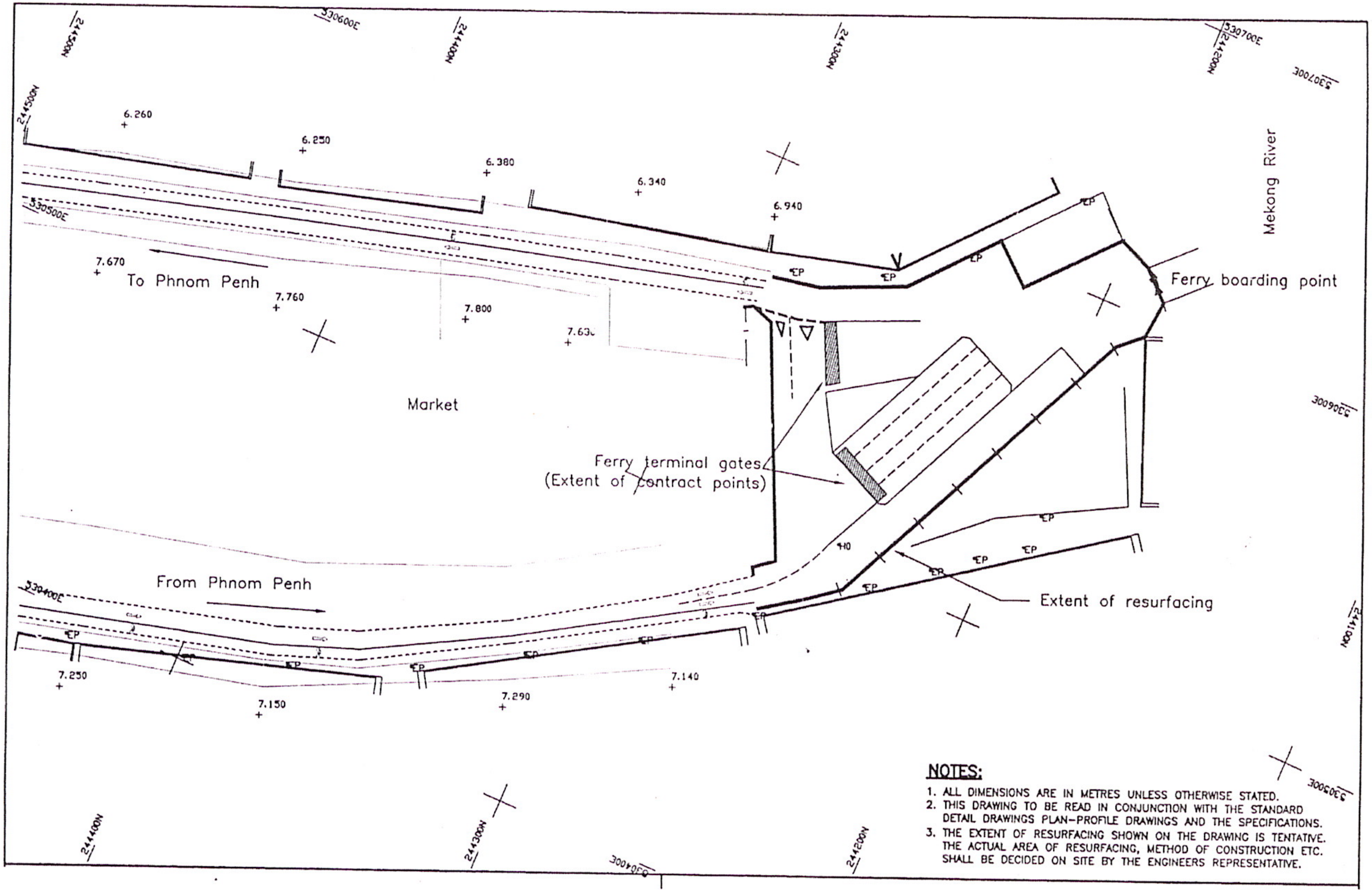

Fig. 6-4-4 Neak Loueng Ferry Terminal

6.4.3 Traffic Control at Kokir Market

Traffic at the Kokir Market Section is very congested. This congestion is attributed to the moto-remorks and moto-dops parking on the road. These vehicles are expecting the passengers and tend wait as close to the market as possible. As a result, they often park on the carriageway in front of the market, hindering the traffic passing there. Interference by these vehicles is so extensive that this location (Kokir Market Section) is becoming one of a few major traffic bottlenecks along the Study Road.

