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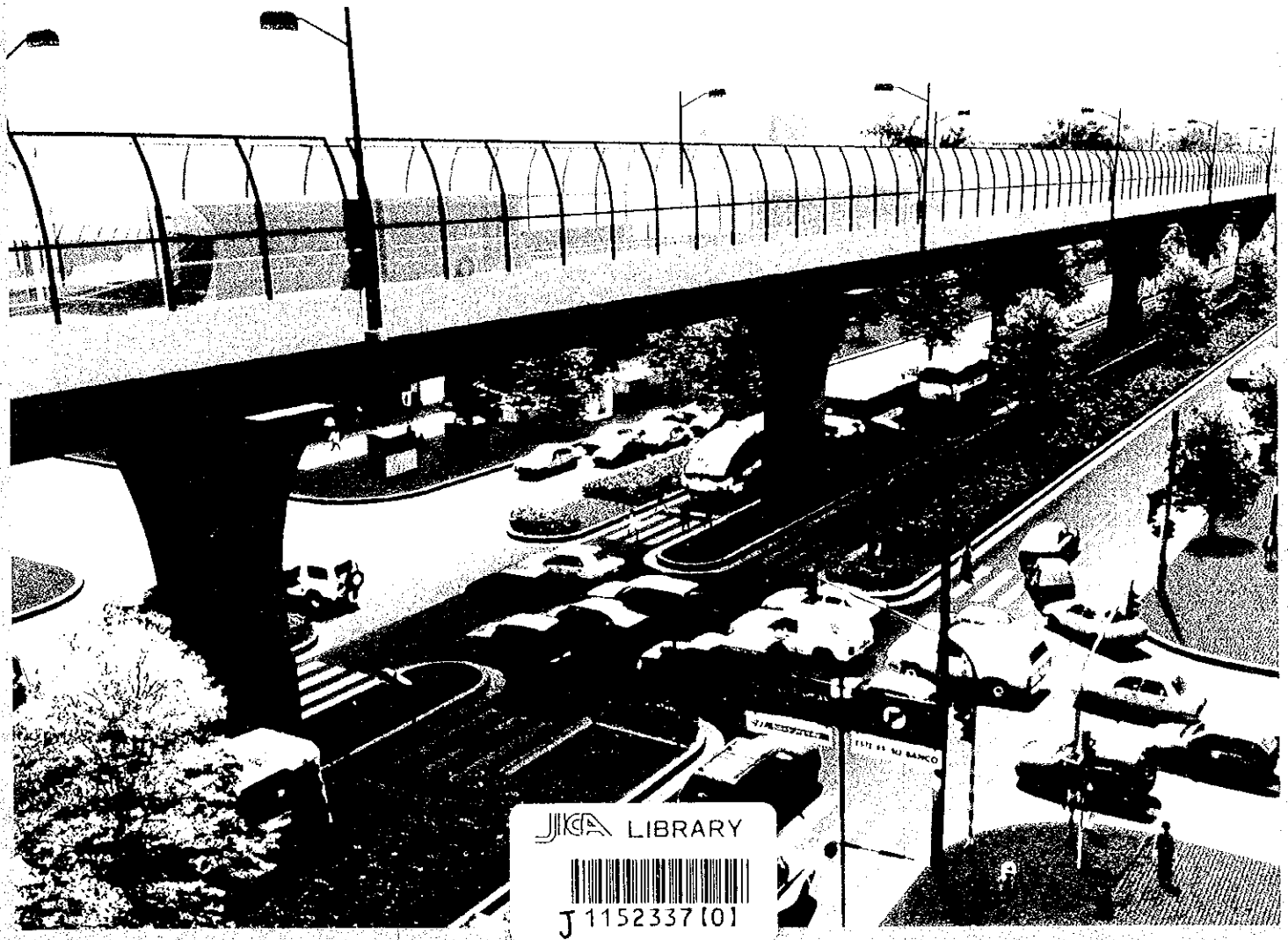
Japan International Cooperation Agency (JICA)
Santa Fe de Bogota
The Republic of Colombia

No. 51

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

Final Report (Summary)



June 1999

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

Japan International Cooperation Agency (JICA)
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Exchange Rates: November 1998

US$ 1.00 = Peso$ 1,580

US$ 1.00 = ¥116

Preface

In response to a request from the Government of the Republic of Colombia, the Government of Japan decided to conduct the Feasibility Study on the Project of Highway and Bus-Lane of Santa Fe de Bogota in the Republic of Colombia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Koichi Tsuzuki of Chodai Co., Ltd., to Colombia, three times between April 1998 and March 1999. In addition, JICA set up an advisory committee headed by Koichi Yamagata, Professor of Ibaraki University between April 1998 and March 1999, which examined the study from specialist and technical points of view.

The Team held discussions with the officials concerned of the Government of Colombia, and conducted a field survey at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Colombia for their close cooperation extended to the team.

June 1999

Kimio Fujita

President
Japan International Cooperation Agency

Letter of Transmittal

June, 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency

Dear Sir.

It is a great honor for me to submit herewith the final reports of the Feasibility Study on the Project of Highway and Bus-Lane of Santa Fe de Bogota in the Republic of Colombia.

A study team, which consists of Chodai Co., LTD. and Yachiyo Engineering Co., LTD. and headed by myself, conducted field surveys, data analysis and planning works of feasibility study in Bogota based on the terms of references instructed by the Japan International Cooperation Agency (JICA) from April, 1998 to March, 1999.

The study team held thorough discussions and investigations with officials concerned of the Government of Colombia, accordingly, various traffic surveys, present condition analysis, preliminary engineering design, conduct of environmental impact assessment, preparation of implementation program and project evaluation. The results were collected in the final reports, main and summary reports.

On behalf of the team I wish to express my heartfelt appreciation to the Officials concerned of the Government of Colombia for their warm friendship and cooperation extended to us during our stay in Colombia.

Also, I wish to express my sincere appreciation to JICA, the Ministry of Foreign Affairs, the Ministry of Construction, the Ministry of Transport, the Embassy of Japan in Colombia and other concerned government authorities for their valuable advice and cooperation given to us in the course of the site surveys and preparation of the final reports.

Yours Faithfully,

Koichi Tsuzuki

Team Leader

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

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

Study Duration: April 1998 – March 1999
Requesting Organization: Santa Fe de Bogota

Outline of the Study

1. STUDY BACKGROUND

Santa Fe de Bogota, the capital city of Colombia, is recently experiencing urban transport problems caused by insufficient transport facilities against to the rapid growth of population and car ownership. Accordingly, heavy traffic congestion is prevailing in many places of the city and has been disturbing sound and functional activity, efficiency and fair environmental condition of the capital city. Bus transport is the only mass public transport in Bogota. The current public bus transport system has many problems and issues. Every bus route concentrates into the central area in Bogota from the residential areas near fringe of Bogota. It causes traffic congestion in the central urban area. Weak administration tolerates illegal bus route operations and security problems on board.

Recognizing the importance of the improvement of traffic and transport system in the city, the Government of Colombia requested the Government of Japan to conduct a Feasibility Study following the Master Plan (The Urban Transport Master Plan Study in Santa Fe de Bogota) carried out under the technical cooperation of the Government of Japan from 1995 to 1996.

In response to the request made by the Government of Colombia, the Government of Japan conducted the Feasibility Study on the Project of " Highway and Bus-lane of Santa Fe de Bogota" in the Republic of Colombia (hereinafter referred to as " the Study"). The Study was carried out in 1998 and 1999.

2. STUDY OBJECTIVES

The objectives of the Study are as follows;

1) to formulate a Feasibility Study for Inner Ring Expressway (IRE) as an urban expressway project recommended as high priority project in the Master Plan,
2) to formulate a Feasibility Study for Trunk and Express Busway Projects recommended as high priority projects in the Master Plan and
3) to transfer relevant technology and know how to the Colombian counterpart personnel in the course of the Study.

The year 2005 is defined as the target year for the Feasibility Study.

3. STUDY AREA

The Study Area for the Feasibility Study covers the city of Santa Fe de Bogota. The planning route for Inner Ring Expressway is inside the central urban area, while the Study trunk busways are on six (6) existing major roads.

4. STUDY DURATION

The Study was commenced in April, 1998 and completed in March, 1999.

5. OUTLINE OF THE STUDY

Major activities of the Study are as follows:

1) Data collection and its analysis
2) Natural conditions and road inventory survey such as topographic, environment and soil investigation surveys
3) Identification of planning policies and strategies
4) Future traffic and transport demand forecast
5) Preliminary engineering design of Inner Ring Expressway
6) Preliminary engineering design of Six (6) Trunk Busways
7) Conduct of environmental impact assessment
8) Preparation of implementation program
9) Economic and financial evaluation
10) Project evaluation

6. RECOMMENDATION

6.1. INNER RING EXPRESSWAY PROJECT

The outline of proposed plan for Inner Ring Expressway is shown in Table 1. This plan is feasible from the technical, environmental and economical points of view.

Table 1 Proposed Plan for Inner Ring Expressway

Items	Plan	Remarks
Class	Motorway and Toll Road	
Design Speed	60 -80 km/h	
Design Traffic Volume in 2015	35,000 - 45,000 pcu/hour/d	
Number of Lanes /dualway	4 lanes / dualway	
Road Type	Elevated road	
Bridge Type	PC Concert Bridge	
Road Length	16.6 km	
Project Cost	US$ 638.587 thousands	
Economic Internal Rate of Return (EIRR)	14.70%	
Financial Internal Rate of Return (FIRR)	5.60%	

6.2. TRUNK BUSWAY PROJECT

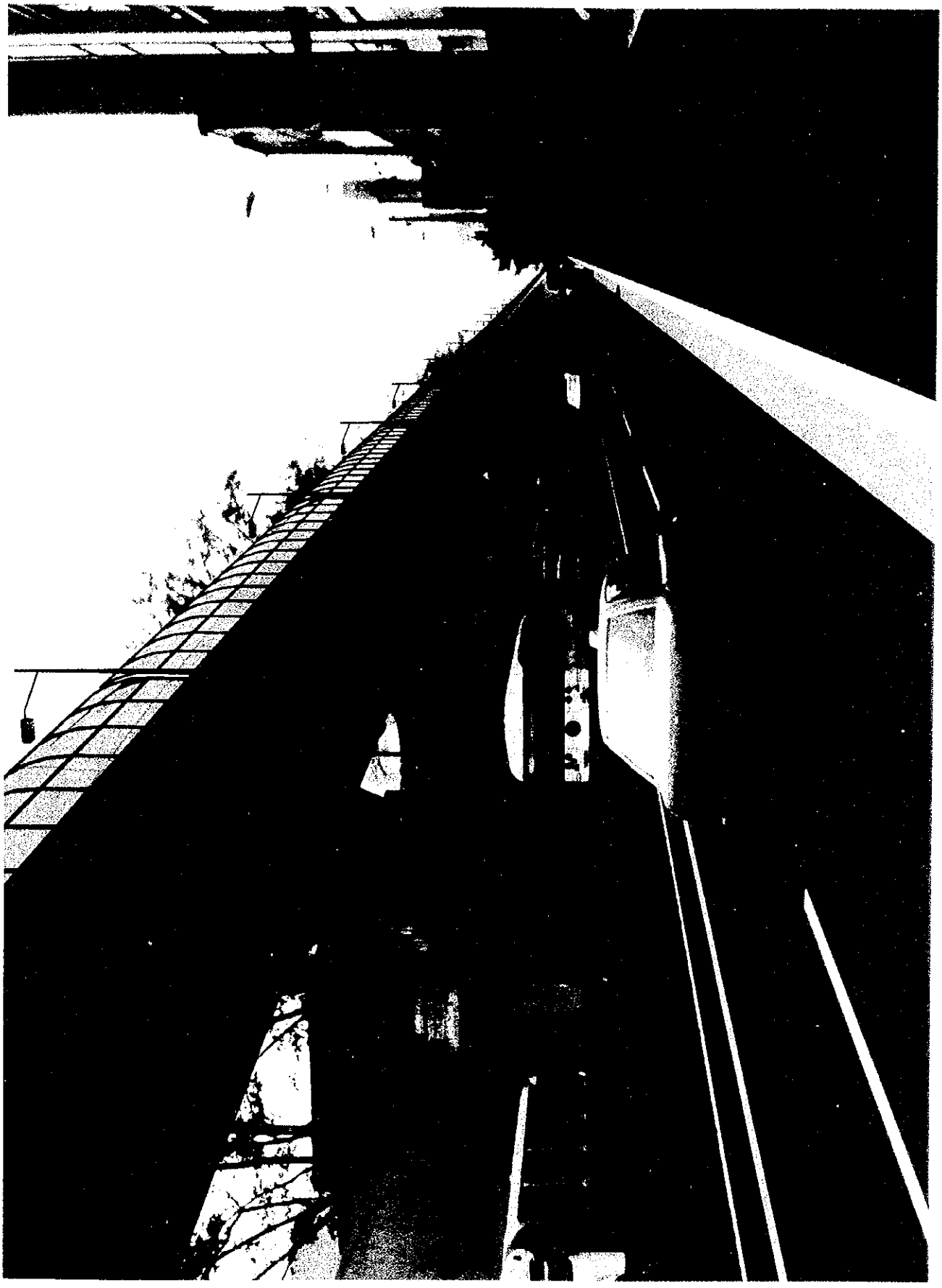
Three types of operation system namely, operation on an express busway, a trunk busway and a bus priority lane are proposed in the trunk busway system. The busways are planed on existing eight (8) major roads. Those busway projects are also feasible from the technical, environmental and economic points of view. Table 2 shows bus passenger demand, operation system, construction cost by busway in the year 2005.

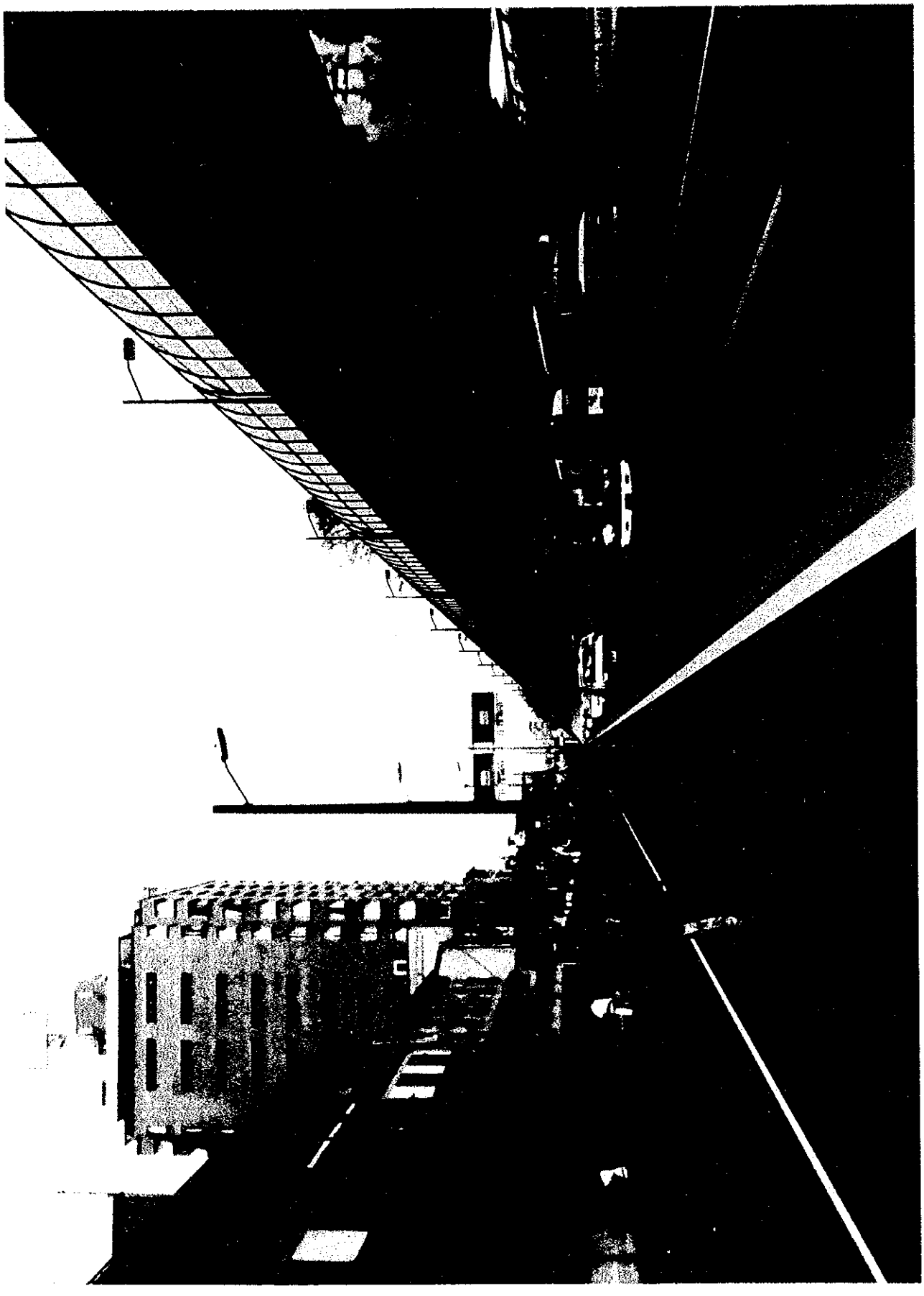
Table 2 Proposed Plan for Trunk busway System

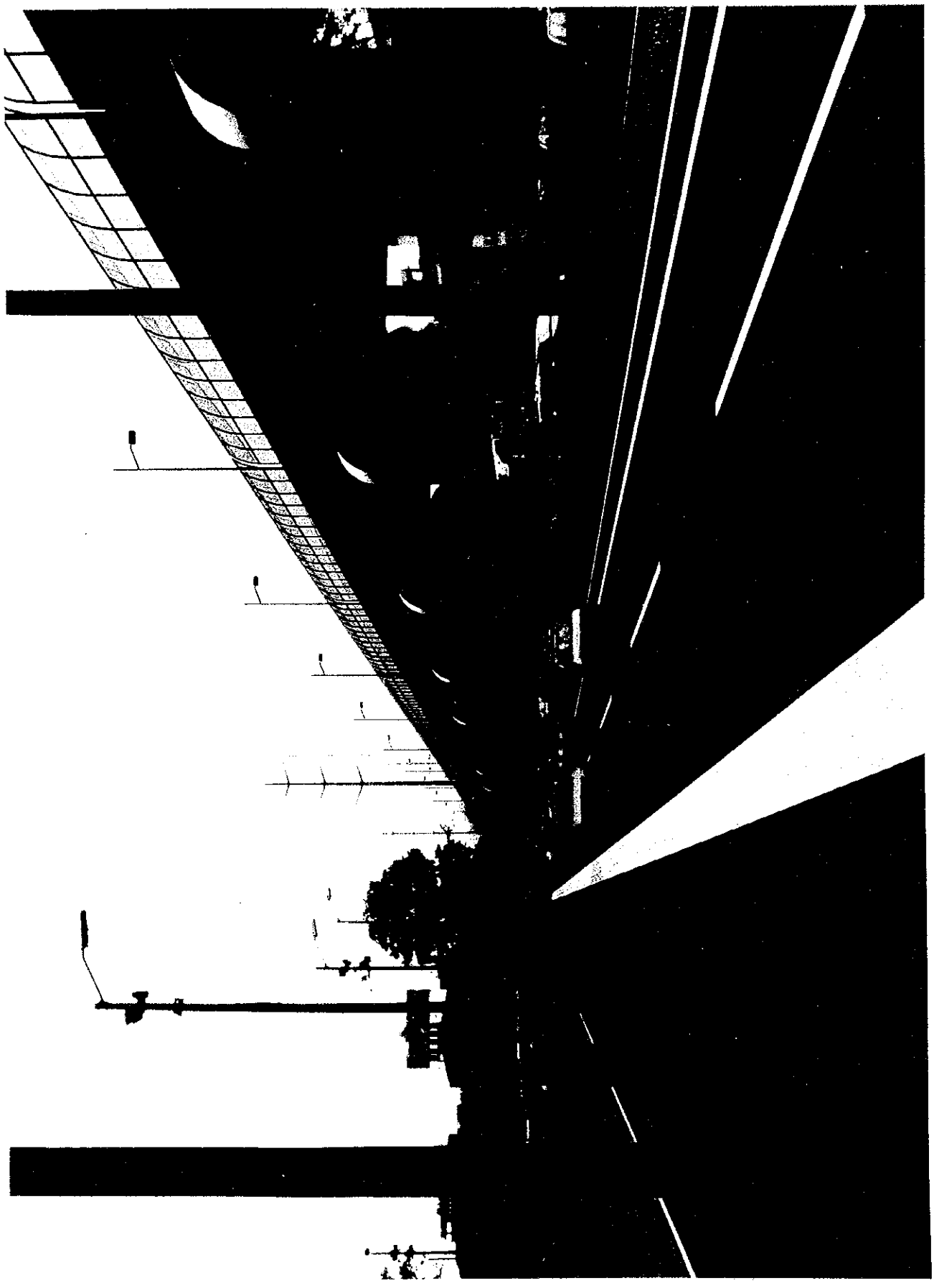
Road Name/Items	Cra. 7a	Av. Quito	Autopista Sur	Av. Caracas	Autopista Norte	Av. Suba	Cra. 68	Calle 170
Width of Existing Road (m)	40	60	60	40	100	30	40	40
Passenger Demand (thousands/hour)	21	23	29	34	23	20	17	12
Operation System	Priority Lan	Trunk Busway	Express Busway Trunk Busway	Express Busway Trunk Busway	Express Busway Trunk Busway	Priority Lane	Trunk Busway	Trunk Busway
Capacity of Proposed Bus fleet (passengers)	100	100	200 100	200 100	200 100	100	100	100
Number of Bus Lanes /dualway	2	2	2 lanes for Exp 2 for Trunk	2 lanes for Exp 2 for Trunk	2 lanes for Exp 2 for Trunk	2	2	2
Structure Type of Busway	At-grade	At-grade	At-grade	Viaduct Structur At-grade	At-grade	At-grade	At-grade	At-grade
Type of Intersection	At-grade	At-grade	Grade-separate At-grade	Grade-separate At-grade	At-grade	At-grade	At-grade	At-grade
Road Length (km)	25	16	11	17	17	15	17	5
Project Cost (million US$)	19	28	144	337	54	9	8	3

