APPENDICES

APPENDIX A - NATIONAL ROAD INVENTORY

Appendix A presents the inventory of national road of Vietnam based on the 1997 road data of the Vietnam Road Administration. The roads have been classified by region and by pavement type.

Table A.1 is a summary of road characteristics by region which include pavement type and length. It is noted that in terms of pavement type, majority of national roads have asphalt and gravel pavement. By region, it is relatively distributed but in terms of road length, national roads are in the Northwest and North Central coast, although in terms of pavement, most of these roads are gravel particularly in the Northwestern part. The North of Vietnam has an extensive network followed by Central Region, in terms of road length, while the south of Vietnam has less number of kms. since there is no contiguous network of roads and inland waterway connections are provided to provide the missing road links in these areas.

Figure A.1 shows the number of each road in the map corresponding to the number of roads in Table A.2 where the road inventory data is presented. For each road, the road class, width, pavement type and the administrative unit responsible to manage and maintain the road are presented.

Table A.1
National Road Characteristics

(1) Length of National Road by Pavement Type and by Region

No.	Region	Length (km)	Pavement Type					
			Concrete	AC	Asphalt	Gravel	Latelite	Earth
1	Red River Delta	1,051.114	2.200	338.733	613.461	53.120	43.600	-
2	Northeast	1,957.281	60.710	88.589	1,010.982	92.000	515.000	190.000
3	Northwest	3,205.278	5.900	272.384	1,365.524	789.000	512.117	260.353
4	North central Coast	2,759.417	1.800	466.300	1,113.687	91.900	1,027.490	58.240
5	South Central Coast	1,155.891	0.650	764.690	68.790	47.780	193.420	80.561
6	Central Highlands	1,636.430	-	488.000	164.600	104.300	879.530	-
7	North eastern South	1,675.169	1.000	1,046.495	249.304	104.200	132.400	141.770
8	Mekong River Delta	1,680.291	-	571.171	460.294	150.446	236.794	261.586
Total		15,120.871	72.260	4,036.362	5,046.642	1,432.746	3,540.351	992.510
% to Total		100.0	0.5	26.7	33.4	9.5	23.4	6.6

(2) Composition of National Road by Pavement Type and by Region

No.	Region	Length (km)	Pavement Type					
			Concrete	AC	Asphalt	Gravel	Latelite	Earth
1	Red River Delta	7.0	3.0	8.4	12.2	3.7	1.2	-
2	Northeast	12.9	84.0	2.2	20.0	6.4	14.5	19.1
3	Northwest	21.2	8.2	6.7	27.1	55.1	14.5	26.2
4	North central Coast	18.2	2.5	11.6	22.1	6.4	29.0	5.9
5	South Central Coast	7.6	0.9	18.9	1.4	3.3	5.5	8.1
6	Central Highlands	10.8	-	12.1	3.3	7.3	24.8	-
7	North eastern South	11.1	1.4	25.9	4.9	7.3	3.7	14.3
8	Mekong River Delta	11.1	-	14.2	9.1	10.5	6.7	26.4
Total		100.000	100.000	100.000	100.000	100.000	100.000	100.000

(3) Length of National Road by Pavement Type

No.	Region	Length (km)	Pavement Type					
			Concrete	AC	Asphalt	Gravel	Latelite	Earth
1	North	6,213.673	68.810	699.706	2,989.967	934.120	1,070.717	450.353
2	Central	5,551.738	2.450	1,718.990	1,347.077	243.980	2,100.440	138.801
3	South	3,355.460	1.000	1,617.666	709.598	254.646	369.194	403.356
Total		15,120.871	72.260	4,036.362	5,046.642	1,432.746	3,540.351	992.510
% to Total		100.0	0.5	26.7	33.4	9.5	23.4	6.6

(4) Composition of National Road by Pavement Type

No.	Region	Length (km)	Pavement Type					
			Concrete	AC	Asphalt	Gravel	Latelite	Earth
1	North	41.093	95.226	17.335	59.247	65.198	30.243	45.375
2	Central	36.716	3.391	42.588	26.693	17.029	59.329	13.985
3	South	22.191	1.384	40.077	14.061	17.773	10.428	40.640
Total		100.000	100.000	100.000	100.000	100.000	100.000	100.000

APPENDIX B – INVENTORY OF BRIDGES ON NATIONAL ROAD

In this Appendix B, the inventory of bridges on national roads is presented based on the 1997 data of the Vietnam Road Administration. The inventory includes the management unit responsible for the maintenance of the bridge, the length, loading capacity, bridge width, span length, type of material, number of spans as well as the year when each bridge is constructed. These data provide the complete profile of the bridges in the different national roads and regions of Vietnam.

APPENDIX C
VIETNAM HIGHWAY and BRIDGE DESIGN STANDARDS
(Currently being considered by VRA/MOT)

C.1 Existing Highway Standards

The Vietnam Highway Design Standards (TCVN 4050-85) have been established including the classification by function and geometric guidelines with road categories. Significant definitions and guidelines for network planning are provided for road design standards and given in Tables C.1.1- C.1.5.

Table C.1.1
Highway Function and Category

Importance of Highway	Technical Category to Apply
1. National highways having special importance to the economy, politics, cultural affairs, and defense of the entire nation, having importance in international communication - International highways	I-II
2. International highways - Main axis connecting political, economical and cultural centres of the country - Highways connecting important industrial areas - Highways connecting important transit centers	II-III
3. Secondary axis connecting important regional political, economical and cultural centers - Highways connecting large industrial and agricultural areas - Highways connecting main maritime ports, railroad stations and airports	III-IV
4. International provincial roads - Roads connecting middle-size industrial and agricultural areas - Roads connecting regional transit centers - Roads connecting secondary maritime ports, railroad stations and airports	V
5. Regional provincial roads interconnecting countries - Roads connecting small industrial centers and agricultural cooperatives	VI

Notes:
1. The average daily traffic mentioned in Table C.1 is that prescribed in article 1.5 of this design standard.
2. The average daily traffic evaluated in this design standard, when not mentioning specific type of vehicle, denotes units of any type of motor vehicle.

Table C.1.2
Average Daily Traffic by Road Category

Road Category	I	II	III	IV	V
Average Daily Traffic	> 6000	3000-6000	1000-3000	300-1000	50-300

Table C.1.3
Vehicle Speed by Road Category

Road Category	Speed Evaluated (km/hr)	
	Normal Topography	Hard, Mountainous Topography
I	120	-
II	100	80
III	80	60
IV	60	40
V	40	25
VI	25	15

Table C.1.4
Plain Topography

Main Characteristics of Road Transversal Section	I	II	I	II	III	IV	V
	W/o Bicycle Lane (& Nonmotorized Vehicles)		W/ Bicycle Lane (& Nonmotorized Vehicles)				
Number of Lanes	4	2	4	2	2	2	1
Width of Lane (m)	3.75	3.75	3.75	3.75	3.50	3.0	3.5
Width of Road (m)	2 x 7.5	7.5	2 x 7.5	7.5	7.0	6.0	3.5
Separation Band (m)	3.0		3.0				
Safety Band (m)	4 x 0.5	2 x 0.5	4 x 0.5	2 x 0.5			
Width of Roadside (m) including:	2 x 3.0	2 x 2.5	2 x 6.5	2 x 6.5	2 x 2.5	2 x 1.5	2x1
- Separation band for bicycle lane (or nonmotorized vehicles)			2 x 3.0	2 x 3.0			
- Width of bicycle lane (& nonmotorized vehicles) (m)			2 x 3.0	2 x 3.0	2 x 2.0		
- Width for enlarging road surface						2 x 1.0	2 x 1
- Width of road surface base (m)	26.0	13.5	33.0	21.5	12.0	9.0	6.5

Table C.1.5
Dry Mountainous Topography

Main Characteristics of Transversal Section	Category I and II	
	In Limited Conditions or with Few Circulating Bicycles and Nonmotorized Vehicles	
	I_b	II_b
- Number of Lanes	4	2
- Width of Lane (m)	3.75	3.75
- Width of Road Surface	2 x 7.5	7.5
- Separating Band	0.5	
- Width of Roadside	2 x 3.5	2 x 3.0
Including:		
- Width of Bicycle Lane (and Nonmotorized Vehicles (m)	2 x 3.0	2 x 2.5
- Width of Road Surface	22.5	13.5

C.2 Bridge Design Standards

The design of bridges in Vietnam is covered by a design document entitled "Specification for Bridge and Culvert Design". This document is believed to be based on the 1962 Russian bridge design code/manual and is based on the following conditions.

