CHAPTER 16
Construction Planning and Cost Estimate

16. CONSTRUCTION PLANNING AND COST ESTIMATE

16.1. GENERAL

This chapter describes construction planning and set up a program as well as cost estimate for facilities of trunk busway system and inner ring expressway. Both the construction planning and the cost estimate are based on the design described in Chapters 14 and 15.

Since the construction works are carried out on the existing roads under heavy traffic, it is most advisable to select construction methods to avoid interference with traffic and to minimize the construction period and cost.

In section 16.2, most appropriate construction method, block numbers and working program for each project are defined. In section 16.3, quantities for each projects are indicated. In section 16.4, detailed cost of each project consisting of construction cost, land acquisition and compensation cost, engineering cost and contingency are included. In Section 16.5, maintenance costs are indicated.

Technical capacity and procurement of materials in the region are described in section 15.5.BRIDGE DESIGN of chapter 15.

Projects are classified as:

1) Trunk Busway Facilities

1) Carrera 7a to Crrera10a
2) Autopista del Norte
3) Avenida Caracas with Express Bus Viaduct
4) Avenida Primero de Mayo
5) Avenida Suba
6) Avenida Suba 2 (Calle 127)
7) Avenida Ciudad de Quito
8) Autopista del Sur and Calle 6 with Flyovers / Viaducts
9) Avenida 68 to Calle 100
10) Calle170
11) Central Urban Bus Terminal
12) Suburban Bus Terminals

2) Inner Ring Expressway (Av. 7a ~ Calle 100 ~ Av. Ciudad de Quito)

16.2. CONSTRUCTION PLANNING AND PROGRAM

16.2.1. CONSTRUCTION PLANNING FOR TRUNK BUSWAY FACILITIES

(1) Carrera 7a to Carrera 10a (Proposed Length = 24.06km)

This stretch consists of three sections namely Inner Ring Expressway section (Calle 123 to Calle 100 - about 2.1km), double lane dual trunk bus ways section (Avenida 10,Calle 125 to Calle 35S - about 6.78km) and the remaining section of single bus priority lane segregated from other vehicles by color asphalt pavement.

Construction method of Inner Ring Expressway section will include the following works:

1) to rearrange carriageway (removal and provision of concrete curb, gutter, median, side walk and drainage system),
2) to scarify the existing asphalt concrete pavement by 4cm thickness,
3) to spray asphalt tack coat,
4) to pave,
5) to mark lanes and
6) to carry out other incidental works

At Carrera 10 section (approx. 6.78km), double lane bus priority ways are provided. And section between Calle 20S and Calle 35S (approx. 1.4km), double lane busways are provided at center median side (W=8.0m).

Construction method for widening section will include the following works:

1) to remove existing center median,
2) to excavate, lay geotextile and back fill with selected material,
3) to lay and compact subbase and base course,
4) to provide concrete curb, drainage and median,
5) to carry out asphalt paving and color pavement,
6) to mark lanes and
7) to carry out other incidental works.

(2) Autopista del Norte (Proposed Length = 17.24km)

Double lanes for express bus and trunk bus system are provided at center median side of the stretch. A main water supply pipe line (ϕ 1,500m/m) for the city runs under ground along the center of Autopista del Norte between suburban bus terminal and Calle 172 section (approx. 7.4km), and continues under ground along the right side of center median between Calle 172 and Calle 129 section (approx. 4.3km).

The first section of the above work requires color pavement for bus priority lanes and also pavement on shoulder portion to protect bus priority lanes. Construction method of this section is similar to Carrera 7a –Carrera10a.

At the second section on the above, the centerline has to be shifted from present line approx. 5.5m to the left to provide bus priority lanes.

The construction method of this section will include the following works:

1) to remove existing center median, curb, drainage system,
2) to excavate, lay geotextile and back fill with selected material,
3) to lay and compact subbase and base course,
4) to provide concrete curb, drainage and median,
5) to carryout asphalt paving and color pavement,
6) to mark lanes,
7) to build bus stops including pedestrian bridges and
8) to carry out other incidental works.

At the remaining section (Calle 129 to Calle 80 at Avenida Caracas), express bus and trunk bus systems are provided at the center of the stretch with color pavement. The major construction items on the stretch are widening of carriageway to the inner median to provide additional two lanes at each side, provision of median for bus and other traffic and provision of concrete curb and drainage system.

(3) Avenida Caracas with Express Bus Viaduct

1) Bus Lane Improvement (Proposed Length = 24.06km)

Trunk busway system on this stretch has two different sections. On selection between Calle 80 and Calle 48A (approx. 15.5km), where a viaduct for single lane dual carriageway express busway will be built and trunk bus runs under the same. On other section, between Calle48A and suburban bus terminal (approximately 3.6km), where a single lane dual carriageway for trunk and express bus will be provided.

Construction of trunk busway under the viaduct will include following works:

1) to remove existing center median, curb, drainage system and sidewalk,
2) to prepare temporary work for viaduct construction,
3) to excavate, lay geotextile and back fill with selected material,
4) to lay and compact subbase and base course,
5) to provide concrete curb, drainage and median,
6) to carry out asphalt paving and color pavement,
7) to mark lanes,
8) to build bus stops and pedestrian bridges and
9) to carry out other incidental works.

The second section requires color pavement for bus lanes. Construction method on the section is similar to Carrera 7a – Carrera10a.

2) Express Bus Viaduct

In order to avoid interference of existing traffic and to maintain carriageway as much as possible, the construction will be carried out day and night. As shown in Figure 16.2-1, the foundation and substructure construction will include the following works:

1) to drive sheet pile together with temporary bracing,
2) to place temporary deck cover after primary excavation,

3) to drive ϕ 1.0m bored piles,
4) to carry out foundation excavation after all the piles are driven,
5) to place blinding concrete, treat pile head and assemble reinforcing bars and
6) to install form-work for pile cap concrete,
7) to erect reinforcing bars and form-work for pier and place pier concrete,
8) to carry out back-filling, deck cover removal, sheet pile extraction and paving,
9) to assemble bracket /support for supporting soffit of pier head/beam and
10) to assemble reinforcing bars and form-work for placing pier head/beam concrete.

Working area shall be protected from traffic by movable type safety barrier and/or fence with colored blinking lights and illumination for night work.

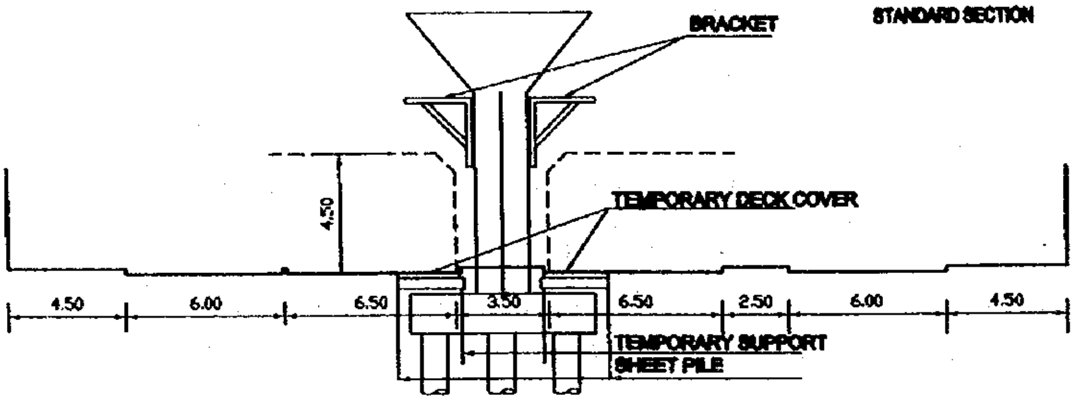


Figure 16.2-1 Express Bus Way Viaduct – Sub Structure

As shown in Figure 16.2-2, superstructure work will be carried out by employing advanced shoring method which will place Hollow Slab/ Box Girder deck concrete and travel span by span without any interference to road traffic. However, taking the existing traffic condition into account, the major activities of works are to be carried out during nighttime when the traffic is lighter.

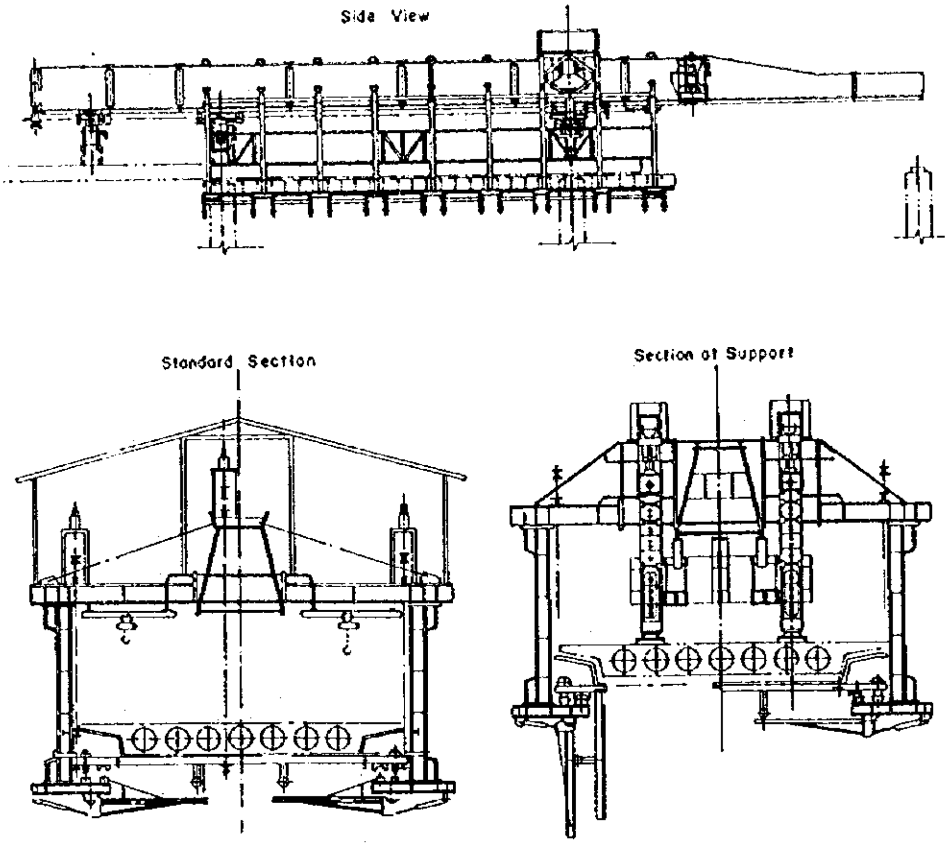


Figure 16.2-2 Express Bus Viaduct - Advanced Shoring

Number of blocks for the project is divided into twenty-three (23) of maximum 750m in length.