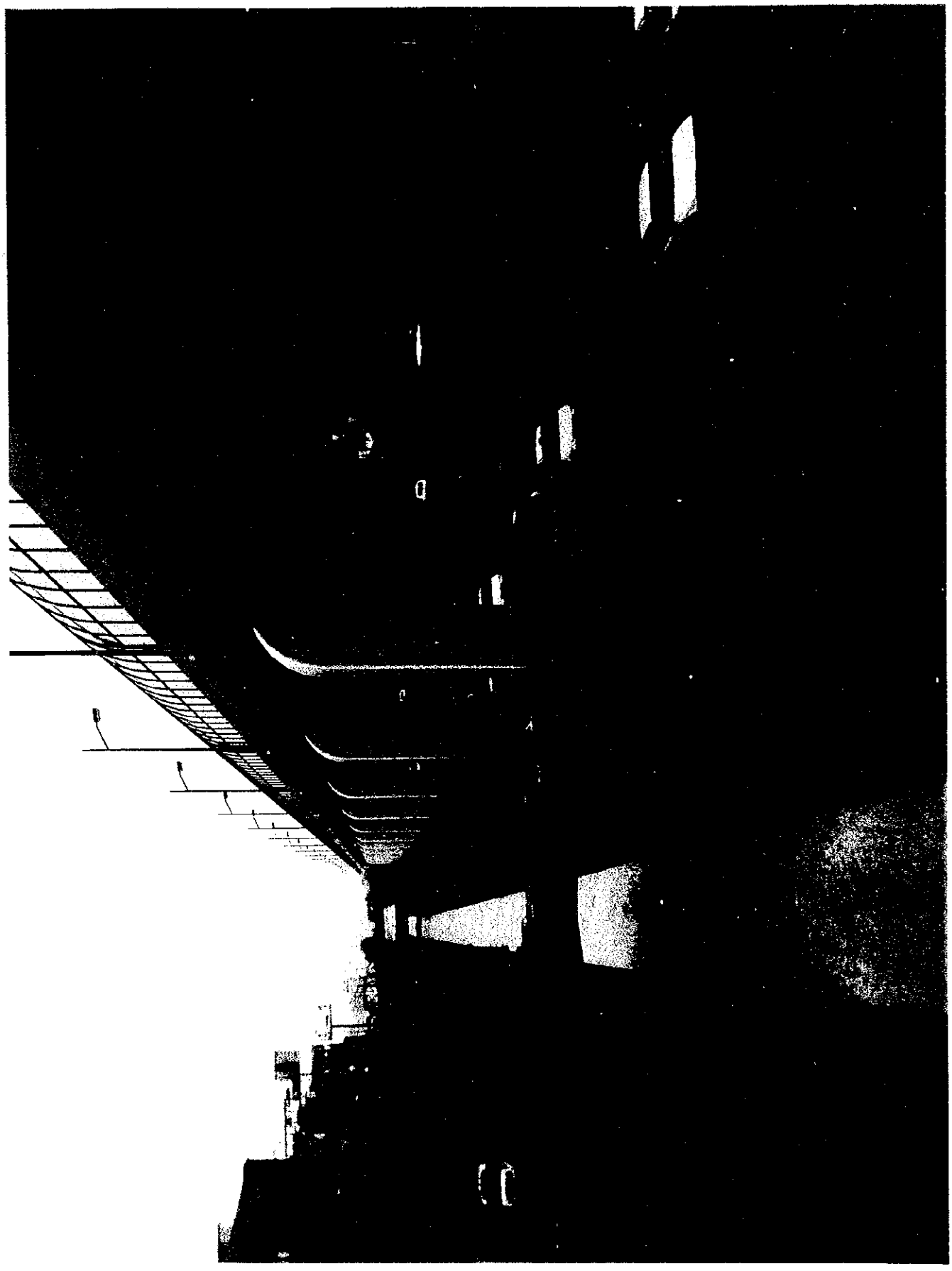
6.3. ENVIRONMENT ASSESSMENT

Damages or effects on social and natural environment caused by construction of the projects are not significant because the existing road area will be utilized for Inner Ring Expressway project and trunk busway projects. In order to decrease the noise impact caused by proposed viaduct structure of express busway and Inner Ring Expressway, noise barriers are provided on those structures. Air pollution in the Study area is lower for the "With" project case than "Without", due to the improvement of traffic flows. Therefore, the Study projects contribute the improvement of environment in the Study area.









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1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Total population of Colombia in 1997 is estimated at approximately 35 million of which 5.5 million live in Santa Fe de Bogota. Population in Bogota has been increasing year by year due to comparatively high birth rate and inflow of people from other areas. Accordingly, heavy traffic congestion is prevailing in many places of the city and has been disturbing sound and functional activity, efficiency and fair environmental condition of the Capital City.

Recognizing the importance of the improvement of traffic and transport system in the city, the Government of Colombia requested the Government of Japan to conduct a Feasibility Study following the Master Plan (The Urban Transport Master Plan Study in Santa Fe de Bogota) carried out under the technical cooperation of the Government of Japan from 1995 to 1996.

In response to the request made by the Government of Colombia, the Government of Japan conducted the Feasibility Study on the Project of " Highway and Bus-lane of Santa Fe de Bogota" in the Republic of Colombia (hereinafter referred to as " the Study"). The Study was carried out in 1998 and 1999.

1.2. STUDY OBJECTIVES

Objectives of the Study are as follows;

1) to formulate a Feasibility Study for Inner Ring Expressway (IRE) as an urban expressway project recommended as high priority project in the Master Plan,
2) to formulate a Feasibility Study for Trunk and Express Busway Projects recommended as high priority projects in the Master Plan and
3) to transfer relevant technology and know how to the Colombian counterpart personnel in the course of the Study.

1.3. TARGET YEAR FOR THE STUDY

The year 2005 is defined as the target year for the Feasibility Study.

1.4. STUDY PROJECTS

The Study projects covered under the Study are one (1) Inner Ring Expressway route and six (6) Trunk Busway routes, including Carrera 7a to Carrera 10 (21.4 km), Avenida Quito to Autopista del Sur (28.8 km), Calle 100 to Carrera 68 (15.9 km), Calle 170 (4.9km), Avenida Suba (5.4 km), and Avenida Caracas to Autopista del Norte (37.5 km) as shown in Figure 1-1.

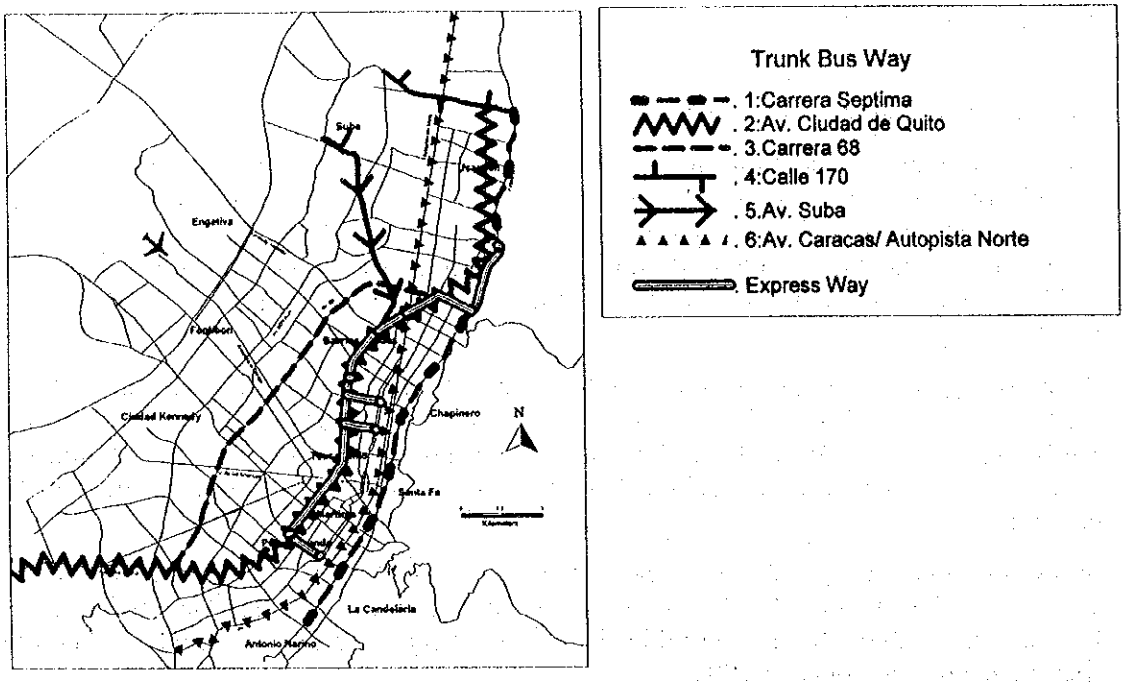


Figure 1-1 Location of the Routes

1.5. SCOPE OF THE STUDY

Major activities of the Study are classified into four (4) stages, and the schedule of the stages is as shown in Figure 1-2; Study Flow Chart.

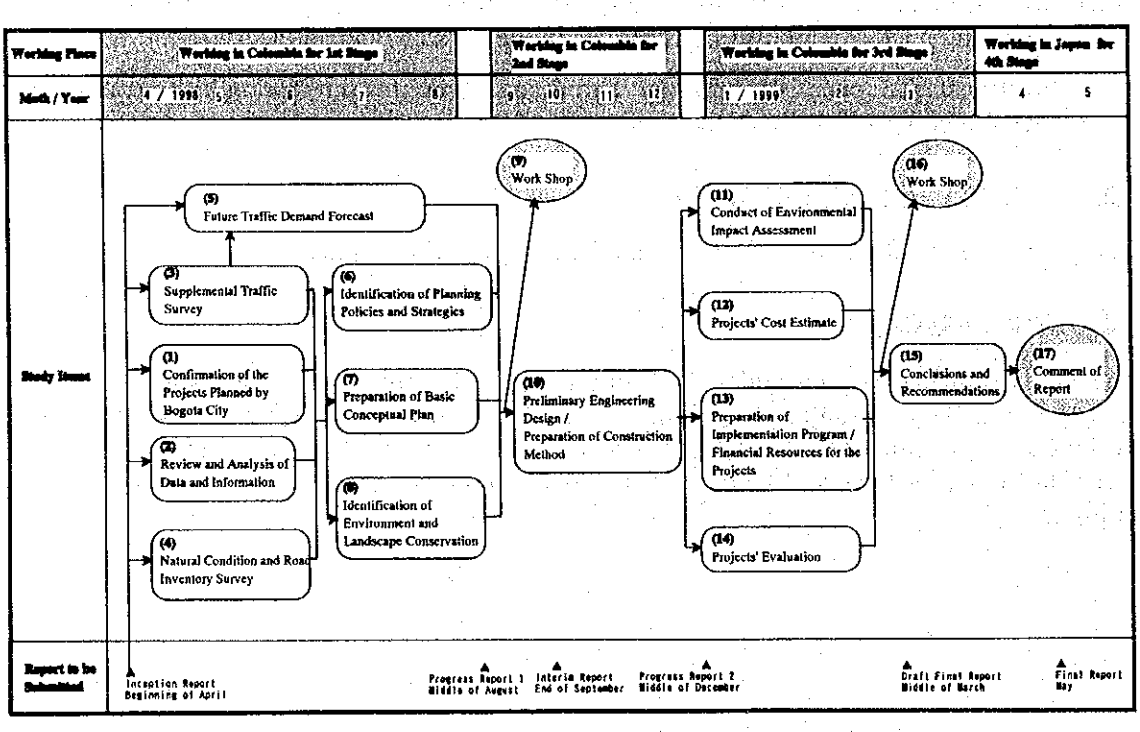


Figure 1-2 Study Flow Chart

1.6. THE STUDY ORGANIZATION

In order to conduct the Study, JICA organized the Study Team headed by Mr. Koichi Tsuzuki and the Advisory Committee chaired by Dr. Koichi Yamagata. At the same time, the Government of Colombia organized the Counterpart Team and formed the Steering Committee chaired by Dr. Enrique Penalosa Londono, Mayor of the city. Figure 1-3 shows the organization for the Study.

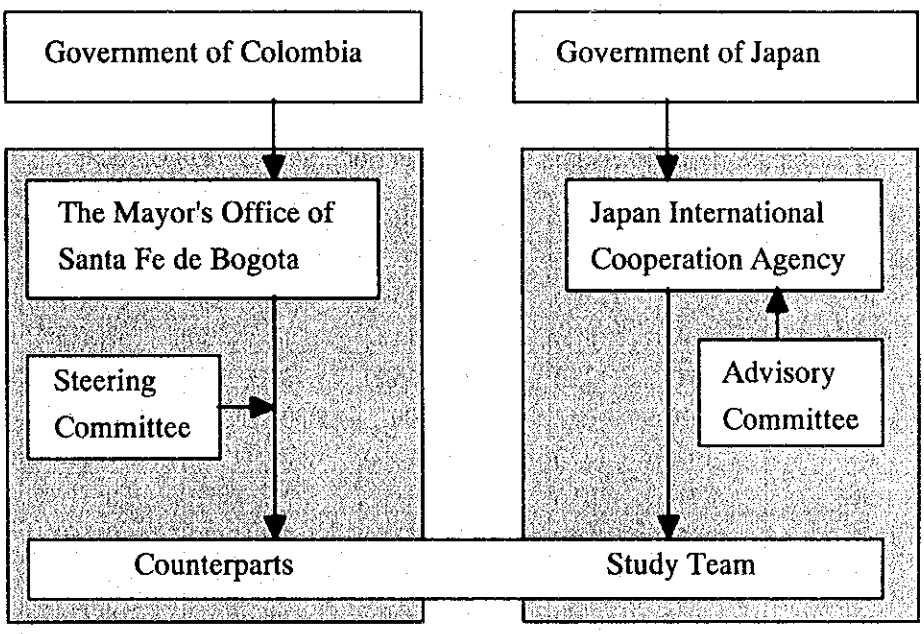


Figure 1-3 Study Organizations

2. EXISTING TRAFFIC AND TRANSPORT CONDITION

2.1. TRAFFIC VOLUME AND HOURLY FLUCTUATION ON AUTOPISTA NORTE AND AVENIDA CARACAS.

According to the traffic survey carried out in 1998, traffic volumes on Autopista Norte and Avenida Caracas are as shown in Table 2-1. The highest traffic volume of passenger cars and buses per hour per direction is approximately 4,500 to 4,800 units for passenger car and 700 to 800 units for bus. Composition rate of lorries and trucks shows a very small figure of 5 to 6 percent of total traffic volume.

As shown in Figure 2-1, peak hour of bus traffic is between 8:00 and 9:00 a.m. and peak hour ratio is 12 to 20 percent of total bus traffic volume.

Table 2-1 Traffic Volume on Autopista Norte and Avenida Caracas

Direction	Location	Location 3		Loc. 4 (out)		Loc. 4 (center)		Loc. 9 (out)		Loc. 9 (center)	
N -> S	Peak AM	7:00-8:00		6:00-7:00		6:00-7:00		9:00-10:00		11:00-12:00	
	Car	2,159	(15%)	4,444	(13%)	1,046	(9%)	1,563	(11%)	0	(0%)
	Truck	147	(6%)	129	(4%)	48	(5%)	67	(13%)	0	(0%)
	Bus	219	(12%)	560	(8%)	145	(21%)	0	(0%)	755	(12%)
S -> N	Peak AM	8:00-9:00		11:00-12:00		9:00-10:00		10:00-11:00		8:00-9:00	
	Car	1025	(7%)	3,367	(10%)	1,668	(10%)	1,271	(10%)	0	(0%)
	Truck	210	(10%)	356	(11%)	39	(8%)	50	(12%)	0	(0%)
	Bus	161	(9%)	834	(12%)	49	(12%)	0	(0%)	547	(10%)
N -> S	Peak PM	12:00-13:00		15:00-16:00		16:00-17:00		17:00-18:00		12:00-13:00	
	Car	1046	(7%)	2,796	(8%)	1,024	(9%)	1,418	(10%)	0	(0%)
	Truck	275	(10%)	255	(9%)	77	(8%)	40	(8%)	0	(0%)
	Bus	149	(8%)	395	(6%)	51	(7%)	0	(0%)	608	(10%)
S ->N	Peak PM	15:00-16:00		17:00-18:00		15:00-16:00		17:00-18:00		17:00-18:00	
	Car	1396	(10%)	4,793	(14%)	1,806	(11%)	1,244	(9%)	0	(0%)
	Truck	202	(10%)	277	(8%)	107	(23%)	25	(6%)	0	(0%)
	Bus	108	(6%)	260	(4%)	32	(8%)	0	(0%)	502	(10%)

Note: Numbers in parenthesis ( ) indicate peak ratio over 12 hours, i.e., ratio of peak hour volume to total of 12 hours.

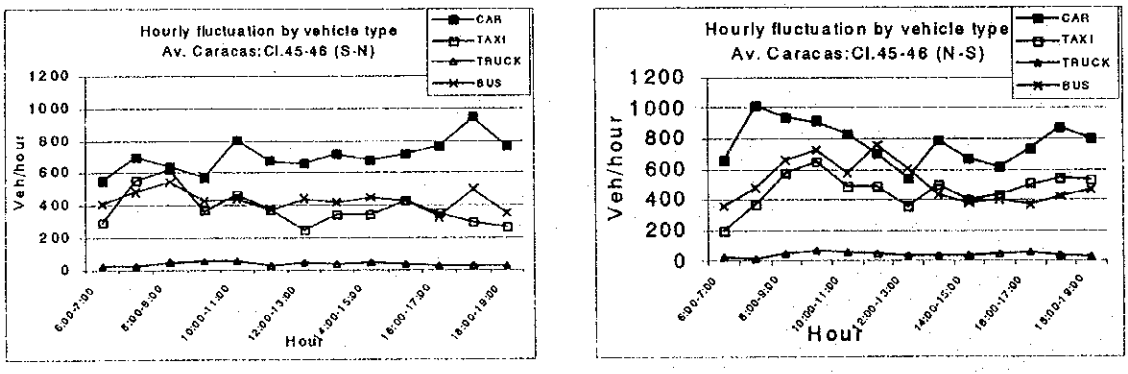


Figure 2-1 Hourly Vehicle Volume Fluctuation on Autopista del Norte and Avenida Caracas

2.2. CHARACTERISTICS OF BUS PASSENGER

On the bus passenger interview carried out in 1998, almost half of interviewees are in the income class of between 210,000 and 420,000 pesos per month. Minimum monthly income in Colombia is about 210,000 pesos. Figure 2-2 shows the income distribution among interviewees. As can be seen, the lowest three classes' income people, i.e., less than 629,999 $pesos per month, dominate as 88% of total bus users. 74 % of passengers are non-car owners and 26% of passengers are family-car owners.

