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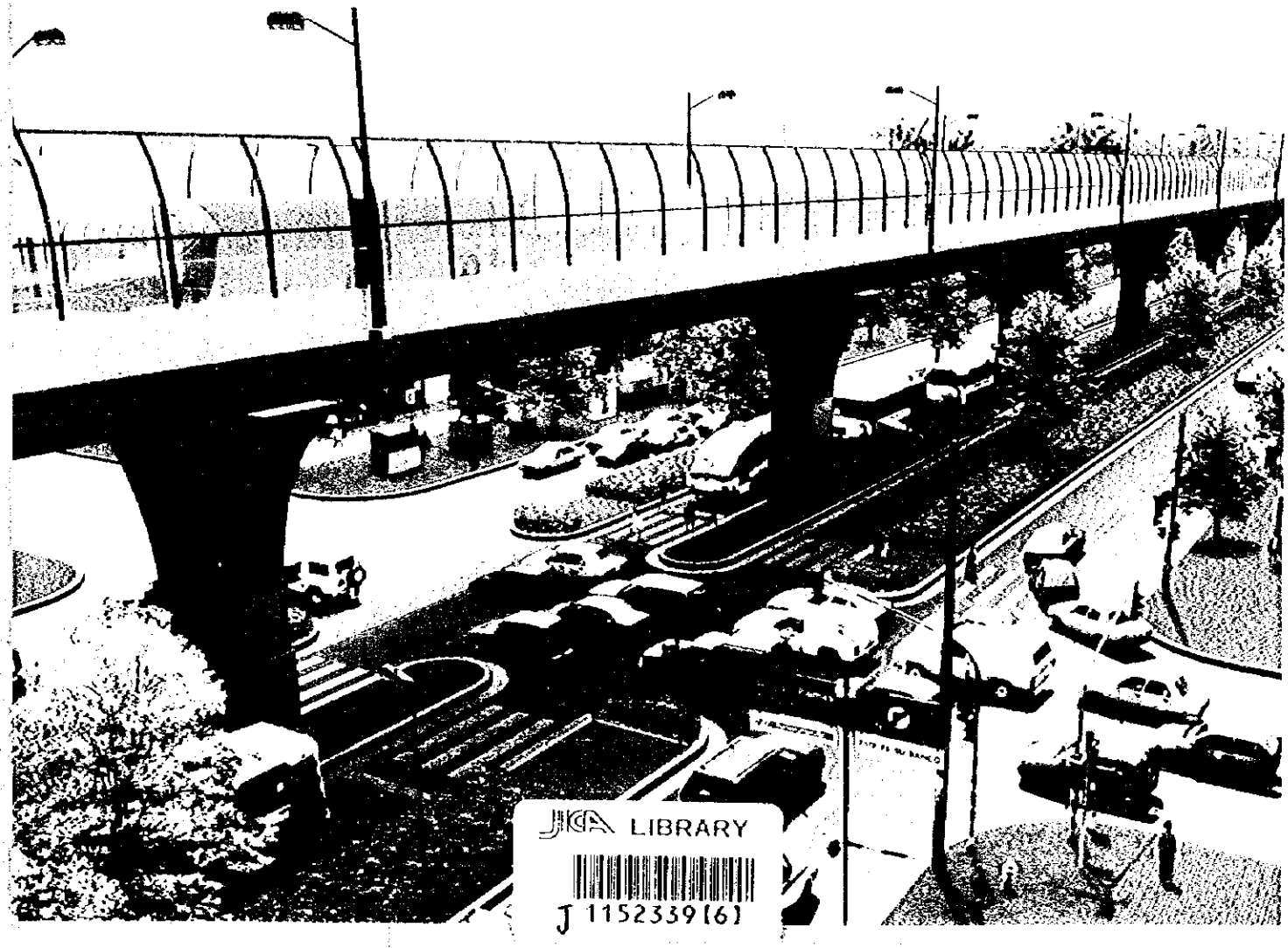
The Feasibility Study on The Project of Highway and Bus-Lane of Santa Fe de Bogota in The Republic of Colombia

Final Report (Main Report) Volume-II



June 1999

Chodai Co., Ltd
in Association With
Yachiyo Engineering Co., Ltd

Japan International Cooperation Agency (JICA)
Santa Fe de Bogota
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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
B/C	Benefit/Cost
BMA	Bogota Metropolitan Area
Bogota	Santa Fe de Bogota
CBD	Central Business District
CAR	Corporación Autónoma Regional
C/D	Capacity/Demand
DAMA	Departamento Técnico Administrativo del Medio Ambiente
DANE	Departamento Administrativo Nacional de Estadística
DAPD	Departamento Administrativo de Palneación Distrial
DNP	Departamento Nacional de Planeación
FEDESARROLLO	Fundación para la Educación Superior y el Desarrollo
EIRR	Economical Internal Rate of Return
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GRDP	Gross Reginal Domestic Product
HRT	Heavy Rail Transit
IBRD	International Bank for Reconstruction and Development
IDU	Instituto de Desarrollo Urbano
JICA	Japan International Cooperation Agency
LRT	Light Rail Transit
OD	Origin-Destination
PCU	Passenger Car Unit
PT	Person Trip
ROW	Right of Way
SOP	Secretaría de Obras Públicas del Distrito
STT	Secretaría de Trasporte y Transito
TDM	Transport Demand Management
TTC	Travel Time Cost
UTP	Unidad de Transporte Publico
V/C	Vehicle/Capacity
VOC	Vehicle Operating Cost
NPV	Net Present Value
$	Colombian Peso
US$	US Dollar

PART D

PRELIMINARY ENGINEERING OF TRUNK BUSWAY AND INNER RING EXPRESSWAY

CHAPTER 14
Preliminary Design for Facilities of Trunk Busways

PART-D PRELIMINARY ENGINEERING OF TRUNK BUSWAYS AND INNER RING EXPRESSWAY

14. PRELIMINARY DESIGN FOR FACILITIES OF TRUNK BUSWAYS

14.1. GENERAL

This chapter discusses the preliminary design for facilities of trunk busway system. An appropriate, systematic facilities design for trunk busway is essential for the safe, smooth flow of the bus traffic on busways. Section 14.2 of this chapter deals with the main design of the trunk busway including the busway itself and bus priority lane, with a review of the road conditions based on the bus operation system plan. It also includes new projects in the study roads and the surroundings. In section 14.3, bus stop design pertaining to trunk busway is shown. In section 14.4, bus terminal design for the trunk busway is discussed. For the bus terminals in the Study Area, two kinds of bus terminals will be designed in accordance with the stage of construction; one is central urban bus terminal and the other is suburban bus terminal. Finally in section 14.5, design of traffic safety facilities is covered, including traffic sign board, marking signals and traffic lights.

14.2. TRUNK BUSWAY

14.2.1. PREMISES

The premises for design of trunk busway are described below:

a) The plan of trunk busway in the study area involves eleven routes: Autp. Norte - Av. Caracas, Av. Quito - Autp. Sur, Av. 7a-Av. 10a, Av. 68-Cll. 100, Av. Suba, Cll. 170, Av. 81. Av. De Las Americas, Av. Centenario, Av. Boyaca and Cra. 39-Trv. 43. Of the total of these eleven routes, the following six routes are designed:

   1) Autopista Norte - Avenida. Caraas: 37.5 km

   2) Avenida Quito - Autopista Sur: 28.8 km

   3) Avenida 7a – Avenida 10a: 21.4 km

   4) Avenida 68-Calle 100: 15.9 km

   5) Avenida Suba: 5.4 km

   6) Calle 170: 4.9 km

   The design of roads, the usage of bus track and the length for the trunk busway by stages are shown in Figure 14.2-1, Figure 14.2-2 and Table 14.2-1.

b) The trunk busway is classified into two types as arterial busway and sub-arterial busway. The arterial trunk busway is operated by express bus and trunk bus on segregated lanes. Peak hour demand of hourly passengers on the arterial trunk busway is predicted to range from 21,000 to 47,000 passengers in one direction. On the other hand, the sub-arterial busway is operated by trunk bus of priority lane system during peak hours. Peak hour demand of passengers on sub-arterial busway is predicted to range from 12,000 to 29,000 passengers in one direction.

c) With regard to the bus operation system, the express bus will be operated on high demand routes in order to decrease the travel time. Either the improvement of

segregated lane or construction of viaduct and fly-over system will be planned so that priority is given to the operation of express bus. The express way will be operated on two routes: Autopista Norte – Avenida Caracas and Autopista Sur. In the case of route of Autopista Norte, since the width of existing right-of-way is sufficient, the express bus should be operated on segregated lane. However, the express bus on Avenida Caracas should be operated on viaduct busway due to narrow width of existing right-of-way. The selection of type of structure such as viaduct system or widening system is discussed in connection with the necessity of viaduct on Avenida Caracas in section 14.2.2. The express bus on Autopista Sur is given the priority of passage by construction of fly-over system at major intersections. On the other hand, the bus priority lane system is adopted to operate on the routes where passenger demand is less than in the arterial busway. The system of bus priority lane will be operated along the sides, and the time periods are established so that the priority is given to morning and evening peak hours.

d) Current road surface maintenance projects on these proposed trunk roads are already in progress, therefore, the improvement of surface conditions is implemented on road sections where only trunk busways are constructed.

e) Since it is difficult to deal with diverging and merging of buses at cross points with grade separation or complicated geometric structure, such road sections will be generally excluded from the route of trunk busway. However, in those cases where improvements are considered to provide more smooth bus flow, then grade separations such as ramp way, should be considered for introduction in the long-term plans.

f) In principle, the trunk busway is planned along an existing right-of-way. Based on the estimation of traffic demand, the partial widening of road will be introduced where it is deemed especially necessary.

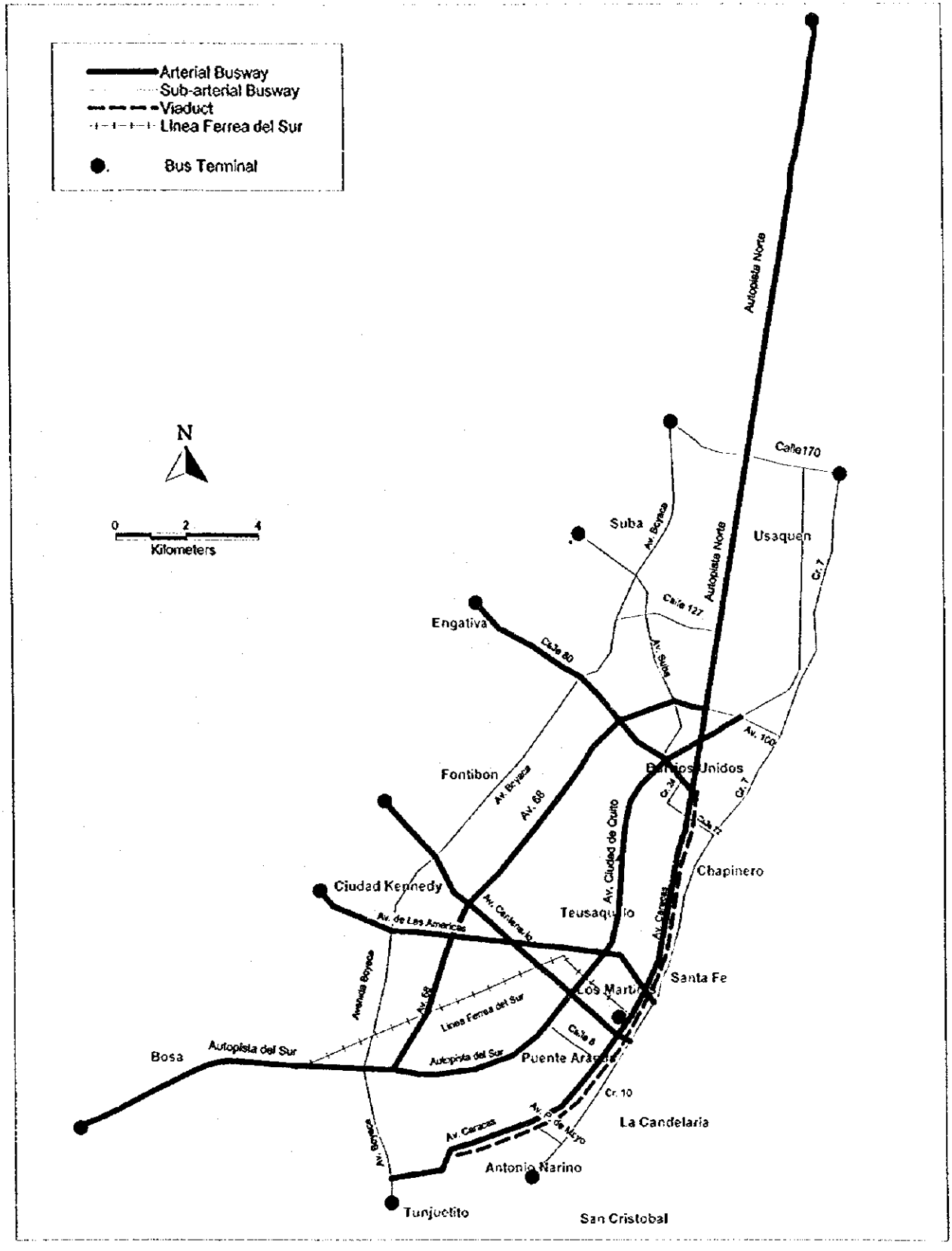


Figure 14.2-1 Type of Trunk Busway

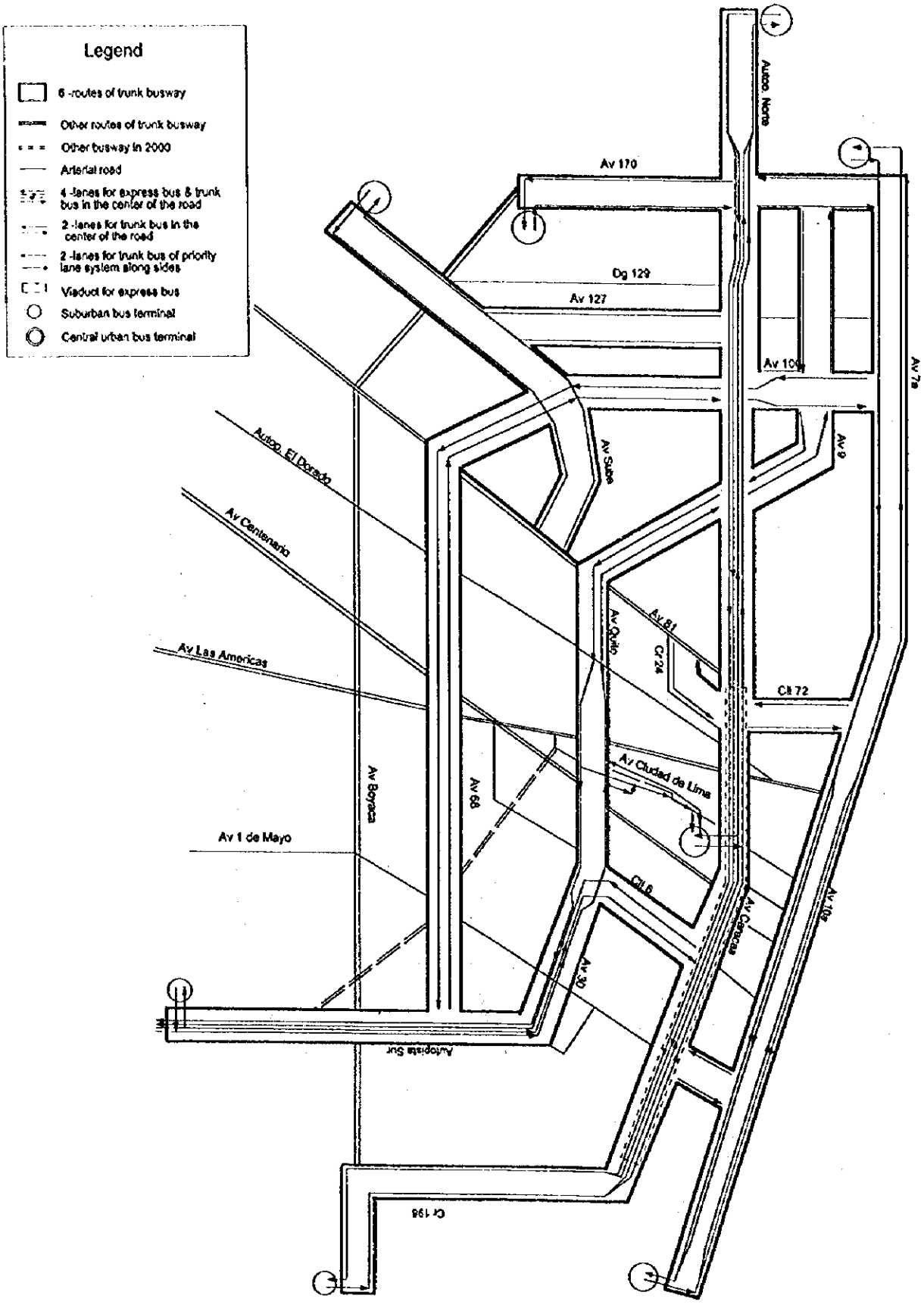


Figure 14.2-2 Plan for Bus Track System of Busway in 2005

Table 14.2-1 Design Roads of Trunk Busway by Stage

In Year of 2000

No.	Name of Road	Section	Distance (km)	Busway System		Type of Bus Track			Type of Busway Structure
				Arterial	Sub-arterial	Center	Shift	Sides	
1	Autopista Norte	Bus terminal - Cll.183	5.6	o				o	Ground level
		Cll. 183 - Dg. 129	5.5	o			o		Ground level
		Dg. 129 - Av. 81	5.5	o		o			Ground level
2	Av. Caracas	Av. 81 - Cr. 19B	14.3	o		o			G.L & Viaduct
		Cr. 19B - Bus terminal	3.9	o				o	Ground level

In Year of 2005

No.	Name of Road	Section	Distance (km)	Busway System		Type of Bus Track			Type of Busway Structure
				Arterial	Sub-arterial	Center	Shift	Sides	
1	Autopista Norte	Bus terminal - Cll.183	5.6	o				o	Ground level
		Cll. 183 - Dg. 129	5.5	o			o		Ground level
		Dg. 129 - Av. 81	5.5	o		o			Ground level
2	Av. Caracas	Av. 81 - Cr. 19B	14.3	o		o			G.L & Viaduct
		Cr. 19B - Bus terminal	3.9	o				o	Ground level
3	Av. Quito	Cll. 170 - Cr. 15	10.3		o			o	Ground level
		Cr. 15 - Cll. 6	11.1		o	o			Ground level
		Cll. 6 - Cll. 8S	1.4	o		o			Ground level
4	Autopista Sur	Cll. 8S - Bus terminal	8.1	o		o			G.L & Fly-over
5	Avenida 7a	Av. 19 - Cll. 170	19.5		o			o	Ground level
6	Avenida 10a	Av. 19 - Cll. 35S	5.5		o			o	Ground level
7	Avenida 1 de Mayo (option)	Av. 10a - Av. Caracas	1.1		o			o	Ground level
8	Avenida 68	Autp. Sur - Autp. Norte	14.8		o	o			Ground level
9	Avenida 100	Autp. Norte - Av. 7a	2.3		o			o	Ground level
10	Avenida Suba	Cr. 104 - Av. 81	10.7		o			o	Ground level
		Av. 127 - Autp. Norte	2.2		o			o	Ground level
11	Carrera 24(option)	Av. 81 - Cll. 72	0.8		o			o	Ground level
12	Calle 72 (option)	Cr. 24 - Av. 7a	1.5		o			o	Ground level
13	Avenida 170	Av. 7a Trans. 64	1.5		o			o	Ground level

14.2.2. NECESSITY OF VIADUCT ON AVENIDA CARACAS

(1) Future Bus Passenger Demand on Av. Caracas.