During the construction, as shown in Figure 16.2-3, existing traffic lane will be reduced especially at where bus stop is constructed thus, Avenida Caracas should be reserved mainly for buses. And as shown in Figure 16.2-4,ordinary passenger cars and other vehicle shall be diverted to Carrera 7a – Carrera 10a for the North bounds and Avenida Ciudad de Quito for the South bounds as much as possible in order to have a smooth traffic on the road. Due to this circumstance, some modification of existing bus stop may be required as shown in Figure 16.2-5.

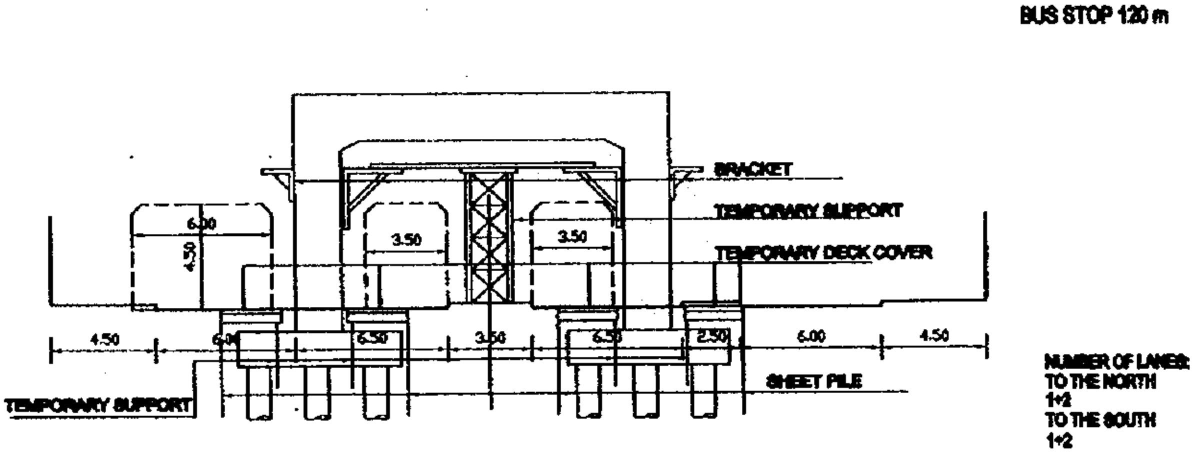


Figure 16.2-3 Express Bus Way Viaduct – Bus Stop

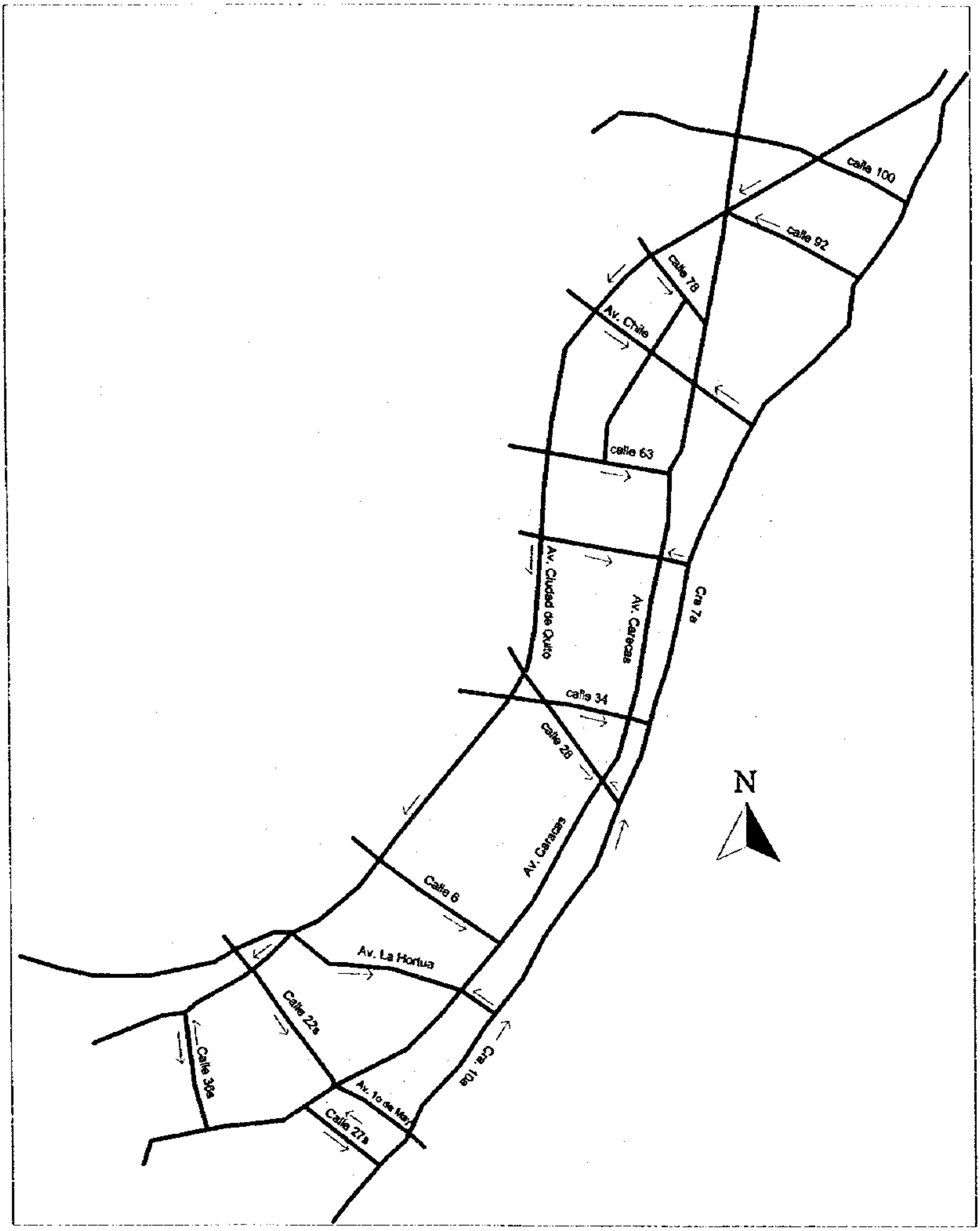


Figure 16.2-4 Express Busway Viaduct – Traffic Diversion

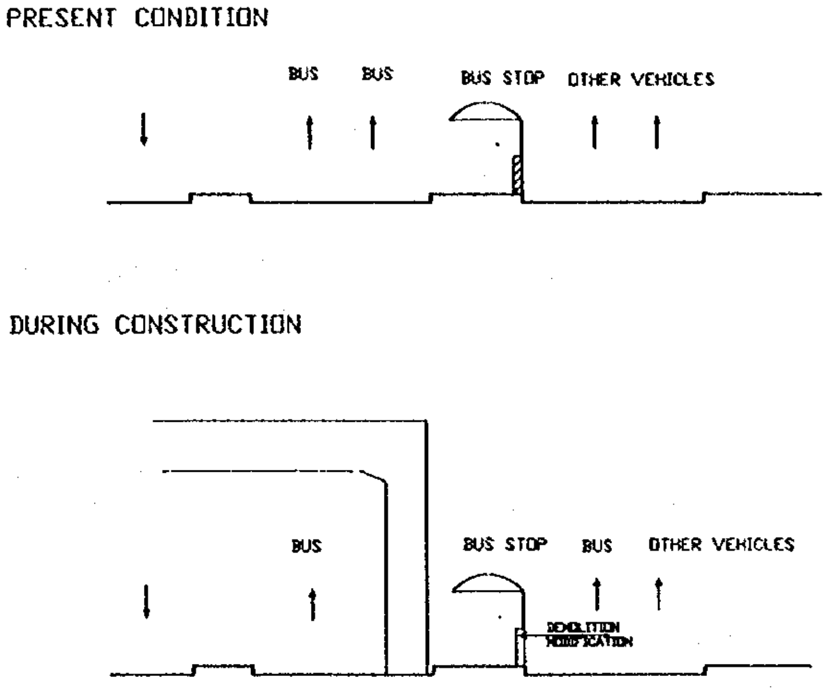


Figure 16.2-5 Modification of Bus Stop

(4) Avenida Primero de Mayo (Proposed Length = 1.09km)

Bus priority lane of this segment requires color pavement and construction method is similar to Carrera 7a – Carrera 10a.

(5) Avenida Suba (Proposed Length = 13.15km)

Bus priority lane of this segment requires color pavement and construction method is similar to Carrera 7a – Carrera 10a.