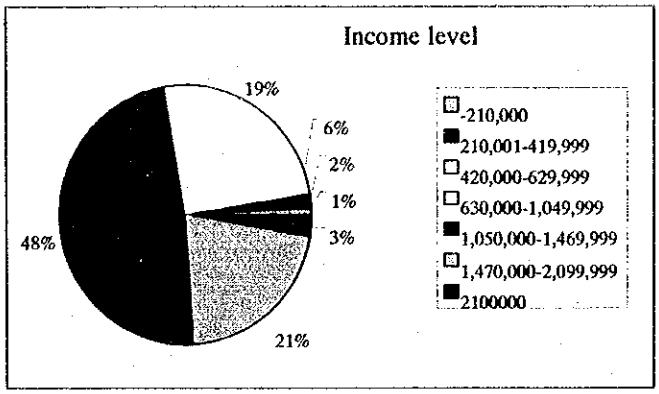


Figure 2-2 Income Level of Passenger

2.3. BUS PASSENGER MOVEMENT

Figure 2-3 shows the bus loading conditions in the inbound and outbound directions in the morning peak. The number of passengers on board presents a line graph and number of passengers at boarding and alighting present a bar graph.

As can be seen, at the starting bus terminal, approximately 60 passengers are on board and gradually decrease as they go North. Since Intermedio bus has seating for 40- 45, approximately 15 –20 passengers are standees in the peak hour. In the outbound direction, a maximum 40 –45 passengers are carried without standees.

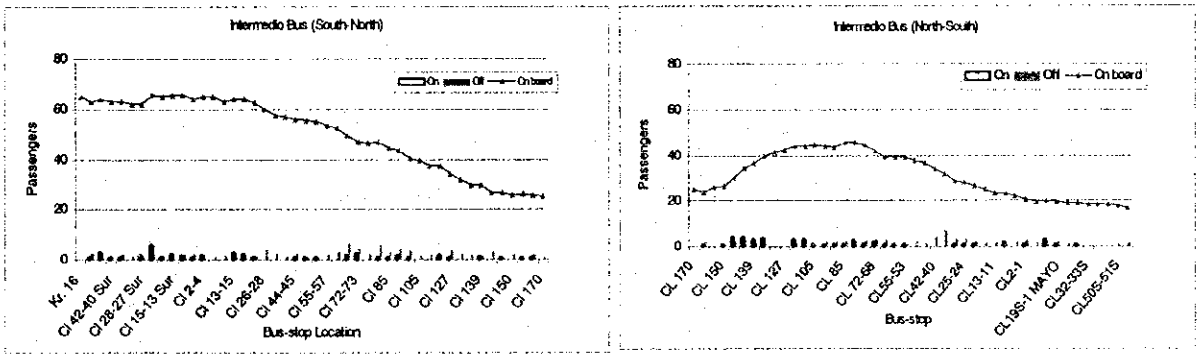


Figure 2-3 Bus Passengers on Board in the Morning Peak Hour on Av. Caracas

2.4. TRAVEL TIME BY BUS PASSENGERS

Figure 2-4 shows the composition of bus passenger's travel time on board. 29 % of passengers spend travel time of 40 to 60 minutes. And 27% of passenger spend travel time of 60 to 90 minutes, followed by 23% of 20 to 40 minutes and 11 % of 90 to 120 minutes. The average travel time spent is approximately 50 minutes.

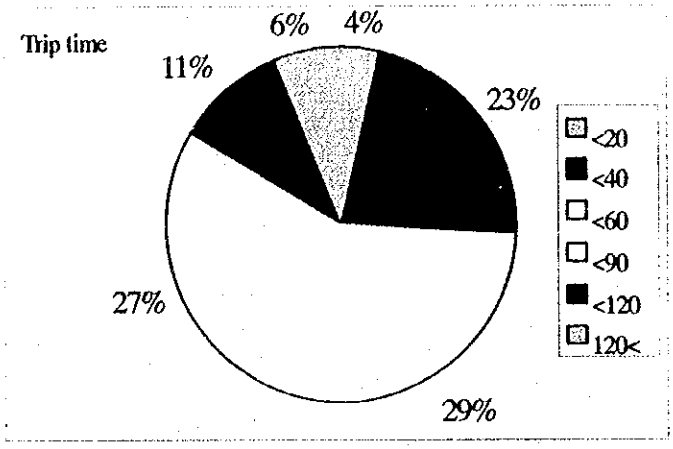


Figure 2-4 Travel Time on Board in a Bus

2.5. TRIP PURPOSE BY BUS PASSENGER

According to the interview, trip purpose of bus passengers is as shown in Figure 2-5. The trip purpose of more than 50 % of passengers in the morning hour is " to work " while in the evening hour, the purpose is "to home" both of which are the highest each time. It implies that the majority of passengers using public transport are categorized as 'working people' of a rather low income group.

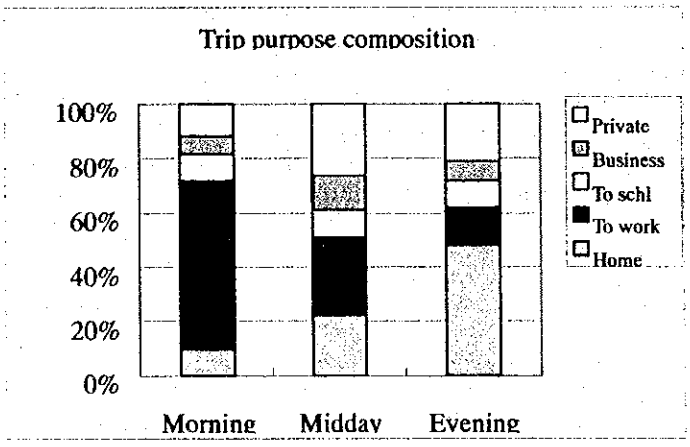


Figure 2-5 Trip Purpose Composition of Bus Passenger

3. TRUNK BUSWAYS PROJECT

3.1. PLANNING POLICY AND STRATEGY

(1) Planning Policy

Bus transport is one of the most space-efficient and cost-effective means for transporting large numbers of passengers. Where traffic volume is well below the capacity of road network, buses can share road space with other traffic and, in general, there is less requirement for the priority for bus transport. However, in the city where road traffic volume is high against the road capacity, bus transport suffers from congestion and delays caused by other road users. Therefore, priority measures are required to relieve the congestion of bus transport. Due to the above reason, a policy **"to provide a rapid, economical and reliable public transport system"** is set up for planning the project.

(2) Planning Strategy

The planning strategy of the projects is decided as follows:

1) to give priority to public transport for using a public space,
2) to maintain present fare level,
3) to minimize negative impact on the existing public transport business and
4) to minimize project cost in public transport plan.

(3) Scope of the Planning

There are many transport projects authorized in the city such as mass transit railway project (SITM), trunk busway improvement projects (Transmilenio), and some other road construction and improvement projects. After an elaborate discussion with counterparts and related authorities, it was decided that the Study includes an evaluation of the following projects, along with schedules for completion to meet the demand analysis.

1) Railway project (stage-1): to be completed in the year 2005
   (stage-2): to be completed in the year 2010
2) Urban Expressway: to be completed in the year 2005
3) Cundinamarca toll road: to be completed in the year 2000
4) Extension of Boyaca road: to be completed in the year 2000

(4) Staged Improvement Plan

In Bogota the current public buses are operated on approximately 860 bus routes by many private bus companies and unions organized under control of Secretaria de Transporte y Transit (STT). Because of the complicated situation of the current bus operation and organization as well as difficulty of changing bus operation system, staged implementation plan is proposed in the Study.

3.2. PROPOSED TRUNK BUSWAY

(1) Trunk Busway Routes

Figure 3-1 shows the trunk busway network to be introduced on the existing roads.

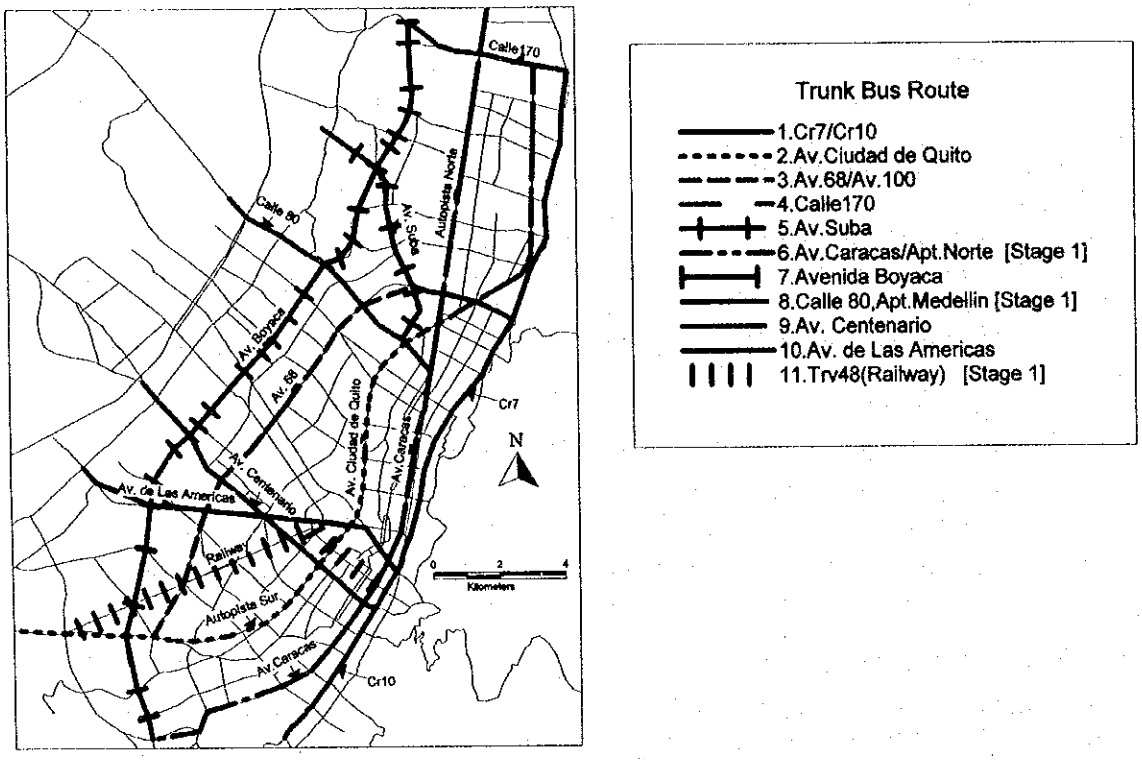


Figure 3-1 Location of Trunk Busways

3.3. DEFINITION OF TRUNK BUSWAY SYSTEM

Trunk busway system consists of three different types of operation systems namely, operation on an express busway, a trunk busway and a bus priority lane. The outline and function by each type are as follows,

(1) Express Busway (EB) System

1) Operation speed of express busway is maintained at 30 km/h.
2) EB system is introduced on the existing roads where bus transport demand is forecasted very high.
3) Busway is proposed with fully segregated lane from other traffic in the center part of an existing road.
4) Road surface is paved with colored asphalt concrete.
5) Intersections of the express busway and an existing road are grade-separated with no traffic signal.
6) Bus stop spacings are designed to be comparatively long, 1,000 to 1,500m to provide a higher operation speed.
7) Articulated buses with capacity of 200 passengers are introduced.

(2) Trunk Busway (TB) System

1) Operation speed is maintained at 20 to 25 km/h.
2) TB system is introduced on the existing roads where bus transport demand is comparatively high.
3) Basically, buses run on exclusive bus lanes segregated from other private vehicles at the center part of an existing road.
4) The surface is paved with colored asphalt concrete.
5) Exclusive bus lanes are planned as at-grade structures at major intersections crossing each other at minor intersections.
6) Bus stop spacings are designed to be 500 to 600 meter long.
7) Larger buses with capacity of 100 passengers are introduced.

(3) Bus Priority (BP) Lane

1) Operation speed is maintained at 20 to 25 km/h.
2) Bus priority lanes are introduced on the existing roads where bus transport demand is comparatively light and there is insufficient space for trunk bus lane construction.
3) Bus priority lanes are provided on the side lanes of existing roads and the surface is paved with colored asphalt concrete.
4) Basically, operation system shall be the same as the current one, however, punctual operation should be encouraged.

3.4. FUTURE BUS PASSENGER DEMAND

Future bus passenger demand in the year 2005 is simulated by various alternative cases of trunk bus system such as trunk bus route, tariff system, non-reciprocal operation system with transit assignment model. The best alternative (case-5) is selected from among the alternatives, of which future bus passenger demand is shown in Figure 3-2.

Under the condition of the selected alternative (case-5), following matters are pointed out.

1) At peak hour, heavy inbound passenger flows are predicted on Avenida Caracas, Calle 80, Avenida Centenario, Carrera 10, Avenida Boyaca and Autopista del Sur with over 20,000 passengers per hour per direction.
2) Passenger demand in the peak hour on Avenida Caracas is predicted at approximately 30,000 to 35,000 passengers and the same on Calle 80 at approximately 40,000 to 50,000 passengers.
3) Volume of passengers in the peak hour is different for inbound and outbound traffic.

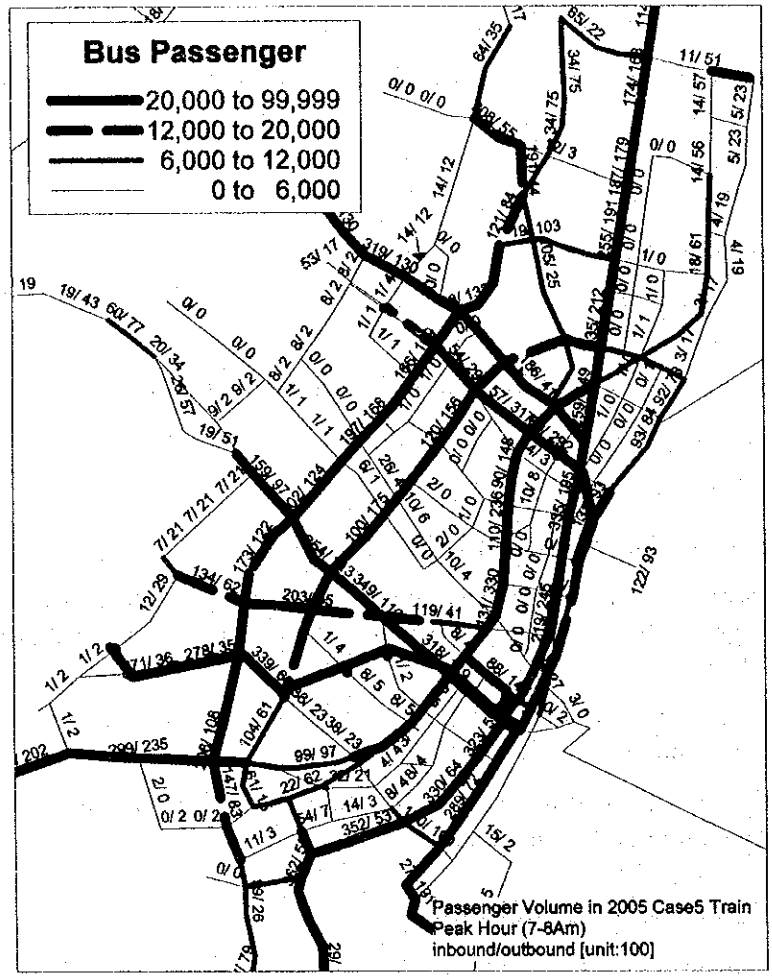


Figure 3-2 Future Bus Passenger Volume on Peak Hour in 2005

3.5. BUS PASSENGER CAPACITY

Public bus passenger demand at the present and in future is quite heavy especially during peak hour. When the trunk bus system is introduced, higher capacity bus is required since the large bus decreases operation cost and also ensures better service to bus passengers. The advantages and disadvantages of the large capacity buses are;

1) Advantage

1) operation cost per unit decreases since the bus is able to transport more passengers at a time, and

2) line capacity increases almost linearly according to the increase of bus size. By introducing the large buses, street congestion decreases and service becomes better.

2) Disadvantage

3) maneuverability of bus becomes worse because of the large size, and

4) while riding comfort becomes better in case of single-body bus, the comfort becomes worse in case of articulated or double-deccker because of the bus structure.

In order to maintain smooth operation of the bus system to cope with the future bus transport demand, introduction of bigger size buses is strongly recommended.

General views of single-body bus and articulated bus are shown in Figure 3-3.

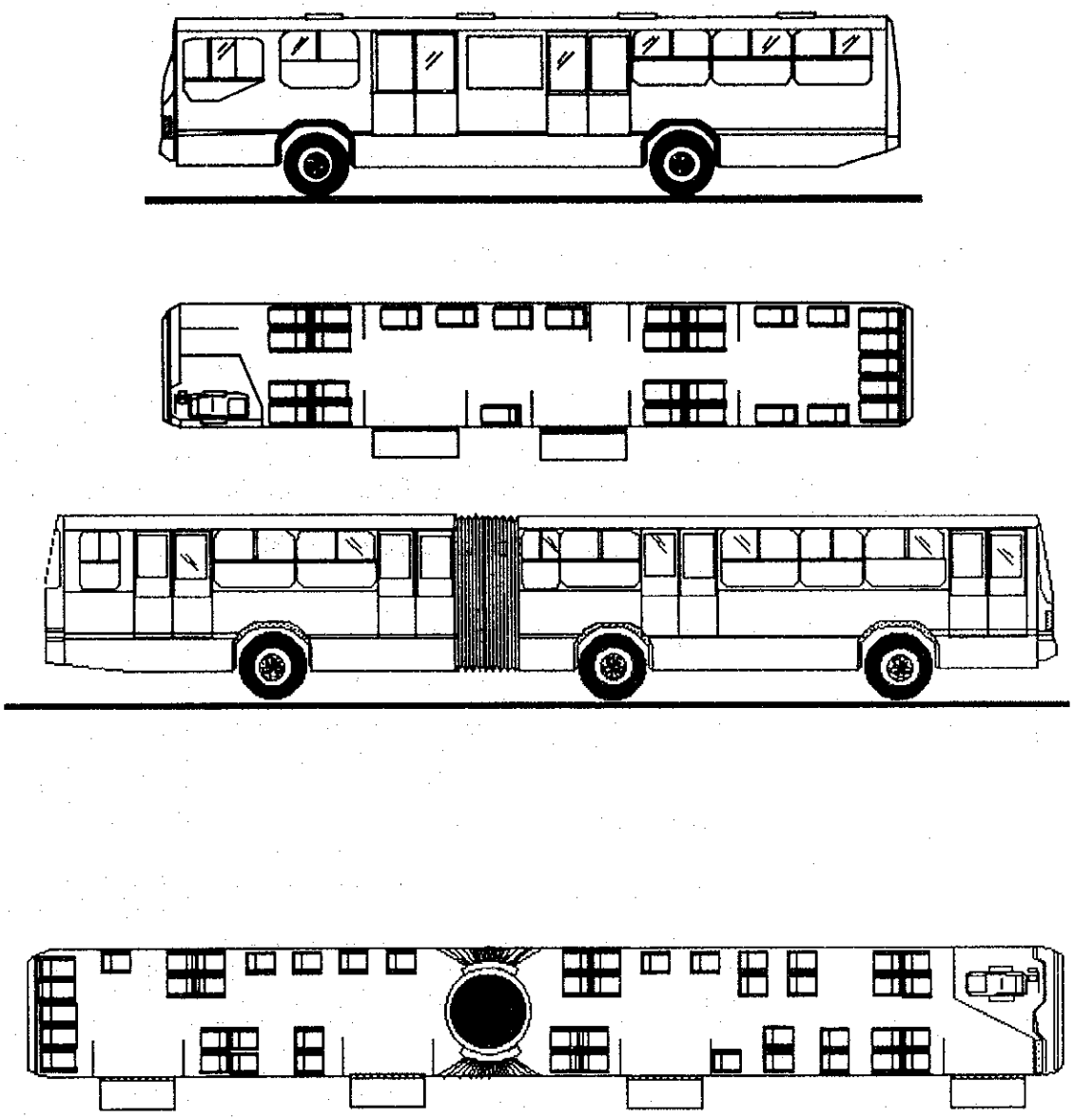


Figure 3-3 General View of Single and Articulated Buses

3.6. BUS OPERATION SPEED

The existing bus operation speed in the peak hour is in the range of 7 to 15 km/h at the central area of the city. By introducing the trunk bus system, the speed can be improved up to 20km/h for the trunk bus operation and to 30km/h for the express bus operation, respectively.