As previous mentioned in Chapter 9, the future bus passenger demand per the peak hour (7:00 am to 8: 00 am) in year 2000 and 2005 were forecast. In 2005, the total 32 new bus operation routes were identified, and the 14 new bus operation routes of total are passing through on the Avenida Caracas, and the number of bus fleets which are passing through on Avenida Caracas are presented below in accordance with in Chapter 9.

1) Express Bus System: 142 buses / hour / direction

2) Trunk Bus System: 410 buses / hour / direction

In total, 552 buses per direction will be passed through on the Avenida Caracas during the peak hour from 7: 00 am to 8:00 am, therefore, the scale of infrastructure of bus way should be maintained above mentioned large number of bus fleets without traffic congestion.

(2) Capacity of Bus Way

The capacity of bus way is identified based on the following items:

a) Number of bus lanes

b) With or without bus bay

c) Number of bus platform

d) Number of boarding passengers at bus stop

e) Time needed for on boarding by one passenger

f) Time needed for deceleration and acceleration by buses at the bus stop

g) Type of bus (number of doors)

1) Combination of items of a), b), and c) alone

Several conditions in the Bogota city such as bus operation system, the existing road facilities conditions, building condition along the existing roads, and future passenger demand are considered, many different cases can be identified such as the following:

Case-A: 1-lane bus way with 1-bus platform without bus bay for one direction.

Case-B: 1-lane bus way with 2-bus platforms without bus bay for one direction.

Case-C: 1-lane bus way with 1-bus platform with bus bay for one direction.

Case-D: 1-lane bus way with 2-bus platforms with bus bay for one direction.

Case-E: 2-lane bus way with 1-bus platform without bus bay for one direction.

Case-F: 2-lane bus way with 2-bus platforms without bus bay for one direction.

Case-G: 2-lane bus way with 1-bus platform with bus bay for one direction.

Case-H: 2-lane bus way with 2-bus platforms with bus bay for one direction.

Case-I: 2-lane bus way with 2-bus platforms on each way with bus bay for one direction.

2) Item d)

As a result of bus passenger survey on the existing bus stop along the Avenida Caracas, the average number of boarding bus passengers at each bus stop was observed at 4 to 6 persons.

In the year 2005, the average number of boarding bus passengers at about each bus stop may be estimated at about 6 to 8 persons. Based on for going, the number of boarding passengers was identified as 8 persons for calculation of bus way capacity approximately.

3) Item e)

As a results of the bus passenger survey by JICA Study Team in 1998, the average time required for boarding to the bus was observed at about 2 seconds, therefore, the time required for boarding by one passenger is adopted at 2 second for calculation of bus way capacity.

4) Item f)

The time of deceleration and acceleration for the bus stop is required at 3 to 4 seconds for one bus platform based on the results of bus survey, and at 3 seconds for two bus platforms was estimated at 5 to 6 seconds respectively.

5) Item g)

In this study, two kinds of bus types will be considered; the express bus is adopted at Articulated buses with 200 passenger capacity and Single body bus with 100 passenger capacity. The number of doors for the Articulated bus is prepared at 4 doors and the Single body bus is prepared at 2 doors respectively.

The results of calculation of bus way capacity / peak hour / one direction on each of the above-mentioned cases are listed in Table 14.2-2 and Figure 14.2-3.

Table 14.2-2 Busway Capacity by Case

Case	No. of bus lane/dir.	No. of boarding (pax	Time to decele.(sec	Time to boarding(sec)	Time to accele.(sec	Total stop time(sec)	Capacity (bus/h/dir.)
A	1	8	2	16	2	20	180
B	1	8	2	16	2	20	180
C	1	8	2	16	2	20	180+x
D	1	8	3	16/2=8	3	14	257
E	2	8	2	16	2	20	180+x
F	2	8	3	16/2=8	3	14	257
G	2	8	2	16	2	20	180+x
H	2	8	3	16/2=8	3	14	257+x
I	2	8	2	16	2	20/2=10	180+257=437

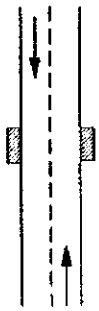
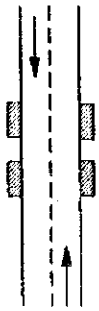
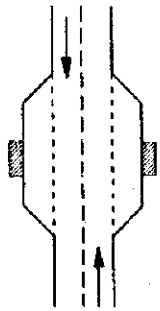
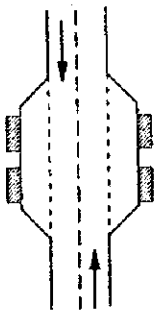
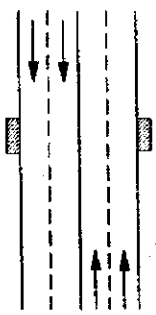
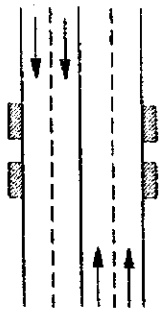
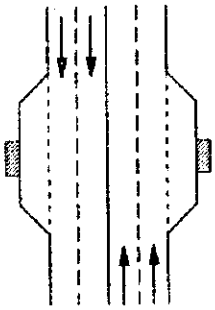
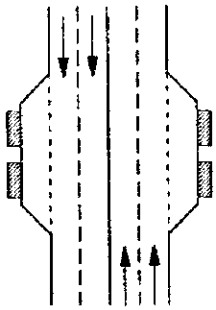
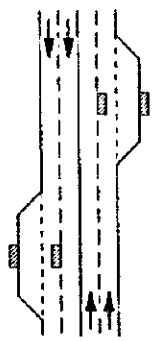
Case - A	Case - B	Case - C
Capacity = 180 bus/hour/direction	Capacity = 180 bus/hour/direction	Capacity = 180 + X bus/hour/direction
		
Case - D	**Case - E**	**Case - F**
Capacity = 257 bus/hour/direction	Capacity = 180 bus/hour/direction	Capacity = 257 bus/hour/direction
		
Case - G	**Case - H**	**Case - I**
Capacity = 180 + X bus/hour/direction	Capacity = 257 bus/hour/direction	Capacity = 437 bus/hour/direction
		

Figure 14.2-3 Busway Capacity by Case

(3) Bus Facilities Required on the Avenida Caracas Without Viaduct

As a result of comparative study between the capacity of bus way and future bus demand, the following facilities, without viaduct are required in order to maintain the smooth traffic flow for buses, keep traffic safety, and maintain the good urban activities.

1) The number of bus fleets on Avenida Caracas is forecast as 142 bus fleets/hour/ direction for express bus system (bus fleet by 200 passengers) and additional 410 bus fleets/ hour/ direction for trunk bus system (bus fleet by 100 passengers).

2) As mentioned earlier, Case-I involves the maximum capacity among the 9 cases (Case-A to Case-I). Case-I, which is the largest case, will be adopted for Avenida Caracas, however, about 153 bus fleets (410- 257 =153) can not be accommodated.

3) Therefore, the passenger capacity on each trunk bus should be changed from 100 passengers to 200 passengers due to decrease the number of bus fleets. When large bus (200 passenger) are used, the bus fleets of trunk bus system may be decreased to 205 buses.

4) Considering the above mentioned conditions, the following typical cross section (on bus stop section) with 45 meters ROW should be adopted. Additional land acquisition will also be required, (minimum 5 meters *100 meters at each bus stop) (See Figure 14.2-4 and Figure 14.2-5).

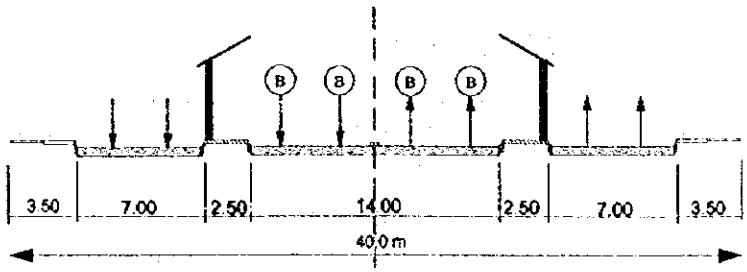


Figure 14.2-4 Existing Typical Cross Section

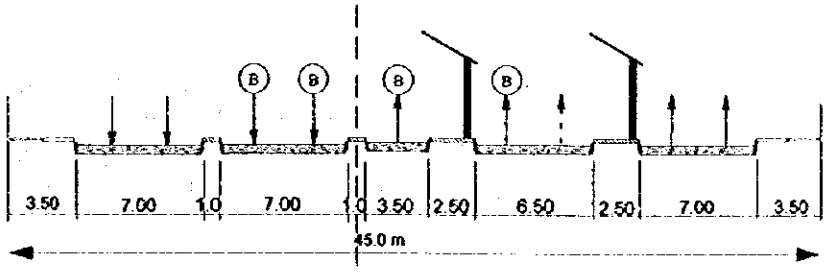


Figure 14.2-5 Minimum Cross Section for Trunk Bus System by At-grade Road Type

(4) Reasons for Viaduct Adopted on Avenida Caracas.

The viaduct road type is adopted on Avenida Caracas for the introduction of the new trunk bus system. The major reasons for selection are as follows:

1) As mentioned previous, the Case-I can be maintained the future bus passenger demand on Avenida Caracas, however, at least 5.0 meters additional land should be acquired at each bus stop located. It is very difficult to acquire the additional land along the existing Avenida Caracas, due to the fact that there are many tall buildings constructed for housing and commercial use along both sides of the road.

2) The minimum area for additional land to be acquired is a length of approximately 100m, and a width of approximately 5 meters, at each 500 to 600 meters interval, which is located on bus stop. In accordance with the past experience of implementation of the land acquisition and compensation, long time discussions and heavy negotiations has been required. Considering these conditions, the new trunk bus system may not be introduced or constructed during the short team period.

3) The area of minimum additional land to be acquired at each bus stop is very small space (100 m length* 5 m width), however, if any building will be affected in a part or as a whole, the whole building needs to be demolished.

4) Since demolision of high rise buildings and additional land acquisition of new land along the Avenida Caracas is not realistic, therefore, the viaduct road type is adopted for introduction of new trunk bus system on Avenida Caracas.

14.2.3. Typical Busway Cross Section

(1) Usage of Bus Track and Segregation

In the Study, busway track is located along an existing right-of-way. For an existing right-of-way, the bus track is generally planned both in the center of the road (median) and along the sides (lateral), depending on the road width.

The degree of grade separation between buses and other traffic can have a major influence on performance. The proposed busways physically segregate buses and other traffic along their entire length using curbs or fences exclusive of some roads where segregation is only at island bus stops.

As for the median lanes, bus operation speeds on such lanes are faster than in the lateral lanes. But pedestrian islands must be provided at all stops for safety and convenience.

In general, a segregated busway decreases turbulence in both traffic flow of cars and buses and therefore, often increases speeds of not only buses, but of the car traffic in other lanes as well. A disadvantage of segregated busway is, however, that they tend to discourage mutual overtaking of buses from different routes. Normally, overtaking reduces their delays. On bus streets, overtaking is common. Therefore, the 2-lane busway per direction is proposed for the Study.

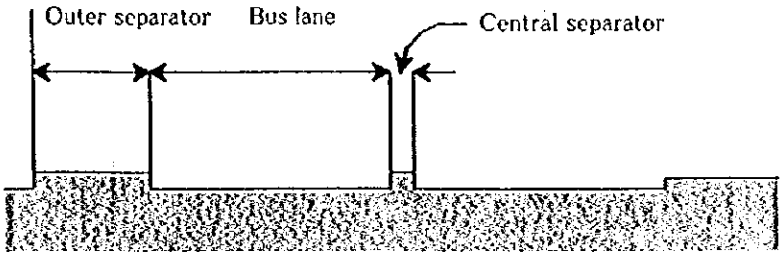
The width of a busway depends on design speed, vehicle width and operational characteristics. The width of bus lane on the Study roads is classified into 4 ranks ranging between 3.25 and 4.00 meters. Table 14.2-3 gives proposed lane widths for busways, in order to carry in excess of 60 buses per hour ranked according to design speeds.

Table 14.2-3 Recommended Cross-Section Widths for Median Busway

Carrying More Than 60 Buses per Hour

Design speed (km/h)	Width (m)		
	Bus Lane	Central Separator (between lanes)	Outer Separator (between bus lane and other traffic)
100	4.00	0.4	0.75
80	3.75	0.4	0.50
60	3.25	0.4	0.30
40	3.00	0.4	0.20

(source: RATP)



(2) Typical Busway Cross Section by Study Road

1) Autopista Norte

The existing right-of-way is 100 meters wide, and consists of 6-lanes or 10-lanes. Since the Autopista Norte will be defined as an arterial trunk busway, this road will be operated by express bus and trunk bus. This road should be generally preserved for 2-lane busway per direction by reduction of width of median: one lane is for trunk bus and the other lane is for express bus. For special mention, there is a large-sized water pipe (diameter 78 or 60 inches) under the median of Autopista Norte. Taking conditions of underground water pipe into consideration, the busway cross section is established as follows (See Figure 14.2-6 to Figure 14.2-8):

a) Section Calle 183-Surburban bus terminal: 1-lane priority lane per direction, 1-lane is for mixed lane of trunk and express bus along sides.

b) Section Calle 183-Calle 129: 2-lanes busway per direction, 1-lane is for trunk bus and other lane is for express bus in the other side of road separating from the water pipe.

c) Section Calle 129-Av.81: 2-lanes busway per direction, 1-lane is for trunk bus and other lane is for express bus in the center of road.

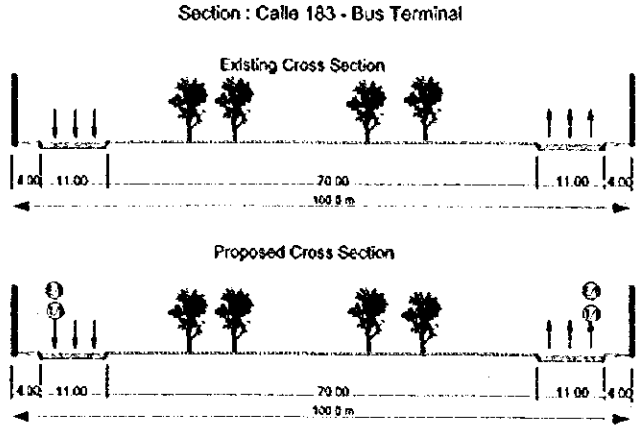


Figure 14.2-6 Typical Cross Section on Autopista Norte (1)

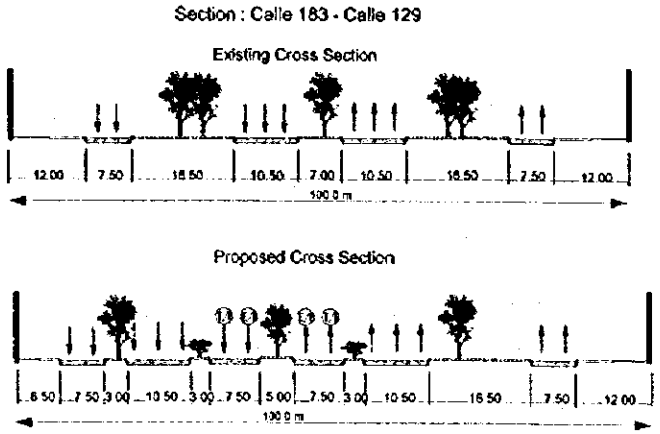


Figure 14.2-7 Typical Cross Section on Autopista Norte (2)

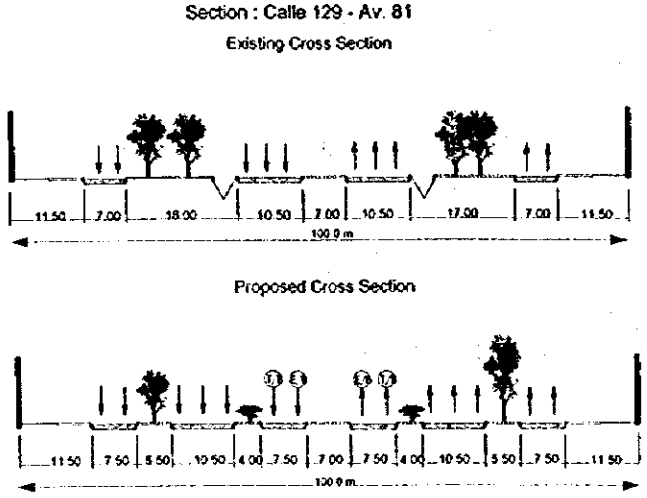


Figure 14.2-8 Typical Cross Section on Autopista Norte (3)

2) *Avenida Caracas*

The existing right-of-way averages 40 meters in width and consists of 8-lanes. At present, the bus exclusive lane system is located in section between Avenida 78 and Calle 51 Sur on Avenida Caracas. 4-lanes for bus exclusive in the central part of road, are planned.

Avenida Caracas will be defined as an arterial trunk busway based on bus demand. This road will be used by express bus and trunk bus. The operation of express bus will be planned for the full median segregated busway. Since the width of existing right-of-way is not enough due to the central built-up area, the express bus should be operated on viaduct busway for high performance. In addition, street trees will be provided along the viaduct in order to improve the road environment. In the southern part of Avenida Caracas, the plan for express bus lanes of trunk busway was selected based on evaluation of cost estimate of the two options: either the extension of viaduct system or the widening of road. As a result of the cost estimate, it was found that it is more economical to extend the viaduct system than to widen the road. The busway cross section is established as follows (See Figure 14.2-9 and Figure 14.2-10):

a) Section Av. 78-Av. Ciudad de Lima (Calle 18A): 2-lanes busway per direction, 1-lane is for trunk bus in the center of road and other lane is for express bus on viaduct.

b) Section Av. Ciudad de Lima (Calle 18A)-Calle 48A: 2-lane busway per direction, 1-lane is for trunk bus and other lane is for express bus in the center of road, alternative is viaduct type, alternative 2 is widening of road type.

c) Section Calle 48A-Surburban bus terminal: 1-lane priority lane per direction, 1-lane is for mixed lane of trunk and express bus along sides.