(6) Avenida Suba 2 (Calle 127) (Proposed Length = 2.14km)

Bus priority lane of this segment requires color pavement and construction method is similar to Carrera 7a- Carrera 10a.

(7) Avenida Ciudad de Quito

Trunk bus system is required for this segment. In addition, following items are to be considered for the construction of bus lane.

1) Total 1.1km of new road construction at the beginning section of the segment is required under this project.
2) Between Calle 100 and Calle 13(end of project), the location of pier for inner ring expressway is to be carefully considered.
3) Between Calle 100 and Autopista El Dorado, bus priority lane will be provided at inner side of inner median.

Construction method of this segment is similar to Carrera 7a – Carrera10a.

(8) Autopista del Sur with Flyovers

1) Bus Lane Improvement (Proposed Length = 11.09km)

This segment will involve the trunk and express busway system. Tollowing construction requirements are to be considered.

1) Express and trunk bus lane at the center of road.
2) Flyovers are to be constructed at major intersections.
3) Widening at east side of the segment from Calle 8S intersection at SANTA MATILDE to Calle 12 intersection at PRIMAVERA is to be included in this project.

Construction method of this segment is similar to Autopista del Norte.

2) Flyovers

In order to avoid interference with existing traffic and maintain carriageway as much as possible, the works are to be carried out day and night. As shown in Figure 16.2-6. The substructure construction will include the following works:

1) to drive sheet piles together with temporary bracing,
2) to place temporary deck cover after primary excavation where required,
3) to drive ϕ 1.0m bored piles,
4) to carry out foundation excavation after all the piles are driven,
5) to place blinding concrete, to treat pile head and assemble reinforcing bars and to install form-work for pile cap concrete,
6) to assemble reinforcing bars and form-work for pier and place pier concrete,
7) to carry out back-filling, deck cover removal, sheet pile extraction and paving,
8) to assemble bracket /support for supporting soffit of pier head/beam and
9) to assemble reinforcing bars and form-work for placing pier head/beam concrete.

Working area shall be protected from traffic by movable safety barrier and/or fence with colored blinking lights and illumination for night work.

As shown in Figure 16.2-6, superstructure work will be carried out:

1) to erect Precast Pre-Stressed beams, and
2) to assemble form-work and reinforcing bars to place deck concrete.

Taking the existing traffic condition into account, the major activities of the works will be carried out during nighttime.

Sections at Calle 6 junction and between Calle 2s and Calle 30s are of the same type and method as that of Express Bus Viaduct at Av. Caracas as shown in Figure 16.2-1.

Land acquisition at east side of the segment from Calle 8S intersection at SANTA MATILDE to Calle 12 intersection at PRIMAVERA shall be completed prior to the commencement of the project.

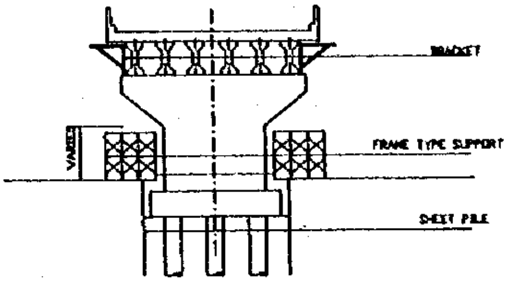


Figure 16.2-6 Autopista Sur Flyover – Typical

(9) Avenida 68 ~ Calle 100(Proposed Length = 17.53km)

Bus priority lane of this segment requires color pavement. Construction method is similar to Carrera 7a – Carrera10a.

(10) Calle 170(Proposed Length = 5.12km)

Bus priority lane of this segment requires color pavement. Construction method is similar to Carrera 7a – Carrera 10a.

(11) Central Urban Bus Terminal

Central Urban Bus Terminal to accommodate both of express bus system and trunk bus system will be built in an area of 144.0m x 147.0m between Calle15 and Calle17 at west side along Avenida Caracas. The terminal is partially a 2-story structure with mezzanine floor. The building will be of reinforced concrete supported by cast insitu piles and has 124.0m x 139.0m of area on the first floor and 124.0m x 88.0m on the second floor with height clearance of 11.0m.

The first floor will mainly serve the trunk bus system and the second floor will serve the express bus system only.

The first floor will be connected with Avenida Caracas and Avenida Ciudad de Lima by access roads and the second floor will be connected with the Express Bus Way Viaduct over Avenida Caracas by on-off ramp of level crossing.

As shown in Figure 16.2-7, construction method of the terminal will include the following works:

1) demolition of existing buildings and structures,
2) to level ground,
3) to drive ϕ 1.0m cast insitu piles,
4) to excavate for pile caps,
5) to place blinding concrete and treat pile heads,

6) to assemble reinforcing bars and forms and place pile cap concrete,
7) to assemble reinforcing bars and forms and place 1st lift of column concrete to support mezzanine floor,
8) to erect framed supports for mezzanine floor beams,
9) to assemble form work and reinforcing bars for placing mezzanine floor beam concrete,
10) to erect pre-cast pre-stressed floor beams and place mezzanine floor concrete,
11) to assemble reinforcing bars and form works for placing 2nd lift of column concrete 12)
12) to support 2nd floor,
13) to erect framed supports for 2nd floor beams and floor,
14) to assemble form works and reinforcing bars for placing 2nd floor beam concrete,
15) to place cast insitu pre-stressed hollow slab,
16) to build stair cases and pedestrian bridges,
17) to excavate, lay geotextile and back fill on the 1st floor,
18) to provide concrete curb, drainage and median on the 1st floor,
19) to build bus bays and pedestrian bridges on the 1st floor,
20) to carry out paving and color pavement on the 1st floor,
21) to build bus bays on the 2nd floor,
22) to pave the 2nd floor and
23) to carry out other incidental works such as provision for elevators, illumination etc.

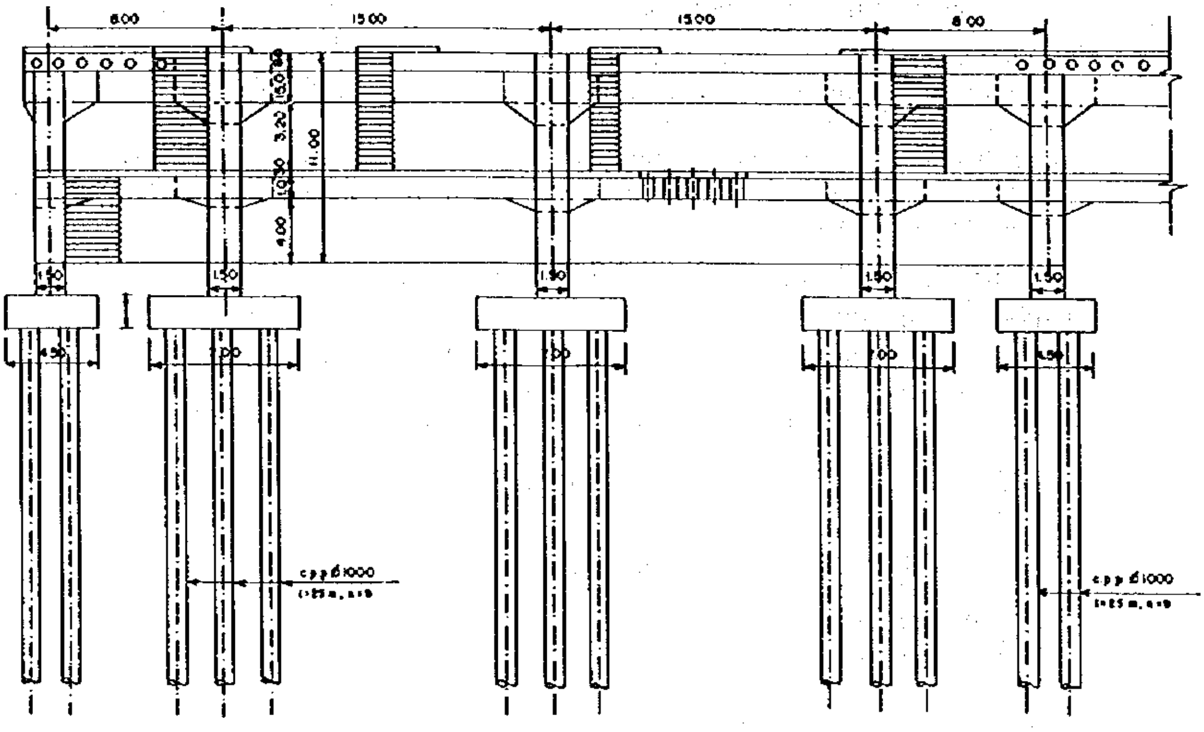


Figure 16.2-7 Structural Frame – Central Urban Bus Terminal

(12) Sub-urban Bus Terminals(Type 1~Type4)

Four (4) different types of suburban bus terminals will be constructed under this project. Each type is different in area and size, however structural types and facilities are similar.

Construction method will include:

1) to grub and clear the site,
2) to level ground,
3) to excavate, lay geotextile and back fill,
4) to construct buildings,
5) to lay and compact subbase and base course,
6) to provide concrete curb, drainage and median,
7) to build bus bays and pedestrian bridges,
8) to carry out paving and color pavement,
9) to mark lanes and
10) to carry out other incidental works.

16.2.2. LIST OF EQUIPMENT FOR TRUNK BUSWAY

List of equipment used for each project is as shown in Table 16.2-1 to Table 16.2-5, respectively.