3.7. BUS TICKETING SYSTEM

The passengers have to pass through a turnstile at entrance/exit door before paying bus fare under the current ticketing system. Under this system, it is taking 5 to 10 seconds for 2 to 3

passengers to get on and off board. In order to reduce a dwelling time at bus stop, a flat rate fare plus additional fare system at every transfer are recommended in the Study, in addition to the following measures.

1) In the future, since heavy bus passenger demand is predicted, it is indispensable to decrease the dwelling time for boarding and alighting at bus stops. Therefore, a simple flat rate system is proposed in the Study.

2) The length of trunk bus route is planned to be comparatively short, in the range of 15 km to 20 km. An average travel distance of bus passengers is approximately 10km. According to the characteristics of trip length and trunk bus route length, the flat rate system is also proposed.

3.8. TRUNK BUS OPERATION SYSTEM IN 2000

(1) Demand and Operation

Table 3-1 summarizes the trunk busway operation plan by each busway which shows passenger volume, busway types and number of lanes. In the year 2000, trunk bus passenger flows on Avenida Caracas during the peak hour will be 20,000 to 30,000/hour in the inbound direction. On Calle 80, approximately 24,000 passengers / hour in the inbound direction will pass through. Autopista del Norte and Sur also show heavy passenger flows.

Table 3-1 Trunk Bus Operation System in 2000

Busways	Bus Passengers/hour			Type and No. of Lanes/dir.	Remarks
	Total (Trunk+Ordinary)	Trunk Buses	Ratio of Trunk		
Autopista Notre	20,000	11,000	55.0%	1-lane trunk busway/dir and 1-lane express busway/dir	Existing right of way: 100m
Caracas in south	29,000	20,000	69.0%		ROW: 40 m
Caracas in central	35,000	30,000	85.7%		ROW: 40 m
Calle 80	28,000	24,000	85.7%	1-lane trunk busway, and 1-lane express bus	Under construction of trunk busways with 2-lane /dir.
Ferreo de Sur	19,000	19,000	100.0%	2-lane trunk buway	

(2) Schedule and Frequency

Frequency and bus headway are summarized in Table 3-2 aggregating all lines. The figures indicate big volume of bus flows, mainly in the inbound direction. Avenida Caracas is the busiest with bus transport. Total number of buses in the peak hour is about 430units / hour/ direction, of which 140units are express buses and 290units are trunk buses. On Calle 80, the number of buses is about 190units/hour with headway of 19 seconds.

Table 3-2 Trunk Bus Flows on Busway in 2000

Busways	Frequency/hour			Headway (sec)		
	Express Buses	Trunk Buses	Total	Express Buses	Trunk Buses	Total
Caracas	143	286	429	25	13	8
Norte	29	58	87	124	62	41
Calle 80	63	126	189	57	29	19
Ferreo de Sur	-	187	187	-	19	19

3.9. TRUNK BUS OPERATION SYSTEM IN 2005

(1) Demand and Operation

Table 3-3 shows the trunk bus system plan in 2005. In the year of 2005, out of eleven busways, Avenida Caracas, Autopista del Norte, Calle 80 and Autopista del Sur require introduction of express bus system, since the number of passengers on these busways will exceed 20,000 passengers /hour /direction. On Avenida Suba, however, an introduction of the trunk bus system is rather difficult because many houses have been built along the road and the right of way of the road is quite narrow. Therefore, the bus priority lane system is introduced.

Table 3-3 Demand and Trunk Bus System Plan in 2005

Busways	Bus Passengers/hour			Type and No. of Lanes/dir.	Remarks
	Total (Trunk+Ordinary)	Trunk Buses	Ratio of Trunk Buses		
Cra 7a	21,000	21,000	100.0%	1-lane trunk busway/dir.	ROW: 30 m (difficulty of widening)
Car.10	29,000	19,000	65.5%	2-lane trunk busway/dir.	Difficulty of widening
Caracas in south	34,000	34,000	100.0%	Trunk and express busways (1-lane/dir. each)	ROW:40 m
Caracas in central	34,000	33,000	97.1%	Trunk and express busways (1-lane/dir. each)	ROW: 40 m
Autopista Norte	23,000	21,000	91.3%	Trunk and express busways (1-lane/dir. each)	ROW: 100 m
Av. Quito	23,000	20,000	87.0%	1-lane trunk busway/dir.	ROW: 60 m
Autopista Sur	29,000	27,000	93.1%	Trunk and express busways (1-lane/dir. each)	Possibility of widening
Calle 80	47,000	46,000	97.9%	Trunk and express busways (1-lane/dir. each)	Propose completing SITM's railway project until 2005
Cra.68	17,000	17,000	100.0%	1-lane trunk busway/dir.	ROW: 40 m
Av. Suba	20,000	13,000	65.0%	1-lane trunk busways/dir and 1-lane trunk busway on other busway route	Difficulty of widening
Calle 170	12,000	12,000	100.0%	1-lane trunk busway	Possibility of widening

(2) Schedule and Frequency

Trunk bus operation frequency and headway in 2005 are summarized in Table 3-4. Bus lines and the bus flows become larger mainly in the inbound direction. Avenida Caracas will still be the busiest with bus transport. Total number of buses at peak hour will be about 550units / hour /direction of which 140units are the express bus and 410 units are the trunk buses. On Calle 80, the number of buses is expected to be 410units /hour /direction.

Table 3-4 Bus Frequency and Headway in 2005

Busways	Frequency/hour			Headway (sec)		
	Express Bus	Trunk Bus	Total	Express Bus	Trunk Bus	Total
Cr7a	-	239	239	-	15	15
Cr10a	-	167	167	-	22	22
Quito	-	373	373	-	10	10
Auto. Sur	47	158	205	77	23	
Cra. 68	-	188	188	-	19	19
Calle 170	-	141	141	-	26	26
Av. Suba	-	63	63	-	57	57
Av. Caracas	142	410	552	25	9	
Boyaca	-	200	200	-	18	18
Calle 80	80	331	411	45	11	
Centenario	7	343	350	514	10	10
Americas	12	162	174	300	22	21
Auto. Norte	49	102	151	73	35	24

3.10. BUS FACILITIES

(1) Bus Stop

Bus stop capacity is an important determinant of overall bus system performance. Bus stop spacing also influences performance. In general, when the stop spacing is longer, the commercial speed is higher. The spacing employs an average spacing of approximately 1.5 km for the express bus system and 600 m for the trunk bus system. Location of each bus stop on the trunk busway is proposed in place adjacent to a bus lane with bus bay at the same height of the existing road. The bus stop location on the express busway at Avenida Caracas is just alongside of the bus lane without a bus bay on a viaduct.

(2) Central Urban Bus Terminal

Function and characteristics of a central urban bus terminal as a major transport point are as follows:

1) to connect various public transport mode such as express buses, trunk buses, present buses and railway;
2) to connect two transport modes namely private and public transport mode;
3) to provide spaces for bus parking, car parking and bicycle parking;
4) to provide a space for offices related to bus;
5) to provide a space for shops and other facilities; and
6) to provide an open space.

Location of the central urban bus terminal is determined between Avenida Caracas and Avenida Jimenes, near to the central railway station taking into account good accessibility and space available in which DAPD is now planning an urban redevelopment project in the same area.

(3) Sub-Urban Terminal

Sub-urban bus terminals are proposed at the end of each trunk busway near peripheral areas. The suburban terminals are planned as a terminal and transfer point used by bus

routes or between local buses. Major function and characteristics of the sub-urban bus terminal are as follows,

1) to connect different public transport systems such as express bus system, trunk bus system and the existing bus system,
2) to connect private and public transport modes,
3) to provide spaces for bus, car and bicycle parking,
4) to provide spaces for a bus operation office and a gas filling station and
5) to provide spaces for a shopping facility and an open space.

The eleven (11) sub-urban bus terminals are proposed in total in 2005. The location is selected based on the following viewpoints: a) capacity related to bus demand, b) accessibility to major roads, c) allowance of preservation area and d) possibility of land acquisition.

3.11. PRELIMINARY DESIGN OF TRUNK BUSWAY

(1) Preliminary Design Facilities

The passenger demand analysis on the trunk bus system with eleven (11) trunk busways is conducted. Preliminary design of bus busway, however, is made only for following six (6) trunk busways out of eleven (11) in accordance with the scope of work for the Study, agreed between the Government of Colombia and the Government of Japan.

Contents of the preliminary design are as follows.

1) Busways including structure
   - Avenida Caracas to Autopista del Norte
   - Avenida Quito to Autopista del Sur
   - Cra. 7a to Calle 10
   - Avenida Suba
   - Avenida 68 to Calle 100
   - Calle 170
2) Central urban bus terminal
3) Sub-urban bus terminals
4) Bus stops

Figure 3-4 shows the locations of trunk busway and bus facilities.

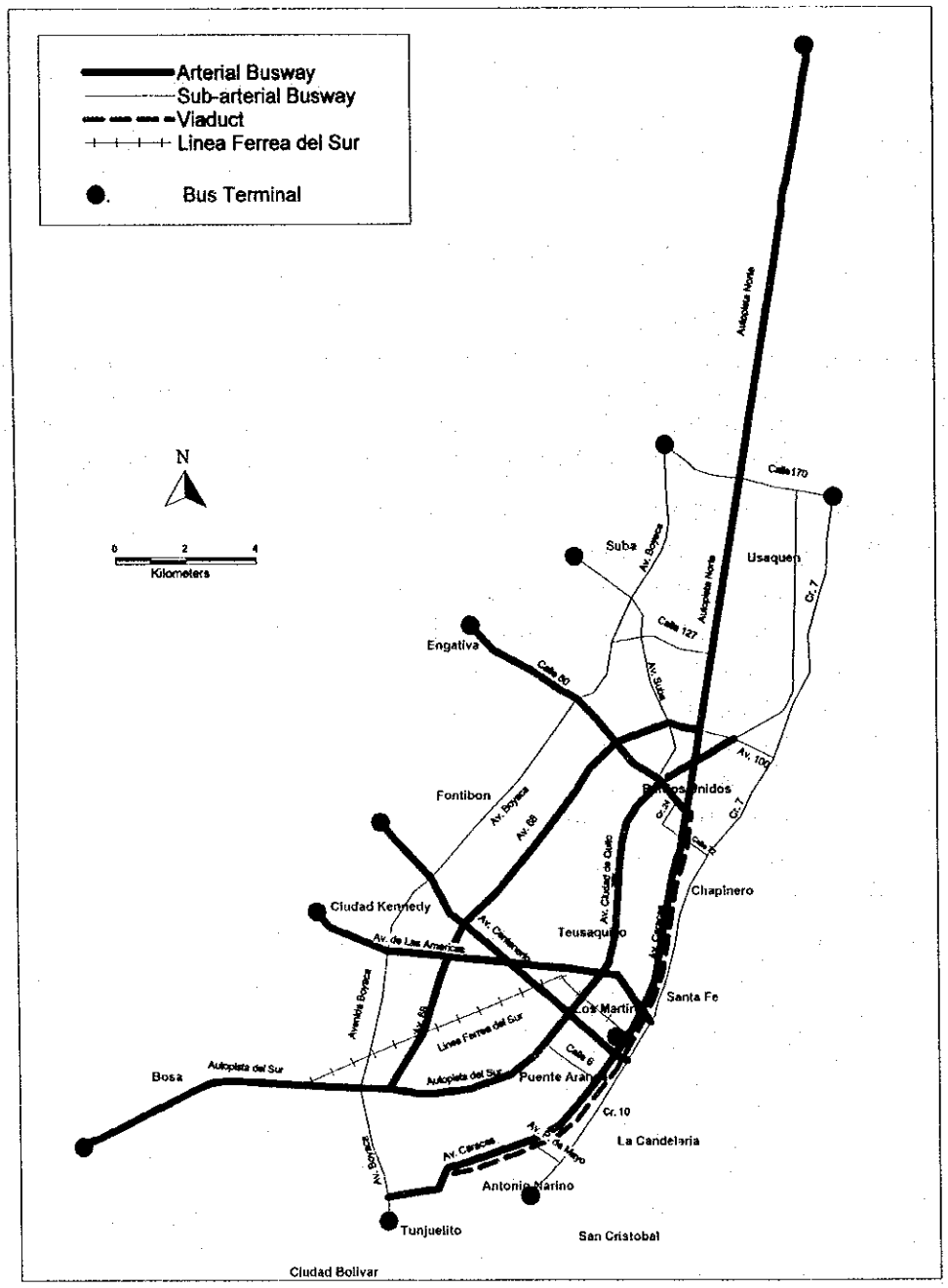


Figure 3-4 Locations of Trunk Busways and Bus Facilities

(2) Plan and Profile of Busways

In the Study, three different types of the trunk busway systems; the express bus system, the trunk bus system and the bus priority lane system are recommended. The express busways are constructed with full access control and the trunk busways are constructed by utilizing the center lanes on the existing roads, while the outer lane on the existing roads will be utilized for the bus priority lanes. An elevated type structure is recommended for the express busway on Avenida Caracas. The planned six (6) trunk busways by the Study including additional busways are shown in Figure 3-5.

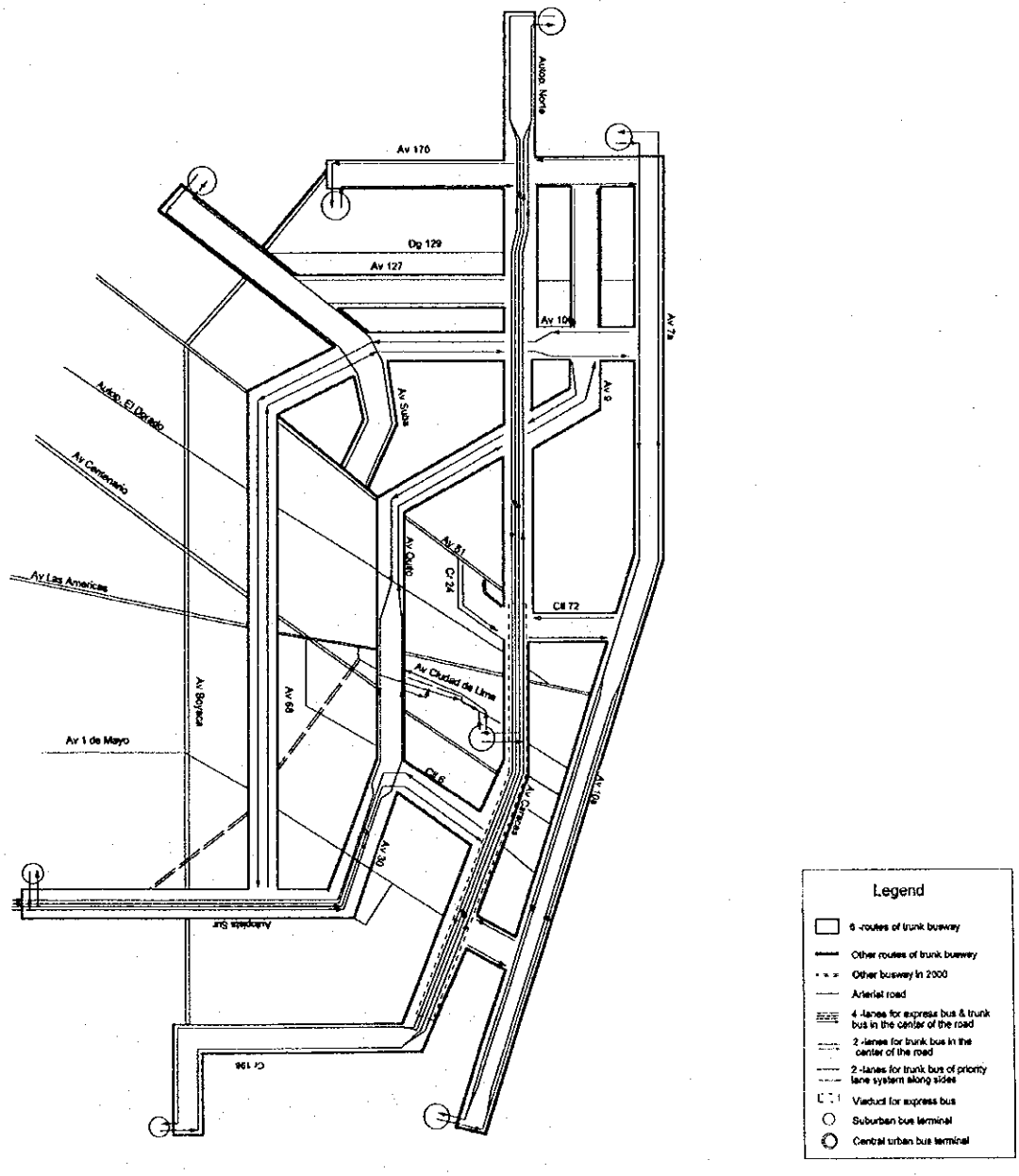
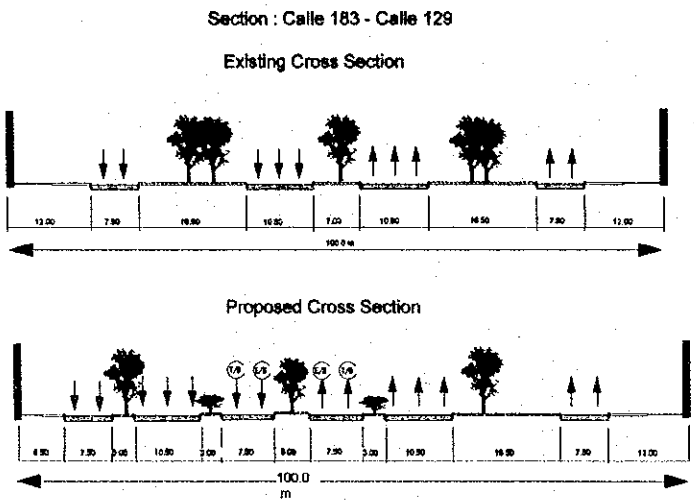


Figure 3-5 Locations of Planned Trunk Busways

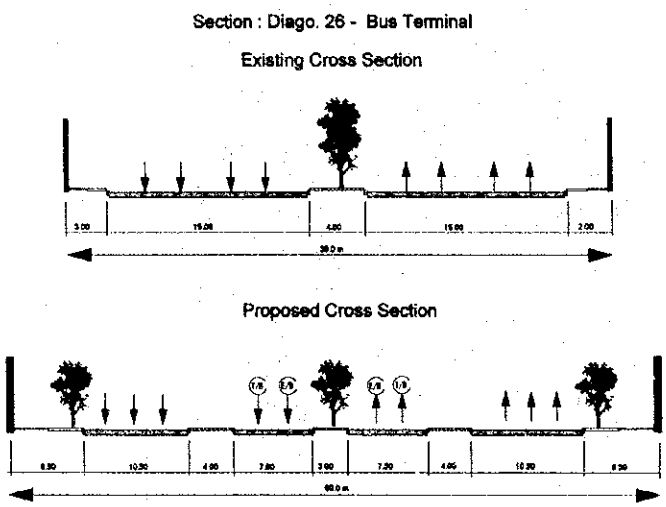
(3) Typical Cross Section

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. The location and the layouts of trunk busway lanes and the private vehicle lanes are as shown in Figure 3-6. The lane width of the trunk busway is determined at 3.5 meter and the shoulders of 0.5 meter are provided at both sides of the carriageway.