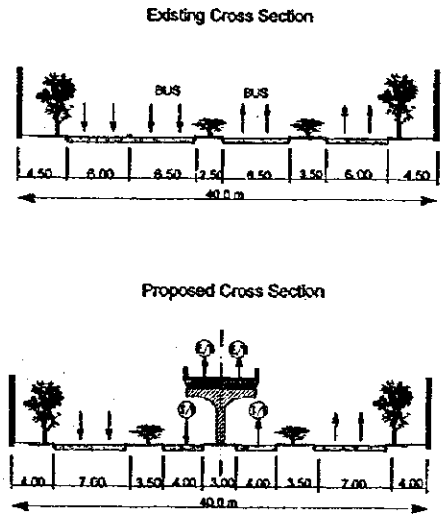


Figure 14.2-9 Typical Cross Section on Avenida Caracas

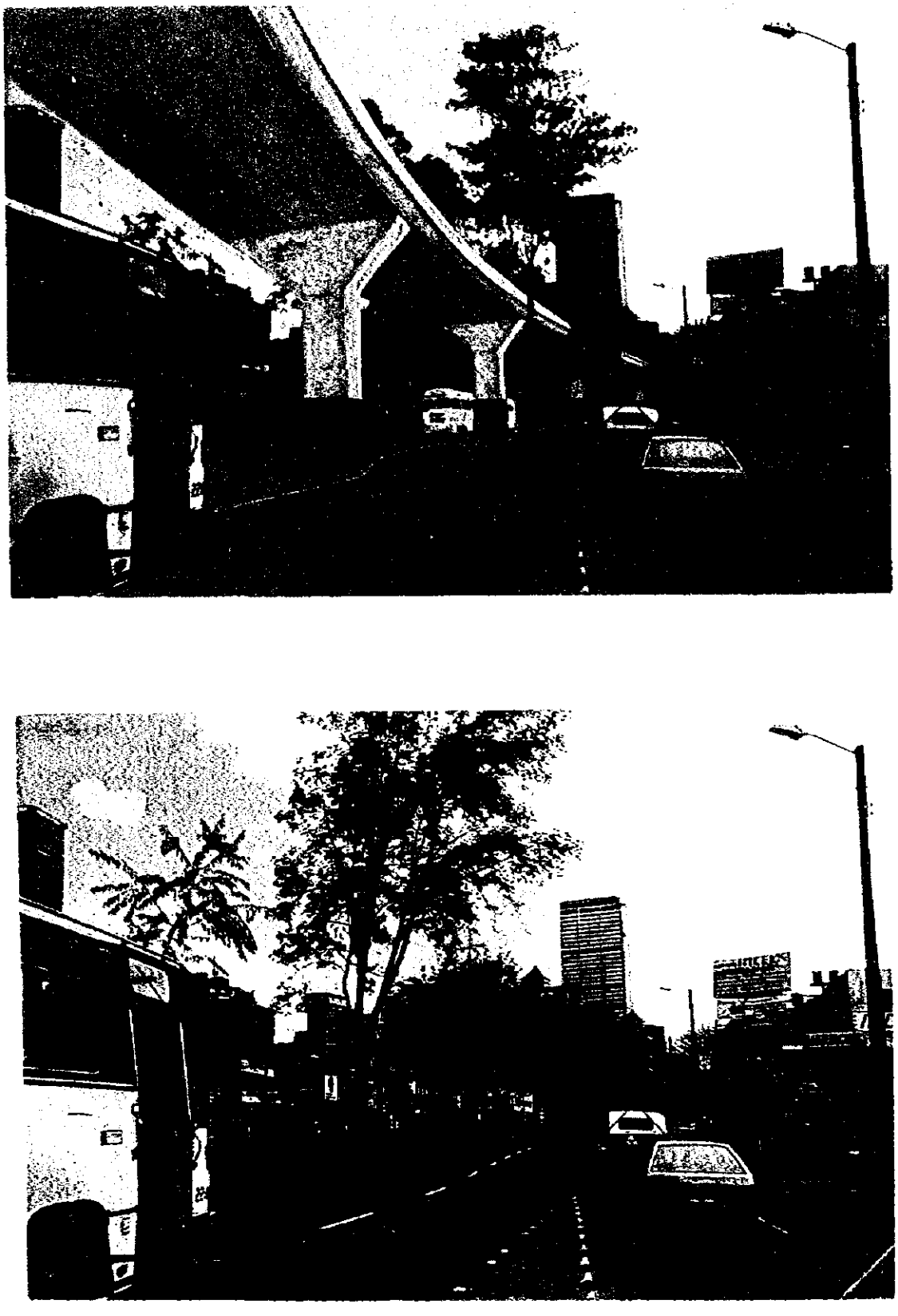


Figure 14.2-10 Image Plan of Busway on Avenida Caracas

3) Avenida Quito

The existing right-of-way ranges between 50 and 70 meters in width and consists of either 8-lanes or 10-lanes. Avenida Quito will be defined as arterial trunk busway. This road will be used by trunk bus. The trunk bus will be planned in the center of the road in order for it to be segregated. In section between Carrera 15 and Calle 6, the urban expressway is located in the center of the road. In accordance with construction of expressway, the gateway to the central bus terminal will be accessed from Calle 6 to Avenida Caracas by grade separation. In addition, street trees will be provided along the viaduct in order to improve the road environment. The busway cross section is established as follows (See Figure 14.2-11 to Figure 14.2-16):

a) Section Carrera 15-Calle 170: 1-lane of busway per direction, 1-lane of the total 3-lane per direction is for trunk bus along sides.

b) Section Carrera 15-Calle 68: 1-lane of busway per direction, 1-lane of the total 6-lanes (including 2-lanes of viaduct) per direction is for trunk bus in the center of the road.

c) Section Calle 68-Calle 51: 1-lane of busway per direction, 1-lane of the total 7-lane (including 2-lane of viaduct) per direction is for trunk bus in the center of the road.

d) Section Carrera 51-Calle 6: 1-lane of bus priority per direction, 1-lane of the total 6-lane (including 2-lane of viaduct) per direction is for trunk bus in the center of the road.

e) Section Calle 6-Calle 8S, 2-lane busway per direction, 1-lane is for trunk bus and the other lane is for express bus in the center of the road.

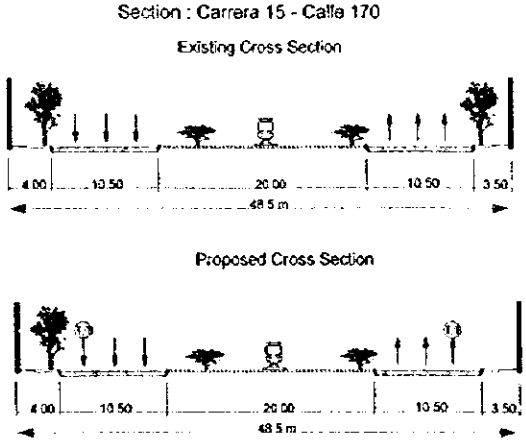


Figure 14.2-11 Typical Cross Section on Avenida Quito (1)

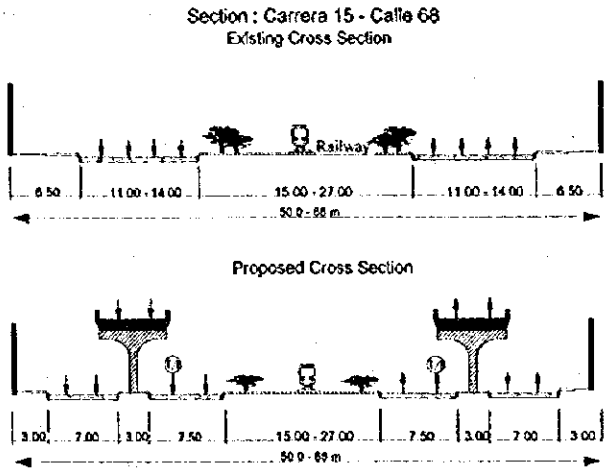


Figure 14.2-12 Typical Cross Section on Avenida Quito (2)

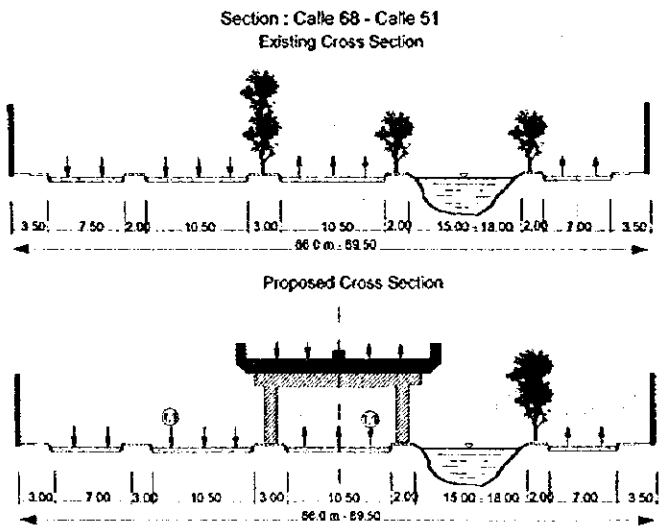


Figure 14.2-13 Typical Cross Section on Avenida Quito (3)

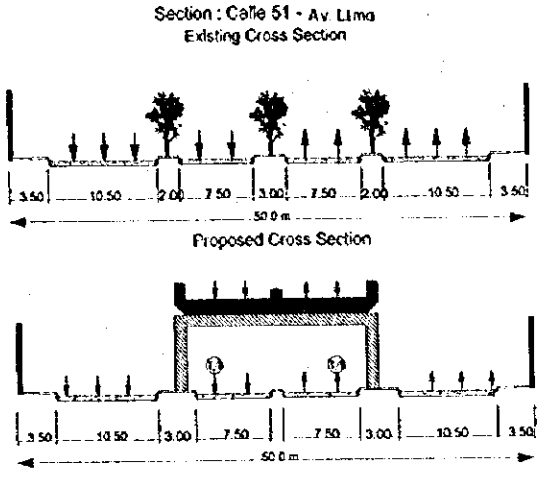


Figure 14.2-14 Typical Cross Section on Avenida Quito (4)

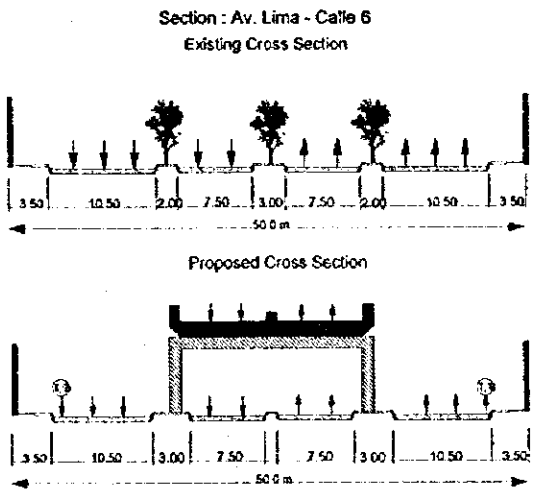


Figure 14.2-15 Typical Cross Section on Avenida Quito (5)

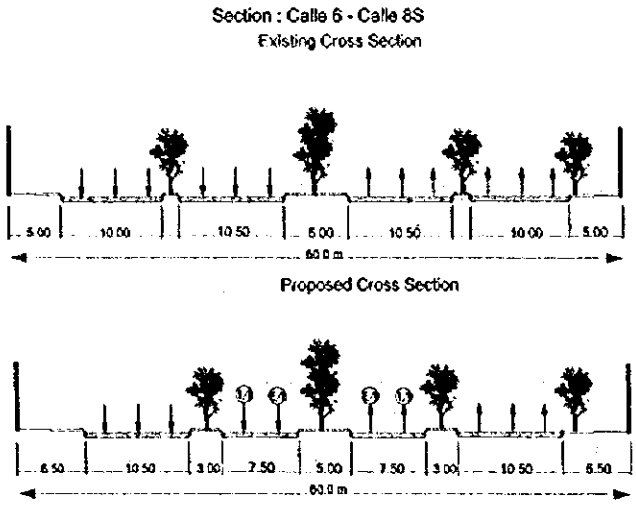


Figure 14.2-16 Typical Cross Section on Avenida Quito (6)

4) Autopista Sur

The existing right-of-way averages 60 meters in width and consists of 12-lanes. Autopista Sur will be defined as an arterial trunk busway. This road will be used by express bus and trunk bus. It is necessary to reduce the width of median in order to provide 4-lanes for busway. The busway cross section is established as follows (See Figure 14.2-17 and Figure 14.2-18):

a) Section Calle 8S-Suburban bus terminal: 2-lanes busway per direction, 1-lane is for trunk bus and other lane is for express bus in the center of the road.

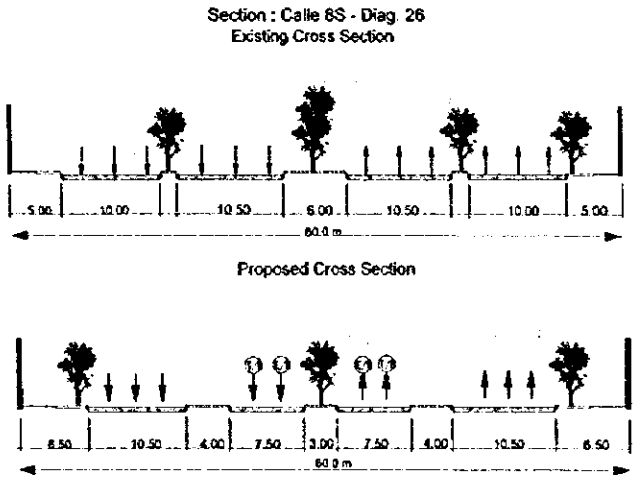


Figure 14.2-17 Typical Cross Section on Autopista Sur (1)

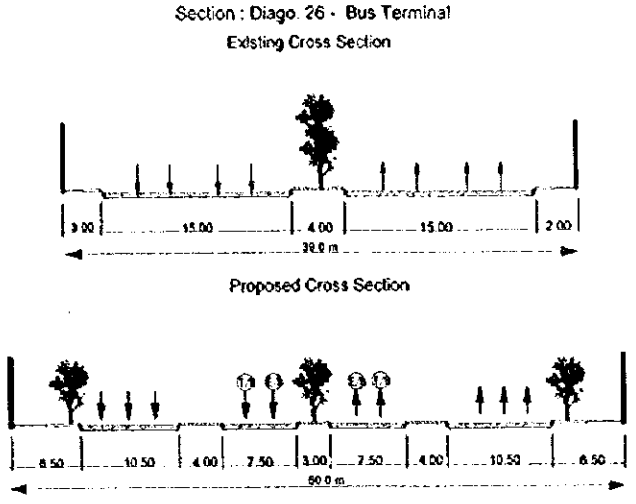


Figure 14.2-18 Typical Cross Section on Autopista Sur (2)

5) Avenida 7a

The existing right-of-way ranges between 30 and 50 meters in width and consists of either 6-lanes or 8-lanes. Avenida 7a will be defined as sub-arterial trunk busway. This road will be used by trunk bus of priority lane system during peak hours. This road can only take busway with 1-lane per direction along the sides. In the section between Calle 100 and Calle 116, the urban expressway is located in the center of the road. The busway cross section is established as follows (See Figure 14.2-19 to Figure 14.2-21):

a) Section Av. 19-Calle 100: 1-lane of bus priority per direction, 1-lane of the total 3-lanes per direction is for trunk bus along sides.

b) Section Calle 100-Calle 116: 1-lane of bus priority per direction, 1-lane of the total 4-lanes per direction is for trunk bus along sides.

c) Section Calle 116-Calle 170: 1-lane of bus priority per direction, 1-lane of the total 3-lanes per direction is for trunk bus along sides.

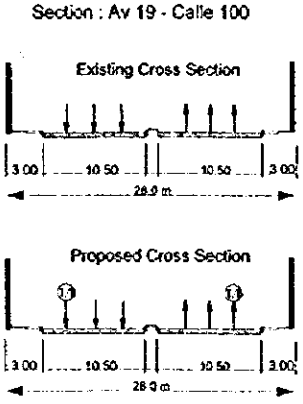


Figure 14.2-19 Typical Cross Section on Avenida 7a (1)

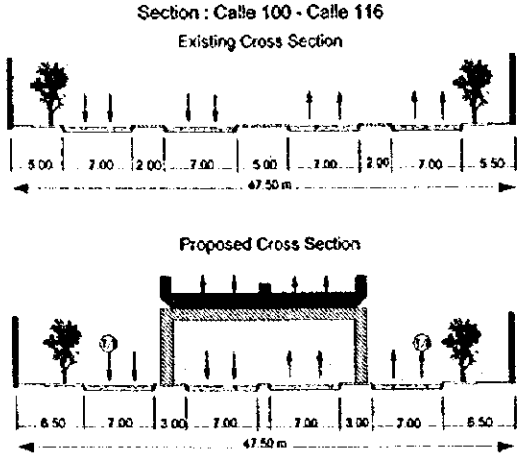


Figure 14.2-20 Typical Cross Section on Avenida 7a (2)

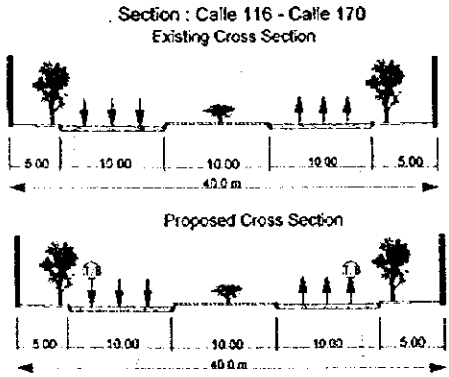


Figure 14.2-21 Typical Cross Section on Avenida 7a (3)

6) *Avenida 10a*

The existing right-of-way averages 40 meters in width and consists of 8-lanes. Avenida 10a will be also defined as sub-arterial trunk busway. This road will be used by trunk bus of priority lane system during peak hours. Avenida 10a continues from Avenida 7a, and in particular, bus passenger demand will tend to be heavier than in Avenida 7a. Owing to 8-lanes of road, 2-lanes of bus priority per direction will be operated. The busway cross section is established as follows (See Figure 14.2-22):

a) Section Av. 19-Calle 35S: 2-lane of bus priority per direction, 2-lane of the total 4-lanes per direction is for trunk bus along the sides.

(Additional Route: Avenida 1 de Mayo)

b) Section Avenida 10a-Avenida Caracas: 1-lane of bus priority per direction, 1-lane of the total 3-lanes per direction is for trunk bus along the sides.

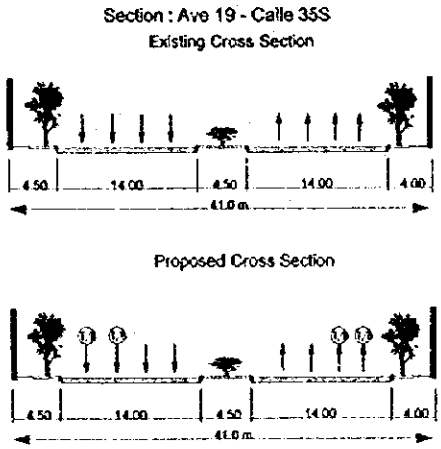


Figure 14.2-22 Typical Cross Section on Avenida 10a

7) *Avenida 68*

The existing right-of-way is approximately 40 meters wide and consists of 8-lanes. Avenida 68 will be defined as arterial trunk busway. This road will be used by trunk bus. This cross section is the same as that of existing right-of-way. The bus priority lane will be planned in the center of the road in order to be segregated as well. The busway cross section is established as follows (See Figure 14.2-23):

a) Section Autopista Norte-Autopista Sur: 1-lane of busway per direction, 1-lane of the total 8-lanes per direction is for trunk bus in the center of the road.

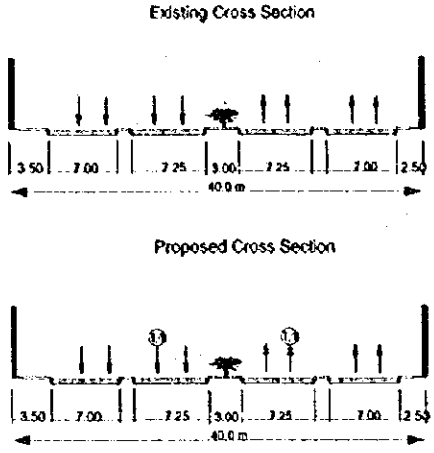


Figure 14.2-23 Typical Cross Section on Avenida 68

8) Avenida 100

The existing right-of-way is approximately 60 meters wide and consists of either 8-lanes or 10-lanes. Avenida 100 will be defined as sub-arterial trunk busway. This road will be used by trunk bus of priority lane system during peak hours. This road can only take busway with 1-lane per direction along the sides. In the section between Autopista Norte and Avenida 7a, the urban expressway is located in the center of the road. Especially, street trees will be preserved as nearly as possible to the existing condition. The busway cross section is established as follows (See Figure 14.2-24):

a) Section Autopista Norte-Avenida 7a: 1-lane of bus priority per direction, 1-lane of the total of 6-lanes or 7-lanes per direction is for trunk bus along sides.