For concrete structures, three conditions are considered as follows:
- Ultimate capacity (strength, stability or endurance)
- Deformation
- Cracking

All loads have factors applied to them which depend on load type and combination. The ultimate strength in bending is derived by assuming a linear distribution of strain across the section and timing strain of 0.003 for concrete. Material factors called "factors of uniformity" are then applied. For steel reinforcement the factor is 0.85 and for structural concrete the factor varies slightly but is approximately 0.45.

Traffic live load is based on a continuous train of trucks in all traffic lanes or one abnormal load applied at any point within the bridge's carriageway. For all national roads with categories of I to IV, the standard loading is H30-XB80 (30-ton trucks at 17.6 m centers of a single 80-ton abnormal vehicle). For all other roads, the standard loading is H13 – X60 (13-ton trucks at 12 m centers or a single 60-ton vehicle).

For ongoing projects, live loads are available to use up to 125% increasing HS20-40 (AASHTO Standard). To apply as a Vietnam standard, this load must be established in accordance with international standards to account for an increase in motorized transport in the future.

The guidelines for maintenance and operation were issued by the MOT on 11 October 1996. This is specified mainly for process decomposition, which specify the preparation plan, monthly schedule, performance repair work, and accepted works done, but excluding evaluation for damages.

C.3 Revised Highway Standards

1) Scope of Application

This standard is used to construct, upgrade and improve highways. Specific roads, such as expressway, urban road, mining road, forestry road, and others, have their respective standards. When designing a highway, consideration must be given to its interrelation to various aspects, such as railway, hydraulics, hydroelectricity, etc., and must be approved by the State and concerned agencies.

2) Quoted Standards

The standards currently used for designing a highway are TCVN 5729-1997.

3) General Regulations

(1) Design Specifications: The design must combine horizontal alignment and cross-section to create a road that will be technically satisfactory and environmentally friendly as well as pleasing to the eye. Highways under categories I to III should be designed in a way that they will not pass through the urban center. Roads connecting to city centers must be designed according to the master plan. Protective corridors of highway should be designed according to the current or existing regulations.

It is imperative to consider divergent investment. This one must be a part of the general alternative and suitable for traffic volume. The general alternative must take advantage of most, if not all, divergent constructions. Calculating the places for future completed works must be considered while realizing the divergent project.

(2) Design Vehicle: Except for trucks, all transport means are allowed to operate, but they must conform to the allowed vehicle dimensions (see Table C.3.1). For those that do not, they are considered special vehicles and can run only if allowed by authorities.

Table C.3.1
Dimensions of Design Vehicle

Type	Overall Length	Overall Width	Height	Overhang Front	Overhang Rear	Distance Between Axles
Car	6.00	1.80	2.00	0.80	1.40	3.80
Truck	12.00	2.50	4.00	1.50	4.00	6.50
Truck w/ trailer	16.00	2.50	4.00	1.20	2.00	4.00÷8.80

(3) Design Traffic Volume: Design vehicle volume is the number of cars exchanged from other vehicle types through a cross-section per one time unit by the target year, which is the 20th year after the road was built or the 15th year after it was upgraded or improved.

If there is nothing special, exchange coefficients from other vehicle types to cars are shown on Table C.3.2.

Table C.3.2

Exchange Coefficient from Other Vehicle Types to Cars

Type	Bicycle	Motor	Car	2-axle Truck and Bus with less than 25 Sites	Truck with 3 or more Axles and Large Buses	Truck with Trailer or Bus with Trailer
Exchange Co-efficient	0.2	0.3	1	2.0	2.5	3.0

Note: For highway with four lanes or more, bicycle coefficient is not exchanged due to a separate lane for them. It is used only to calculate the number of bicycle lanes.

(4) Class of Highway: Roads are classified according to function as shown in Table C.3.3. This classification is also used for road management and repair.

Table C.3.3

Class of Management

<table>
<tr><th>Class of Management</th><th>Technical Class</th><th>Design Speed $V_{disigned}$,km/h</th><th>Required No. of Lanes</th><th>Main Functions</th></tr>
<tr><td>I</td><td rowspan="3">80 and 60</td><td rowspan="3">80 and 60</td><td>6</td><td rowspan="3">Highways linking national economic, political and cultural centers</td></tr>
<tr><td>II</td><td>4</td></tr>
<tr><td>III</td><td>2</td></tr>
<tr><td>IV</td><td>60 and 40</td><td>60 and 40</td><td>2</td><td>Highways linking local economic, political and cultural centers with the main trunk road or expressway</td></tr>
<tr><td>V</td><td>40 and 20</td><td>40 and 20</td><td>2 or 1</td><td>Highways linking commercial and residential areas</td></tr>
</table>

Note: The number of lanes is calculated following Article 4.2 of this standard.

Technically, highways are classified into the following categories:

Table C.3.4

Technical Grades of Road

Technical Grade	Designed Speed (V_d, km/h)	Minimum Design Volume (PCU)
80	80	≥ 3000
60	60	≥ 900
40	40	≥ 150
20	20	< 150

The design speed in the preceding table is used to calculate the main technical criteria of a highway in difficult cases. A highway's technical grade is based on its functions. However, a pre-feasibility study is necessary to choose the grades. While doing the Pre-F/S, if the data for classifying a highway is not enough, the classification in Table C.3.4 and C.3.5 is accepted.

Table C.3.5
Technical Class of Highways by Topography

Class	Technical Class		
	Plain	Hill	Mountain
I, II, III	80; 60	80; 60	60
IV	80; 60	60; 40	40; 20
V	40	40; 20	20

Note: The topography is based on the common cross-slopes as shown below:
Plain < 10% Hill 10 to 20% Mountain > 25%

Road sections must have the minimum length of the same class. For the class of 80-60, the minimum length is 10km, and for the class of 40-20, it is 5km. The design speed of contiguous sections must not differ from more than 20 km/h.

A route crossing the plain or low hill with limited point is allowed to lower its design speed until it is in the same management class, but it may not be lower than the width of the road surface and subpavement.

(5) Cross Section

a) General Regulations: A road consists of the carriageway and shoulder in both direction. A part of the shoulder is paved, when the $V_{design} \geq 40$ kph is achieved. A median is added when necessary. It should be paved when the carriageway has four lanes or more. Its width is shown on Table C.3.6. The structure of the paved shoulder is simpler than that of the pavement (fewer and thinner layer and less suitable material). But its surface course should be of the same materials as that of the carriageway. When the $V_{design} < 40$ kph, it can be made of different materials (see Figure C.3.1).

b) Shoulder: For road with Vtt ≥ 40 kph, part of the shoulder is paved. A road with a design speed of $V_{tt} \geq 60$ km/h should have lane marking, a line of white or yellow paint, 20-cm wide on the shoulder next to the edge of the carriageway. At intersections and entry to/exit from the lane, the mark is a dotted line to comply with road signal rules.