Typical Cross Section on Autopista Norte



Typical Cross Section on Autopista Sur

Figure 3-6 Typical Cross Sections on Trunk Busway

(4) Avenida Caracas

On Av. Caracas the future trunk bus transport demand in the year 2005 is predicted to be 30,000 to 35,000 passengers/ hour/ direction. An elevated structure is recommended for express busway system on Avenida Caracas. The main reasons to adopt the elevated road are as follows.

1) The existing passenger demand for bus transport on Avenida Caracas is almost reaching the capacity of 4-lane at-grade busways. In order to ensure a smooth and safe traffic flow, at-grade busway with 6-lanes is required. However the existing road is quite difficult to be widened since housings and buildings have been built along the road.

2) Although the elevated express busway is provided, future passenger demand will reach the capacity of trunk bus system on Avenuda Caracas sooner or later. It will become indispensable to introduce a mass transit system. The structure is easy to be transferred from the express busway to a mass transit system.

The cross-section and image plan of busway are as shown in Figure 3-7 and Figure 3-8. As a mitigation measure of noise pollution, the noise barriers are provided on both sides of the carriageway.

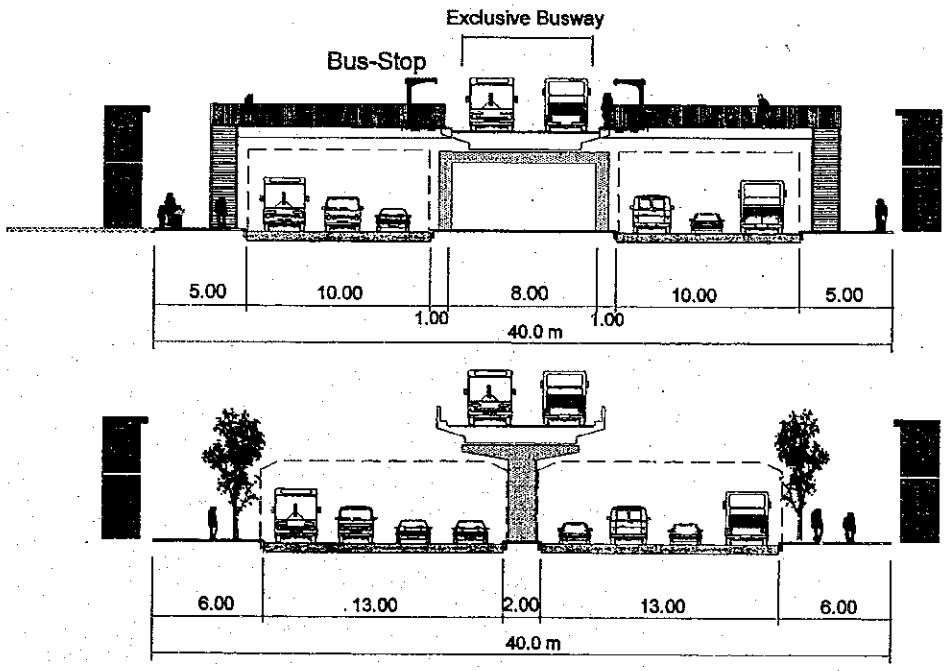


Figure 3-7 Typical Cross Section Of Viaduct Busway on Avenida Caracas

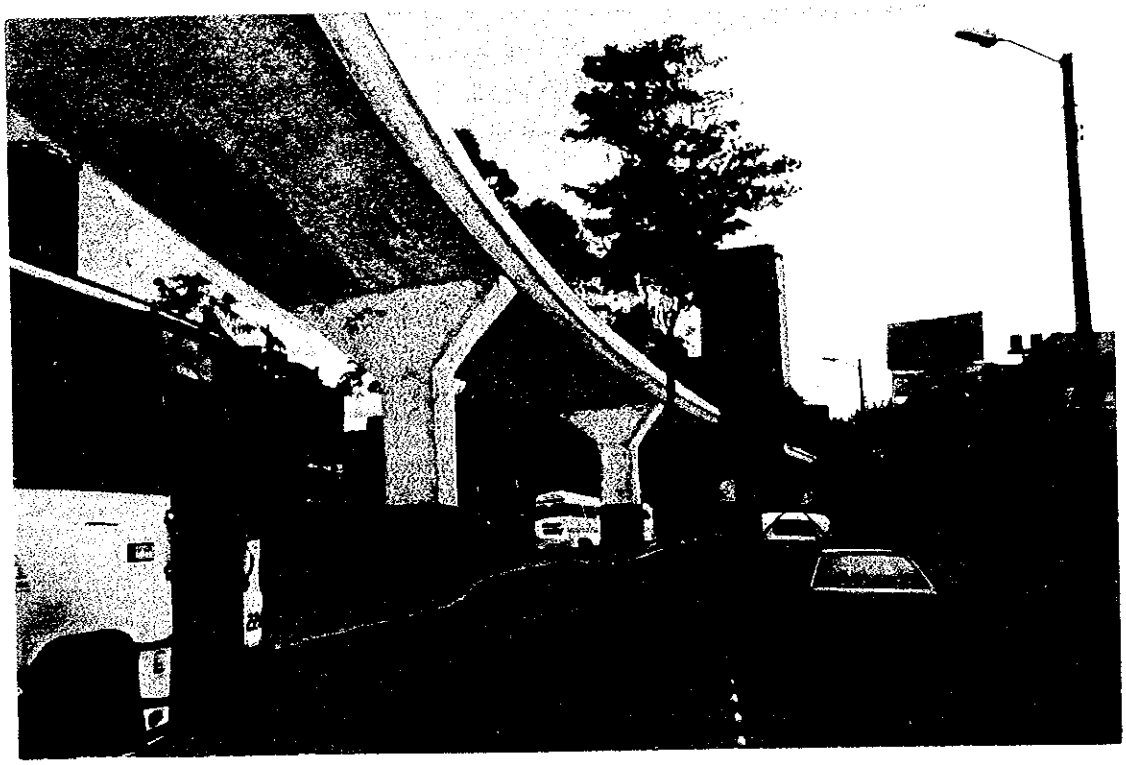


Figure 3-8 Image Plan of Viaduct For Trunk Busway on Avenida Caracas

(5) Bus Stop

A bus stop with two bus booths is recommended to maintain a smooth traffic flow and to increase bus flows. Nine different types of bus stops are designed and the optimum type of bus stop is selected in accordance with the characteristics of the road facility conditions on the trunk busway. The bus stops are basically provided on the location before crossing the intersection. The outline of bus stop facility is shown below. The typical bus stops are shown in Figure 3-9.

1) Length of platform: 46m for the express bus system
   30m for the trunk bus system
2) Width of platform: 3.0m
3) Bus stop capacity: 2 buses at each bus bay
4) Width of bus bay facility: 3.0m
5) Taper length of bus bay: 30m
6) Preparation of pedestrian bridges

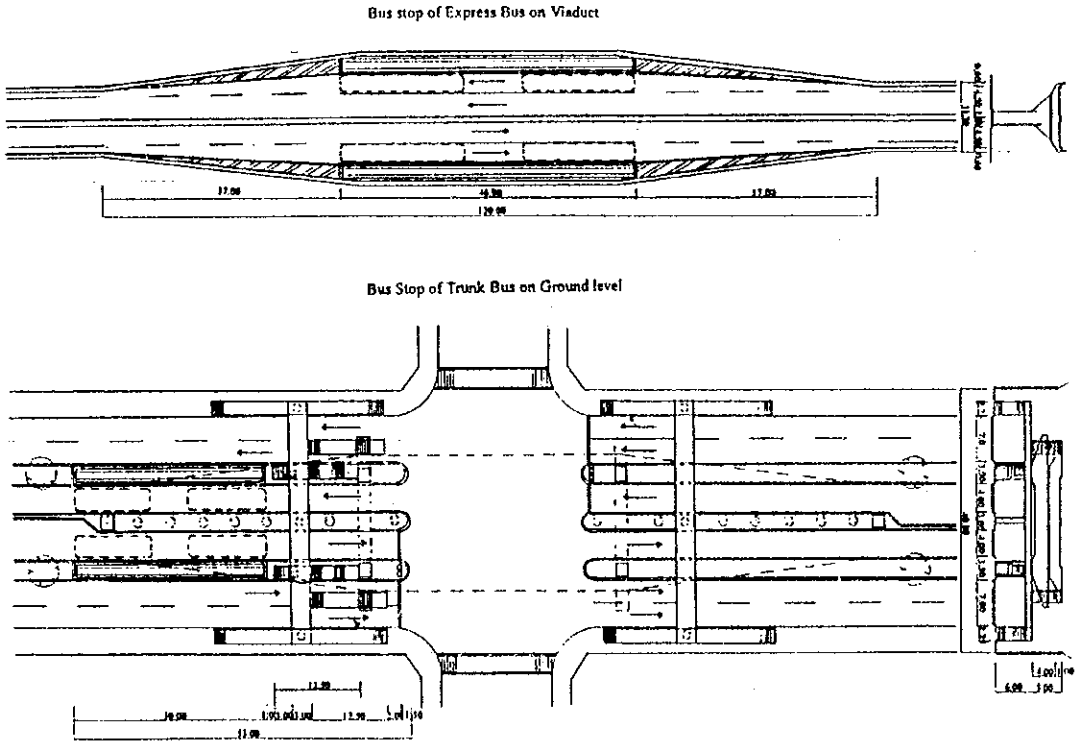


Figure 3-9 General View of Typical Bus Stop

(6) Central Urban Bus Terminal

The size of central urban bus terminal is determined at 2.5ha which are included for spaces of trunk bus parking, transfer, maintenance shops, service facility, etc. The facility plan of the central bus terminal is shown below. A plan and an image plan of the central urban bus terminal are as shown in Figure 3-10 and Figure 3-11, respectively.

1) Two-story building is proposed; the first floor is for the trunk bus and the second floor is for express bus.
2) The viaduct structure for express bus directly connects to the second floor of the terminal.
3) In order to alleviate the congestion near entrance, two approach roads are planned; one is from/to Av. Caracas and the other is from/to Av. Quito.
4) Escalators are provided for connecting to each floor.
5) In order to avoid a conflict between private and public traffic flows, parking space for the private is provided near the approach road.
6) Greenery is provided around the terminal to conserve the natural environment.
7) Number of planned bus booths
   - 1 booth for local buses
   - 23 booths for trunk buses
   - 9 booths for express buses

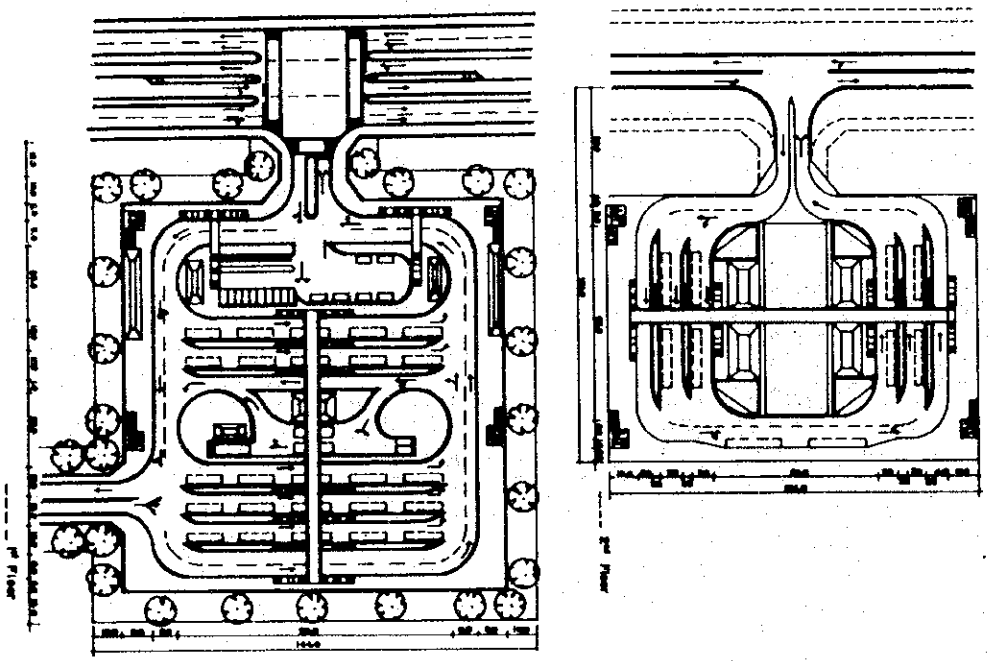


Figure 3-10 Plan of Urban Bus Terminal

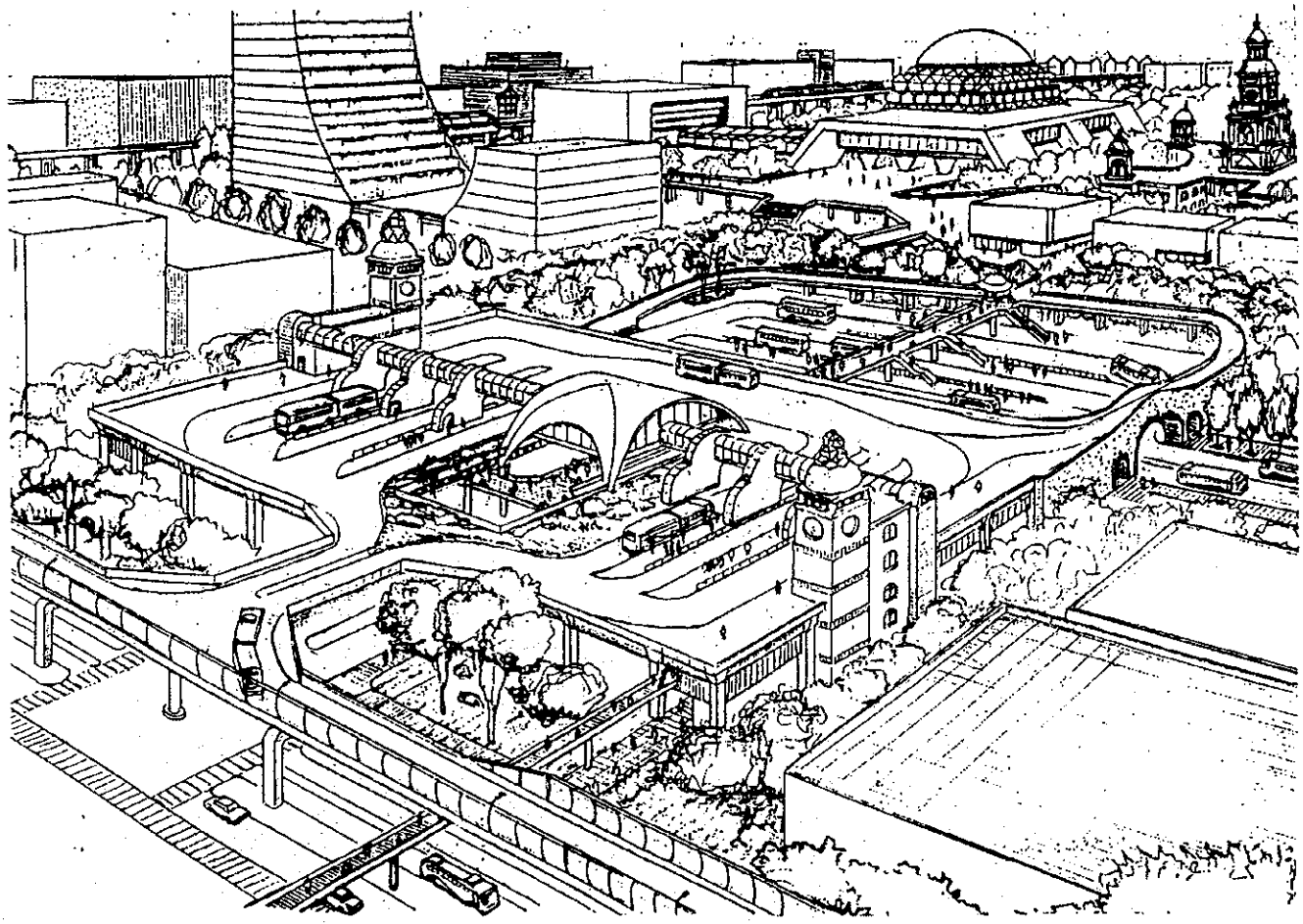


Figure 3-11 Image Plan of Urban Bus Terminal

(7) Sub-Urban Bus Terminal

The preliminary design of five (5) sub-urban bus terminals was made out of eleven terminals. The sizes of sub-urban bus terminals are determined at approximately 1.0 to 1.5ha depending upon the future bus transport demand. A general plan and an image plan of the sub-urban bus terminal are as shown in Figure 3-12 and Figure 3-13, respectively. The facility plan of the sub-urban bus terminal is summarized in Table 3-5.

Table 3-5 Summary of Sub-Urban Bus terminals

Location	No. of Parked Buses (buses/hour)	No. of Bus Booths	Area (m2)
Auto. Norte	345	7	974
Av. 7a	160	4	508
Calle 170	162	4	512
Av. Suba	376	6	836
Auto. Sur	392	8	1,586