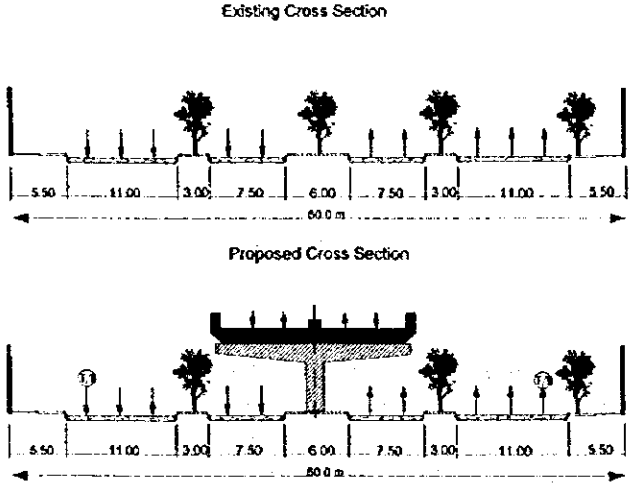


Figure 14.2-24 Typical Cross Section on Avenida 100

9) Avenida Suba

The existing right-of-way is approximately 40 meters wide and consists of 6-lanes. Avenida Suba will be defined as sub-arterial trunk busway. This road will be used by trunk bus of priority lane system during peak hours. This cross section is the same as that of existing right-of-way. This road can only take busway with 1-lane per direction along the sides. The busway cross section is established as follows (See Figure 14.2-25):

a) Section Carrera 104-Avenida 81: 1-lane of bus priority per direction, 1-lane of the total 3-lanes per direction is for trunk bus along the sides.

b) Section Avenida 127-Autopista Norte: 1-lane of bus priority per direction, 1-lane of the total of 3-lanes per direction is for trunk bus along the sides.

(Additional Route: Crrera.24)

c) Section Avenida 81-Autopista Norte: 1-lane of bus priority per direction, 1-lane of the total of the 3-lanes per direction is for trunk bus along the sides.

(Additional Route: Calle 72)

d) Section Autopista Norte- Avenida 7a: 1-lane of bus priority per direction, 1-lane of the total the 3-lanes per direction is for trunk bus along the sides.

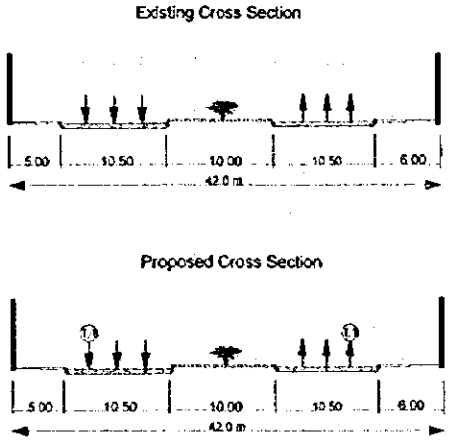


Figure 14.2-25 Typical Cross Section on Avenida Suba

10) Calle 170

The existing right-of-way is approximately 50 meters wide and consists of either 4-lanes or 6-lanes. Calle 170 will be defined as sub-arterial trunk busway. This road will be used by trunk bus of priority lane system during peak hours. This cross section is the same as that of existing right-of-way. This road can only take busway with 1-lane per direction along the sides. The busway cross section is established as follows (See Figure 14.2-26):

a) Section Avenida 7a-Transversal 64: 1-lane of bus priority per direction, 1-lane of the total the 2-lanes or 3-lanes per direction is for trunk bus along the sides.

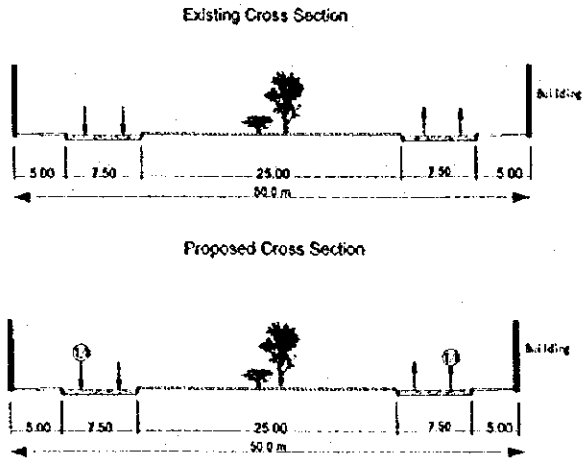


Figure 14.2-26 Typical Cross Section on Calle 170

14.2.4. VIADUCT AND PHYSICAL SEGREGATION

Busway structure is classified into three types as followings:

1) Viaduct for Express Busway built on Avenida Caracas,
2) ON-OFF ramp for the above, and
3) Fly-over for Express Busway on Autopista Sur.

1) Viaduct

Viaduct is planned to be built for 14.5km from around Calle 86 junction at south end of Autopista Norte, to Calle 48A at south end of Avenida Caracas. The Characteristics of the plan are as follows;

a) Viaduct has 2-lanes single carriageway of 3.5m with clearance of 0.5m at center and 1.0m at side and has no separation block A chatter bar is provided at center taking accident cases of buses into account. (See Figure 14.2-27).

b) Viaduct height is minimum 11.0m from the existing road surface sufficient to clear over pedestrian bridges.

c) Three span continuous PC Hollow Slab is used as super structure of viaduct however, where bus stop is provided, three continuous spans PC Box Girder will be used due to the longer span.

d) As for sub structure, tapered shape column is used for standard section from aesthetic point of view and rigid frame gantry column is used for Express bus stop section due to wider super structure.

e) Piled foundation of ϕ 1.0m bored piles is used for foundation.

2) ON-OFF Ramp

5 ON-OFF ramps are planned to be constructed at Calle 86, Clle 78 and Calle 6 of north side and Calle45 of south side of Avenida Caracas, and at interchange between Calle 6 and Avenida Ciudad De Quito. Characteristics of plan are as follows;

a) Combined ON-OFF approach has 2-lane single carriageway of 3.5m with clearance of 0.5m at center and 1.0m at side with no median block but chatter bar is provided for accident case. (See Figure 14.2-28, Figure 14.2-29 and Figure 14.2-31)

b) Abutment structure is supported by cast in-situ pile with U shape retaining wall supported by the same pile to sustain and prevent settlement of fill. (See Figure 14.2-28, Figure 14.2-29 and Figure 14.2-31)

c) For ON-OFF ramp viaduct, three span continuous PC Hollow Slab is used as super structure.(See Figure 14.2-30)

d) As for sub structure, for single lane viaduct, T shape column is used to simplify structure design and for 2-lane single carriageway viaduct, tapered shape column is used from aesthetic point of view (See Figure 14.2-30 and Figure 14.2-32).

e) Piled foundation of ϕ 1.0m bored piles is used for foundation.

Each ON-OFF ramp plane view and section is as shown in Figure 14.2-28 ~ Figure 14.2-32, respectively.

3) Fly-over

9 fly-overs are planned to be constructed on Autopista Sur. Characteristics of plan are as follows:

a) Section of fly-over is the same as viaduct and height is minimum 7.0m from the existing road surface to be crossed. (See Figure 14.2-33).

b) Total length of each fly-over is planned as 360m with 5.0% of slope.

c) Due to soft ground, abutment is a provided 3.0m above existing road surface, to prevent from settlement, by filling. The abutment has an U shape retaining wall.

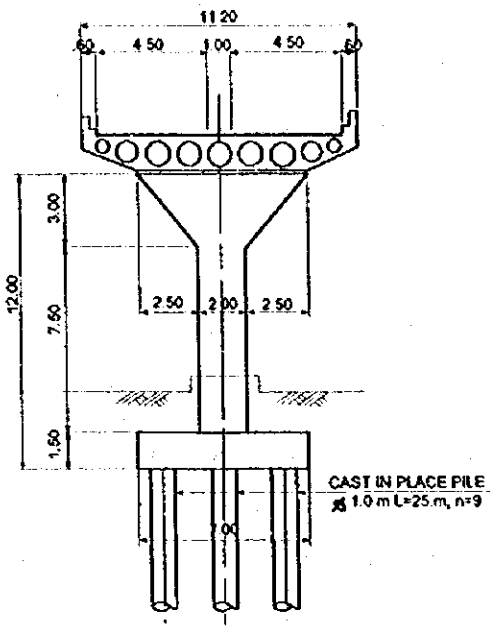
d) 30m-38span bridge is planned from economic point of view.

e) Due to limited clearance above the existing road surface, PC Simple Composite Girder is used for super structure.

f) Ordinary wall type column is employed for sub structure.

g) Piled foundation of ϕ 1.0m bored piles is used for foundation.

The detail plan of each structure is described in Chapter 15.4.



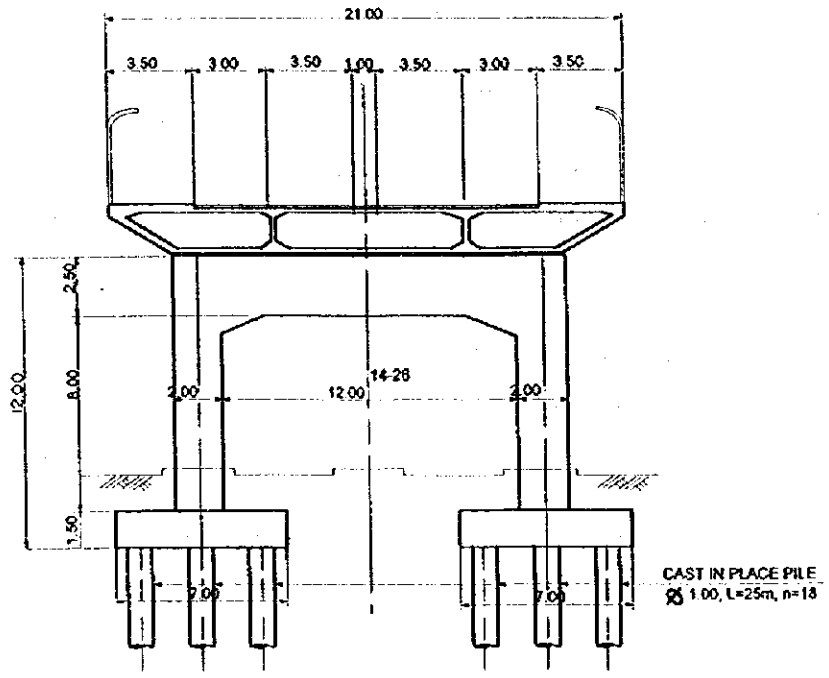


Figure 14.2-27 Typical Cross Section of Viaduct

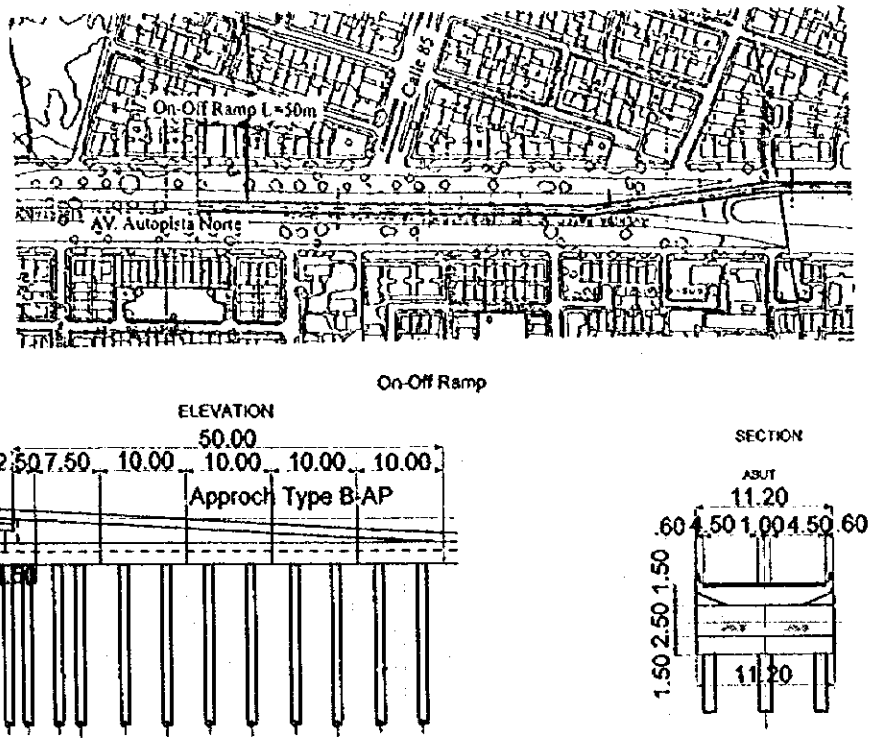


Figure 14.2-28 On-Off Ramp on Autopista Norte-Calle 86

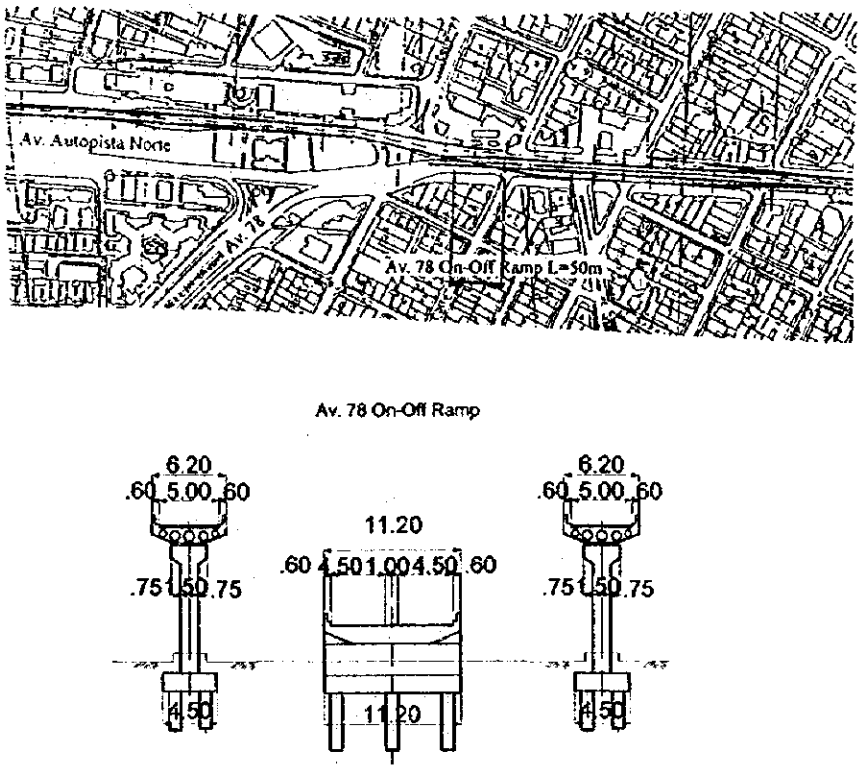
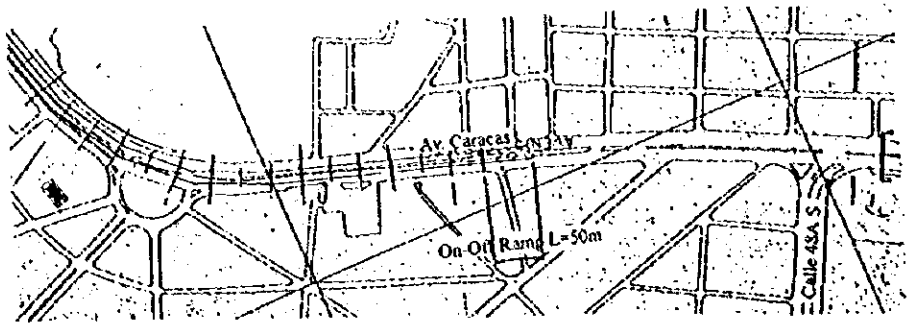


Figure 14.2-29 On-Off Ramp on Autopista Norte-Avenida 78



On-Off Ramp

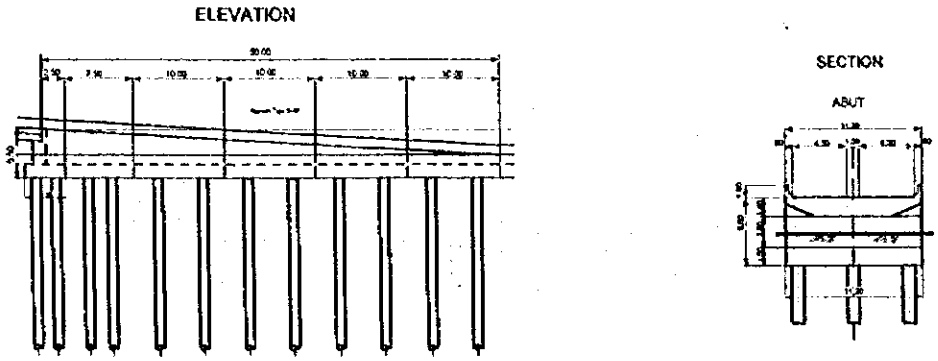
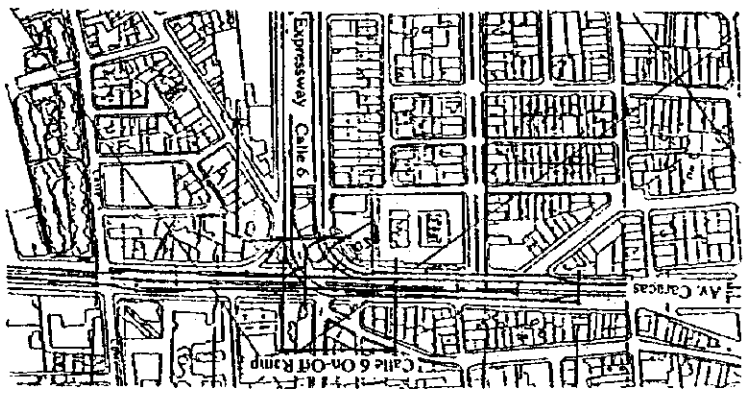


Figure 14.2-30 On-Off Ramp on Avenida Caracas-Calle 6



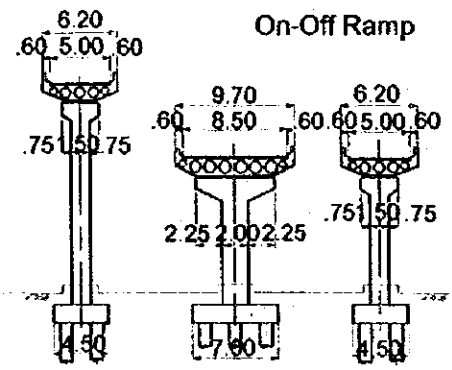


Figure 14.2-31 On-Off Ramp on Avnida Caracas-Calle 48 S

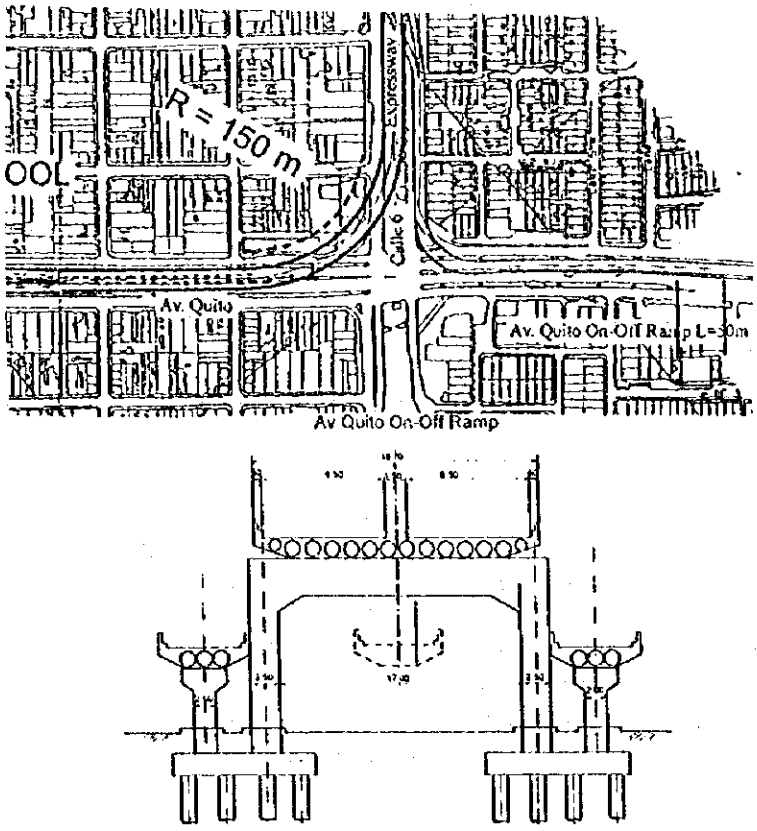


Figure 14.2-32 On-Off Ramp on Avnida Quito-Calle 6

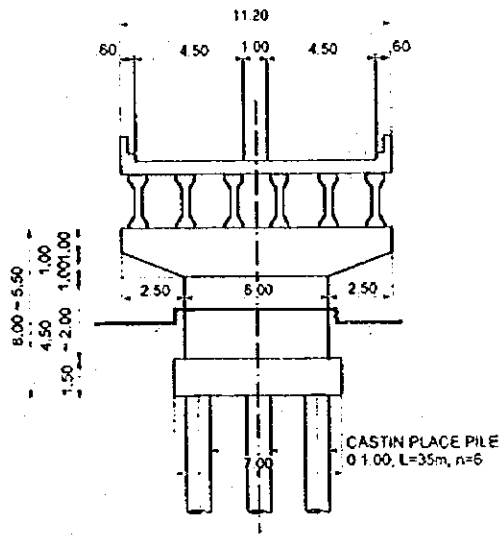


Figure 14.2-33 Typical Cross Section of Fly-over

14.2.5. INTERSECTION DESIGN AND CONTROL

1) Objective

The objective of intersection design and control is to improve at-grade intersection in order to achieve a smooth flow of large sized trunk buses.