Table 16.2-1 List of Equipment for Busway Construction

Name of Equipment	Type/Capacity	Number	Remarks
1.Earth Work			
Back Hoe	0.4 ~ 1.0m^3	47	
Concrete Cutter	50ps, $H_{...}$=40cm	32	
Vibratory Compactor	3.5 ~ 5.0 ps	32	
Roadplaner	Rx - 30 Dynaplane	30	
Motor Grader	125hp	32	
2.Aggregate Course			
Motor Grader	125hp	30	
Vibrating Roller	10 ton	30	
Water Truck	2.000 l ~ 3.000 l	30	
3.Asphalt Pavement Work			
Asphalt Mixing Plant	40 ~ 60tom/hr.	30	
Pneumatic Tire Roller	10 ~ 15 ton	30	
Tandem Roller	8 ~ 12 ton	30	
Vibratory Steel Roller	5 ~ 8 ton	30	
Vibratory Steel Roller	3 ~ 4 ton	30	
Asphalt Paver	2.4m ~ 4.5m	30	
Bitumen Distributor	2.000 l ~ 3.000 l	30	
4.Concrete Pavement Work			
Concrete Mixing Plant	60m^3/hr	29	
Transit Mixer	5.0 ~ 7.0m^3	87	
Vibrator	0.05m dia.	29	
Concrete Cutter	50ps, $H_{...}$=40cm	29	
5.Others			
Generator	65 ~ 80 ps	73	
Air Compressor	30 ~ 50 ps	73	
Concrete Mixer	0.1cm^3	73	
Truck Crane	2 - 5 ton	73	
Excavator	0.8m3	73	
Lane Marking Machine		32	
Dump Truck	7.0m^3	365	

Table 16.2-2 List of Equipment for Express Busway Viaduct Construction

Name of Equipment	Type/Capacity	Number	Remarks
1.Foundation Work			
Concrete Cutter	20ps	23	
Truck Crane	20ton Hydraulic	23	
Truck Crane	35ton Hydraulic	23	
Vibration Hammer	30kw High Frequency	23	
Electric Drill	100kw	115	
Pile Driver (Earth Drill)	ϕ1000m/m, 125ps	23	
Back Hoe	$0.45m^3$	23	
2.Substructure Work			
Truck Crane	20ton Hydraulic	23	
Concrete Breaker	$1.2\ m^3/min$	115	Also for
Bar Bender	ϕ32m/m	23	Sub/Superstructural Work
Bar Cutter	ϕ32m/m	23	Sub/Superstructural Work
Concrete Mixing Plant	$70\ m^3/hr$	23	Sub/Superstructural Work
Transit Mixer	$8\ m^3$	138	Sub/Superstructural Work
Concrete Vibrator	200kw	230	Sub/Superstructural Work
Concrete Pump	$50\ m^3/hr$	23	Sub/Superstructural Work
Wheel Loader	$1.5\ m^3$	23	
Vibratory Roller	6ton, 80ps	23	
Asphalt Finisher	2.5~4.5m, 43kw	23	
3.Superstructure Work			
Truck Crane	35ton Hydraulic	23	
Truck Crane	50ton Hydraulic	46	Advance Shoring Ass./Dis.
Advance Shoring	30mx2lanes Hollow	23	
Advance Shoring	Slab	11	
Stressing Jack	40mx3cells Box	46	
Grout Pump		46	
4.Pavement Work			
Asphalt Mixing Plant	40~65ton/hr	23	
Bitumen Distributor	16ps	23	
Macadam Roller	10~12ton	23	
Pneumatic Tire Roller	10~15ton	23	
Asphalt Finisher	2.5~4.5m, 43kw	23	
5.Others			
Gas Cutter			
Welding Machine	100A/25V	46	
Engine Generator	100~150KVA	69	
Air Compressor	$7\sim11\ m^3/min$, 5~110ps	46	
Dump Truck	$8\ m^3$	115	
Trailer	30~50ton	23	
Truck	10~15ton	46	

Table 16.2-3 List of Equipment for Autopista Sur Flyover Construction

Name of Equipment	Type/Capacity	Number	Remarks
1.Foundation Work			
Concrete Cutter	20ps	10	
Truck Crane	20ton Hydraulic	10	
Truck Crane	35ton Hydraulic	10	
Vibration Hammer	30kw High Frequency	10	
Electric Drill	100kw	50	
Pile Driver (Earth Drill)	φ1000m/m, 125ps	10	
Back Hoe	$0.45m^3$	10	
2.Substructure Work			
Truck Crane	20ton Hydraulic	10	
Concrete Breaker	1.2 m^3/min	50	Also for
Bar Bender	φ32m/m	10	Sub/Superstructural Work
Bar Cutter	φ32m/m	10	Sub/Superstructural Work
Concrete Mixing Plant	70 m^3/hr	10	Sub/Superstructural Work
Transit Mixer	8 m^3	60	Sub/Superstructural Work
Concrete Vibrator	200kw	100	Sub/Superstructural Work
Concrete Pump	50 m^3/hr	10	Sub/Superstructural Work
Wheel Loader	1.5 m^3	10	
Vibratory Roller	6ton, 80ps	10	
Asphalt Finisher	2.5~4.5m, 43kw	10	
3.Superstructure Work			
Truck Crane	35ton Hydraulic	10	
Truck Crane	50ton Hydraulic	20	Advance Shoring Ass./Dis.
Advance Shoring	30mx2lanes Hollow	10	
Advance Shoring	Slab	7	
Stressing Jack	40mx3cells Box	20	
Grout Pump		20	
4.Pavement Work			
Asphalt Mixing Plant		10	
Bitumen Distributor	40~65ton/hr	10	
Macadam Roller	16ps	10	
Pneumatic Tire Roller	10~12ton	10	
Asphalt Finisher	10~15ton	10	
5.Others	2.5~4.5m, 43kw		
Gas Cutter			
Welding Machine		20	
Engine Generator	100A/25V	30	
Air Compressor	100~150KVA	20	
Dump Truck	7~11 m^3/min, 85~110ps	50	
Trailer	8 m^3	10	
Truck	30~50ton	20	
	10~15ton		

Table 16.2-4 List of Equipment for Central Urban Bus Terminal Construction

Name of Equipment	Type/Capacity	Number	Remarks
1.Earth Work			
Back Hoe	$1.0m^3$	2	
Vibratory Compactor	3.5 ~ 5.0 ps	1	
Motor Grader	120 ~ 130ps	1	
Wheel Loader	$1.0m^3$	1	
2.Aggregate Course			
Motor Grader	125hp	1	
Vibrating Roller	10 ton	1	
Water Truck	2,000 l ~ 3,000 l	1	
3.Pavement Work			
Asphalt Mixing Plant	40 ~ 60tom/hr.	1	
Pneumatic Tire Roller	10 ~ 15 ton	1	
Tandem Roller	8 ~ 12 ton	1	
Vibratory Steel Roller	5 ~ 8 ton	1	
Vibratory Steel Roller	3 ~ 4 ton	1	
Asphalt Paver	2.4m ~ 4.5m	1	
Bitumen Distributor	2,000 l ~ 3,000 l	1	
4.Concrete Pavement Work			
Concrete Mixing Plant	$60m^3$/hr	1	
Transit Mixer	5.0 ~ $7.0m^3$	3	
Vibrator	0.05m dia.	1	
Concrete Cutter	50ps, H_{max}=40cm	1	
5.Building			
Concrete Mixing Plant	$60m^3$/hr	1	
Transit Mixer	5.0 ~ $7.0m^3$	3	
Truck Crane	10 - 20ton	2	
Concrete Pump	70 to 80 m^3/hr	1	
Tower Crane	8.0ton	2	
Concrete Mixer	$0.1cm^3$	3	
4.Others			
Generator	65 ~ 80 ps	6	
Air Compressor	30 ~ 50 ps	6	
Truck Crane	2 - 5 ton	6	
Excavator	0.8m3	6	
Dump Truck	$7.0m^3$	6	
Lane Marking Machine		1	

Table 16.2-5 List of Equipment for Suburban Bus Terminal Construction

Name of Equipment	Type/Capacity	Number	Remarks
1.Earth Work			
Back Hoe	$1.0m^3$	2	
Vibratory Compactor	3.5 ~ 5.0 ps	2	
Motor Grader	120 ~ 130ps	2	
Wheel Loader	$1.0m^3$	2	
2.Aggregate Course			
Motor Grader	125hp	2	
Vibrating Roller	10 ton	2	
Water Truck	2,000 l ~ 3,000 l	2	
3.Pavement Work			
Asphalt Mixing Plant	40 ~ 60tom/hr.	2	
Pneumatic Tire Roller	10 ~ 15 ton	2	
Tandem Roller	8 ~ 12 ton	2	
Vibratory Steel Roller	5 ~ 8 ton	2	
Vibratory Steel Roller	3 ~ 4 ton	2	
Asphalt Paver	2.4m ~ 4.5m	2	
Bitumen Distributor	2,000 l ~ 3,000 l	2	
4.Concrete Pavement Work			
Concrete Mixing Plant	$60m^3/hr$	2	
Transit Mixer	$5.0 \sim 7.0m^3$	6	
Vibrator	0.05m dia.	2	
Concrete Cutter	50ps, H_{max}=40cm	2	
5.Building			
Concrete Mixing Plant	$60m^3/hr$	2	
Transit Mixer	$5.0 \sim 7.0m^3$	6	
Truck Crane	10 - 20ton	2	
Concrete Pump		2	
4.Others			
Generator	65 ~ 80 ps	3	
Air Compressor	30 ~ 50 ps	3	
Concrete Mixer	$0.1cm^3$	9	
Truck Crane	2 - 5 ton	3	
Excavator	0.8m3	3	
Dump Truck	$7.0m^3$	9	
Lane Marking Machine		3	

16.2.3. WORKING PROGRAM FOR TRUNK BUSWAY

Net working days of the region are as shown in Table 16.2-6.