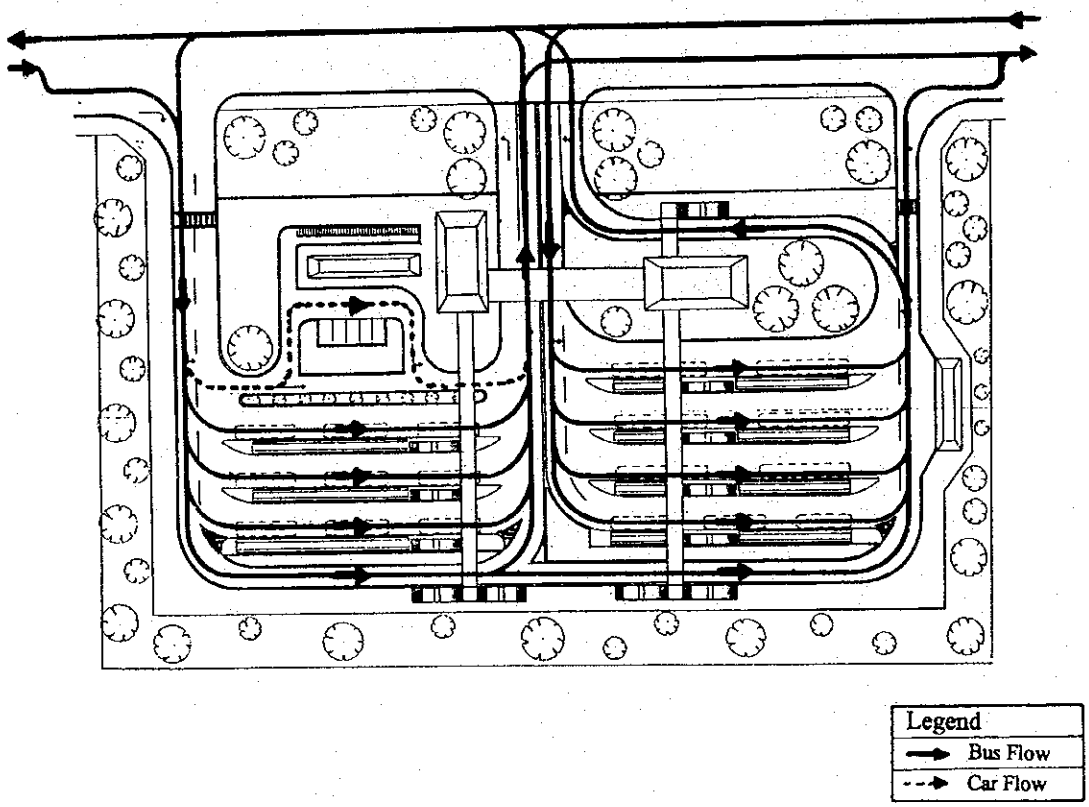


Figure 3-12 Typical General Plan of Sub-urban Bus Terminal

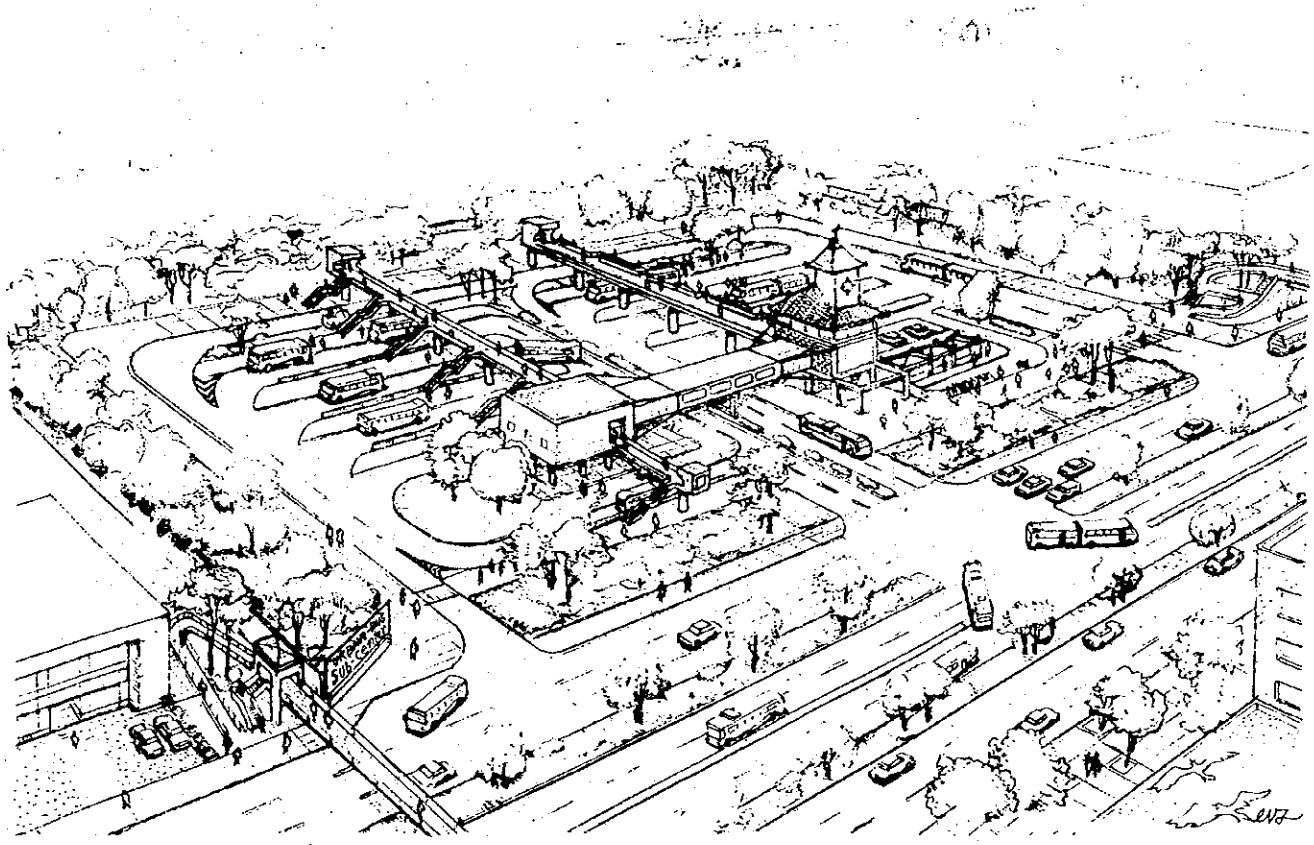


Figure 3-13 Image Plan of Sub-Urban Bus Terminal

4. INNER RING EXPRESSWAY (IRE) PROJECT

4.1. MAJOR OBJECTIVES OF IRE

There are two major measures to mitigate the traffic congestion in Bogota such as introduction of traffic demand management (TDM) and effective utilization of the existing roads. The TDM is temporarily decreased traffic demand by political procedure. On the other hand, the effective utilization of existing road space is to increases the road capacity with construction of new road facilities. However, within the highly developed areas, it is difficult to newly construct a road due to acquisition of a road space. In the central of Bogota, the effective utilization of an existing road space is the best solution to alleviate the congestion. The proposed inner ring expressway project is included in this concept.

The major objectives of IRE are as follows;

1) to decrease the traffic congestion in the central areas of the city,
2) to decrease the traffic accidents,
3) to maintain a sound city activity in the city,
4) to contribute to the socioeconomic activity in the city and
5) to create good city environment.

4.2. ROUTE FOR IRE

In the Master Plan, the urban expressway network which consists of 1st and 2nd ring roads, and 4 radial routes was recommended as a future expressway network. The 1st ring road was also recommended as an urgent implementation program, and this 1st ring expressway is defined as the Inner Ring Expressway. The study area of IRE for expressway network alternatives where traffic flows are directly influenced is defined as shown in Figure 4-1.

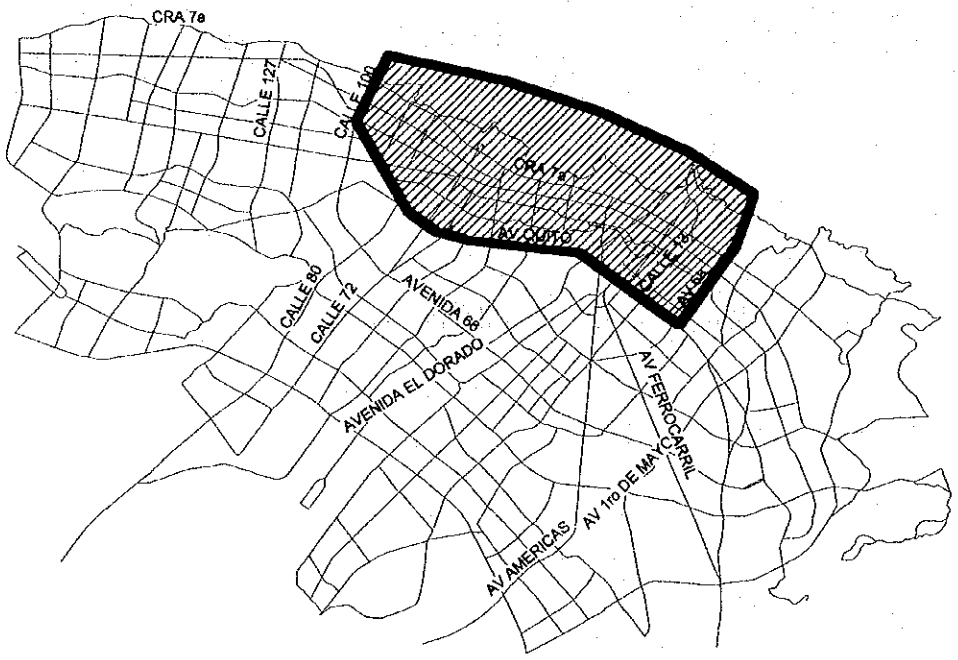


Figure 4-1 Study Area of IRE

4.3. DESIGN CRITERIA FOR INNER RING EXPRESSWAY(IRE)

(1) Full Access Traffic Control System

In order to maintain the safety of traffic, full access traffic control system, which limits the passage of small motorcycle and bicycles, is recommended for IRE. Since IRE does not serve for bus system, no bus stop is needed.

(2) Toll System

In general, construction cost of urban expressway is very high since a viaduct or tunnel type expressway is usually adopted to avoid interfering with existing infrastructures. Urban expressways have been built in many cities in the world and normally those are operated under a toll system because of high initial investment, limited budget for public services, etc.

(3) Design Speed

The urban expressway is designed as a major trunk road with design speed of 60 to 80 km/h.

(4) 2-lane Dual Carriageway

In general, the number of lanes is determined depending on future traffic demand. However, in order to maintain the function of the major trunk road, 2-lane dual carriageway is adopted not related to the traffic demand.

4.4. ROUTE LOCATION

(1) Preparation of Alternative Route

The principles of alternative network routes are followings;

1) to meet future traffic demand,
2) to meet the existing road network configuration,
3) to avoid a negative effect on the historical monuments' preservation,
4) to preserve the natural and social environment,
5) to avoid a route on the existing narrow width roads and
6) to plan a simple method of construction to minimize construction costs.

(2) Outline of Alternative Routes

Three (3) alternative routes (Alternative-1, -2 and –3) are prepared as shown in Figure 4-2. The network configuration of Alternative-1 is full ring road composed of Av. New Cirucumbaral road and Av. Quito with 35km road length. Alternative-2 is composed of Cra. 7a and Av. Quito with 30km length as a segment of full ring road. Alternative-3 with 19km length is partial ring network with Av. Quito. The outline of each alternative route is as shown in Table 4-1.

Table 4-1 Outline of Each Alternative Plan

Alternative	Alt. Route-1	Alt. Route-2	Alt. Route-3
Network Pattern	Full Ring	Full Ring	Partial Ring
Land Use	Mountain , Urban	Urban	Urban
No. of Lanes	4-lane dual	4-lane dual	4-lane dual
Design Speed	60 –80 km/h	60 – 80 km/h	60 –80 km/h
Max. Grade	5 %	3 %	3 %
Bridge Length	25.89 km	29.42 km	18.82 km
Tunnel Length	6.84 km	0	0
Earth Length	2.14 km	0	0
Total Road Length	34.87 km	29.42 km	18.82 km

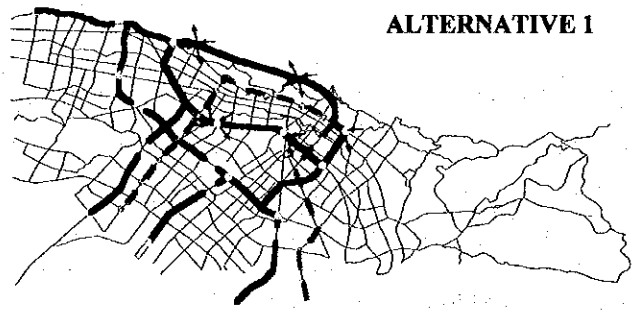


Figure 4-2 Locations of Alternative Routes

(3) Selection of Alternative Route

The alternative route-3 is selected as an optimum route from technical, economic and environmental viewpoints. The construction cost of alternative route-1 which passes through Av. New Cirucumbaral road located in mountainside is higher. Alternative-1, however, is very important for the future road network configuration of the city, because the trunk road network can contribute to the promotion of development activity. Approximately 30% of total length in Alternative-2 are difficult in construction method on Cra. 7a where SITM metro line is planned with tunnel structure.

(4) Traffic Volume on Selected Alternative Route

The future traffic volume in the year 2015 on the alternative route-3 is as shown in Figure 4-3. As can be seen, the future traffic volume on IRE is estimated at 33,000 pcu/day to 49,000 pcu/day.

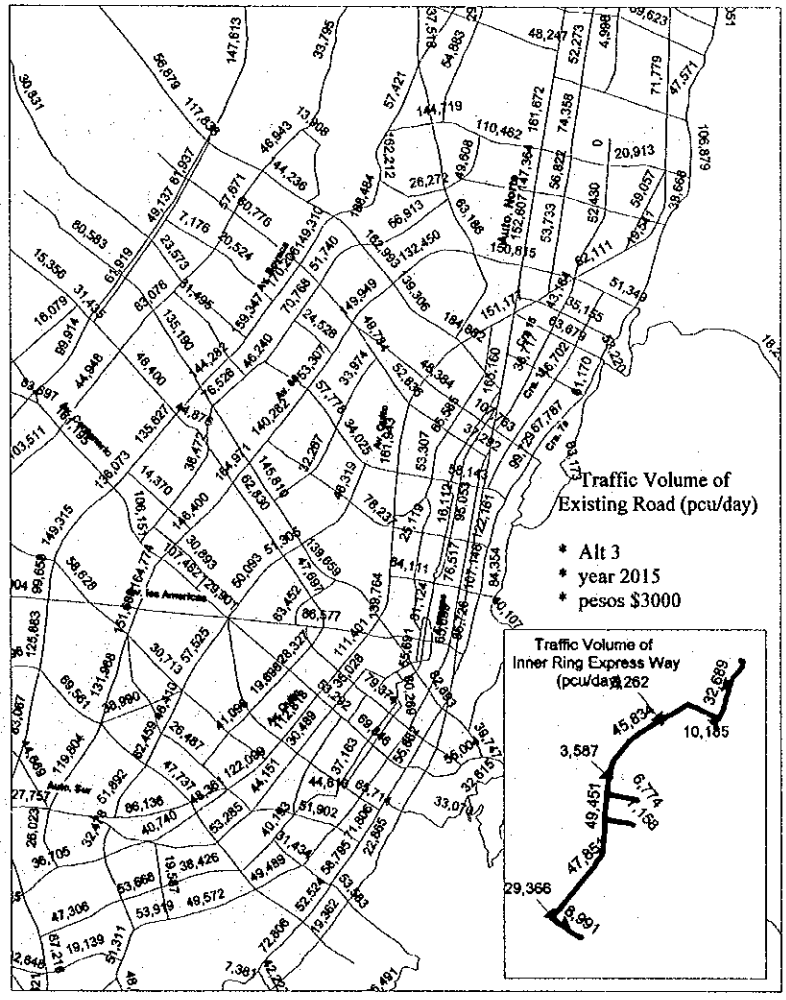


Figure 4-3 Future Traffic Volume on Existing Road and IRE in 2015

4.5. PRELIMINARY DESIGN FOR INNER RING EXPRESSWAY (IRE)

(1) Horizontal and Vertical Alignment

The alignment of IRE is planned along by Cra. 7a, Calle 100, Avenida Quito and Calle 6. Since the right of way on these roads maintains the width of 60m with a central median strip and sidewalks on both sides of road, these existing road spaces are utilized.

The horizontal alignment is decided at the center of the existing road in order to provide enough clearance space between IRE and buildings along the existing road.

The vertical alignment is designed taking into account the existing road conditions, such as the foundation structures, and span length of existing flyovers and/or pedestrian bridges over the Avenida Quito. The IRE is planned as elevated road. The proposed height is 14 meters from the existing road.

The general horizontal and vertical alignments are as shown in Figure 4-4.

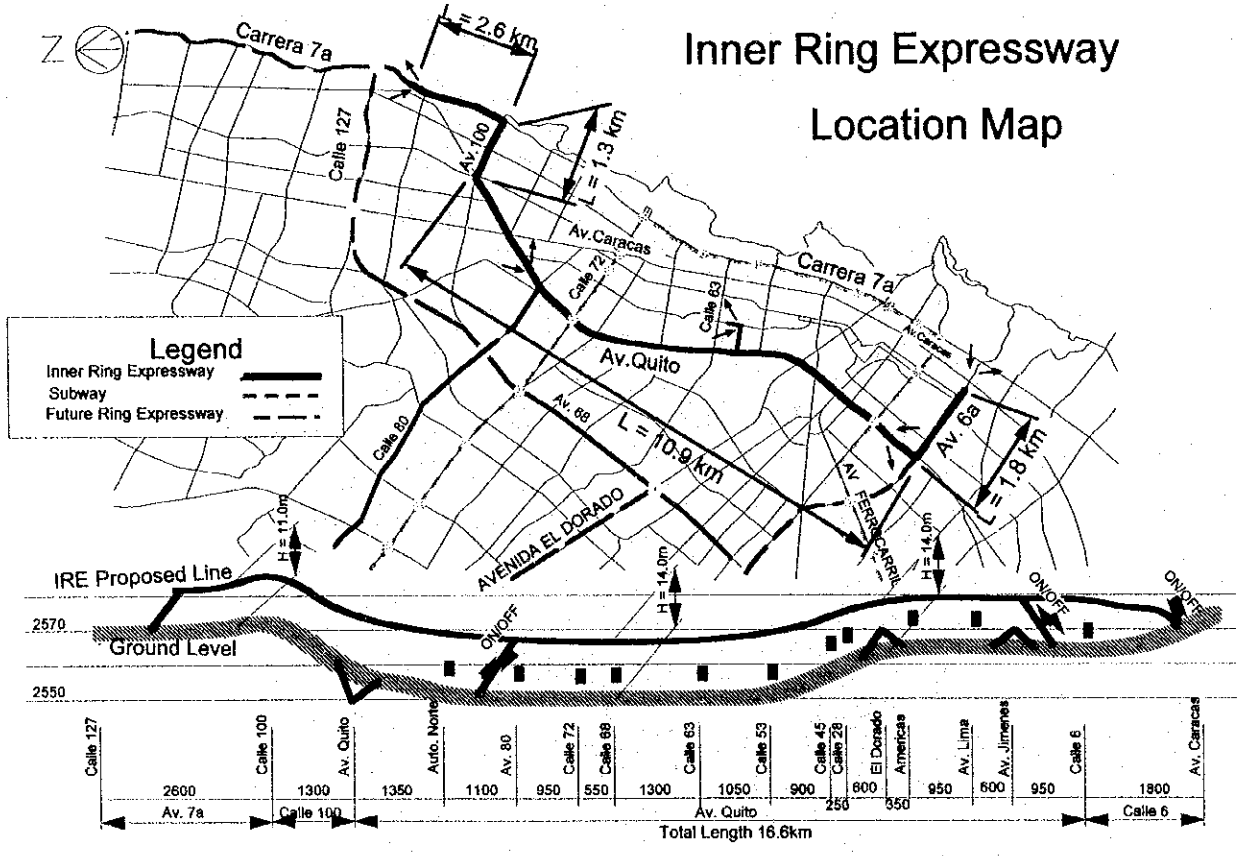


Figure 4-4 General Horizontal and Vertical Alignment of IRE

(2) Typical Cross Section

Several typical cross sections of a viaduct type structure by road segment of Av. Quito where the cross sections are different are designed. The dimension of each cross-section is as follows and typical cross sections are as shown in Figure 4-5.

1) Number of lanes: 2-lane dual carriageway
2) Lane width: 3.5 m
3) Median strip width: 1.0 m
4) Right shoulder width: 1.0 m
5) Left shoulder width: 0.5 m

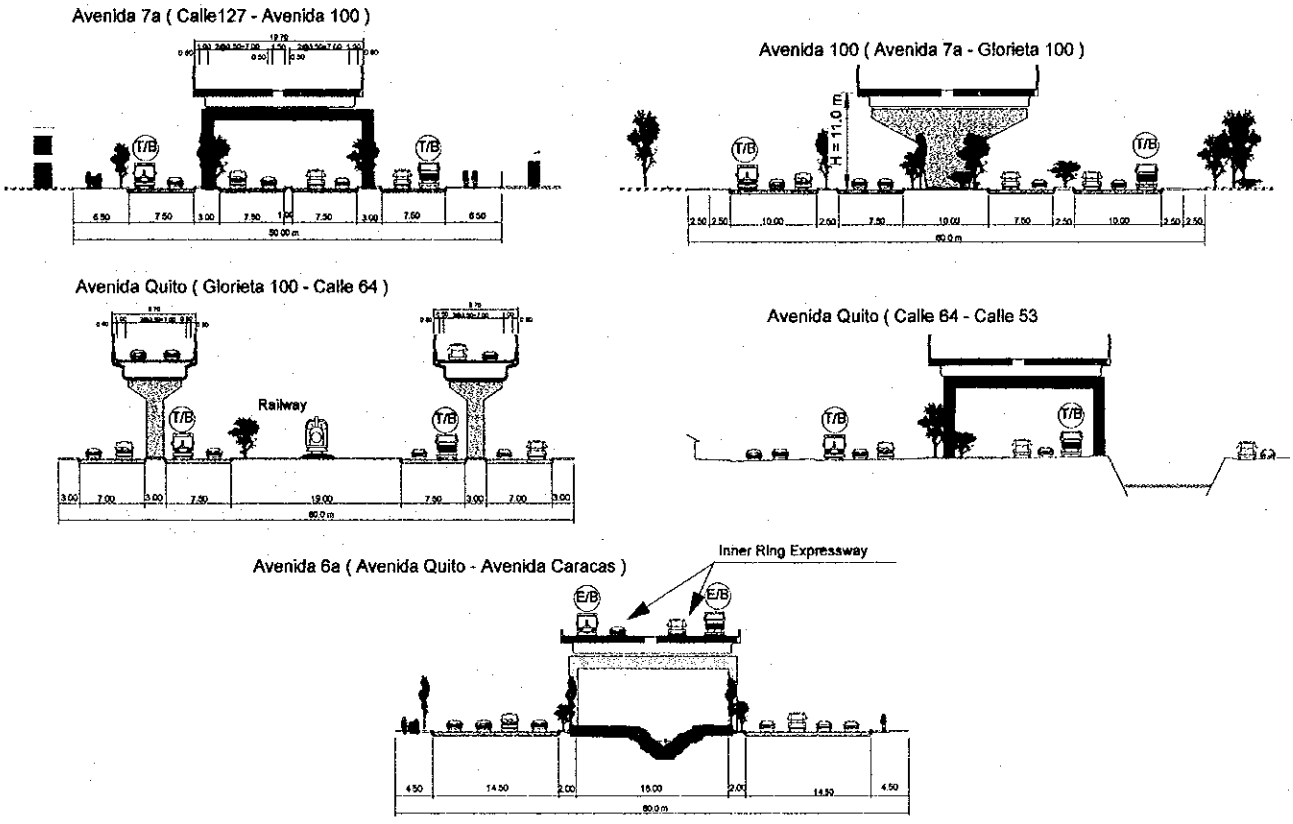


Figure 4-5 Typical Cross Sections

(3) Bridge Structure.