2) Basic Policy

The basic policy for intersection design and control is described below:

a) The plan of intersection design and control is particularly important to make the maximum use of the existing road facilities,

b) The improvement of signalized intersection is proposed through introduction of widening of corner cut and bus priority signal light.

c) These improvements represent a low cost in comparison with plan of widening of road.

3) Intersection Layout

In 2005, eleven trunk busways will be completed and trunk and local buses will be operated on bus route network. The proposed bus routes will turn at major intersections along the Study roads. It is necessary to manage left and right turns of large buses at intersections. Ideally, left turns should be either made from separate lanes, or prohibited; right turns should be specially regulated. Since most of the proposed busways have two lanes per direction, separate lanes prepared for left turns can not be afforded to install on busway. In central commercial areas, planning of grade-separated intersections on the busway is difficult due to the narrow width of roads and difficulty of widening of roads. Therefore, the intersection layout in central commercial areas on the trunk busway will be considered "at grade intersections".

Figure 14.2-34 shows typical intersection layouts of trunk busway. The right and left turn lanes are planned at one lane without preparing both lanes for left turns, even though the proposed busways have two lanes per direction, and despite basic prohibition for left turn movements in Bogota. The left turn at a few intersections on Av. Caracas is approved now. In this Study, the left turn at only major intersections is planned for the following reasons:

a) It is very difficult to make trunk bus routes without left turn

b) If the left turn is prohibited, the bus routes must pass through on narrow collector roads by right turn movements.

c) Therefore, traffic conflict occurs on narrow collector roads and additional traffic management measures are needed.

4) Intersection Improvement

As mentioned before, larger size buses are operated in the trunk and feeder bus system, with overall length of 12 m for a standard bus and 16 to 18 m for an articulated bus, in contrast to 10 – 11 m for buses in the current system.

As for right turn of large buses at intersections, the relationship between inner body clearance of the rear wheels of bus and the intersection, geometric dimension on busway, becomes an important issue to be considered. A standard bus is more critical than the articulated bus which usually has the same turning radius as the standard bus although with a narrower turning path than standard buses.

Figure 14.2-35 shows turning geometry of a standard bus with an overall length of 12 m. In this case, the inside wheel path radius is approximately 9.46 m. A minor collision with other cars running on the adjacent lane is easy to occur. This is especially true when a trunk bus is out of service and moving to terminal on narrow roads where busway or bus lane does not continue. In such a case there is a high possibility that inner wheel touches curb stone on roads.

In this case, intersection improvement needs to take into account the inner body clearance of trunk bus.

5) Bus Priority Signal

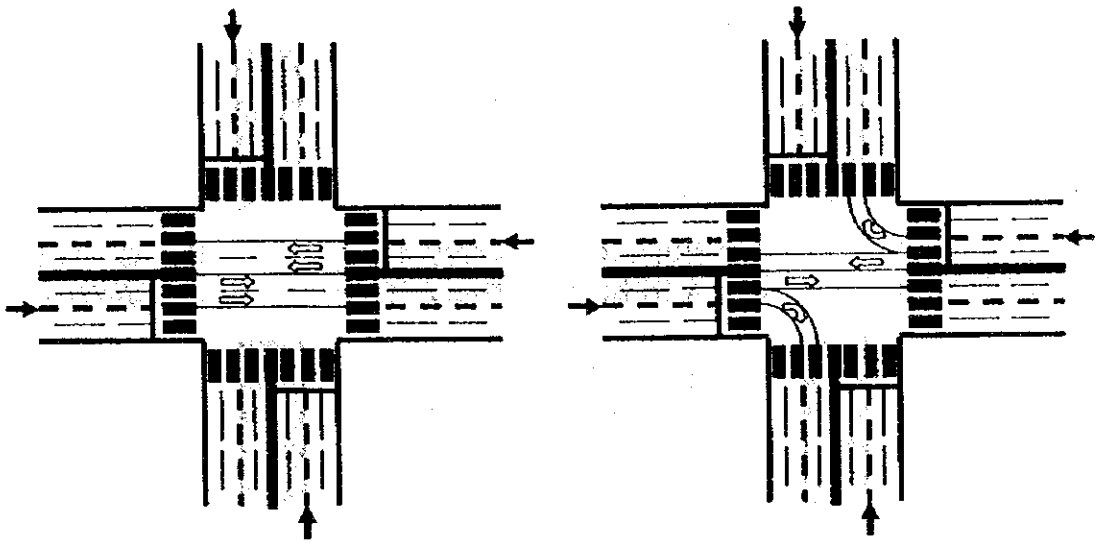
A high degree of traffic signal control is generally required in order to manage bus and other traffic, without excessive delay. In case of intersection with left and right turns for trunk bus, signal control can be used to aid bus movements in the following ways:

a) Selective detection of buses to extend a green phase or to recall a green phase

b) Signal time biasing to favor a stream with high proportion of trunk bus.

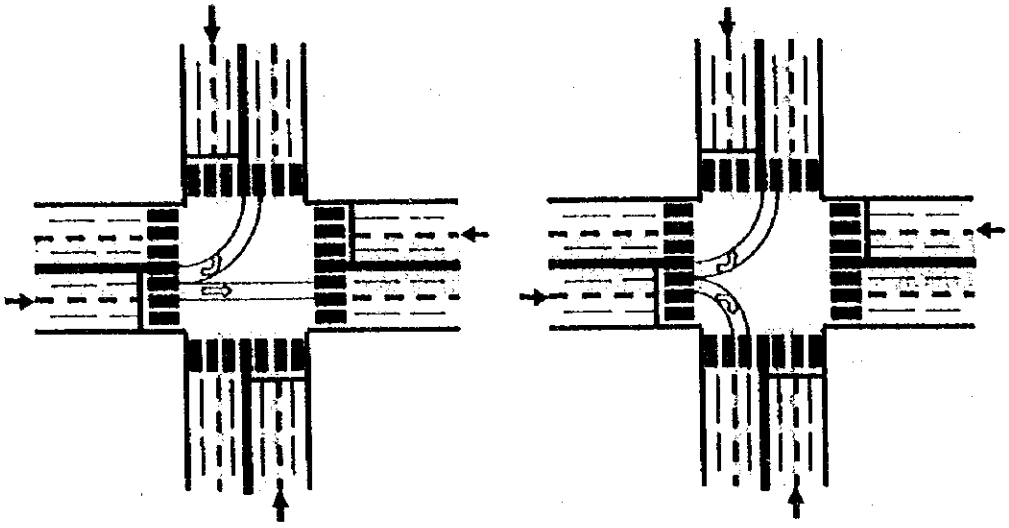
c) Signal time with bus priority phase.

Figure 14.2-36 shows typical pattern of signal phase at standard intersection.



a) Straight Movement b) Straight and Right Turn

Figure 14.2-34 (1) Intersection Layout of Trunk Busway



c) Straight and Left Turn　　d) Right and Left Turns

Figure 14.2-34 (2) Intersection Layout of Trunk Busway

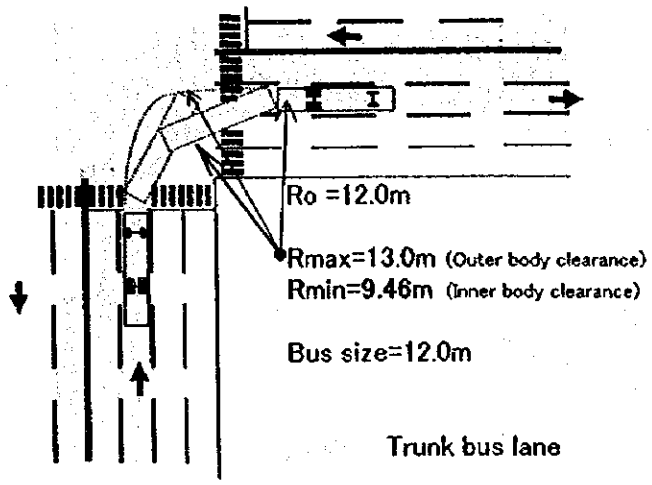


Figure 14.2-35 Turning Geometry of Standard Bus

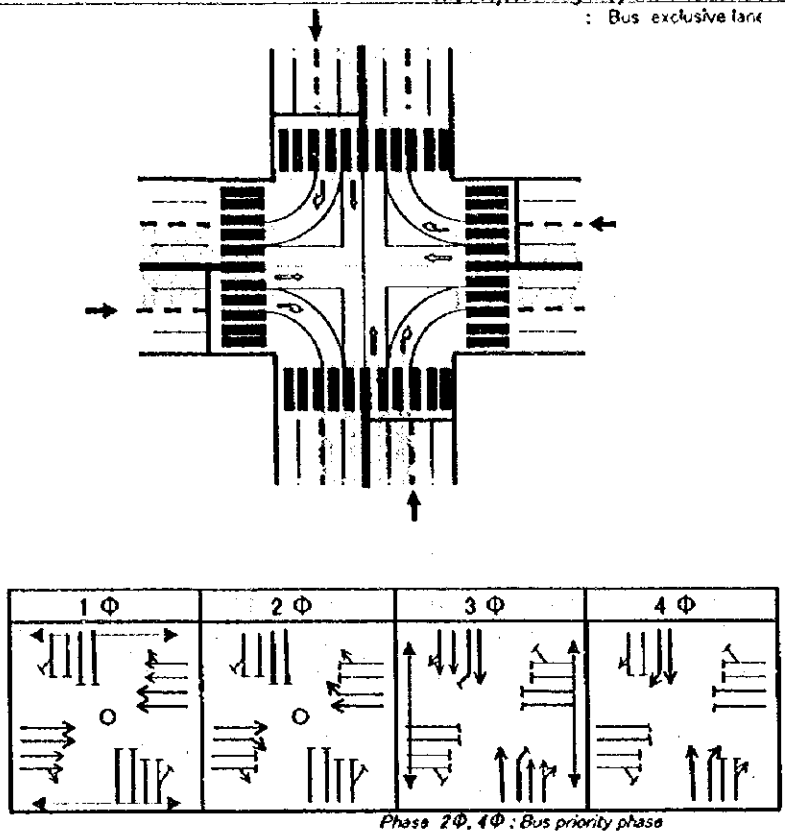


Figure 14.2-36 Typical Pattern of Signal Phase at Standard Intersection

14.2.6. ROAD SURFACE CHARACTERISTICS

Improvement and modification of road surface by introduction of Busway are as follows:

a) Color pavement in red (t=4.0~5.0cm). The pavement will be coated for bus lane in order to distinguish from other lanes

b) Exclusive lane for Express Bus and Trunk Bus is provided at center lane of road.

c) Modification of drainage system due to widening and/or reduction of side walk.

d) Vegetation to outside separate-trial and sidewalks.

According to b) of the above work, road pavement works classified below, are considered.

a) Pavement work due to widening and/or reduction of center separate-trial.

b) Pavement work due to provision of bus stop at outside separate-trial.

Following two road-sections are planned depending on soil condition of the place (See Figure 14.2-37).

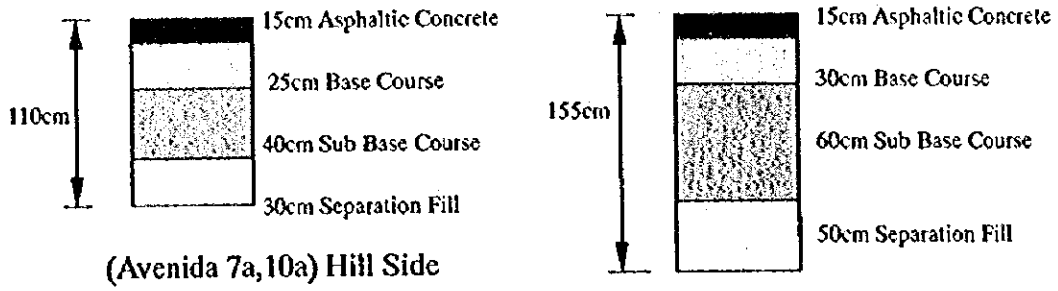


Figure 14.2-37 Composition of Pavement Thickness

14.3. BUS STOP

The locations and designs of bus stops have a major influence on operating efficiency and on passenger convenience. Planning of stops along a bus route involves four major aspects such as distance of bus stop, locations and design of bus stop.

(1) Distance of Bus Stops

Distance of bus stop has a large influence on commercial speed, with high performance being associated with relatively longer distance of bus stops. The distance of each bus stop for trunk bus is 500 to 600m on the average, taking into account walking distance. As for express bus, however, it is better to take longer distance where buses stop a distance of 1.0 to 1.5 km, equivalent to sum of 2 or 3 bus stops of trunk bus in order to provide high quality service (speed and comfort).

(2) Locations of Bus Stop

1) Locations of Bus Stop by Route

The plan for the locations of bus stop will be shown on trunk busways in the study routes, based on analysis of current situation. They are considered to be important points with most passengers. The locations of bus stops by route are shown in Figure 14.3-1 to Figure 14.3-5. In determining the locations for installation of bus stops, the following criteria are used taking the current locations of bus stops into consideration:

a) Average distances of bus stops are; trunk bus, 500-600 m, and express bus 1.0-1.5 respectively.

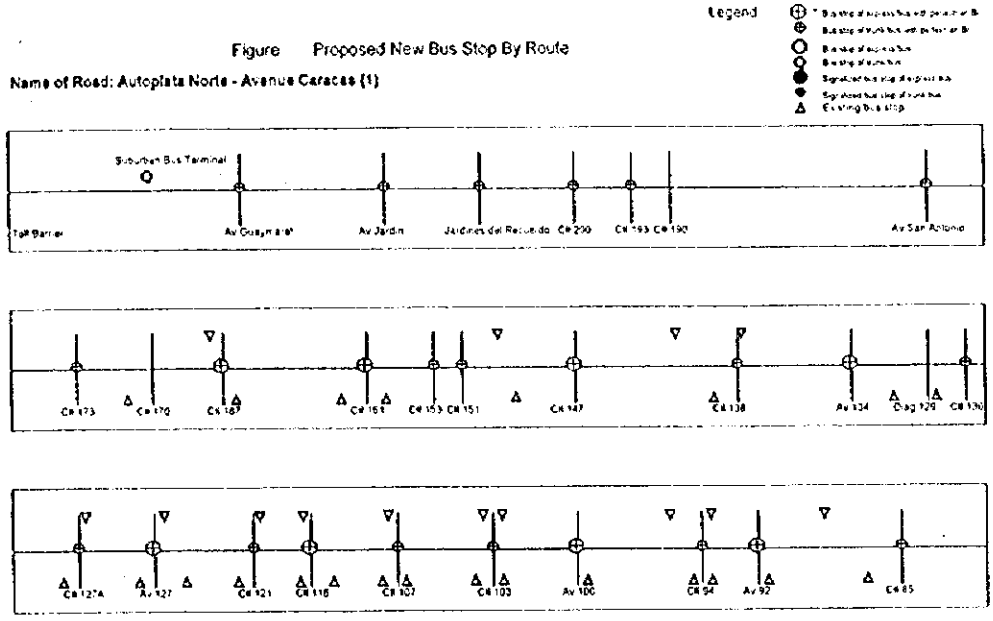
b) Transfer points of trunk busway routes.

c) Near cross points of arterial roads.

d) Heavy attraction and generation of passengers.

e) Major signalized intersection.

f) Inter modal points between the Metro and the Busway.