At some portions of auxiliary lanes, such as climbing lane and speed-change lane, the paved part of shoulders will be substituted by auxiliary lanes. If the rest of the shoulder is not wide enough, the road bed will be widened to ensure that the minimum width of the roadside is 0.5 m.

Bicycle lanes are added in highways with four lanes or more and should be on the right side of the carriageway's outer lane. For other road categories, when a traffic lane has a N_{cdh} of 750 PCU/h or more and a bicycle volume of 500/h per direction, it is necessary to have a separate bicycle lane. This lane's width in one direction is calculated by the following formula:

$$\mathbf{B = 1 \times n + 0.5\ m}$$

wherein “n” is the number of bicycle lanes in one direction. The circulation capacity of a bicycle lane is 1,000 bicycle/h/direction. When designing the lane’s width, the traffic capacity of other nonmotorized modes should be considered. Its surface must also be as flat as the adjacent lane of the carriageway.

c) Medians: A highway median of $V_{tt} \geq 80$ kph consists of the separator in the middle and two safety portions on both sides as shown in Figure C.3.2 and Table C.3.6.

Table C.3.6
Width of the Central Median

(unit:m)

Structure	Separator	Safety portion	Minimum width
With curb stone, cover and without the pier pile of work	0.05	2 x 0.5	1.50
With curb stone, cover and the work piers	1.50	2 x 0.5	2.5
Without cover	3.00	2 x 0.5	4.00

Notes: a lift up b same elevation, surface c lower, course

When roadbed is divided into two, the width of each direction consists of the carriageway and two shoulders. The shoulder’s paved portion is reduced to 0.5 m. There is also a 0.20-m lane marking next to the edge of the carriageway.

If median width is less than 3 m, the separator should be paved and curbed. If it is 3-4.5 m wide and:

– If the separator should be curbed, the soil on the shoulder will not dirt the road surface (the level of the soil is lower than the curb).
– If there is no curbstone, grass or bushes ought to be planted to hold the soil.

If the median is wider than 4.5 m (reserved for road widening when roadbed is divided into two separate directions), then the separator should be designed sag-type to prevent water from penetrating the road base. The structure of the shoulders will follow the design mentioned above.

At a certain point the median should end to allow traffic turning. Turning places are designed:

– at least 500 m away from each other (when median width is less than 4.5 m) and not more than 2 km (when median width is > 4.5 m)
– before tunnels and big bridges

The length of cut and cut edge of the separator must be enough for 3-axle trucks to turn around.

d) <u>Clearance</u>: Clearance is a space limit to ensure traffic for all kinds of vehicle. There should be no obstacle in it, including signboards, lamppost and others.

In case the bicycle lane or sidewalk is separated from the carriageway, the minimum clearance required for them is 2.5 m in height and 1.5 m in width. This clearance may run next to that of the carriageway or may be separated by a side median.

The shoulder meanwhile is where guardrails are installed. Only highways with the following characteristics are installed with rails:

- Highway with $V_d \geq 80$ km/h with median
- Highways of different categories without median.

For big bridges which are ≥ 100 m in length, road width is based on the clearance standard of bridge design. For those with a length of < 100 m, road width is as wide as is necessary to accommodate traffic from pedestrians and bicycles, but not more than the width of the road bed. For small bridges (length < 25 m) road width is as wide as the bridge width.

d) <u>Climbing Lane</u>: A climbing lane is included in the highway design:
- When $V_{tt} \geq 80$ kph
- When the highway has less than four lanes.
- When the gradient is more than 3% and longer than 800 m.
- To save travel time.

This lane is 3.5 m in width but may be reduced to 3.0 m. It may be arranged, thus:
- on the right, next to the main traffic lane and separated by a 0.2-m lane mark. Its roadside must be at least 0.5 m wide.
- on a separate roadbed, but passing vehicles must be considered in case of breakdown or overtaking.

The transition section to auxiliary lane and from there back to the main road is 1:10.

e) <u>Cross-slope</u>: The elements of a cross-section must have a cross-slope following the specifications in Table C.3.7. Cross-slopes of curves have different measurements.

Table C.3.7
Cross-slope of Cross-section

Cross-section	Cross-slope
Road surface and consolidated roadside	1.0 – 2.5
Cement concrete and asphalt concrete	2.5 – 3.0
Other types, even good, flat stone pavement	3.0 – 3.5
Medium-quality stone pavement, stone Macadam, rough out, lower category	3.0 – 3.5
Roadside	6.0
Median	depends on the cover material

4) Plan, profile and combination of their elements

The main technical standards of various category roads are prescribed in the table below.

Table C.3.8
Main Technical Standards of Road

Standards		Design Speed (kph)			
		20	40	60	80
1	Maximum super elevation (%)	6	6	6	6
2	Minimum radius of the horizontal curve (concerning super-elevation 6%),m	15	60	125	250
3	Normal minimum radius of the horizontal curve (concerning super-elevation 4%), m	40	125	250	400
4	Nonsuper elevation radius of the horizontal without super elevation, m	100	200	500	1000
5	Sight distance to fixed obstruction, m	20	40	75	100
6	Sight distance to opposite vehicles	40	80	150	200
7	Passing sight distance	100	200	350	550
8	Maximum gradient, %	9	8	7	6
9	Minimum radius of crest curve, m	200	700	2500	4000
10	Minimum radius of sag curve, m	100	450	1000	2000

APPENDIX D
PROPOSED ROAD CLASSIFICATION AND DESIGN STANDARDS

D.1 Introduction

One of the principles of a road infrastructure development is to develop a road network that exhibits a configuration based on hierarchical function, comprising of national roads down to local roads. Considering that roads play multiple roles – a traffic function and exerting major influence in the existing land use, it is noted that a hierarchical function of roads must be developed to formulate a more effective and well coordinated road geometry and structure.

Appendix D presents the design standards that are proposed to be considered in the revision of the Vietnam Highway Standards.

D.2 Design Standard

The basic road design standards and criteria are based on the Japanese Road Design Standard and ASSHOT. In Vietnam, what is presently used as Vietnam Highway Standard (TCVN 4054-85) is formulated by Russia, and which is currently for revision, to become the Vietnam Highway Specification for Design (TCVN 4054-1998). In this Section, some issues on the road design standards are discussed to be considered as possible amendments to the revised draft of the Vietnam Highway Specifications for Design.

1) Situation/Condition of Vietnam National Roads

In formulating the Road Geometric Design by the JICA study team, typical Vietnam traffic conditions have to be made clear and these include the following conditions particularly in inter-city roads:

- Mixed traffic comprising of vehicles, motor-bikes and bicycles which run on the roads.
- There are many roads without lane marks.
- No traffic regulations and drivers do not observe traffic rules and courtesy.
- There is the predominance of two-wheeled vehicles compared to large passenger vehicles.
- There is no guardrail along the sides of the road.
- Road side is used as drying area for agricultural crops such as rice.
- There is no pavement shoulder, and carriage way pavement have been extended and in deteriorated condition.
- There is no pedestrian crossing and people just cross the road whenever and wherever possible.
- Buses do not observe speed limit on the road and “race” with other buses in highways.
- Cattle and other animals cross roads and are therefore hazardous to traffic.

2) Assumptions in the Formulation of Design Standard

- Adopt whenever appropriate and applicable, Vietnamese Highway Standards.