In Bogota, most of flyovers and bridges have been built as concrete structures. These bridges indicate appropriate design and high construction standard. In consideration of the above facts, a concrete viaduct, partially with steel structure, is recommended. PC concrete superstructure, which is a length of 30m span with bored pile foundation in a standard section is recommended as the most simple and economical structure. Viaduct span where it crosses over the existing flyovers, varies from 40m~50m. According to the results of the sub-surface soil investigation, the length of piles is determined at about 40m. The typical general view of IRE is shown in Figure 4-6.

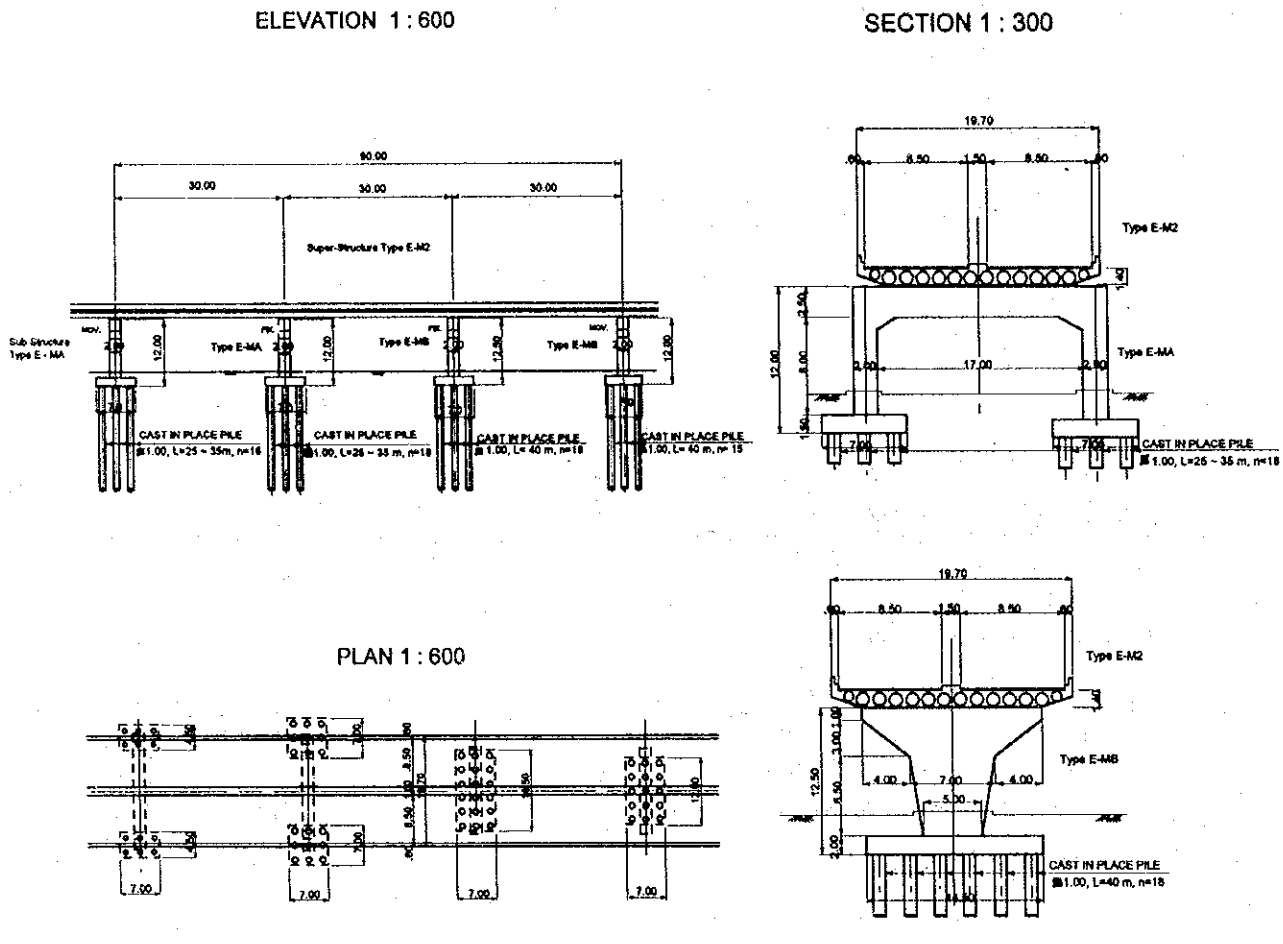


Figure 4-6 General View of Bridge on IRE

5. PROJECT COST ESTIMATE

The project cost is estimated in US dollars based on the preliminary design. The project cost consists of construction cost including overhead, engineering cost, administrative cost, and physical contingency, land acquisition and compensation. The project cost is estimated by using the prices of November 1998. The exchange rate is as below.

US dollar1.00 = Colombia Pesos 1,580

US dollar1.00 = Japanese Yen 116

The project cost of each project is shown in Table 5-1.

Table 5-1 List of Project Cost

Unit: 1,000 US Dollars in 1998

Name of Project	Scale of	Project Cost	Remarks
1. Trunk Busway Project			
1-1 Carrera 7a & Calle 10 Project	L= 25.15 km	19,409	1 de Major
1-2 Avenida Quito Project	L= 16.33 km	28,902	
1-3 Autopista Sur Project	L= 11.10 km	144,838	
1-4 Avenida Caracas Project	L= 17.58 km	371,754	Viaduct L=14.5km
1-5 Autopista Norte Project	L= 17.24 km	54,133	
1-6 Avenida Suba Project	L= 15.29 km	8,846	Calle 127
1-7 Avenida 68 & Calle 100 Project	L= 17.53 km	8,404	
1-8 Calle 170 Project	L= 5.12 km	3,050	
2. Bus Terminal Project			
2-1 Urban Bus Terminal	1 Vol.	59,751	
2-2 Sub-urban Bus Terminal Project	7 Vol.	18,715	
Sub Total (1+2)	125.32 km	717,802	
3. Inner Ring Expressway Project			
3-1 Inner Ring Expressway(IRE)	15.0 km	638,586	
Total Projects Cost		1,356,388	

The project cost on Avenida Caracas is estimated at approximately US$ 372 millions, of which the viaduct busway (L=14.5km) is approximately US$ 338 millions and the balance is for the trunk busway. Unit construction cost of the viaduct is approximately US$ 17 millions per km.

The project cost of IRE (L=16.6 km) is estimated at approximately US$ 639 millions out of which construction cost is approximately US$ 504 millions. Unit construction cost is approximately US$ 30 millions per km.

The project cost of Autopista del Sur is estimated at approximately US$ 145 millions. However, this cost includes the cost of flyovers of approximately US$ 110 millions. If excluding the flyover, the cost of at-grade trunk busways is estimated to be approximately US$ 35 millions.

6. IMPLEMENTATION PROGRAM AND INVESTMENT

6.1. IMPLEMENTATION PROGRAM

As mentioned in Chapter 3, the trunk busway projects are composed of eighteen (18) individual projects, while Inner Ring Expressway project is only one project. The implementation program of the project is prepared for a period of 7 years from 1999 to 2005, considering the following basic concept;

1) to balance investment required in each year,
2) to adjust a construction schedule among projects, and
3) to control traffic near an effected area while each project is under construction.

Figure 6-1 shows the implementation program.

Project Name and Cost	Length	1999	2000	2001	2002	2003	2004	2005
M US$	km	M US$	M US$	M US$	M US$	M US$	M US$	M US$
Avenida 7a	24.060							
18.897					0.746	10.319	7.832	
Autopista del Norte	17.240							
54.133		1.899	26.592	25.642				
Avenida Caracas/Viaduct	17.575							
371.754		9.696	76.475	126.926	126.926	31.733		
Avenida Primero de Mayo	1.090							
0.512						0.016	0.496	
Avenida Suba 1	13.150							
7.588		0.265	4.736	2.557				
Avenida Suba 2(calle 127)	2.140							
1.288				1.288				
Avenida Ciudad de Quito	16.325							
28.902				0.401	14.492	14.009		
Autopista del Sur/Flyover	11.095							
144.838		3.736	31.066	48.906	48.906	12.224		
Avenida 68-Calle 100	17.525							
8.404							3.627	4.777
Calle 170	5.120							
3.05							1.316	1.734
Central Bus Terminal								
59.751			20.041	19.066	16.515	4.129		
Suburban Bus Terminal 1								
3.282			2.311	0.971				
Suburban Bus Terminal 2								
1.564				0.306	1.016	0.242		
Suburban Bus Terminal 3								
2.002		0.179	1.415	0.438				
Suburban Bus Terminal 4								
3.264				0.726	2.075	0.463		
Suburben Bus Termianl 5								
2.689					0.009	2.201	0.479	
Suburban Bus Terminal 6								
1.939					0.013	1.311	0.0615	
Suburban Bus Terminal 7								
3.945						0.015	3.518	0.411
Inner Ring Expressawy	15.000							
638.586			11.122	26.090	67.965	205.587	205.586	122.236
1.356.388	140.32	15.775	173.758	253.317	278.663	282.249	223.469	129.158

Figure 6-1 Implementation Program

6.2. INVESTMENT REQUIRED

The investment required for each year is estimated based on the implementation program as shown in Figure 6-1. The largest amount, about US$ 282 millions, will be needed in the year 2003, and the average annual investment required from 2000 to 2005 is estimated at about US$ 223 millions.

1) In the year 1999 = US$ 16 millions
2) In the year 2000 = US$ 174 millions
3) In the year 2001 = US$ 253 millions
4) In the year 2002= US$ 279 millions
5) In the year 2003 = US$ 282 millions
6) In the year 2004 = US$ 223 millions
7) In the year 2005 = US$ 129 millions

6.3. DEVELOPMENT SCHEME AND INSTITUTIONAL ARRANGEMENT

(1) Development Scheme

1) Trunk Bus System

Infrastructures for the trunk bus system should be properly developed by the Government, which regards them as amenities to satisfy people's basic needs. In the long run, the trunk bus operation under the proposed bus fare rate of 600 pesos per ride will generate about US$ 70 million at the present value in an accumulated profit between 2000 and 2020 (balance of revenue and operation cost). On the current fare rate, however, this business will not pay. If it is possible for the bus companies to introduce a soft loan, the trunk bus business generates a few profits under the proposed fare rate. The loan is urgently needed to renew the current bus fleet. In principle, it is recommended that the profit is spent to upgrade the bus service or to reduce the bus fare.

2) Bus Terminals

The bus terminal projects are not only inevitable for the trunk bus system, but also highly profitable, possibly enough to invite private capital. As the private finance initiative (PFI) scheme such as BOT or BLT could be considered, necessary incentives to invite the private sector should be studied. Another way is that a new public bus company now under planning by the Municipal Government of Santa Fe de Bogota should undertake this project by itself. It would be a non-profit agency, and consequently, the terminal project can benefit to passengers or operators through expansion or upgrading of bus infrastructure or financing for new bus procurement. An advantage of this project is that the capital requirement is rather small.

3) Inner Ring Expressway

A PFI scheme is difficult to be applied to IRE project, because its FIRR is only 4.9%. However, its economic significance has been proven in this study. The EIRR is 16% or even higher unless constructed some trunk bus routes or a subway project is not implemented as scheduled. As an executing body for construction, maintenance and operation, establishment of such an agency as the Bogota Metropolitan Expressway Corporation is recommended. Therefore, the Government should seek a soft loan for the Public Corporation, for example, of few percent of interest rate with 5 to 10 year's grace. If the Government subsidizes a fund to solve the financial difficulty for the first ten year period when accumulated net profit is a deficit, the project can financially sustain itself. The total subsidized fund requirement will be less than 30% of the total investment.

(2) Institutional Arrangement

1) Legal Arrangement

Colombia has almost no experience with private sector-financing for urban transport infrastructure development. In order to introduce private capital to the infrastructure sector, laws and regulations should be established to specify the right and the responsibility of the public and private sector as well as the scope of incentive measures.

The new trunk bus system and the urban expressway will need a new organization with public nature to execute and operate these projects. Prior to setting up these organizations, relevant laws and regulations are to be enacted to give them a legal background.

2) Financial Arrangement

The Central and the Municipal Government should take an initiative to promote implementation of the projects proposed under this Study, especially in the field of financing. Private financing can be expected only for the terminal project. Other components will definitely need public financing. The Government has to seek every opportunity to raise the needed funds through official budgeting, bond issuance and international or domestic loan borrowing.

Another urgent financial issue is bus fleet renewal. More than a half of the current fleet has to be legally replaced in five years. This study also proposes to curtail about two thirds of the present bus lines within seven years. Most of bus operators have to be absorbed in the new scheme, preferably with new fleet. Most of present bus operators, however, have no capacity to procure a new bus by themselves. An institutional financing scheme has to be established to finance a bus purchaser with feasible conditions.

3) Public Corporation of Bus Service

The Municipal Government is now setting up a new public company for operation of new bus system. According to the plan, the company will administer all the trunk bus routes, assigning them to the operators in the private sector with large-sized buses. The company will have an important financial function to fairly redistribute a profit among the private sectors in a reasonable way. By doing this, the member operators can work as if they belong to one company and new services become possible such as fare reduction for transfer from a trunk bus to another or to a feeder bus and introduction of a common ticket system.

The public corporation plan seems good and appropriate. However, the company itself is a public one and it should be noted there are few examples in the world of successful operation of public transport directly operated by a government. A careful trial and error approach will be needed so as not to choke free competition and growth of a private sector by an excessive control and intervention by the public sector. To make this new trial successful, three conditions will be essential: (1) To establish a system for information collection and processing such as passenger volume by routes and proceeds, (2) To have a powerful and capable unit of planning and analysis and (3) To realize a open system of operational and financial information.

4) Continuity of Urban Transport Policy

In Bogota, it is not easy to execute a transport policy continuously pursued. One reason is that the high-ranked government officials in the position of decision making are changed too frequently. Under such circumstances, a policy tends to be a temporary one. Therefore, a long-term plan becomes more important in order to secure a continuity of policies and plans. A master plan should be authorized and have some security of continuation against the frequent personnel changes.

(3) Toward a Mass Transit System

Bogota has a long history of a rail transit plan but no single project has been realized yet. In some cases, the Government looked for private sector financing for an urban railway project. However, the required amount of initial investment was too large while passengers paying capacity was too low to invite private capital.

Many plans proposed Av. Caracas as the first priority route of a mass transit. The street is one of the routes with heaviest demand in Bogota city. In the Study, an elevated exclusive bus way is proposed along Av. Caracas. It will cost more than US$ 300 millions. However, according to our estimate, the time will be between the year 2015 to 2020 when the demand exceeds the capacity of bus transport.

We, therefore, recommend strongly to design the structure so as to accommodate future rail transit such as an LRT. For this, some modification of design will be needed in its vertical and horizontal alignment and the strength of the structure has to be checked, which will possibly increase the cost a little. However, by doing this, when the time comes, the express bus system can transform to a mass transit system smoothly with some additional cost. If the balance of the debt in the cost of the elevated structure is transferred from the trunk bus to the mass transit, financial viability of both projects will be significantly improved. A consensus formation for this policy is needed among related agencies as well as among citizens.

7. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The EIA study was carried out through the discussion with Ministry of Environment, DAMA and counterpart personnel of the Study based on the conducted preliminary design. In general, the damages or effects of construction of the projects on environment are not significant because the existing road area will be utilized for IRE project and trunk busway projects. In the EIA study, the following matters are pointed out.

1) Noise impacts in "With project (70 to 75 dBA)" and "Without project (70 to 75 dBA)" indicated almost same value as at the present.
2) These figures (70 to 75 dBA) are slightly higher than the standard value (65 to 70 dBA)
3) To decrease the noise impact, noise barriers are provided on the viaduct of express busway and IRE.
4) About 270 trees have to be removed for construction of IRE. These trees have to be re-planted on the sidewalks or medians to preserve a natural environment.
5) About 100 trees have also to be removed for construction of express busway on Avenida Caracas. These trees have to be re-planted on the sidewalks and medians.
6) Air pollution with project is lower than the Without project, due to the lower traffic volume.
7) As shown in Figure 7-1, there is no significant environmental damage from the viaduct on Avenida Caracas.

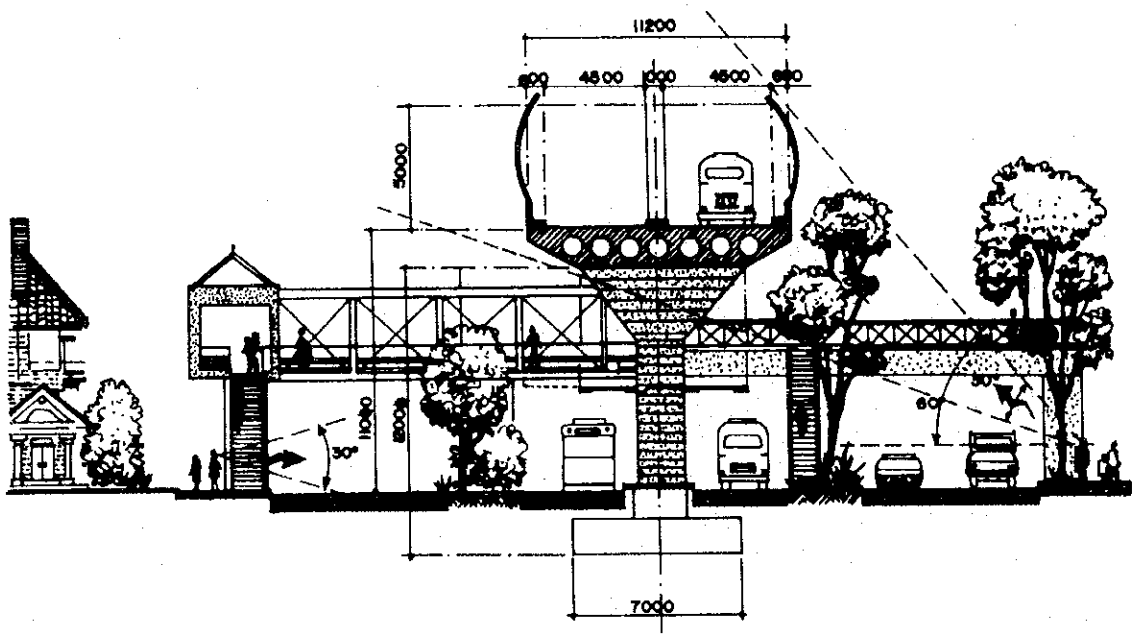


Figure 7-1 Elevation Angle of Viaduct From Avenida Caracas

8. ECONOMIC AND FINANCIAL EVALUATION

8.1. ECONOMIC EVALUATION

Economic evaluation was carried out on the Study projects by comparing the economic cost with the direct benefit to be generated by the projects i.e. savings in vehicle operating cost and travel time cost. The period of evaluation is 22 years from 1999 to 2020 and the residual value in 2020 is taken into the analysis. The economic discount rate is assumed at 12%, widely used in Colombia.