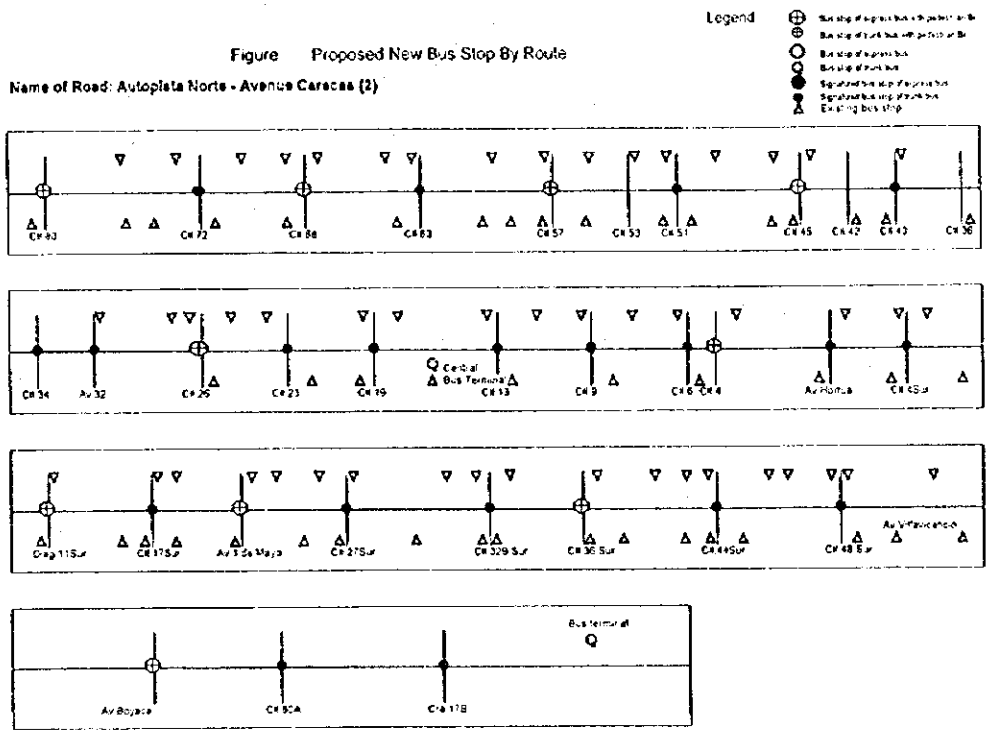
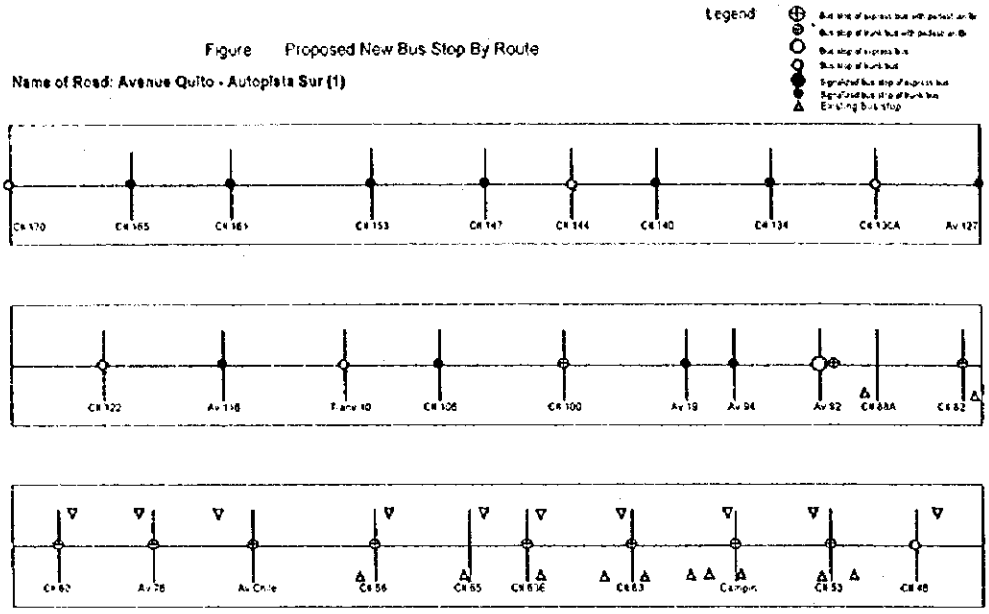


Figure 14.3-1 Proposed New Bus Stop by Route (1)



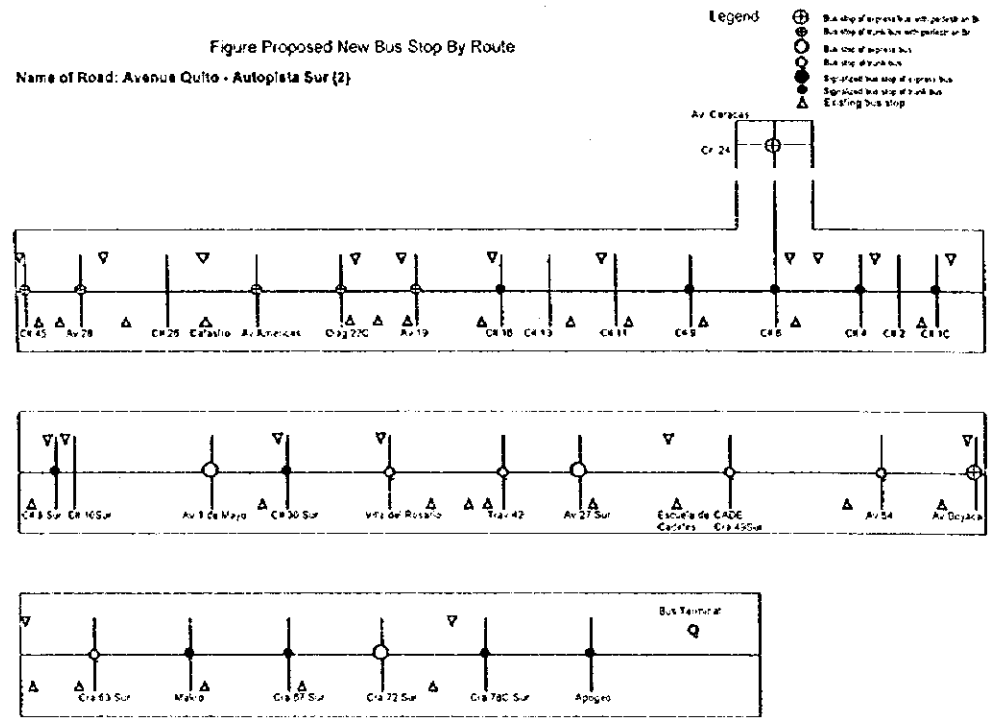
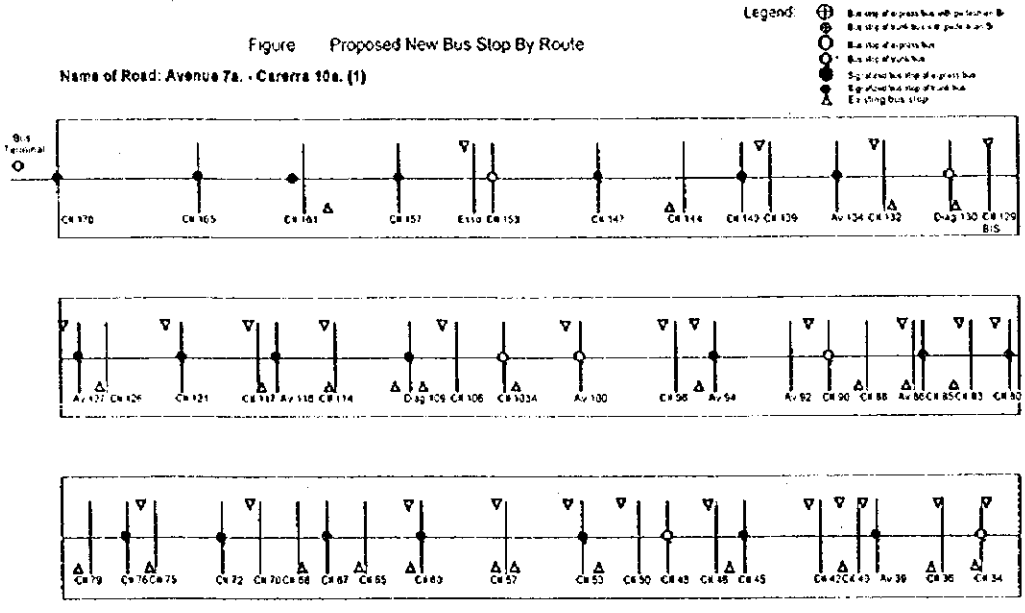


Figure 14.3-2 Proposed New Bus Stop by Route (2)



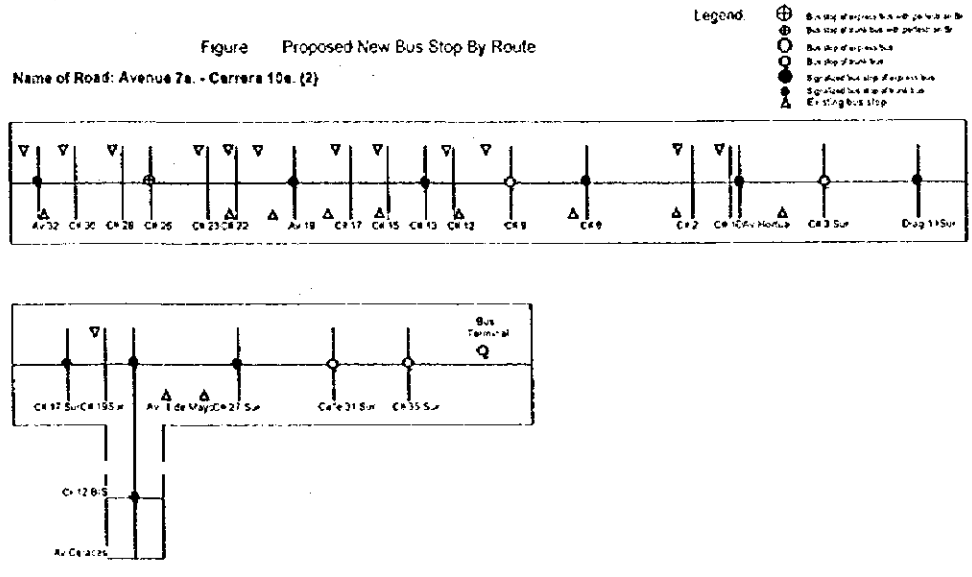
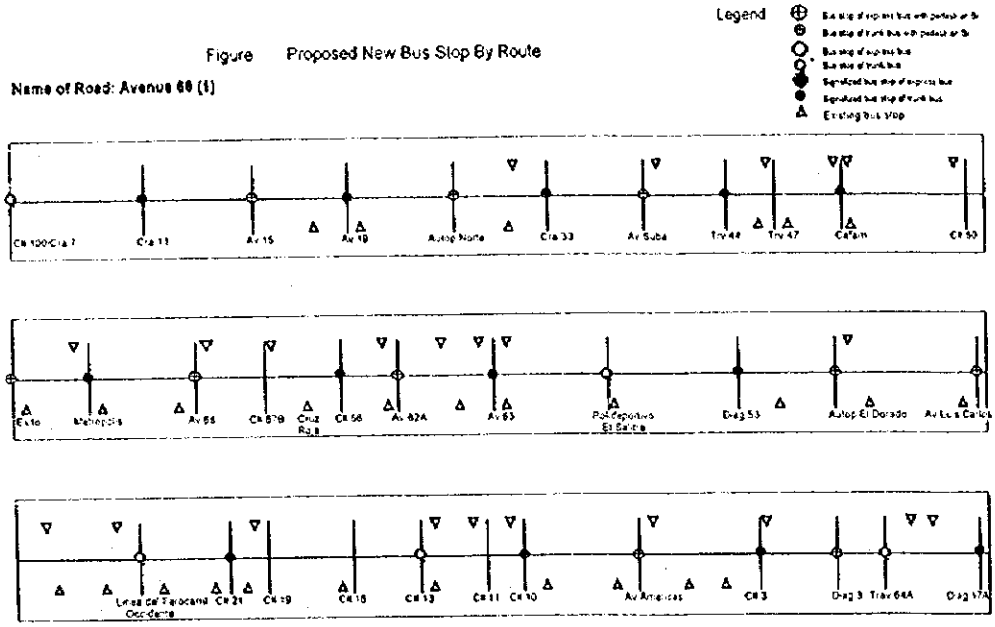


Figure 14.3-3 Proposed New Bus Stop by Route (3)



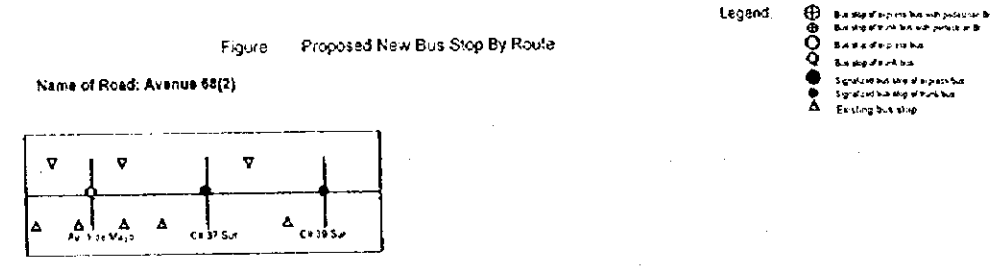
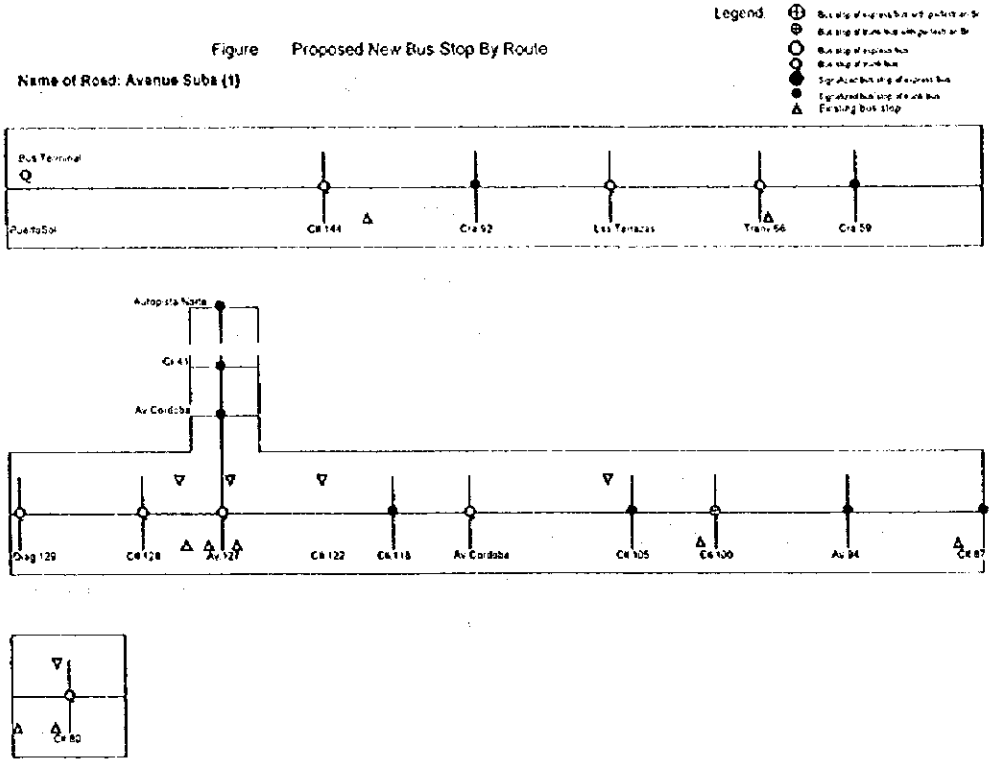
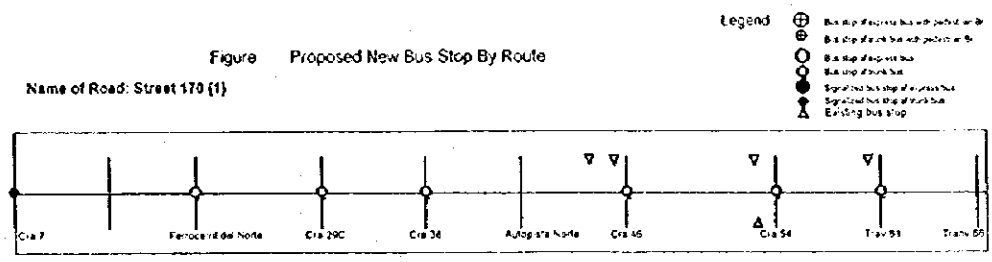


Figure 14.3-4 Proposed New Bus Stop by Route (4)





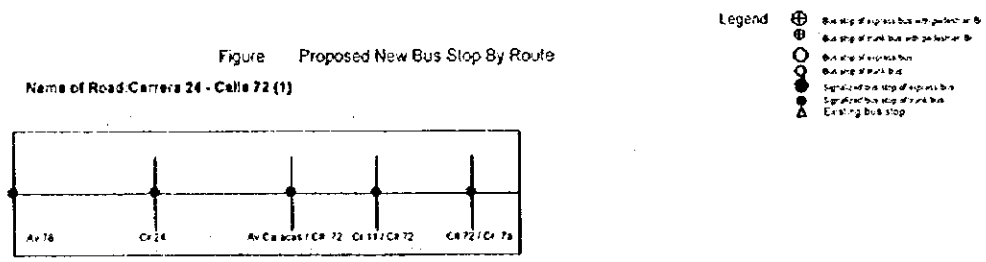


Figure 14.3-5 Proposed New Bus Stop by Route (5)

2) Locations of Transit Bus Stops

There are three types of locations for transit stops along streets:

1) Near-side (NS), at an intersection before crossing the street.
2) Far-side (FS), at intersection after crossing the street.
3) Mid-block (MB), away from intersections.

It is common in many cities to adopt one type of stop location (usually NS) and to use it throughout the city. In Bogota, however, three types of locations along the streets exist at present. On Av. Caracas, three types were observed.

Since several different factors influence the choice of location, variation among stop locations along a street, particularly NS and FS, can often bring considerable advantage in terms of higher bus speeds and passenger comfort.

Major factors influencing the choice of stop locations are:

1) Traffic signal coordination
2) Passenger access including transfers from other routes
3) Vehicular and pedestrian traffic conditions at intersections
4) Geometry of bus turning and stopping.

Actual locations of bus stops on the Study busway are under examination now taking into account passenger crossings (see Figure 14.3-6).

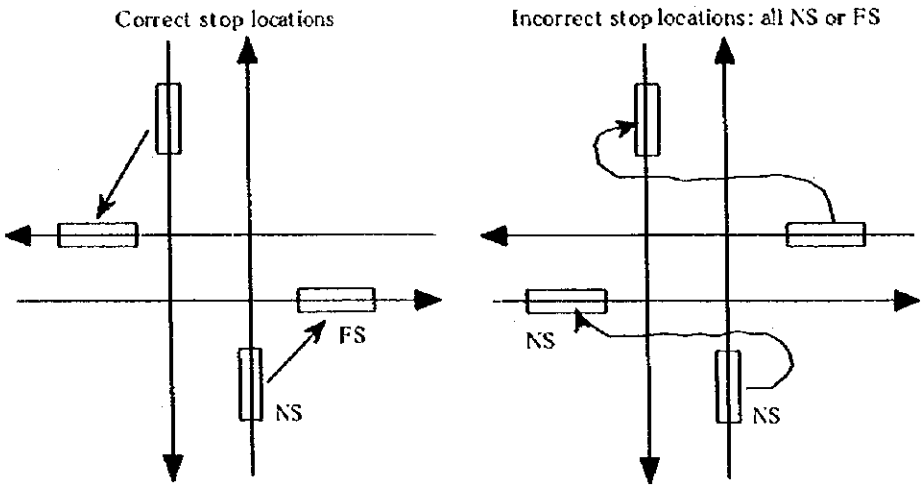


Figure 14.3-6 Impacts of Bus Stop Locations for Passenger Transfers

(3) Number of Bus Berths

The number of bus berths at each stop on the busway will typically vary between one to six, depending on the transfer demand. The capacity of a bus stop will be affected by its layout. The bus stop with higher volume transfer will need multiple off-line berths. The bus stop, which has medium volume passengers, will require on-line, single or double bus berths. On-line berth allows no special overtaking facility; the buses stop on the busway track. Off-line berth has a stop area, which is separated from the main running track; as a result buses can easily overtake one another at bus stops.

(4) Design of Bus Stop

1) Premises for Design of Bus Stop

The premises for design of bus stop are described below:

a) Based on conditions of road width and bus operation system, nine (9) types of bus stops are considered for trunk busway.

b) In case of the simplest type of bus stop, this is the bus stop in the curb lane along roadsides where the road width is not sufficient.

c) In order to provide space for bus bay along roadsides, the right-of–way will be widened by reducing the width of the median.

d) Bus stops of trunk bus and express bus on wide roads should be generally installed on central and outer median. Additionally, the locations of these bus stops will be constructed as near to the existing pedestrian bridges if possible, in order to reduce the cost of construction. The bus stops for express bus on Avenida Caracas will be located on viaduct.

e) Bus stops at signalized intersection will be located at entrance of intersection.