- Adopt Category I for expressway with design speed 120km/hour and thus, must not be used as National Highway.
- Category V could be adopted as District Road, or Village road, but they are not considered to be part of the National Highway.
- Category II, III and IV are considered as National Highway.
- Category II,III and IV may be similar to the Japanese Standard on class 3.
- Consider the low capacity lanes (which means the displacement of low capacity motor bike and bicycle for each 1m, but must consider separating large vehicles and low capacity vehicles such as motorbikes.
- Geometric Design Standard shall follow those specified in Table D.2.1.

Table D.2.1
Examination of Geometric Design Standard

			Design Category					
			I	II	III	IV	V	VI
Design Speed (km/h)	Present		120	100(80)	80(60)	60(40)	40(25)	25-15
	Revising		80-60	80-60	80-60	60-40	40-20	-
	Recommendation		120-100	80-60	60-40	60-30	40-20	-
Width of Lane (m)	Present		3.75	3.75(3.5)	3.5(3.0)	3.00(2.75)	3.5	-
	Revising		-	-	-	-	-	-
	Recommendation		-	3.75 - 3.50	3.50 - 3.00	3.25 - 3.00	3.00 - 2.75	-
Number of Lanes	Present		4	2	2	2	1	-
	Revising		6	4	2	2	2-1	-
	Recommendation		-	4-2	2	2	2	-
ADT for Single Carriage Way	Present		>6,000	3,000-6,000	3,000-1,000	1,000-300	300-50	-
	Revising		-	≥3,000	≥3,000	≥900	≥150	-
	Recommendation		>30,000	>20,000	20,000-4,000	4,000-1,500	1,500-500	-
Radius of Horizontal Curb	Present		-	-	-	-	-	-
	Revising Min		250-125	250-125	250-125	125-60	60-15	-
	Recommendation	Max	710-460	280-150	150-60	150-30	60-30	-
		Min	570-380	230-120	120-50	30	30	
Primary				◎	○	▲		
Secondary					◎	○	▲	
Tertiary						◎	○	▲
Local							◎	▲

Notes:

1) ADT: Average Daily Traffic Volume
2) Revising" a new Vietnam Standard is currently being discussed.
3) Primary, secondary and tertiary refer to road network discussion in this study.
4) Figures in parentheses apply to mountainous area

5) Level of service grade: ◎-used, ○-conditioned, ▲-exceptional.

D.3 Examination of Standard Road Cross-section

Road cross-section structure consists of travel Lane, median and shoulder. Dimension of these elements is examined based on the dimension of the design vehicle and vehicle clearance for safety movement, so that road cross section can be determined.

At present, the Vietnam Highway Design Standard is being revised as part of the ODA technical cooperation program and what is presented in this Appendix are suggestions to supplement the revision work.

Considered to be the most difficult part of the revision of the Highway Standard is the determination of the Cross Sectional Structure. Design speed and vertical/ horizontal alignment standard can be based on the Japanese standard and AASHTO(USA). However, traffic characteristics in Vietnam eg. there is very little larger vehicle traffic but since traffic comprise mainly of motorcycle and bicycle, established design standards are difficult to adopt and VITRANSS will examine this specific issue more detail.

1) Basic Dimensions

The principal elements of standard cross sections are shown in Figures D.3.1 and Table D.3.1 for:

- Two-lane rural roads
- Four-lane median-separated rural roads

The design vehicle for motorized traffic is 2.50m wide and 4.00m high. For bicycles and pedestrians, standard design dimensions of 0.80 and 0.75m wide and 2.00m high can be used.

(1) Lateral Moving Space

The lateral moving space is the space needed by a nontrack-guided vehicle to compensate for driving and steering uncertainties as well as for safety distances for lateral projecting parts (like mirrors) or lateral loading overhangs.

The width of the lateral moving space depends on the expected traffic speeds, traffic volumes (frequency of opposing traffic and/or passing maneuvers), and traffic composition (percentage of trucks).

On the basis of these requirements, the width of the lateral moving space is 1.25m for the primary road system and then decreases by increment of 0.25m to 0.00m for secondary and tertiary road system.
For bicycle traffic, the width of the lateral moving space is 0.10m on each side. For pedestrian traffic, no lateral moving space is necessary.

The vertical moving space for motor vehicle traffic is the space needed to compensate for load constraints and the resulting vehicle vibrations on uneven pavements. It is generally 0.25m. For pedestrian and bicycle traffic, the upper moving space is 0.25m.

(2) Basic Lane width

For the individual cross section groups, the basic lane widths shown in Table C.1 are obtained by adding the width of the lateral moving space to the width of the design vehicle.

(3) Opposing Traffic Width Increase

Even on the simplest highway that has one lane of travel in each direction, an increase in the opposing traffic width separating the opposing movements has to be provided. The increase in the opposing traffic width increase should be 0.25m in each direction of travel.

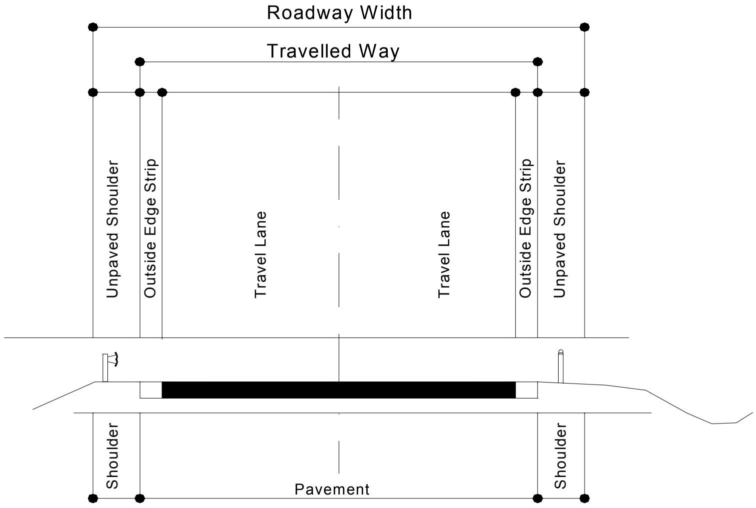
Table D.3.1
Proposed Width of Cross-sectional Elements

Functional Classification	Number of Lanes	Design Vehicle (m)	Lateral Moving Space (m)	Basic Lane Width (m)	Opposite Traffic Width Increase (m)	Travel Lane Width without Opposite Traffic (m)	Travel Lane Width with Opposite Traffic (m)	Edge Strip (m)	Median Left Turn (m)		Paved Shoulder Or Emergency / Multipurpose Lane m	Unpaved Shoulder, m			
									No	Yes		If Col. 10 is Present	If Col. 10 is not Present	Besides Sidewall Bicycle Lane	Outer Separation m
	(1)	(2)	(3)	(4)	(5)	(6a)	(6b)	(7)	(8a)	(8b)	(9)	(10a)	(10b)	(10c)	(11)
Express	6 — 4	2.50	Outside 1.25 Others 1.25	Outside 3.75 Others 3.75	–	Outside 3.75 Others 3.75	—	Outside 0.50 Inside 1.00	≥ 4.00	—	2.50	1.50	–	–	3.00
Primary	6 — 4 — 2	2.50	1.00	3.50	— 2.50	3.50	3.75	0.50 — 0.25	≥ 3.00 —	—	2.00 — 0.25	1.50	— 2.00	—	3.00 — 1.75
Secondary	4 — 2	2.50	0.75	3.25	0.25	3.25 —	— 3.50	0.50 0.25	≥ 2.00 —	5.25 —	2.00 —	1.50	1.50	≥ 0.50	1.75
Tertiary	2	2.50	0.50	3.00	0.25	3.00	3.25	0.25	—	—	—	—	1.50	≥ 0.50	1.75