Working program of each project is identified to examine project scale, characteristics and construction plan. Working program for express busway viaduct is shown in Table 16.2-7. Working program for Avenida Caracas and Autopista Norte are as shown in Table 16.2-8 and Table 16.2-9.

Table 16.2-6 Net Working Days

Item	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Calendar Days	31	28	31	30	31	30	31	31	30	31	30	31	365
Sundays	5	4	4	5	4	4	5	4	4	5	4	5	53
National Holidays	2	0	1	2	2	3	1	2	0	1	2	2	18
Rainy Days	2	2	3	3	5	2	2	3	2	3	3	2	32
Total Non Working D.	9	6	8	10	11	9	8	9	6	9	9	9	103
Net Working Days	22	22	23	20	20	21	23	22	24	22	21	22	262

Note : Average Month = 262/365x100 = 71.2%, 22days/Month

Calculation of Non Working Days by Rain was based on the observation data of National University

Non Working Days by Rain = Average rainfall depth of month / Average maximum rainfall depth of month x 0.60

Table 16.2-7 Express Busway Viaduct Working Program --24spans

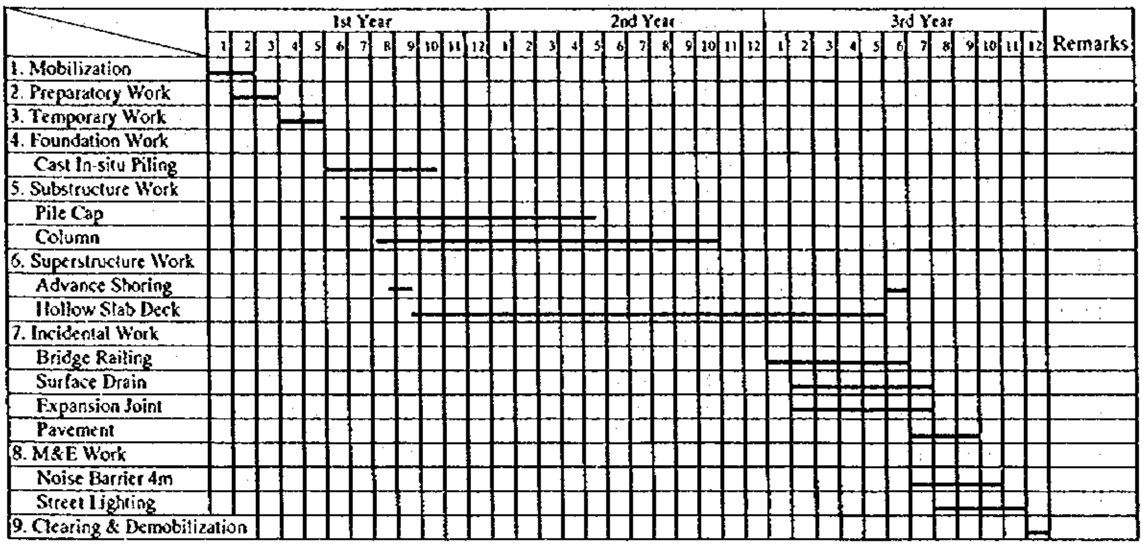


Table 16.2-8 Avenida Caracas Working Program

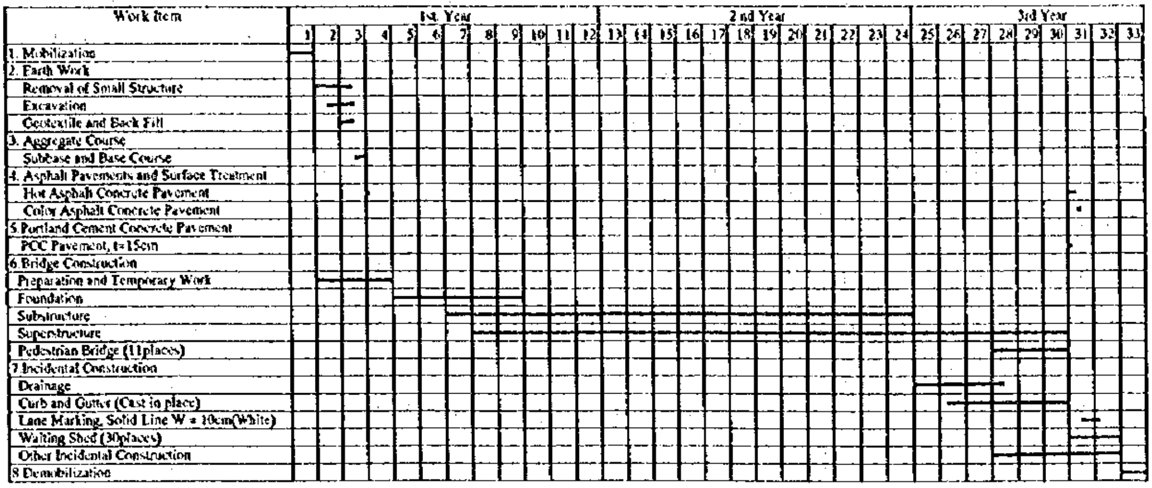
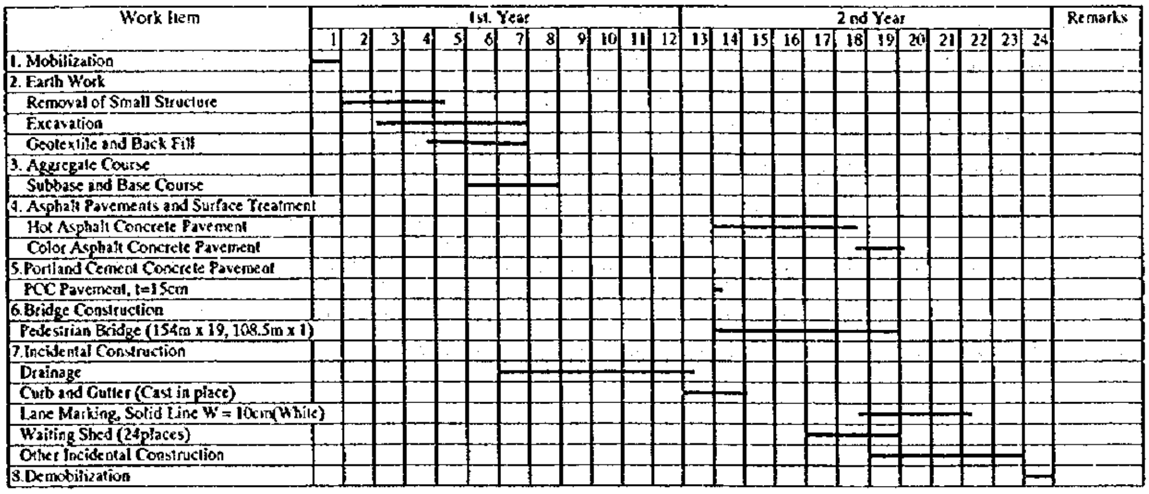


Table 16.2-9 Autopista Del Norte Working Program



16.2.4. CONSTRUCTION PLANNING FOR INNER RING EXPRESSWAY

In order to avoid interference from existing traffic and to maintain carriageway as much as possible, the works are to be carried out day and night. As shown in Figure 16.2-8. The substructure work will include the following:

1) to drive sheet pile together with temporary bracing,
2) to place temporary deck cover after primary excavation,
3) to drive ϕ 1.0m bored piles,
4) to carry out foundation excavation after all the piles are driven,
5) to place blinding concrete, treat pile head and assemble reinforcing bar and form-work to place pile cap concrete,
6) to erect reinforcing bars and form-work for pier, and place pier concrete,
7) to carry out back-filling, deck cover removal, sheet pile extraction and paving,
8) to assemble bracket /support for supporting soffit of pier head/beam and
9) to assemble reinforcing bars and form-work for placing pier head/beam concrete.

As shown in Figure 16.2-9, where head clearance is less than 4.5m, as in Calle 100, hanger type support is employed to support pier head.

And as shown in Figure 16.2-10, where Steel Column and Beam are employed, substructure work above pile cap includes:

1) to embed anchor frame in pile cap concrete,
2) to erect steel column and
3) to provide temporary support to support steel beam appropriately.

Each joint of structural steel is fastened by high tensile bolts and nuts with gusset plates.

Working area shall be protected from traffic by movable safety barrier and/or fence with red warning blinking lights and illumination for night work.