On this section, the width of the land available for widening, judged by the distance between the buildings across the road, is approximately 24 meters or more. This width is sufficient to cater 4-lane road of the urban section described in Chapter 12. However, even if the Study Road is widened, the effect of widening will be greatly reduced if the present condition of parking of moto-remorks and moto-dops will continue. Contrary, the improvement of the Study Road will be fully fruitful when proper control of parking vehicles will bed practiced.

The necessary measures for improvement of parking condition on Kokir Market Section includes the following:

(1) Provision of parking spaces for moto-remorks and moto-dops at appropriate location where these vehicles can wait passengers who come out from the market.
(2) Provision of new place for street vendors who are now occupying side walks and a par of carriage way.
(3) Provision of crosswalk(s) to guide crossing of pedestrians/shopper to appropriate location.
(4) Enforcement of parking regulation at strategic locations.

In addition to these measures, it is desired that mid- to long-term plan of urban development for the area be formulated and implemented which includes the study on the future development of the existing market.

6.4.4 Existing Traffic Control

The quantity of the existing traffic control facilities is insufficient to secure safe and smooth traffic.

<u>Traffic signal</u>

There is no traffic signal installed along the Study Road, even at the most congested intersection near Chbar Ampov Market. Traffic signals are needed along the urbanized sections such as near Chbar Ampov Market and Kokir Market where the traffic is congested and many pedestrians cross the road.

<u>Traffic sign</u>

There are only 25 traffic signs (two one-way regulation, one 30-ton weight limit, 22-school zone) over the entire section of the Study Road. There is no warning/information sing for approaching town or speed limit sign. Traffic signs for speed limit, approaching towns others need to be installed at strategic locations to safely guide the drivers to reduce travel speed.

Pavement marking

There is no pavement marking of centerline or travel lane. This results in very poor delineation of the alignment of the Study Road. Also, there is no pavement marking for pedestrian crossing reducing the effectiveness of school zone signs.

Guard rail

There is no guard rail. This is particularly hazardous on high embankment sections. If vehicles loose control, such as in the case of accident, they may run off the road and fall down the high slope, causing serious damage to the drivers and passengers.

6.4.5 Traffic Safety

Because of the poor condition of traffic control as described in the above, the present condition of traffic safety is considered to be very poor. To identify locations of traffic black spot, it is necessary to analyze the reliable data of traffic accidents. Periodical traffic accident reporting system has been introduced throughout the country except few isolated provinces since year 2000. This system is being implemented with coordination of Ministry of Interior (traffic police), Ministry of Public Health (hospital, clinic), and Ministry of Public Works and Transport (general directorate of transport). However, since the detailed accident records which include information on the exact spot of accident were all written in Khmer, it was judged to be very difficult to translate all the accident record from Khmer to English and analyze them within the timeframe of the Study. Therefore, possible accident-prone locations were detected through eye-inspection of the Study Road.

As described in Chapter 6, the existing alignment of the Study Road is generally favorable except the section described below:

Steep Curve at Km 32+600 ~ Km 32+800

There are very steep curves between Km 32+600 and Km 32+800 with radii of around 160m. The alignment of the adjacent sections on the both side of this location is straight. There are no warning signs for steep curves. There is a very strong possibility that vehicles enter this section with excess speed. Accordingly, this location is judged to be accident-prone.

In addition to the above-described section, there are many curved sections where grasses on the shoulder or embankment slope are reducing sight distance, sometimes causing hazardous situation. However, the drivers seem to be aware of this situation and generally lower the speed at these locations. This problem can be substantially improved if the grasses on the shoulder or on the embankment slope are regularly cut/trimmed.

Further, it is suspected that accident rate is relatively high on the section where the roadside is densely populated and number of pedestrians walking the shoulder or crossing the road is lager than those on the rural sections, although no statistical data are available to the Study Team.

6.5 Issues of Road Maintenance

6.5.1 Present Situation of Road Maintenance

The maintenance situation for existing roads has received attention in a number of recent studies under the sponsorship of the World Bank, the Asian Development Bank and Japan. It is a well-established finding that the maintenance attention given to the existing roads in Cambodia is inadequate because of very limited fund availability and institutional weakness. Furthermore, the road maintenance fund is used mostly for road rehabilitation but not for road maintenance.

The road inventory and its condition in Cambodia are summarized by the study "Strengthening the Maintenance Planning and Management Capabilities at the MPWT" funded by ADB in July 2002. Based on the final report, the inventory of road is as shown in Table 6-5-1.

Table 6-5-1 Road Length under MPWT

Type of Road		Length (km)	
		Kandal	National
N1	Primary National Roads	165.3	2,002
N2	Secondary National Roads	111.2	2,754
N3-1	Provincial Roads	237.8	5,700
N3-2	Urban Roads under MPWT	0	1,700
Total		514.3	12,156

Notes: N1 Roads are the primary national roads with single digit.
N2 Roads are the secondary national roads with double digit.
N3-1 Roads are the provincial roads.
N3-2 Roads are the urban roads under the jurisdiction of MPWT

MPWT is responsible for maintenance of 12,156 km long road, and the source of fund for road maintenance is the revenue accrued from fuel taxes and vehicle registrations.