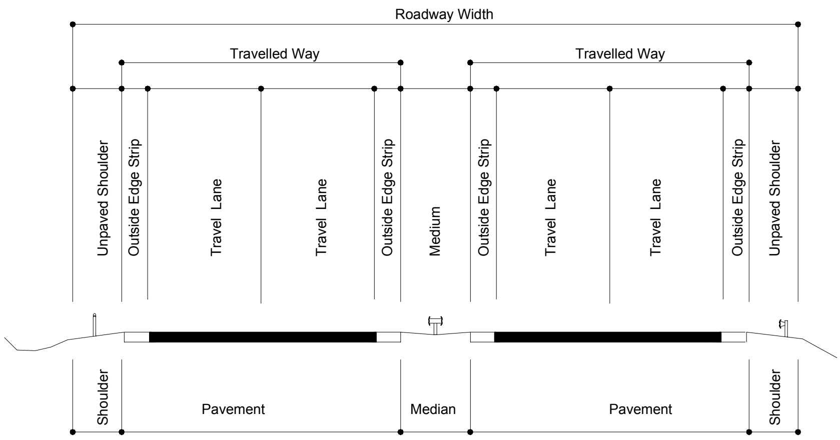
Note: “Outside” means “outside lane”. “Others” means “other lanes”, etc. (see Figs C.3.1)

Figure D.3.1

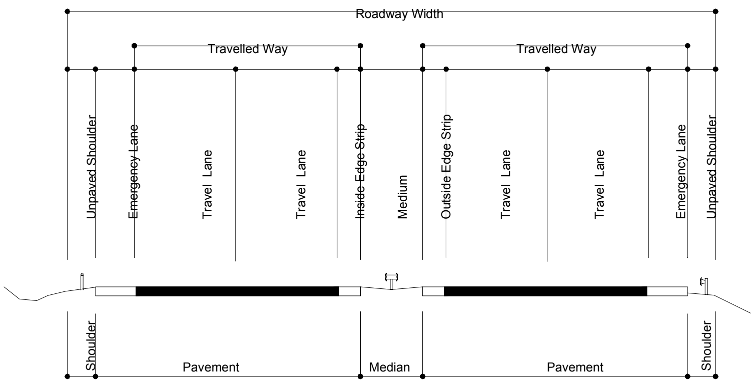
(1) Two-lane rural road without pedestrian and bicycle lanes



(2) Four-lane median-separated road without emergency lanes



(3) Four-lane median-separated road with emergency lanes



2) Clearance

Clearance is that space of the road cross section that must be kept free of rigid obstacles. It is made up of traffic spaces and vertical and lateral safety spaces (see Figure D.3.2). Clearance dimensions are given in Table D.3.2.

(1) Traffic space

The traffic space for motor vehicle traffic is made up of the space of the design vehicle, lateral and vertical moving space, opposite width increase, spaces above the edge strips, and paved shoulders. Its height is 4.25 m. The traffic space for bicycle traffic is 1.00 m wide and 2.25 m high for each driving strip. The traffic space for pedestrian traffic is 0.75 m wide and 2.25 m high for each walking strip. The overall dimensions of traffic spaces can be derived from Tables D.3.1 and D.3.2.

(2) Vertical Safety Space S_v

The height of the vertical safety space is 0.25m for motor vehicle traffic. The necessary clearance height is 4.50 m. An extension of the clearance height to 4.70m is normally recommended to accommodate a pavement overlay in the future. For interstates, a clearance height of 5.00 m is reasonable. For sidewalks and bicycle lanes, the vertical safety space is 0.25 m and the clearance height is normally 2.50 m. Traffic signs are allowed to penetrate the clearance area up to the limit of the traffic space.

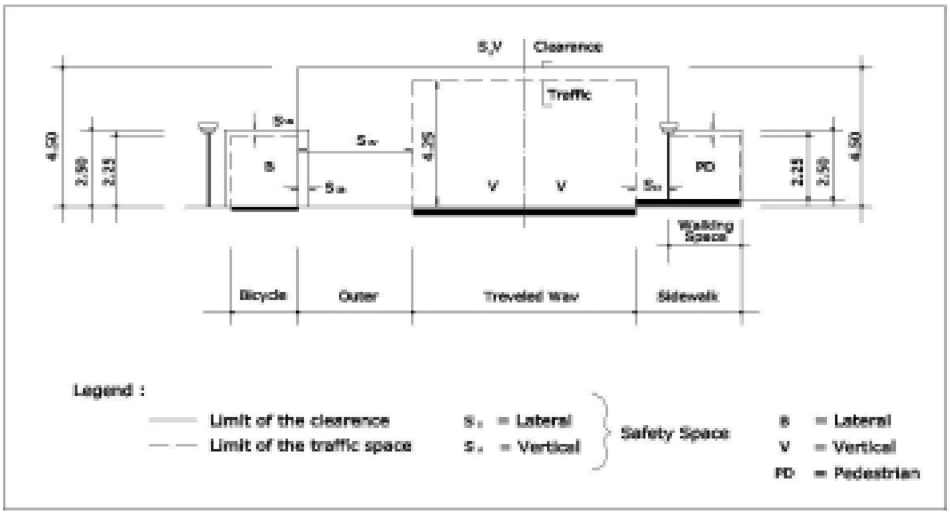


Figure D.3.2 Dimensions of the Clearance

Table D.3.2
Standard Values for Clearance

Kind of traffic (1)	Maximum permissible speed, $V_{perm,}$ km/h (2)	Basic dimensions, km/h (3)	Width of lateral moving space, m (4)	Width of lateral safety space, S_I, m (5)	Design height, m (6)	Height of vertical moving space, m (7)	Height of vertical safety space, S_V, m (8)	Height of clearance, m (9)
Motorized traffic	> 70 $\leq$ 70 $\leq$ 50	2.50 2.50 2.50	According to the cross section group 0.0 to 1.25 (see Table 5.4)	$\geq$1.25 $\geq$1.00 $\geq$0.75	4.00 4.00 4.00	0.25 0.25 0.25	0.25 0.25 0.25	4.50 4.50 4.50
Bicycle traffic		0.80	0.10	0.25	2.00	0.25	0.25	2.50
Pedestrian traffic	0.75			2.00	0.25	0.25	0.25	2.50

(3) Lateral Safety Space S_I

a) Motor Vehicle Traffic SIV: Lateral safety space is based on the fact that motor vehicles cannot pass lateral obstacles such as utility poles, walls and so forth with a distance of zero. Another function of the lateral safety space is to offer a chance to recover control for those motorists who drive on the pavement due to driving error or accidental impact. In any case collisions of vehicles against these rigid obstacles must be avoided. Therefore, lateral safety space has to be kept free from any kind of rigid objects. Greater lateral distances to obstacles are needed as speed increases, implying that lateral safety space is speed-dependent. Exceptions are longitudinal appurtenances for protection such as guardrails or barriers.

The width of the lateral safety space is measured from the edge of the traffic space to the outside of the roadway. The necessary width of the lateral safety space, S_{IV}, depends on the maximum permissible speed.