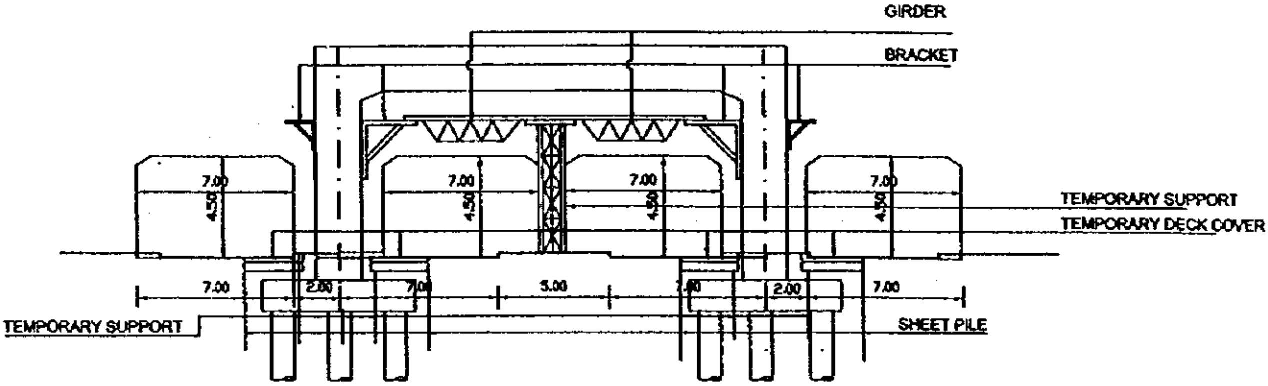


Figure 16.2-8 Inner Ring Expressway – Substructure

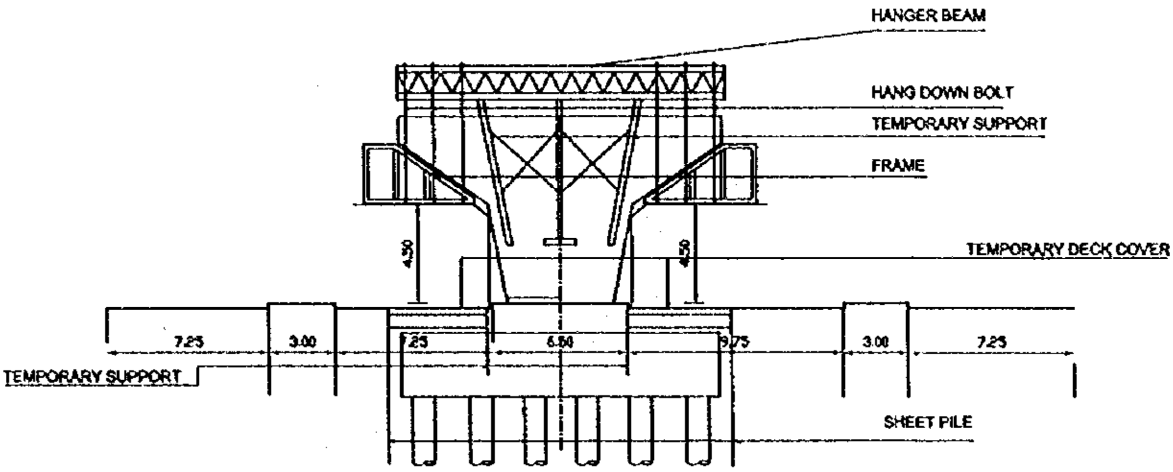


Figure 16.2-9 Inner Ring Expressway – Calle 100

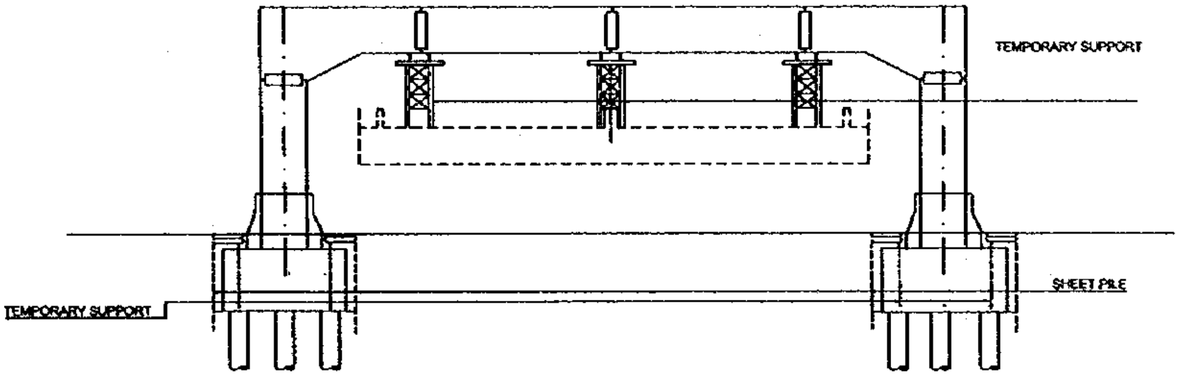


Figure 16.2-10 Inner Ring Expressway – Steel Pier and Beam

As shown in Figure 16.2-11, superstructre work is carried out by using advanced shoring method which places deck concrete (Hollow Slab) and travels span by span without any interference with road traffic. As shown in Figure 16.2-12, where Steel Girder and Precast Pre-Stressed concrete girder are used, movable type erection girder is used for erecting girders to minimize an interference with road traffic. However, taking the existing traffic condition into account, the major activities of works are to be carried out during nighttime when the traffic is lighter.

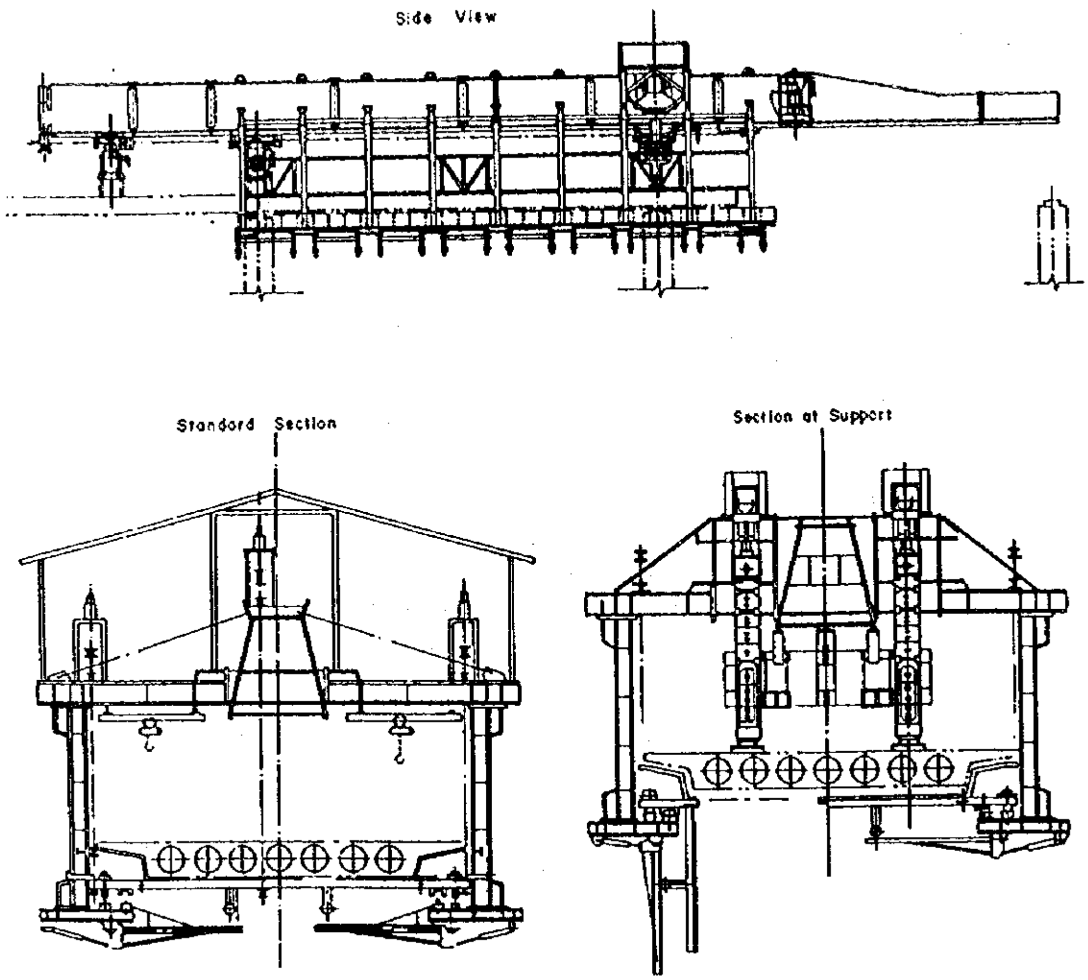


Figure 16.2-11 Inner Ring Expressway – Advanced Shoring

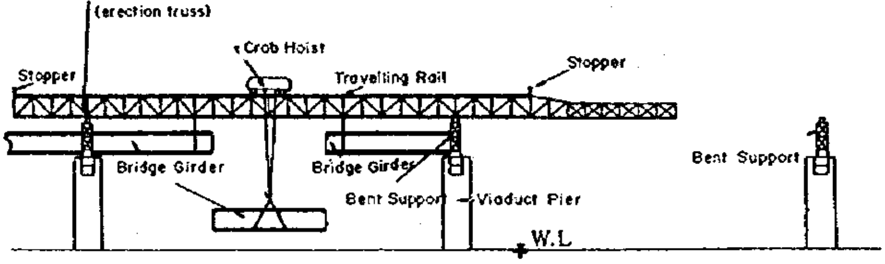


Figure 16.2-12 Inner Ring Expressway – Erection Girder

Number of blocks for project is divided into forty three (43) blocks of maximum 480m in length.

16.2.5. LIST OF EQUIPMENT FOR INNER RING EXPRESSWAY

List of equipment used for the project is as shown in Table 16.2-10.