2) Plan of Bus Stop by Type

9 types of bus stop for the trunk busway are described as follows: (See Figure 14.3-7 to Figure 14.3-15):

a) Type of Bus Stops by Bus Bay on Road Sides

The simplest type of bus stop is where buses travel and stop in the curb lane. Although such stops are convenient for passengers and require the least maneuvering, they block a traffic lane for other traffic. Their applications should therefore be limited to reserved bus lanes, or locations where other traffic is light and buses usually make short stops.

Figure 14.3-7 and Figure 14.3-8 shows typical bus bay layout on Avenida 7a and Avenida Suba, respectively, where off-line berths with overtaking are provided in the curb lane. On both roads, it is necessary to widen the right-of-way on road for installation of off-line bays with overtaking.

b) Type of Bus Stops for Trunk Bus and Express Bus in the Center of Road

These bus stops are classified into four (4) types as follows:

i) Bus stops for trunk bus and express bus on median at section.

ii) Bus stops for trunk bus on median at signalized intersection.

iii) Bus stops for trunk bus on median at signalized intersection under fly-over.

iv) Bus stops for express bus on viaduct.

In case of bus stops for trunk bus and express bus on median at section, this type aims at separating bus traffic from other vehicle traffic. Figure 14.3-9 shows the plan of bus stops on median at section, which covers the roads of Autopista Norte and Autopista Sur. The pedestrian bridge must be installed for passengers.

Two types are proposed on Avenida. Caracas; one is bus stop on median busway at signalized intersection, and the other is for elevated bus stop where express buses operate on viaduct. Figure 14.3-10 and Figure 14.3-11 shows those bus stops on Avenida Caracas.

Bus stops for trunk bus on median at signalized intersection under fly-over is almost the same as type of i) except that the width of bus stop has been changed. This plan is shown in Figure 14.3-12, which covers the road of Autopista Sur.

c) Type of Bus Stops for Trunk Bus in the Center of Road

For the bus stops for trunk bus in center of road, two types are proposed. These types are the same as type of bus stops on roadsides except that bus priority lane of roadsides has been changed to center of the road, in order to separate from other buses. One is bus stop on Avenida Quito, which will be installed on median at piers of the proposed expressway. The locations of these bus stops will be constructed beside the existing pedestrian bridges. The use of existing pedestrian bridges will reduce the cost of construction. Other is for bus stops on Avenida 68 at signalized intersection. The standard design of these bus stops is shown in Figure 14.3-13 and Figure 14.3-14.

d) Type of Bus Stops for Trunk Bus of Double Tracks on Road Sides

Since 2-lanes of bus priority per direction on Avenida 10a will be operated based on passenger demand, two bus stops will be provided at signalized intersection. It is necessary to reduce the width of median in order to provide two lanes of bus stops. Figure 14.3-15 shows this bus stops on Avenida 10a.

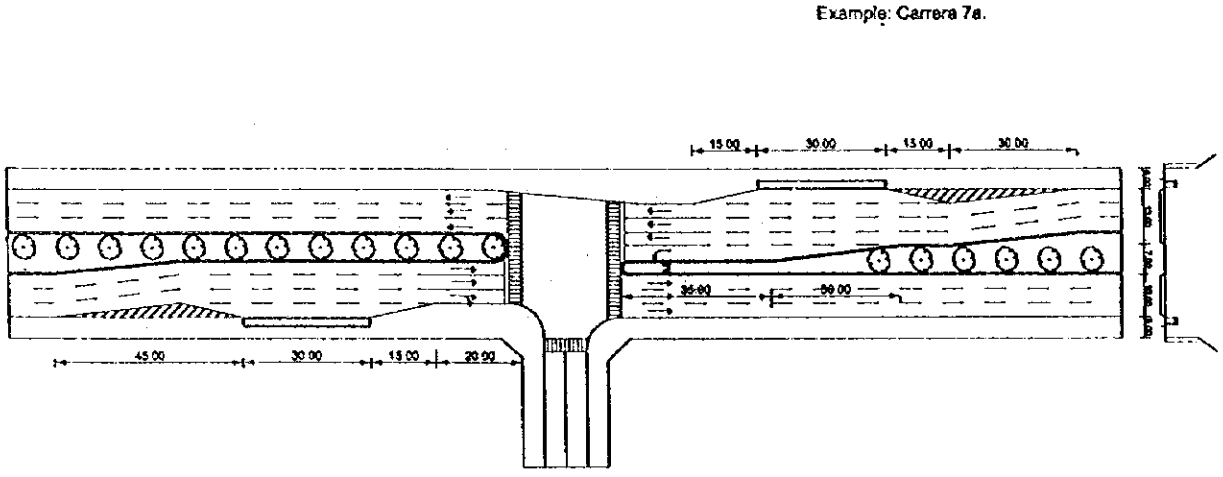


Figure 14.3-7 Type of Bus Stops by Bus Bay on Road Sides (Avenida 7a)

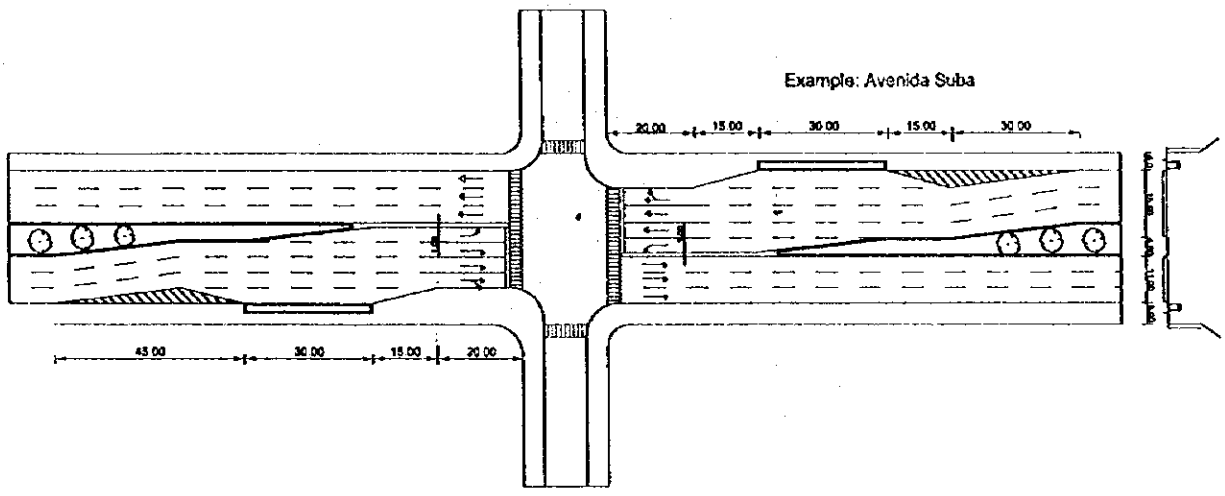


Figure 14.3-8 Type of Bus Stops by Bus Bay on Road Sides (Avenida Suba)

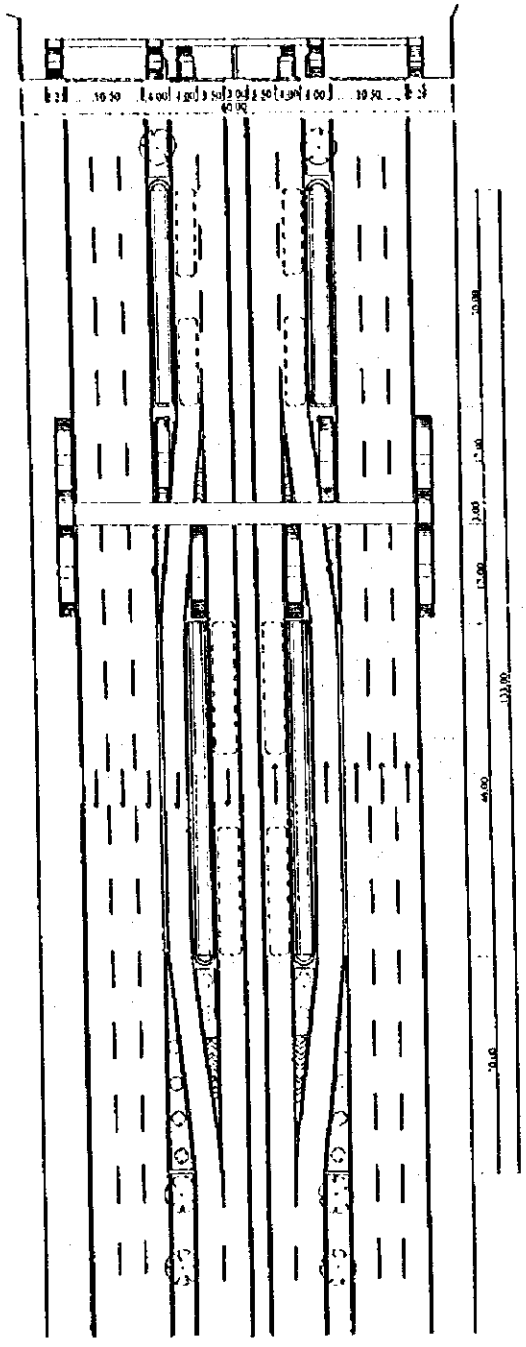


Figure 14.3-9 Type of Bus Stops for Trunk Bus and Express Bus in the Center of Road

(Bus stops for trunk bus and express bus on median at section) (Autopista Norte/Sur)

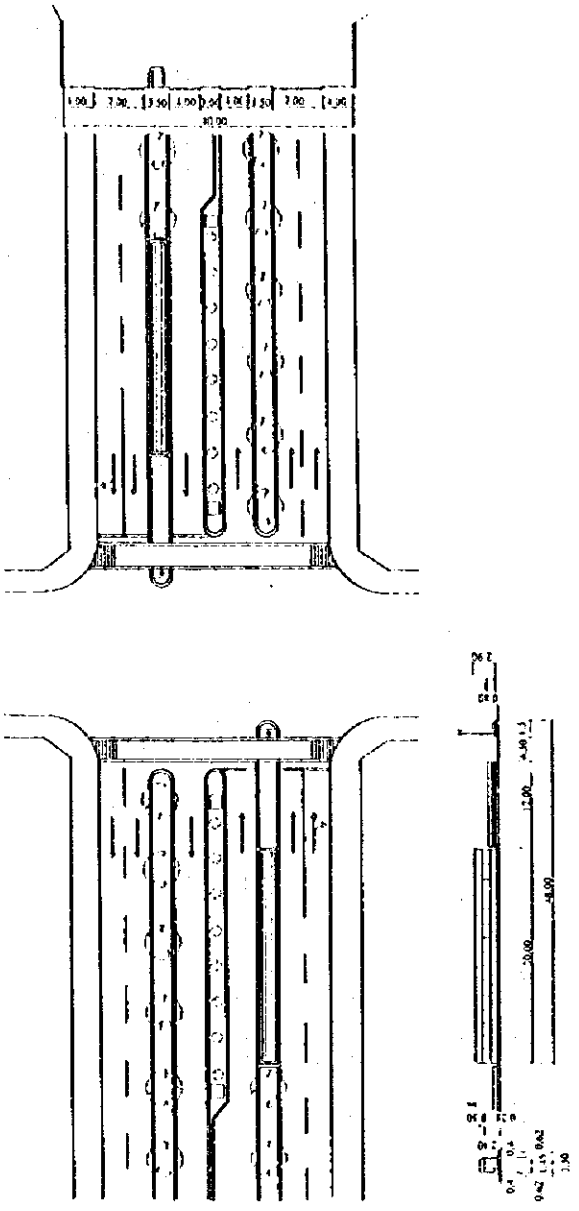


Figure 14.3-10 Type of Bus Stops for Trunk Bus and Express Bus in the Center of Road

(Bus stops for trunk bus on median at signalized intersection) (Avenida Caracas)

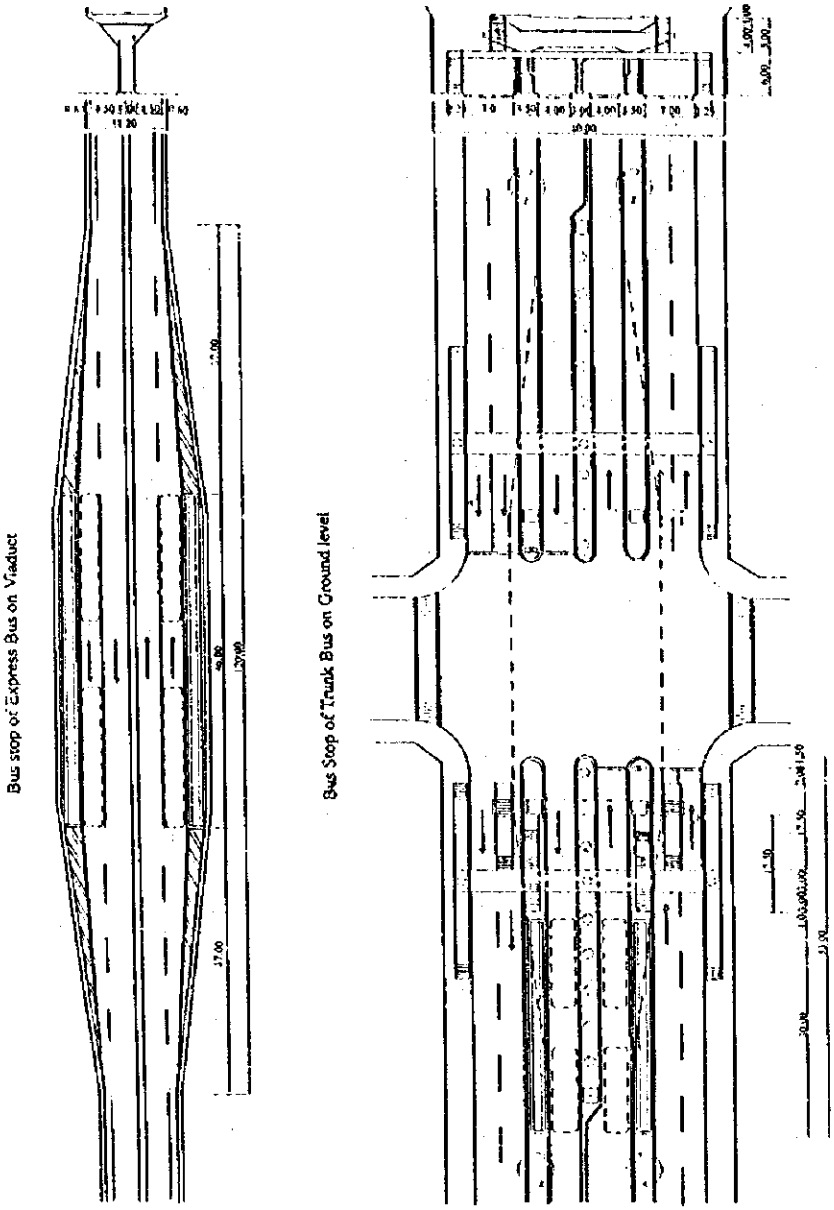


Figure 14.3-11 Type of Bus Stops for Trunk Bus and Express Bus in the Center of Road

(Bus stops for express bus on viaduct) (Avenida Caracas)

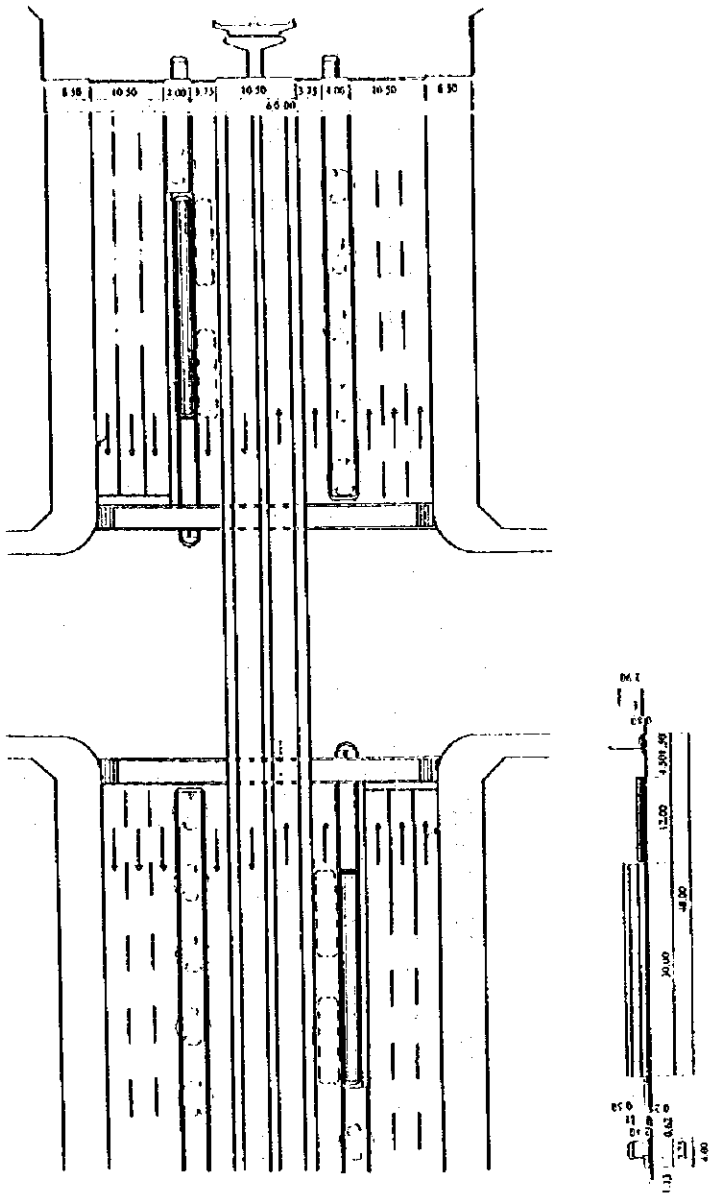


Figure 14.3-12 Type of Bus Stops for Trunk Bus and Express Bus in the Center of Road

(Bus stops for trunk bus on median at signalized intersection under fly-over) (Autopista Sur)

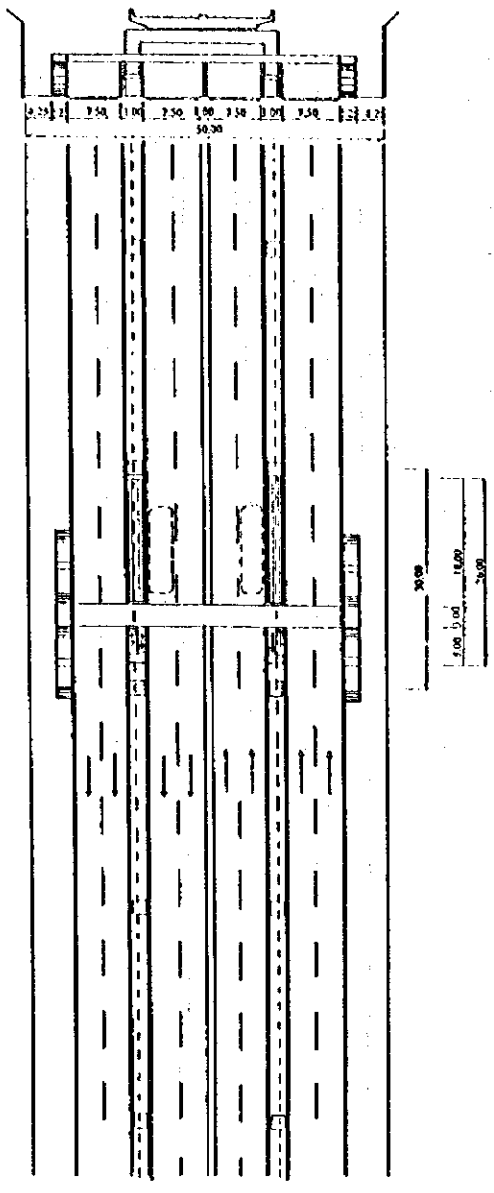


Figure 14.3-13 Type of Bus Stops for Trunk Bus in the Center of Road (Avenida Quito)