Max > 70 km/h	$S_{IV} \geq 1.25$ m
Max $V_{perm} \leq 70$ km/h	$S_{IV} \geq 1.00$ m
Max $V_{perm} \leq 50$ km/h	$S_{IV} \geq 0.75$ m

b) Bicycle Traffic S_{IB}: The width of the lateral safety space is 0.25 m. Traffic signs and traffic installation are allowed to penetrate the clearance area up to the border line of the traffic space.

c) Pedestrian Traffic S_{IPD}: For pedestrians, no lateral safety space is needed. Sidewalks that are directly adjacent to other traffic spaces are made up of the traffic space for pedestrians (walking space) and the corresponding safety space of the adjacent traffic space.

d) Combined Cross-sectional Parts: If portions of different traffic modes are added to an overall cross- section, lateral safety spaces for individual traffic modes are allowed to overlap. With respect to the distance between two traffic spaces, the space with wider lateral safety space is the relevant one.

3) Cross-sectional Elements

The elements of the road cross-section are shown in Table D.3.3 to D.3.5.

(1) Pavement

The pavement width consists of the width of the lane, edge strips and paved shoulders (for example, emergency lanes), if present.

(2) Travel Lane

The most obvious element of a roadway is the travel lane, whose width constitutes a basic cross-sectional characteristic. As a related parameter, the number of lanes to accommodate the travel demand for the roadway also represents important characteristic issues. The lane widths of individual cross-section groups are developed from the basic lane widths and the increase in the opposing traffic width. For multilane highways and freeways separated by medians, the lane widths correspond to the basic lane widths. For two-lane roads, the lane width results from the basic lane widths plus the increase in the opposing traffic width.

(3) Edge Strip

Edge strips belong to the pavement and denote the delineation. The edge strip width is 0.25 m for two-lane cross-sections. For multilane standard cross sections with medians, edge strips of 0.50 m wide must be used, except for the expressway standards where a width of 1.00 m (exceptional case = 0.75 m) must be provided for safety reasons for the inside edge strip adjacent to the median.

(4) Median

Medians serve as the structural separation of lanes for traffic in opposite directions. The standard widths for different cross section groups are:
4.00 m for Expressway, Primary System
3.00 m for Primary System
2.00 m for Secondary System

(5) Outer Separation

The outer separation is the structural separation between the pavement for through traffic lanes and ramps, frontage roads, bicycle lanes, and sidewalks. The following minimum width are recommended for the outer separation of different cross-section groups:

(separation of two traveled ways for motor vehicles)	=	3.00 m
(separation of different traffic modes)	=	1.75 m
(separation of different traffic modes)	=	1.25 m

Wider outer separations should be considered where land acquisition is not a major problem.

(6) Emergency Lane

Emergency lanes offer vehicles the possibility of escaping to the outside or of stopping. In the case of accidents or during construction periods, they make it easier to detour traffic. They also make maintenance operations easier. The widths of emergency lanes are 2.50 m for multilane roads.

(7) Multipurpose Lane

Multipurpose lanes can only be assigned to two lanes and used for slower traffic, maintenance and stopping in emergencies. It should also be considered in cases where there is a high proportion of agricultural vehicles and no parallel farm roads. The width of the multipurpose lane is 1.50 m.

(8) Unpaved Shoulder

Shoulders are the portion of the highway immediately adjacent to the outside edge of the pavement. These are areas where guardrails and traffic signs may be placed and that serve as working space for maintenance crews. The following shoulder widths are recommended for different cross-sections:

Primary	:	2.00 m
Secondary	:	1.50 m
Tertiary	:	1.00 m

If the shoulder is adjacent to emergency/multipurpose lane, then its width is normally 1.50 m.

(9) Bicycle Lane

A single bicycle lane is normally 1.00 m wide and a double bicycle lane is normally 2.00 m wide. For operational and maintenance services, a width of 2.25 m is recommended. Bicycle lanes should normally consist of two strips. The location of the bicycle lane within the cross-section must be far enough from the travel lane to avoid collisions with car doors being opened.

(10) Sidewalk

The width of a sidewalk, which is separated from traffic lanes by a curb, consists of the walking space and the width of the lateral safety space for motorized traffic. The minimum width of a sidewalk consisting of two strips adjacent to the curb should be 2.25 m.

Sidewalks, which are divided by outer separations forming traffic lanes, should be at least 2.00 m wide for maintenance reasons as long as they do not lie directly beside bicycle lanes.

(11) Combined Sidewalks and Bicycle Lanes

On rural roads, combined sidewalks and bicycle lanes on one side of the road can be considered a standard solution. They should be 2.50 m wide. Again, for operational and maintenance services, a minimum width of at least 2.25 m is recommended. However, widths of more than 2.50 m should not be used, since than the combined sidewalk and bicycle lane could be used as a path for motor vehicles.

(11) Curbs and Side Gutters

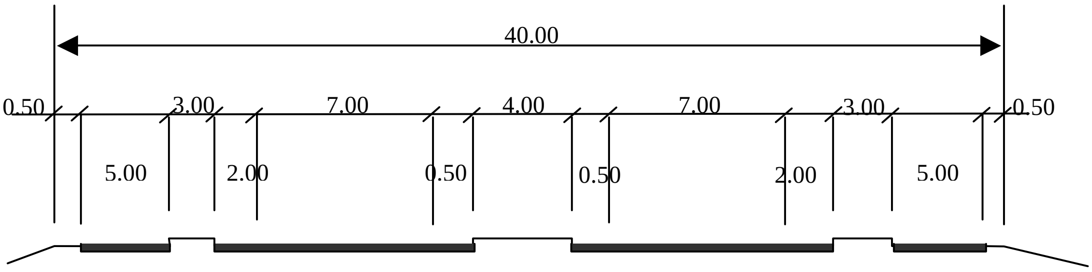
On nonbuilt-up roads, curbs should not be provided, since roads should drain freely for environmental, safety and economic reasons. Furthermore, sidewalks and bicycle lanes are safer if they are located beyond an outer separation rather than next to a curb.

4) Proposed Standards Cross-section

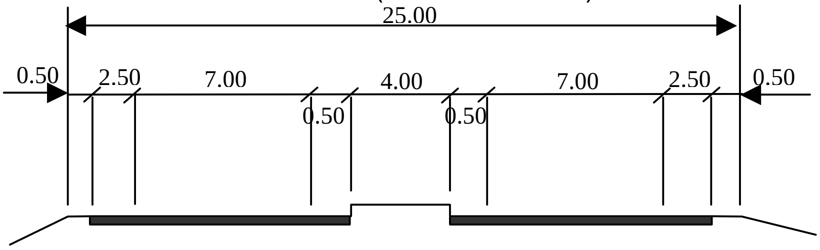
Based on the examination for cross-sectional elements, the following standard cross-sections are recommended for primary, secondary and tertiary road systems.

Figure D.3.3
Primary Road System Proposed Cross-section

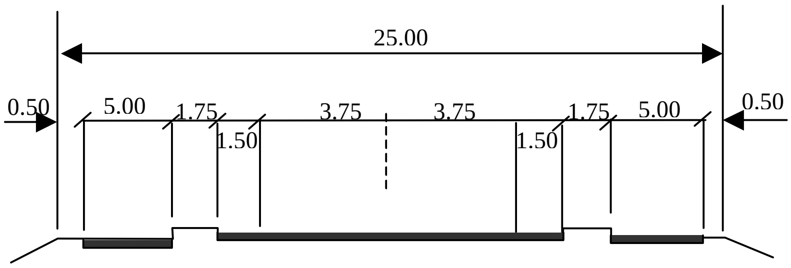
4 Lanes with Motorcycle/Bicycle Lane (Urban Area)



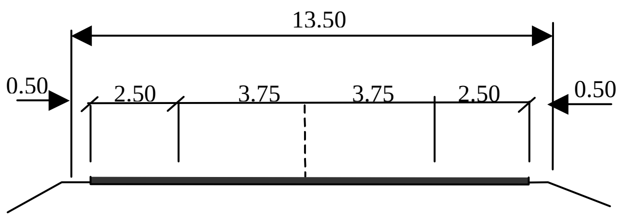
4 Lanes (Normal Section)