Table 16.2-10 List of Equipment for Inner Ring Express Way Construction

Name of Equipment	Type/Capacity	Number	Remarks
1.Foundation Work			
Truck Crane	20ton Hydraulic	43	
Truck Crane	35ton Hydraulic	43	
Concrete Cutter	20ps	43	
Vibration Hammer	30kw High Frequency	43	
Electric Drill	100kw	215	
Pile Driver (Earth Drill)	ϕ 1000m/m, 125ps	43	
Back Hoe	$0.45m^3$	43	
2.Substructure Work			
Truck Crane	20ton Hydraulic	43	
Truck Crane	35ton Hydraulic	43	
Concrete Breaker	$1.2 m^3/min$	215	
Bar Bender	ϕ 32m/m	43	Sub/Superstructural Work
Bar Cutter	ϕ 32m/m	43	Sub/Superstructural Work
Concrete Mixing Plant	$70 m^3/hr$	43	Sub/Superstructural Work
Transit Mixer	$8 m^3$	258	Sub/Superstructural Work
Concrete Vibrator	200kw	430	Sub/Superstructural Work
Concrete Pump	$50 m^3/hr$	43	Sub/Superstructural Work
Wheel Loader	$1.5 m^3$	43	
Vibratory Roller	6ton, 80ps	43	
Asphalt Finisher	2.5~4.5m, 43kw	43	
3.Superstructure Work			
Truck Crane	35ton Hydraulic	86	
Truck Crane	80ton Hydraulic	86	Steel Gantry Frame Erection, Advance Shoring / Erection Girder Ass./Dis.
Advance Shoring	30mx2lanes Hollow Slab	7	
Advance Shoring	30mx4lanes Hollow Slab	25	
Advance Shoring	30mx6lanes Hollow Slab	2	
Erection Girder	30~50mx100ton	11	
Pneumatic Torque Wrench		70	
Stressing Jack		86	
Grout Pump		86	
4.Pavement Work			
Asphalt Mixing Plant	40~65ton/hr	43	
Bitumen Distributor	16ps	43	
Macadam Roller	10~12ton	43	
Pneumatic Roller	10~15ton	43	
Asphalt Finisher	2.5~4.5m, 43kw	43	
5.Others			
Gas Cutter			
Welding Machine	100A/25V	86	
Engine Generator	100~150KVA	129	
Air Compressor	$7\sim11 m^3/min$,85~110ps	86	
Dump Truck	$8 m^3$	215	
Trailer	30~50ton	30	
Truck	10~15ton	86	

16.2.6. WORKING PROGRAM FOR INNER RING EXPRESSWAY

Net working days of the region is as shown in Table 16.2-11.

Working programs are carried out, based on Table 16.2-11, and as shown in Table 16.2-12 and Table 16.2-13.

Table 16.2-11 Net Working Days

Item	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Calendar Days	31	28	31	30	31	30	31	31	30	31	30	31	365
Sundays	5	4	4	5	4	4	5	4	4	5	4	5	53
National Holidays	2	0	1	2	2	3	1	2	0	1	2	2	18
Rainy Days	2	2	3	3	5	2	2	3	2	3	3	2	32
Total Non Working D.	9	6	8	10	11	9	8	9	6	9	9	9	103
Net Working Days	22	22	23	20	20	21	23	22	24	22	21	22	262

Note: Average Month = 262/365x100 = 71.2%, 22days/Month

Calculation of Non Working Days by Rain was based on the observation data of National University

Non Working Days by Rain = Average rainfall depth of month / Average maximum rainfall depth of month x 0.60

Table 16.2-12 Inner Ring Expressway Working Program – Avenida Septima

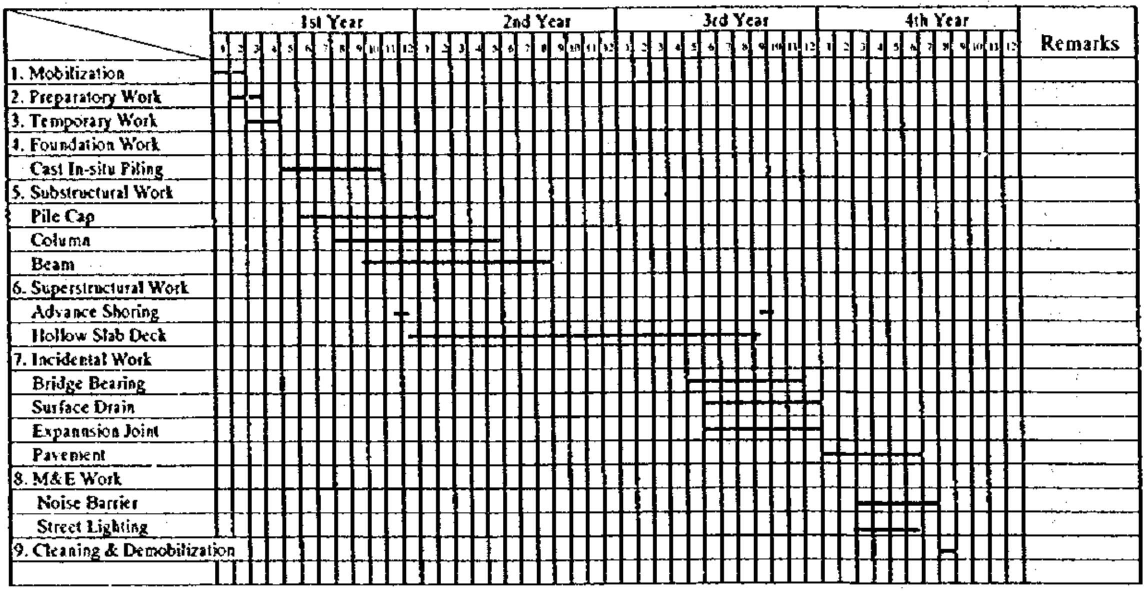
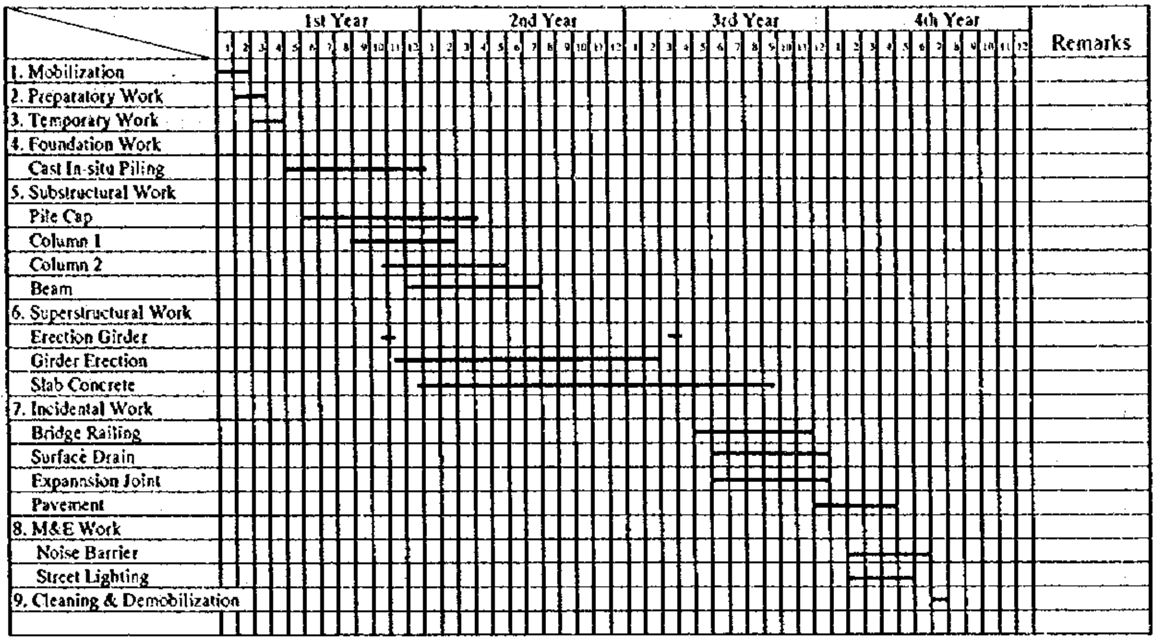


Table 16.2-13 Inner Ring Expressway Working Program – Avenida Quito Steel



16.3. VOLUME OF WORKS

16.3.1. TRUNK BUSWAY FACILITIES

Volume of works for the trunk busway facilities is as shown in Table 16.3-1. Volume of Work for Express Busway Viaduct is as shown in Table 16.3-2 and for Autopista del Sur Flyovers is as shown in Table 16.3-3 respectively.

Table 16.3-1 Volume of Works -- Trunk Busway Facilities

Work Item	Unit	Total Quantity
1. Earth Work		
Excavation Common Soil (Waste)	m^3	1,110,632.00
Removal of Existing Drainage	m	58,713.00
Back Fill	m^3	560,915.00
Removal of Concrete Curb and Gutter	m	227,272.00
Scarification of Existing Asphalt Pavement	m^2	1,009,096.00
Removal of Existing AC & PCC Pavement	m^2	335,944.00
Geotextile	m^2	632,642.00
2. Aggregate Course		
Subbase Course, maximum size 40mm	m^3	388,109.00
Base Course, maximum size 40mm	m^3	234,290.00
3. Asphalt Pavements and Surface Treatment		
Asphalt Prime Coat	ton	786.47
Asphalt Tack Coat	ton	1,047.68
Hot Asphalt Concrete Pavement Binder Course	ton	148,932.15
Hot Asphalt Concrete Pavement Surface Course	ton	81,702.33
Color Asphalt Concrete Pavement (Red Color)	ton	111,954.16
4.Portland Cement Concrete Pavement		
PCC Pavement, t=15cm	m^3	8,784.81
5.Building		
Building A	m^2	11,776.00
Building B	m^2	2,774.00
6.Bridge Construction		
Pedestrian Bridge	m	5,914.00
7.Incidental Construction		
R.C Pipe Culvert 600mm dia.	m	50,547.00
R.C Pipe Culvert 900mm dia.	m	230.00
R.C Pipe Culvert 1,500mm dia.	m	22,236.00
Drop Inlet	each	1,513.00
Curb and Gutter (Cast in place)	m	336,954.00
Concrete Boundary Block	m	18,385.00
Guard Fence	m	2,199.00
Lane Marking, Solid Line W = 10cm(White)	m^2	92,287.00
Waiting Shed	m	16,237.00
8.Bus Facility		
Bus Stop Type 1 —Type 9	each	223.00
Bus Terminal Suburban Type 1	each	2.00
Bus Terminal Suburban Type 2	each	2.00
Bus Terminal Suburban Type 3	each	1.00
Bus Terminal Suburban Type 4	each	2.00