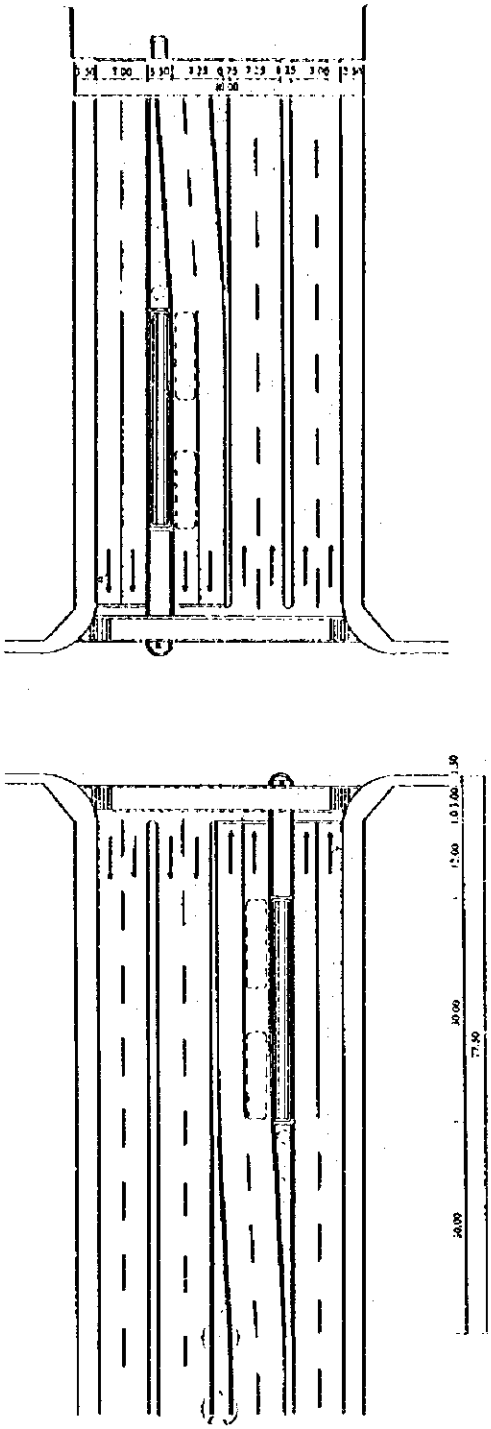


Figure 14.3-14 Type of Bus Stops for Trunk Bus in the Center of Road (Avenida 68)

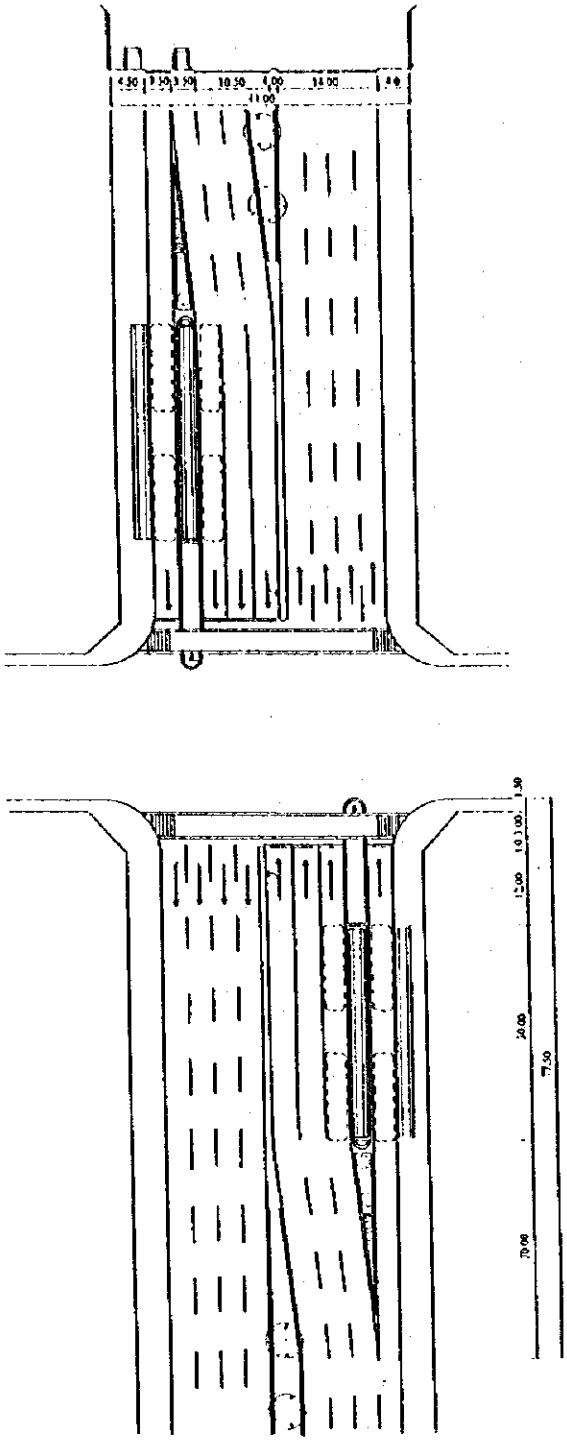


Figure 14.3-15 Type of Bus Stops for Trunk Bus of Double Tracks on Road Sides

(Avenida 10a)

14.4. BUS TERMINAL

Bus terminals are end stations of one or more bus routes; however, the term is often used for any large station with passenger facilities, such as waiting rooms, ticket offices, and so on. In the Study, a central urban bus terminal is defined as a bus terminal and large station at the central commercial area. A suburban bus terminal which is located near peripheral areas is built at terminal and transfer points among several bus routes or between local bus routes. A bus U-turn facility located in the end point of trunk busway will permit the trunk buses to make U-turns and park along a curb at terminal and transfer points between local buses.

The proposed trunk bus route network in 2005 will be composed of bus line network linked between one central urban bus terminal, several suburban bus terminals on the conceptual plan, and the peripheral U-turn facilities. The central urban bus terminal will be located in the central commercial area of Bogota and buses serving this terminal are dispersed throughout a bus route network.

14.4.1. CENTRAL URBAN BUS TERMINAL

(1) Major Functions of Bus Terminal

The function of the central bus terminal is as follows:

1) Main transport point in Bogota effectively connecting all routes of trunk buses.
2) Central point of bus route corridor
3) High flexibility of route choice for bus transfer

(2) Location of Bus Terminal

1) Selection for Location of Bus Terminal

The location of central urban bus terminal is proposed in the place near Sabana Station of the national railway where urban redevelopment projects were started recently. Five (5) alternative locations of the central terminal within that area are shown in Figure 14.4-1. The location will be selected considering the following viewpoints:

1) *Good accessibility*: that area has good accessibility from/ to major arterial roads.
2) *Near Metro station*: metro station will be very near in the future.
3) *Convenience for passengers*: Almost all the people living in the peripheral residential areas concentrate into the central area by means of commuter buses.
4) *High traffic demand*: many bus passengers who board, alight and transfer go into the central commercial area.
5) *Space available*: land space in that area should be sufficient for a central terminal.
6) *Redevelopment project*: the area has a project for urban redevelopment.

The essence of the city center in Bogota is that it is the most accessible point from within and without the city. This accessibility is important for many activities, and in particular for those central functions which need a wide labor market: head offices, central government offices and legal institutions, financial institutions, media firms, theatres, etc. It is necessary to support these central functions by a public transport system. In Bogota, the majority of commuters to /from the center depend almost exclusively on the bus for public transport.

There is an intimate and vital relationship between the well being of the city center and its public transport system. For this reason, since the proposed area also has redevelopment projects, the area will be a good place for the terminal.

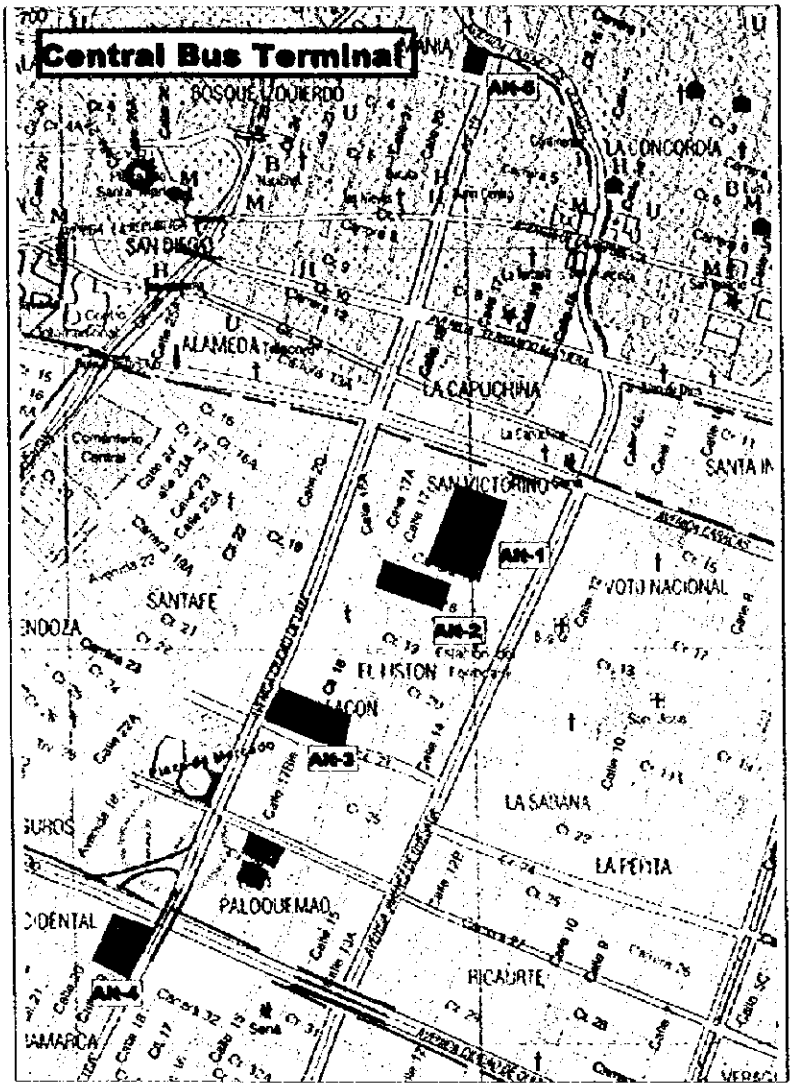


Figure 14.4-1 Alternative for Locations of Central Urban Bus Terminal

2) *Qualitative Assessment for Alternatives of Bus Terminal Location*

Table 14.4-1 shows the strong points and weak points of each alternative. From this evaluation, it is found that alternative that is to say Alternative 1, which ranks relatively well from the standpoint of all the assessment items, is the most desirable alternative. This location is the area defined by Ave. Jimenez, Ave. Lima, Ave. Caracas and Carrera 19. The assessment was carried out based on the following five items:

a) Capacity depends on bus demand.

b) Accessibility of major road.

c) Connection of Metro stations.

d) Permission of usage of preservation area.

e) Possibility of land acquisition.

Table 14.4-1 Qualitative Assessment for Alternatives of Bus Terminal Location

Items of Assessment	Alternatives of Central Urban Bus terminal				
	Alternative-1	Alt.-2	Alt.-3	Alt.-4	Alt.-5
	Av. Caracas-Cra.18- Av. Lima-Jimenez	Cra. 17-Cra.18- Av. Lima - Jimenez	Cra.21 - Cra. 23- Av. Lima - Calle 17	Av. Quito - Cra. 32 - Calle 20 - Av. Lima	Cra. 3- Av. Lime
1. Capacity depends on bus demand	◎	△	△	◎	×
2. Accessibility of major roads	◎	△	×	×	×
3. Connection of Metro stations	◎	◎	×	×	×
4. Allowance of preservation area	△	◎	◎	◎	◎
5. Possibility of land acquisition	◎	◎	◎	◎	◎

Legend: ◎ : Strong point
△ : Tolerable
× : Weak point

(3) Function of Bus Terminal

The function of the central bus terminal is summarized in Table 14.4-2. The public facility consists of bus berth, parking area, maintenance shops, service facility, office, information service, etc according to operation years. In 2005, the basic function will be available for bus operators and passengers. After 2005, the central urban terminal will fully function with additional public service facilities.

Table 14.4-2 Public Facility Plans for Central Urban Bus Terminal

Public Service Facility		2000 Y	2005 Y	After 2005 Y
Facilities for vehicles	Parking space			
	a. Trunk bus berth	-	O	O
	b. Express bus berth	-	O	O
	c. Local bus berth	-	O	O
	d. Lots for working person in term	-	O	O
	e. Lots for passenger car	-	O	O
	f. Bicycle lot	-	O	O
	g. Lots for emergency space	-	O	O
	Maintenance space			
	a. Fuel supply depot	-	-	O
	b. Repairing shop	-	-	O
Service facility	a. Shop	-	-	O
	b. Kiosk	-	O	O
	c. Restaurant	-	O	O
	d. Cafeteria	-	O	O
	e. Telephone box	-	O	O
	f. Rest room	-	O	O
	g. Ticket window	-	O	O
Office & others	a. Ticket office	-	O	O
Information service	b. Sign bored, etc.	-	O	O

(4) Development Needs of Bus Terminal Area

The development needs of central urban bus terminal area were determined according to the bus demand and the public space in relation to number of passengers. The required number of bus berths and land area are shown as below.

1) Number of Berths and Area Required

The number of bus berths for the central urban bus terminal in 2005 was estimated from the peak hour bus volume of 1,731 buses. They consist of 106 local buses, 1,361 trunk and 264 express buses, as discussed in Chapter 9. The number of required berths is determined by dispatching turnover. The calculation method is as follows:

a) Due to introduction of the bus ticket system, average loading or unloading time per passenger is assumed to be approximately 2 seconds.

b) Average passenger occupancy per one bus at bus terminal may be 30%.

c) Average loading or unloading time per one bus is assumed to be between 1.0 min and 2.0 min.

d) Based on the above, the dispatching turnover per hour by type of bus is expected to be 60 times for trunk bus, and 30 times for express bus.

Under such conditions, total number of berths for the central urban bus terminal in 2005 is 33 berths (local bus, 1 berth, trunk bus, 23 berths, and express bus, 9 berths). In terms of the total floor space of parking facilities required, this translates into 4,600 square meters (in case of including bus bay, total area is approximately 6,000 m^2).

2) Unit Area Required for Vehicle Related Facilities

Among terminal facilities, those related to vehicles are shown in Figure 14.4-2. The unit area by type of vehicles including access and exit space are shown below:

a) Local bus and trunk bus: 117.0 m^2

b) Express bus: 196.0 m^2

c) Car and taxi: 27.5 m^2

d) Bicycle: 2.1 m^2

Other area requirement such as staff parking space, temporary parking space in case of emergency, and repair shop are included in public service facilities described below.

Area Required for Public Service Facilities

The area required for public service facility will be determined according to the scale of bus berth as shown in Table 14.4-3. The areas required for public service facilities are shown as follows:

a) Lot for working people in terminal (unit area: 20 m^2): 60 m^2.

b) Lot for passenger cars (unit area: 20 m^2): 400 m^2.

c) Lot for taxis (unit area: 17.5 m^2): 175 m^2.

d) Lot for bicycles (unit area: 1.75 m^2): 53 m^2.

e) Lot for emergency parking (unit area: 45 m^2): 135 m^2.

f) Fuel supply depot (unit area: 105 m^2): 105 m^2.

g) Repairing shop (unit area: 18.0 m^2): 18 m^2.

h) Shop (unit area: 25.0 m^2): 75 m^2.

i) Kiosks (unit area: 7.5 m^2): 38 m^2.

j) Restaurants (unit area: 100.0 m^2): 200 m^2.

k) Cafeteria (unit area: 96.0 m^2): 192 m^2.

l) Telephone boxes (unit area: 0.6 m^2): 12 m^2.

m) Rest rooms (unit area: 7.0 m^2): 168 m^2.

n) Ticket windows (unit area: 6.0 m^2): 18 m^2.

o) Ticket office (unit area: 200 m^2): 200 m^2.

Especially, it is considered essential to construct the green zone within the lot available while paying attention to zoning and environmental conservation. The reserved area for improvement of environmental conditions must be considered when it will be developed along the arterial roads, which is prohibited by the regulation of DAPD. This regulation must be considered only for the suburban bus terminal. Such typical examples are listed below:

a) Green zone to offer rest area at the entrance of the terminal.

b) Maximum 10m wide buffer zone of green around the terminal.

c) Green island, etc.

Such green area including open space for the central urban bus terminal is equivalent to about 28% of the proposed total area of bus terminal. As a result of this estimate, the green area was envisioned with approximately 11,000 square meters.

Based on the above mentioned, the total floor space of public facilities required is assumed to be approximately 13,000 squares meters.

Table 14.4-3 Area Required for Public Service Facilities

Public services facilities	Unit area		Scale of bus berth							
	WxD (m)	Unit area (m^2)	No.	-10	No.	11-20	No.	21-40	No.	41-80
a. Lot for working person in terminal.	2.5x8.0	20.00	2	40	2	40	3	60	10	200
b. Lot for passenger cars	2.5x8.0	20.00	2	40	10	200	20	400	50	1,000
c. Lot for taxis	2.5x7.0	17.50	2	35	2	35	10	175	15	263
d. lot for bicycles	0.7x2.5	1.75	10	18	10	18	30	53	50	88
e. Lot for emergency parking.	3.0x15.0	45.00	-	-	1	45	3	135	5	225
f. Fuel supply depot.	7.0x15.0	105.00	-	-	-	-	1	105	1	105
g. Repairing shop.	3.0x6.0	18.00	-	-	-	-	1	18	1	18
h. Shops.	5.0x5.0	25.00	-	-	-	-	3	75	5	125
i. Kiosks.	2.5x3.0	7.50	1	8	1	8	5	38	5	38
j. Restaurants.	10.0x10.0	100.00	-	-	-	-	2	200	2	200
k. Cafeteria.	12.0x8.0	96.00	1	96	1	96	2	192	3	288
l. Telephone boxes	0.6x1.0	0.60	2	1	10	6	20	12	30	18
m. Rest rooms.	-	7.00	6	42	12	84	24	168	30	210
n. Ticket windows.	2.0x3.0	6.00	-	-	1	6	3	18	5	30
o. Ticket office	-	200.0	-	-	-	-	1	200	1	200
p. Green area & island.	-	40% of total area	1	5,200	1	6,800	1	8,000	1	9,600
Total				5,479				9,848		12,607

Note: Unit area is based on Japanese Design Manual for Service area.

3) *Area Required for Footway and Vehicle Way*

In addition, the area required for others such as the space of footway and the vehicle way are necessary. These areas were established; and the area of footway is equivalent to 24% (about 9,700 m^2) of the proposed total area of bus terminal, and the area of vehicle way is equivalent to 31% (about 12,500 m^2).

4) *Area Required for Approach Roads*

The areas required for the approach roads to the bus terminal are; the area of vehicle way, 14,000 m^2, the area of footway, 1,500 m^2, the area of green area, 5,200 m^2 respectively. This area is in addition to the total floor area of central urban bus terminal.

5) *Total Area for Central Urban Bus Terminal*

From the above, the total floor area including 2nd floor for the central urban bus terminal is estimated at approximately 4.0 hectares.