2 Lanes with Motorcycle/Bicycle lane (Urban Area)



2 Lanes (Normal Section)



2 Lanes (Mountainous Section)

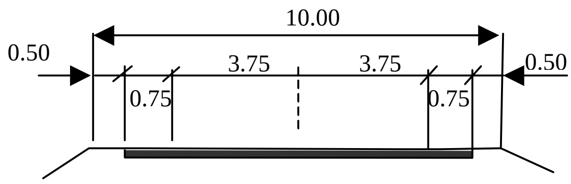


Figure D.3.4
Proposed Cross-section of Secondary Road System

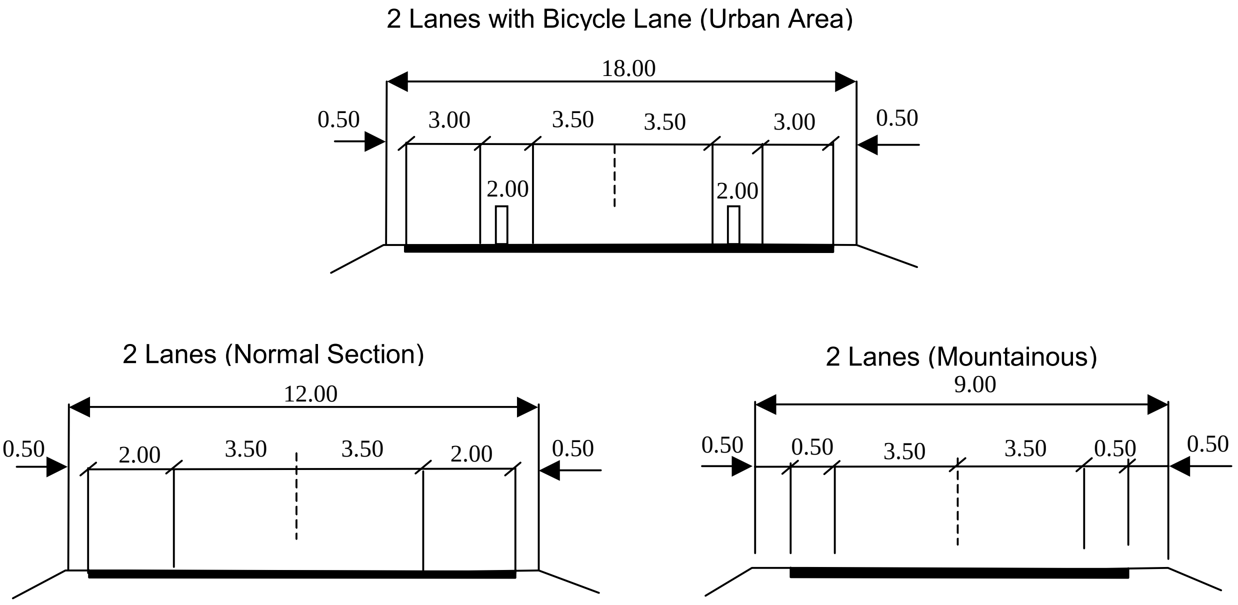
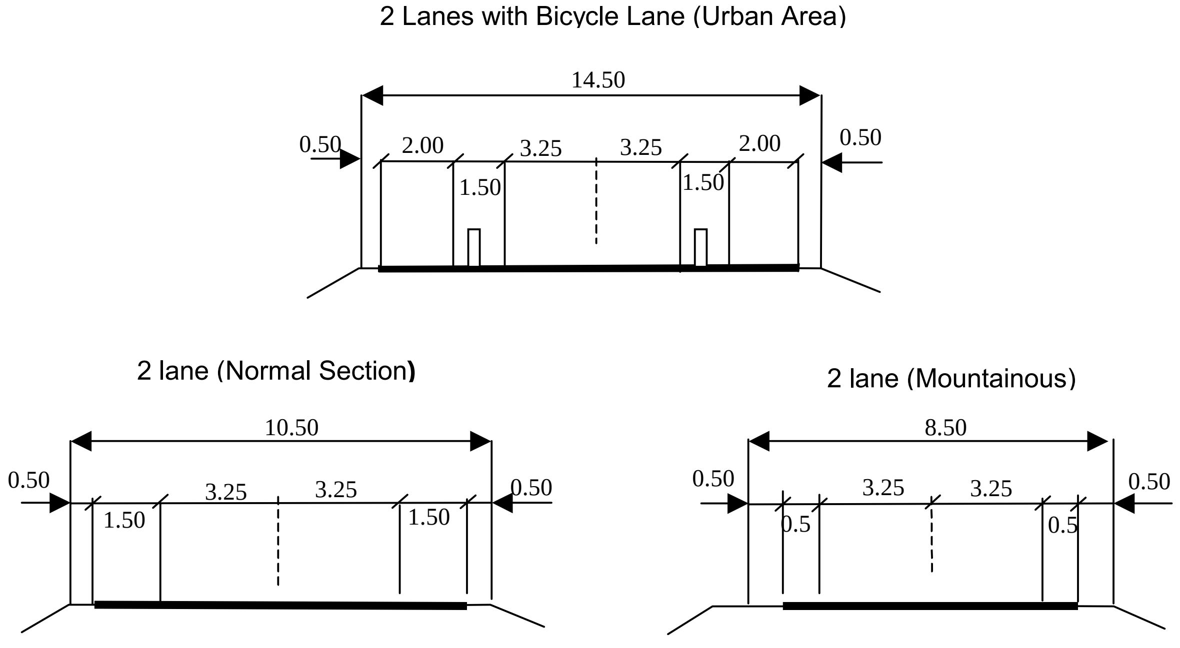


Figure D.3.5
Proposed Cross-section for the Tertiary Road System



APPENDIX E
ROAD CAPACITY

Appendix E presents the methodology developed by the Indonesian Highway Capacity Manual (IHCM) to determine the traffic capacity of each link of the road network. This methodology was also used in the Transport Master Plan for the Central Region of Vietnam (1998, French ODA).

1) Capacity per Hour

According to the methodology developed in this manual, road capacity, which is expressed in terms of passenger car unit (PCU), is given by the following formula:

$$C = C_0 \times FC_W \times FC_{SP} \times FC_{MC} \times FC_{SF}$$

Where, C = Capacity (PCU/h),
C_0 = Base Capacity in ideal conditions (PCU/h),
FC_W = Adjustment factor for carriageway width,
FC_{SP} = Adjustment factor for directional split,
FC_{MC} = Adjustment factor for motorcycle traffic,
FC_{SF} = Adjustment factor for side friction.

(1) Base Capacity: Base capacity (C_0) depends on land use (i.e., urban or interurban), road standards (i.e., number of lanes, lane width, divided or undivided carriageway) and type of terrain. The following table shows the base capacity for a two-lane undivided road according to IHCM.

Table E.1
Base Capacity for Two-lane Undivided Road

	Base Capacity (PCU/h)
Flat Terrain	3,100
Hilly Terrain	2,900
Mountainous Terrain	2,500

(2) Adjustment for Carriageway Width: The adjustment factor for carriageway width (FC_W) for two-lane undivided roads is shown in the following table:

Table E.2
Adjustment Factor for Carriageway Width for Two-lane Undivided Road

Effective Width	FC_W
< 5m	0.69
5m	0.81
6m	0.91
7m	1.00
8m	1.08
9m	1.15
12m	1.27

Source: ICHM

In the actual application, "effective width" was understood to be equal to pavement width for paved roads in the absence of an accurate road inventory. For unpaved roads, it was assumed to be less than 5 m.