(1) Trunk Bus System Project

1) Project Cost

The economic costs are estimated as shown in Table 8-1, applying the shadow wage rate of 75% and deducting the transfer cost from the financial cost.

The market price of a large bus with the capacity of 100 passengers is US$ 140,000 which is converted to the economic price of US$ 120,690 and the price of an articulated bus is US$ 198,000, converted to US$ 170,690.

Table 8-1 Economic Cost of Trunk Bus Project (Million US$)

	Project	(A) Financial Cost	(B) Economic Cost	(B) / (A)
Study Project	Bus ways and Bus Lanes	639.3	559.3	0.88
	Terminals	78.5	73.0	0.93
Non Study Project	Bus ways, bus lanes and terminals	303.5	265.4	0.87

2) Economic Benefit

The trunk bus system project consists of three components of exclusive bus way / lane construction, rearrangement of bus routes and introduction of large buses. Economic benefit of the entire project is estimated at US$ 360 millions in 2005 and US$ 1,306 millions in 2015 (see Figure 8-1). About one-third of the benefit is attributed to the construction of bus way and lanes. The source of the benefit is about 40% by savings in the vehicle operating cost (VOC) and 60% by savings in the travel time cost (TTC).

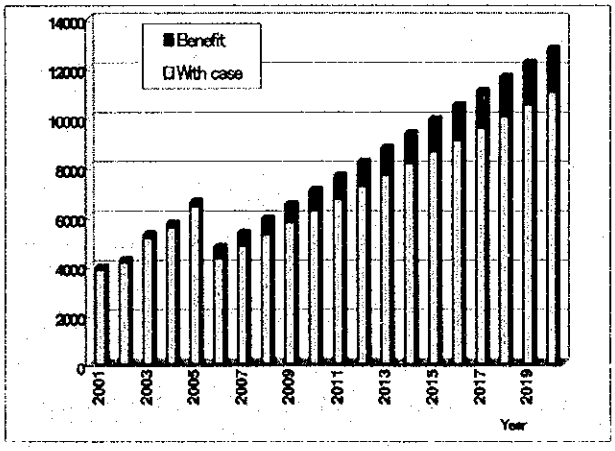


Figure 8-1 Economic Benefit by Year

3) Evaluation Results

The economic viability of the project is extremely high showing 44.6% of IRR and US$ 3,031 millions of NPV. Only 20% of the estimated benefit can make the project feasible (If so, IRR is 13.6%). Without rerouting and introduction of large buses, the construction of bus ways and lanes solely implies 23.7% of IRR. However, if the bus fare rises over 600 pesos per ride, the number of passengers will decrease and then IRR will become lower. Under 2,000 pesos per ride, IRR drops down to 16.6%.

(2) Inner Ring Expressway

1) Toll Rate

At the opening of the expressway in 2006, the toll rate is assumed at 2,000 pesos and gradually raised according to the rise of car users' paying capacity, to 3,000 pesos in 2015.

2) Economic Cost

The project cost is estimated to be US$ 638.5 millions at the market price. It corresponds to US$ 559.2 millions at the economic price.

3) Economic Benefit

The first year benefit is US$ 51 millions and reaches US$ 178 millions in 2015. Approximately 55% is due to savings in VOC and 45% in TTC.

4) Evaluation Result

IRR of the expressway project is estimated at 14.7% and the net present value (NPV) is US$ 89 millions. As the IRR is higher than the discount rate of 12%, the project is judged economically feasible. If the toll rate is raised, IRR will go down and a level of 5,000 pesos will make it marginally feasible at 12.6% (see Figure 8-2).

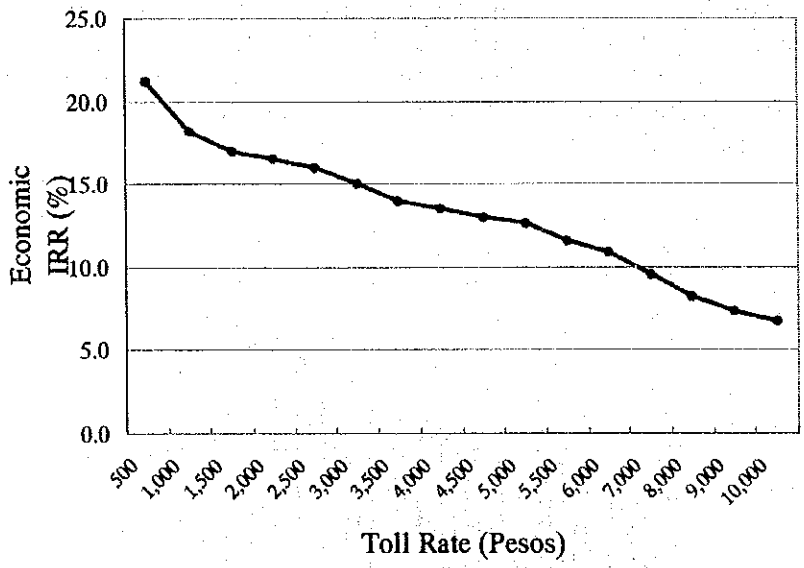


Figure 8-2 Toll Rate and IRR of Expressway Project

8.2. FINANCIAL EVALUATION

(1) Trunk Bus Project

1) Operating Cost

Annual operating cost of the trunk and express buses is forecasted as shown in Table 8-2, which includes depreciation cost and capital opportunity cost as well as running cost like fuel cost.

Table 8-2 Operating Cost of Trunk / Express Bus

Year	Vehicle-km (1000 v-km/day)			Annual Operating Cost (US$ million)		
	Trunk Bus	Express Bus	Total	VOC	Public Corp.	Total
2000	151	80	231	250.6	1.2	251.9
2005	712	120	832	970.4	1.4	971.7
2015	1,508	200	2708	1,001.3	1.6	1,002.9

2) Revenue

Fare level of the trunk and express buses is set at 600 pesos while the current bus fare is 430 pesos per ride in average. Table 8-3 shows annual revenue of trunk and express buses.

Table 8-3 Passengers and Fare Revenue of Trunk / Express Bus

Year	Passengers (1000pax/day)			Annual Fare Revenue (US$ million)		
	Trunk Bus	Express Bus	Total	Trunk Bus	Express Bus	Total
2000	1,198	816	2,014	150.1	102.3	252.4
2005	6,038	1,356	7,394	767.7	172.6	940.3
2015	6,980	1,584	8,564	874.7	198.5	1,073.2

3) Accumulated Net Profit

Figure 8-3 illustrates the changes of accumulated net profit (without tax) by the trunk and express bus business, under several fare levels. The profit and loss is almost balanced until 2005 under the proposed rate of 600 pesos per ride. After the year 2006 when all lines are open, a slight loss will continue for three years but the accumulated loss will be canceled by 2011 and the balance will reach US$ 557 millions in 2020 which is equivalent to US$71 millions at the present value. By the current fare of 430 pesos, this business will not pay. On the contrary, fare rates higher than 600 pesos will cause a serious money shortage in the early stage, although the final balance will be much higher.

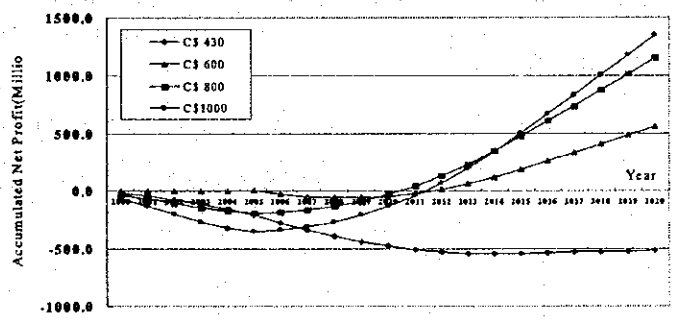


Figure 8-3 Accumulated Net Profit of trunk /Express Bus Business

(2) Bus Terminal

It is assumed that the central terminal and other suburban terminals are managed by one entity.

1) Investment and Operation Cost

Total investment amount is US$ 82 millions, of which 73% is for the central terminal. Cost of maintenance and operation by a company with about 150 employees is in the range of US$ 1.6 – 1.7 millions per annum (see Table 8-4).

Table 8-4 Investment Amount of Terminal Projects

(Million US$)

	1999	2000	2001	2002	2003	2004	2005	Total
Central Terminal	-	20.0	19.0	16.5	4.1	-	-	59.7
Other Terminals	0.2	3.7	2.4	3.8	4.9	5.6	1.5	22.2
Total	0.2	23.7	21.4	20.3	9.0	5.6	1.5	82.0

2) Revenue from Terminal Charge

Table 8-5 shows patronage and revenue of urban bus terminal project. The basic terminal charge is assumed 2,000 pesos for every entrance of a trunk bus to a suburban terminal and 1.5 times of the rate is charged on an articulated bus for express service. The central terminal charges is 1.5 times the charges for a suburban terminal. Total use will be 30,000 entrances a day in 2005 and 40,000 entrances in 2015. Thus, annual revenue will be US$ 15.5 millions and US$ 20.3 millions, respectively.

Table 8-5 Patronage and Revenue of Urban Bus Terminal Project

Year	Patronage (Daily Entrance)			Annual Revenue(Million US$)		
	Central	Others	Total	Central	Others	Total
2005	9,000	21,000	30,000	6.1	9.4	15.5
2015	12,000	28,000	40,000	8.2	12.2	20.3

3) Evaluation Result

Table 8-6 shows IRR of terminal project by change of terminal charge. Under the basic charge of 2,000 pesos, IRR is estimated at 7.5% for the central terminal and 48.3% for the suburban terminals. If aggregating them together, IRR becomes 16.0% and NPV is US$ 30.4 millions. This rate is high enough to attract private capital. Due to the high construction cost, profitability of the central terminal is rather low, which is covered by the profit of the suburban terminals. If the rate becomes below 1,500 pesos, IRR will also be lower than 12%, application of a PFI scheme will become difficult. Nevertheless, it will be still financially viable if a non-profit public organization undertakes the project, using a bilateral or international soft loan.

Table 8-6 IRR of Terminal Project by change of Terminal Charge

Terminal Charge	Central Terminal	Other Terminals	All Terminals
500	-1.6	5.9	0.7
1000	2.0	19.2	6.6
1500	5.0	32.9	11.6
2000	7.5	48.3	16.0
2500	9.8	65.5	20.0
3000	11.9	84.3	23.8

(3) Inner Ring Expressway

A new organization such as the Bogota Metropolitan Expressway Corporation could undertake to construct, maintain and operate the expressway.

1) Investment and Operating Cost

A sum of US$ 638.5 millions will be invested during 1999 – 2005 and the expressway will open in early 2006. Maintenance and operation cost is estimated at US$ 1.4 millions which will gradually increase up to US$ 2.1 millions in 2020.

2) Patronage and Toll Revenue

In the opening in 2006, the number of vehicles using the expressway (patronage) will be 33,200 in PCU and will grow rapidly due to a heavier congestion on the ordinary roads, to 130,000 in 2015. Assuming the toll rate at 2,000 pesos for year 2006 and 3,000 pesos for 2015, annual toll revenue will be US$ 14.6 millions and US$ 81.3 millions, respectively.

3) Evaluation Result

Although the expressway project is economically feasible, the financial IRR is 4.9% and the project hardly seems attractive to the private sector. With no special conditions, private capital will have no interest. As the project implies FIRR of almost 5% in real terms, a soft loan should be sought in order to bear a repayment of principal with interest. If the toll rate is changed, FIRR varies as shown in Figure 8-4.

If the construction is postponed, the curve will shift upward. It may be an alternative to wait until the project becomes matured financially.

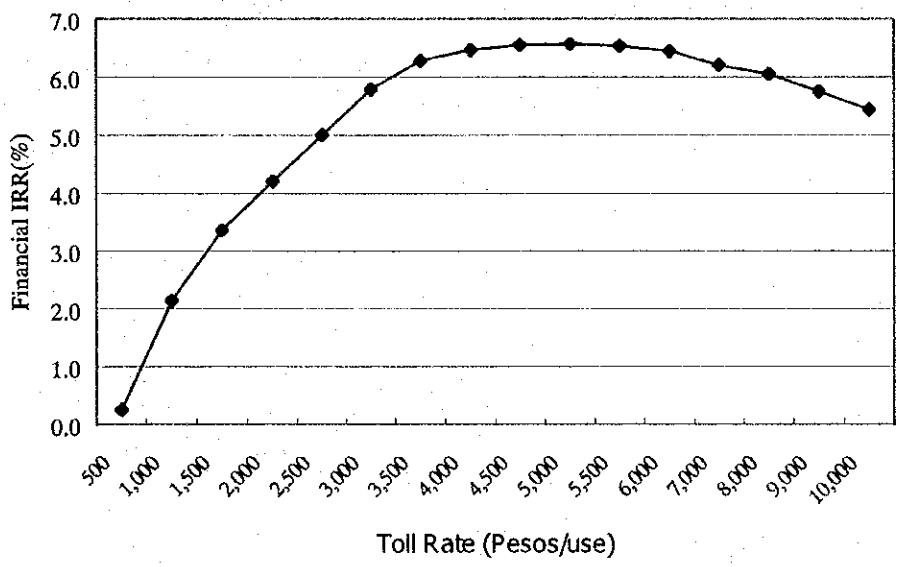


Figure 8-4 Financial IRR of Expressway Project by Toll Rate

9. RECOMMENDATIONS

(1) Necessity for Implementing of the Projects Recommended by Feasibility Study

The Master Plan was conducted by JICA over a period of two years from 1995 to 1996, and the various projects were recommended to improve the traffic congestion and maintain sound activities in Bogota. Following the Master Plan, the Feasibility Study for trunk busway and inner ring expressway projects, which were recommended by the Master Plan as the high priority projects as well as the urgent implementation projects, were conducted. As the implementation of projects recommended under the Study will contribute to the followings, it is necessary to implement these projects as soon as possible:

1) to mitigate and to reduce traffic congestion as well as traffic accidents;
2) to contribute in setting up to maintain a modernized bus transport system, to ensure safety of bus operation system and to increase the use buses by shifting from private car use;
3) to contribute to the social and natural environment by reducing air pollution; and
4) to increase economic and social activities.

(2) Trunk Busway System and Type of Bus Vehicles

As shown in Table 9-1, three types of the trunk bus system are recommended together with the introduction of new types of buses with 100 passenger capacity (single-body bus) for trunk busway and priority lane, and 200 passenger capacity (articulated bus) for express busways.

Table 9-1 Recommended Trunk Busway Type and Bus Vehicles

Type of System	Relation of Private traffic	Type of Busway	Location of Busway on Existing Road	Capacity of Bus Vehicle	Operation Speed to be Ensured	Bus Stop Spacing
1) Express Busway System	Fully Segregated	Elevated At-grade	Center-lane	200 passengers	30 km/h	1,000 ~ 1,500 m
2) Trunk Busway System	Partially Segregated	At-grade	Center or Side –lane	100 Passengers	20~25 km/h	500 ~ 600 m
3) Bus Priority Lane System	Non Segregated	At-grade	Side-lane	100 Passengers	20~25 km/h	500 ~600 m

(3) The Projects and Operation System of Trunk Busway

A total of eleven (11) trunk busways and bus terminal projects are examined under the Study, out of which, preliminary design is conducted for eight (8) trunk busways. Preliminary design is also conducted for one central urban and seven (7) sub-urban bus terminal projects. As shown in Table 9-2, bus operation systems and bus terminals are recommended and the project cost are estimated.

Table 9-2 Recommended Operation System of Each Busway

Name of Project	Scale of Project	Operation System Introduced	Project Cost (Mill. US $)	Remarks
Trunk Busway Project				
1) Carrera 7a and Carrera 10 Project	L=25.15 km	Bus priority lane	19,409	1 de major
2) Av.enida Quito Project	L=16.33 km	Trunk buawy system	28,902	
3) Autopista Sur Project	L=11.10 km	Express busway system Trunk busway system	109,987 34,851	Bridges At-grade
4) Avenida Caracas Project	L=17.58 km (14.5 km)	Express busway system Trunk busway system	337,960 33,794	Viaduct At-grade
5) Autopista Norte Project	L=17.24 km	Express busway system Trunk busway system	54,133	
6) Avenida Suba Project	L=15.29 km	Bus priority lane	8,846	Calle 127
7) Avenida 68 and Calle 100 Project	L=17.53 km	Trunk busway system Bus priority lane	8,404	
8) Calle 170 Project	L=5.12 km	Bus priority lane	3,050	
Bus Terminal Project				
1) Urban Bus Terminal	1 Vol.		59,751	
2) Sub-urban Bus Terminal Project	7 Vol.		18,715	
Total	125.32 km		717,802	

(4) Viaduct on Avenida Caracas Needed for Express Busway

As for the bus transfer demand on Avenida Caracas in the year 2005, 30,000 to 35,000 passengers per direction in the morning peak hour per direction are predicted. It is very hard to transport these large number of passengers safely and maintain smooth traffic flow only by 4-lane at-grade road. For improving the above, the viaduct type express busway system with noise barrier is recommended to improve traffic congestion, maintain city activities and mitigate air pollution. The proposed viaduct is about 14.5km and the project cost is about US$ 338 millions. The project is judged economically and financially feasible.

Although a viaduct type express busway system is introduced, the bus transport demand on Avenida Caracas will reach the limit of bus transport system in around 2015 to 2020. Therefore, some kind of mass transit system on Avenida Caracas will become necessary in the future. As for the smooth transfer from busway system to a mass transit system, the structure has to be so designed to accommodate and meet the future requirements.

(5) Inner Ring Expressway (IRE) Project

In order to reduce traffic congestion in the city, viaduct type IRE is recommended. The project is economically feasible. The difference in noise impact between "With project" and "Without project" is not significant along the roadside. However, noise barrier is

provided to the section passing near residential areas and near schools or hospital. The recommended road system and the structure of IRE are summarized in Table 9-3.

Table 9-3 Recommended Inner Ring Expressway Structures

Items	Contents	Remarks
1) System of Road	Full access control Toll road system	
2) Design Speed	60 ~ 80 km/h	
3) Number of Lane	4-lane dual carriageway	W= 3.5 m
4) Type of Road	Viaduct on the all section	H=11 ~ 14 m
5) Length of Road	15.0 km	
6) Number of Ramp	4 locations	2-lane ramp
7) Utilized Existing Roads	On car.7a from Calle 127, Calle 100, Av. Quito, Car.6 to Caracas.	Center of road is selected for IRE
8) Noise Protection Walls	Special residential areas, Hospitals, schools	H=3 m
9) Project Cost	US $ 638,587 million	

(6) Financial Resources and Implementation Organization

Total investment cost for implementation of the busways and IRE projects is estimated at US $ 1,356 millions. The investment cost from the year 2000 to 2005 is also estimated at about US $ 130 millions to 282 millions. Apparently, these investment costs exceed the budget of Bogota Municipality in recent years. For the early implementation of the projects, certain financial resources should be sought immediately.

In Bogota, it is not easy to execute a transport policy which is continuously pursued. It may be because the high-ranked government officials in the position of decision making are changed too frequently. Under such circumstances, a policy tends to be a temporary one. A long-term plan becomes more important in order to secure a continuity of policies and plans. Thus, for the urgent execution and continuity of the project recommended in the Study, establishment of a stable authority and organization is vital.

(7) Further Studies

In order to proceed with the implementation of the projects recommended by the Study, some further works are required in the next stage.

The Detailed Design of the following projects should be conducted urgently.

1) Busways for the express bus and trunk bus systems on Avenida Caracas and Autopista del Norte.
2) Busways for the express bus and trunk bus systems on Autopista del Sur.

Since 1995, the seismic design method became applicable for bridge design in Colombia. However, the bridges constructed before 1995 did not apply seismic design. In order to ensure soundness and strength of the existing infrastructure in the city, review of the structure design as well as physical inspection of the existing bridges including pedestrian bridges and other infrastructures should be required so their strengthening against earthquakes and other disasters will be carried out.

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Note; * Predecessor

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