6.5.2 Fund for Road Maintenance

In the present budgetary system, the operation expenditure is categorized into construction and maintenance even though the indicators are that a majority of the maintenance funds probably are spent on emergencies by provincial level and results in leaving very little for conventional maintenance activities.

MPWT budget comprises seven chapters, namely salaries and benefit (chapter 10), administrative expenses (chapter 11), field of economic input (chapter 30), field of social and cultural input (chapter 31), field of international input (chapter 32), investment by internal financing (chapter 50) and investment by external financing (chapter 51). It is noted that MPWT budget does not include the loan proceeds from international lending agencies but comprises the fund allocated from the national budget including the counter fund to the loan that is usually planned as chapter 51 "Investment By External Financing".

Since the budgets are drastically changed in 1996 to 2001 depending upon the fluctuation of chapters 50 and 51, the budget of MPWT for the study purpose is prepared excluding chapters 50 and 51.

Fig. 6-5-1 shows the budget of MPWT in 1996 – 2001.

	1996	1997	1998	1999	2000	2001
Plan	4,760	4,125	3,493	4,187	16,039	19,200
Outlay	3,259	3,423	3,213	3,922	14,834	14,664
Official Exchange Rate	2,640	2,991	3,774	3,814	3,859	3,924
US$ ('000)	1,235	1,144	851	1,028	3,844	3,737

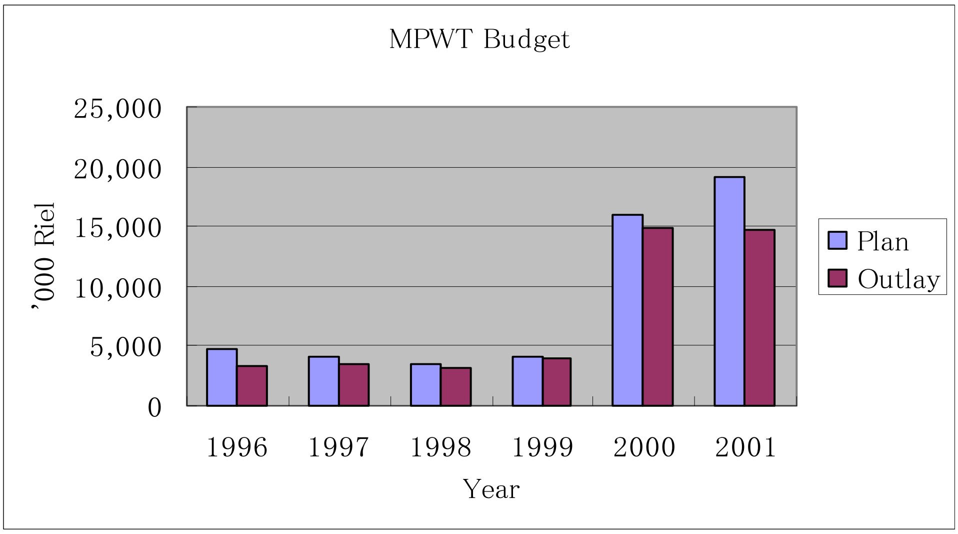

Fig. 6-5-1 Budget of MPWT

The budgets of 2000 and 2001 suddenly increase about 10 billion Riel because the road maintenance fund of 10 billion Riel equivalent to 2.5 million $ is added annually in chapter 30 "Field of Economic Input". The budget for 2002 is planned 16,180 million Riel including the road maintenance fund of 10.5 billion Riel.

6.5.3 Source of Fund for Road Maintenance

Maintenance funding level in 2001 was inadequate for predominantly deteriorated national and provincial roads, which it could not achieve regular maintenance to keep serviceable. Besides, some of the funding might go to rehabilitation of roads, which would further reduce the funds available for maintenance of national roads.

The Ministry of Economy and Finance has enacted legislation to increase fuel taxes for road and bridge maintenance and rehabilitation from January 2002. The rate of increase in fuel taxes is 2 cents per liter for gasoline and 4 cents per liter for diesel, and it is estimated US$ 10 million annually.

However, the road maintenance fund has been used for construction work, resulting in reduction of the amount available for maintenance. The fund should only be used for the maintainable road network and any road construction work should be financed by other sources including the donor countries. Funds for construction/rehabilitation work should be kept separate from the road maintenance fund.