(3) Adjustment for Directional Split: The adjustment factor for directional split (FC_{SP}) depends on the directional split of the traffic as shown in the table below. In fact, however, most of the road links fall in the category of "60-40", judging from the results of the VITRANSS traffic counts.

Table E.3
Adjustment Factor for Directional Split

Directional Split (%)	FC_{SP}
50-50	1.00
55-45	0.97
60-40	0.94
65-35	0.91
70-30	0.88

Source: IHCM

(4) Adjustment for Motorcycle Traffic: According to the IHCM, the adjustment factor for motorcycle traffic (FC_{MC}) is based on the motorcycle ratio as follows:

$$FC_{MC} = 1- Q_{MC}/Q_C$$

Where, Q_{MC} = Motorcycle flow (PCU/hr) = 0.25 x Motorcycle flow (MC/h),
Q_C = Sum of flow for all motor vehicle types expressed in PCU/h

When this formula is applied to the results of the VITRANSS traffic counts (39 stations), FC_{MC} was calculated at 0.662 to 0.935 with an average of 0.820. Stations near HCMC tend to show lower values. In this study, the average is used for the entire road network because traffic data is not available for all road links, and the traffic mix changes quickly depending on the situation of road development and traffic demand. The PCU values used in this study are shown below:

Table E.4
PCU Values used in VITRANSS

Vehicle Type	PCU
Bicycle	0.50
Motorcycle	0.25
Car	1.00
Minibus	1.50
Large Bus	2.00
Light Truck	1.00
Medium Truck	2.00
Heavy Truck	2.50
Articulated Truck	3.00
Others	1.00

Source: IHCM

(5) Adjustment for Side Friction: Adjustment factor for side friction (FC_{SF}) is based on roadside activities and shoulder width. For two-lane undivided roads, this factor is shown in the following table:

Table E.5
Adjustment Factor for Side Friction

Typical Conditions	Side Friction Class	Shoulder Width			
		< 0.5m	1.0m	1.5m	>2m
Rural, agriculture or undeveloped, no activities	Very low (VL)	0.96	0.98	1.00	1.03
Rural, some roadside buildings & activities	Low (L)	0.90	0.92	0.95	0.99
Village, residential activities	Medium (M)	0.83	0.86	0.90	0.96
Village, some market activities	High (H)	0.76	0.80	0.85	0.93
Almost urban, market/business activities	Very high (VH)	0.70	0.74	0.80	0.90

Source: IHCM

However, judging from the fact that side friction is usually large in Vietnamese roads (e.g., nonmotorized vehicles, farmers' activities), it was assumed that road shoulder is always less than 0.5 m regardless of the actual width.

(6) Summary: Based on the above calculations, the hourly capacity of a two-lane undivided road becomes as follows:

Table E.6
Hourly Capacity of 2-lane Undivided Road

(PCU/hour)

Terrain	Side Friction	Pavement Width						
		<5m	5m	6m	7m	8m	9m	12m
Flat	Rural, no activity	1,583	1,858	2,087	2,294	2,477	2,638	2,913
	Rural, some activity	1,484	1,742	1,957	2,151	2,323	2,473	2,731
	Village, residential	1,368	1,606	1,805	1,983	2,142	2,281	2,519
	Village, some commercial	1,253	1,471	1,653	1,816	1,961	2,088	2,306
	Urban	1,154	1,355	1,522	1,673	1,806	1,924	2,124
Hilly	Rural, no activity	1,481	1,738	1,953	2,146	2,318	2,468	2,725
	Rural, some activity	1,388	1,630	1,831	2,012	2,173	2,314	2,555
	Village, residential	1,280	1,503	1,688	1,855	2,004	2,134	2,356
	Village, some commercial	1,172	1,376	1,546	1,699	1,835	1,954	2,158
	Urban	1,080	1,267	1,424	1,565	1,690	1,799	1,987
Mountainous	Rural, no activity	1,276	1,498	1,683	1,850	1,998	2,127	2,349
	Rural, some activity	1,197	1,405	1,578	1,734	1,873	1,994	2,203
	Village, residential	1,104	1,296	1,455	1,599	1,727	1,839	2,031
	Village, some commercial	1,011	1,186	1,333	1,465	1,582	1,684	1,860
	Urban	931	1,093	1,227	1,349	1,457	1,551	1,713

Source: IHCM

2) Capacity per Day

Based on the VITRANSS traffic counts (39 stations), the peak hour ratio (against 24-hour traffic for both directions in terms of PCU, excluding motorcycle and nonmotorized transport) varies depending on the survey station, from 5.0 to 11.9% with typical values between 8 and 9%. Assuming a peak hour ratio of 8.5%, which is the same as the French study, the hourly capacity can be converted into daily capacity as shown in Table B.6.

3) Capacity of Multilane Road

When a two-lane road is widened to four lanes, it is assumed that the capacity increases by its base capacity without multiplying any adjustment factors. The following table summarizes this assumption:

Table E.7
Daily Capacity of Two-lane Undivided Road

(PCU/day)

Terrain	Side Friction	Pavement Width						
		<5m	5m	6m	7m	8m	9m	12m
Flat	Rural, no activity	18,624	21,859	24,553	26,988	29,141	31,035	34,271
	Rural, some activity	17,459	20,494	23,024	25,306	27,329	29,094	32,129
	Village, residential	16,094	18,894	21,235	23,329	25,200	26,835	29,635
	Village, some commercial	14,741	17,306	19,447	21,365	23,071	24,565	27,129
	Urban	13,576	15,941	17,906	19,682	21,247	22,635	24,988
Hilly	Rural, no activity	17,424	20,447	22,976	25,247	27,271	29,035	32,059
	Rural, some activity	16,329	19,176	21,541	23,671	25,565	27,224	30,059
	Village, residential	15,059	17,682	19,859	21,824	23,576	25,106	27,718
	Village, some commercial	13,788	16,188	18,188	19,988	21,588	22,988	25,388
	Urban	12,706	14,906	16,753	18,412	19,882	21,165	23,376
Moun-tainous	Rural, no activity	15,012	17,624	19,800	21,765	23,506	25,024	27,635
	Rural, some activity	14,082	16,529	18,565	20,400	22,035	23,459	25,918
	Village, residential	12,988	15,247	17,118	18,812	20,318	21,635	23,894
	Village, some commercial	11,894	13,953	15,682	17,235	18,612	19,812	21,882
	Urban	10,953	12,859	14,435	15,871	17,141	18,247	20,153

Source: IHCM

Table E.8
Capacity of Multilane Road

Terrain	Capacity Increment (2 lanes to 4 lanes)	
Flat	3,100	36,471
Hilly	2,900	34,118
Mountainous	2,500	29,412

Table E.9
Road Speed Assumptions

Category	Lanes	Designed Speed (kph)[1/]			Actual Application (%)				
					Surface Condition				Bus & Truck
		Flat	Hilly	Mount-ainous	Good	Fair	Poor	V. Poor, Unpaved	
1	4 x 3.75 (m)	120	105	90	100	80	50	30	70
2	2 x 3.75	100	90	80	100	80	50	30	70
3	2 x 3.5	80	70	60	100	80	50	30	70
4	2 x 3.0	60	50	40	100	80	50	30	70
5	1 x 3.5	40	35	25	100	80	50	30	70
6	1. 3.0	25	20	15	100	80	50	30	70

1/ Vietnam Design Standards (TCVN 4054 –85), slightly modified