Table 16.3-2 Volume of Works – Express Bus Way Viaduct

Work Item	Unit	Quantity
1. Substructure		
Sheet Pile	m	288,348.00
Excavation	m^3	105,305.00
Back Fill	m^3	77,397.00
Cast In Situ Pile ϕ 1,000	m	109,700.00
Reinforcing Bar	t	6,769.00
Concrete 300kg/cm^2	m^3	70,028.00
A.C. Pavement	t	180.00
2. Superstructure		
Reinforcing Bar	t	13,068.00
Concrete 400kg/cm^2	m^3	135,332.00
Pre-stressing	t	4,064.00
Noise Barrier h = 4.0m	m	28,790.00
A.C. Pavement	t	19,216.00

Table 16.3-3 Volume of Works – Autopista del Sur Flyovers

Work Item	Unit	Quantity
1. Substructure		
Sheet Pile	t	91,228.00
Excavation	m^3	44,624.00
Backfilling	m^3	48,719.00
Cast In Situ Pile ϕ 1,000	m	34,250.00
Reinforcing Bar	t	2,401.00
Concrete 300kg/cm^2	m^3	30,881.10
A.C. Pavement	t	840.00
2. Superstructure		
Reinforcing Bar	t	3,119.40
Concrete 400kg/cm^2	m^3	18,625.60
300kg/cm^2	m^3	10,790.00
Pre-stressing	t	951.10
Noise Barrier h = 4.0m	m	12,580.00
A.C. Pavement	t	4,932.00

16.3.2. INNER RING EXPRESSWAY

Volume of works (quantities) for Inner Ring Expressway are as shown in Table 16.3-4.

Table 16.3-4 Volume of Works – Inner Ring Expressway

Work item	Unit	Quantity
1. Substructure		
Sheet Pile	m	571,503.00
Excavation	m^3	210,466.00
Backfilling	m^3	153,637.00
Cast in Situ Pile ϕ 1,000	m	280,545.00
Reinforcing Bar	t	16,055.50
Concrete 300kg/cm^2	m^3	172,975.50
Steel Pier	t	12,211.60
2. Superstructure		
Reinforcing Bar	t	22,181.50
Concrete 400kg/cm^2	m^3	214,625.00
300 kg/cm^2	m^3	18,945.80
Pre-stressing	t	6,666.60
Steel Girder	t	11,550.00
Noise Barrier h = 2.0m	m	24,875.00
A.C. Pavement	t	35,201.20

16.4. PROJECT COST

The project cost consists of construction, materials, labor, land acquisition, compensation and engineering costs. Most of these costs are estimated based on the unit cost of work items obtained from a unit price analysis and in comparison with costs of similar projects in Santa Fe De Bogota. The estimate of the project cost was based on the results of preliminary engineering design, quantity take-off of each work item, and the studies on construction method and operation and maintenance.

The fundamental concepts in estimating the project cost are as bellows;

1) Unit cost of each cost component was determined based on the economic condition prevailing in November 2, 1998 (1US$ = 1,580 Colombian Pesos,1 US $ = 116 Yen)
2) Engineering services cost is assumed to be 6% for detailed engineering and 8% for construction supervision of the construction cost.
3) Land acquisition and compensation cost is estimated by report of "Precios Suelo Urbaxio y Formacion de la Renta en Santa Fe De Bogota" March 1998. Economica Consultores and "El Valor Del Suelo Urbano En Bogota 1998" December 1998, LONJA.
4) Physical contingency is estimated to be 10% of the total of construction cost and engineering services cost.

The projects are estimated in financial cost.

16.4.1. CONSTRUCTION COST

(1) Unit Construction Cost

Most of the items of unit cost data required to implement the projects were collected from similar road projects currently being under construction in the city. Since some of construction materials are not available in the country, unit costs of these items were estimated as imported from North America or Central America. The collected data includes the unit costs of individual construction materials, labor and equipment. The unit costs of major work items were also obtained.

1) Unit Labor Cost

Table 16.4-1 includes the labor cost for local workers required for implementing the Project. The labor cost includes allowances such as social benefits, insurance, etc. and is based on eight-hour work per day.

Table 16.4-1 Unit Labor Cost

Classification	Class	Basic Pay	Remarks
Foreman	A	835 US $ / Month	
Foreman	B	645 US $ / month	
Machine Operator	A	8 US $ / Day	
Machine Operator	B	9 US $ / Day	
Operator		6 US$ / Day	
Tradesman	A	504 US $ / Month	
Driver		297 US $ / Month	
Labor	A	1.6 US $ / Hour	
Labor	B	1.8 US$ / Hour	
Labor	C	1.9 US $ / Hour	
Technician	A	2.4 US $ / Hour	
Technician	B	2.7 US $ / Hour	
Technician	C	2.8 US $ / Hour	
Engineer	A	1,208 US $ / Month	
Engineer	B	332 US $ / Month	
Draftsman		322 US $ / Month	
Security Guard		422 US $ / Month	

Note: Salary includes the social security expenses under law

Applied price rate is 1US$ = 1,580 Pesos, at Nov.2, '98

2) *Unit Construction Material Cost*

The material costs are shown in Table 16.4-2, which also clarifies the source of each material. The cost of the imported material is based on the CIF Buenaventura port including handling charge, import duties and customs clearance charges. The cost of local materials is based on the market price in the city.

Table 16.4-2 Unit Construction Material Cost

Materials	Unit	Cost (US $)	Source	Remarks
Diesel Fuel	gal	0.84	Local	
Gasoline, Leaded	gal	1.06	Local	
Unleaded	gal	0.85	Local	
Bitumen Pen. 60/70	kl		Imported	Venezuela
Emulsion	kl	1.73	Local	
Reinforcing Steel, 9mm~16mm	kg	0.43	Local	
19mm~	kg	0.43	Local	
Structural Steel	kg	0.43	Imported	Venezuela
Cement	ton	135.63	Local	
Concrete Aggregate	m^3	18.99	Local	
Sand	m^3	16.46	Local	
Base Course	m^3	14.63	Local	
Subbase Course	m^3	22.85	Local	
Concrete for Pavement 45kg/m^2	m^3	103.29	Local	Hauling Distance 5km
Structural Concrete 3000psi	m^3	93.42	Local	Using Concrete Pump
Structural Concrete 5000psi	m^3	113.10	Local	Using Concrete Pump
Crushed Rock for Stone Masonry	m^3	12.66	Local	
Lumber	lm	12.34	Local	
Plywood t = 12mm	m^2	13.54	Local	
PVC Conduit, 50mm	m	2.44	Local	
Concrete Pipe, 24'	m	41.70	Local	
Concrete Pipe, 36'	m	81.91	Local	
Concrete Pile, 18' x 18'	m	40.16	Local	
P.C. Grader, L = 30m	m^3	182.01	Local	

Note ; Applied price rate is 1US$ = 1,580 Pesos , at Nov.2 ,'98

3) Unit Construction Equipment Cost

The equipment cost used for the estimate of the project is presented in Table 16.4-3 on hourly rental basis.

Table 16.4-3 Unit Construction Equipment Cost

Equipment	Type/Model	Cost (US $ / Hr.)	Remarks
Mobile Crane	10ton~20ton	65.82	
	20ton~40ton	88.10	
	40ton~60ton	113.61	
	60ton	179.49	
Hydraulic Backhoe	0.60m3	69.24	
	1.00m3	94.24	
Bulldozer	D6(165H.P.)	25.32	
	D9(405H.P.)	37.97	
	D10(520H.P.)	41.14	
R/T Loader	0.76m3	25.22	
	1.91m3	56.96	
Motor Grader	120H.P~130H.P.	77.66	
Macadam Roller	10ton~12ton	11.08	
Tandem Roller	8ton~12ton	19.30	
Vibratory Steel Roller	70H.P~80H.P.	28.67	
Pneumatic Tire Roller	70H.P~80H.P.	37.66	
Asphalt Paver	3.05m	112.85	
Bitumen Heater/Sprayer	800 Gallons	17.09	
Compressor	40H.P~50H.P.	9.18	
Backhoe w/Loader	0.04m3	21.14	
Truck w/crane	3ton crane	29.18	
Roadplaner	RX-30 Dynaplane	111.96	
Crushing Plant	Portable 60ton	40.38	
Asphalt Mixing Plant	40ton/hr~60ton/hr	55.57	
Concrete Batching and Mixing Plant	20m3~30m3/hr	33.48	
Concrete Transit Mixer	4~5m3	14.87	
Concrete Pump	50m3/hr	29.24	
Dump Truck	4.0m3	18.10	
Dump Truck	15ton	18.73	
Truck	8ton	14.87	
Truck	12ton	16.20	
Pick-up	2ton	13.16	
Generator	135HP	15.57	

Note: All prices are houly rental rate. Monthly or weekly contract can reduce the rental price.
Source: Applied exchange rate is 1US$ = 1,580 Pesos at Nov. 2 '98.

Foreign, local and VAT component of labor, materials and equipment is as shown in Table 16.4-4.

Table 16.4-4 Foreign, Local and VAT Component of Labor, Material and Equipment

Item	Component (%)			Remarks
	Foreign	Local	VAT	
Skilled Foreign Labor	76	8	16	
Skilled Local Labor	0	84	16	
Unskilled Labor	0	84	16	
Ordinary Portland Cement	46	38	16	
Reinforcing Bar	59	25	16	
Lumber	34	50	16	
Asphalt	50	34	16	
Diesel Oil	50	34	16	
Engine Oil	50	34	16	
Tires	50	34	16	
Locally Procured Mics. Materials	34	50	16	
Heavy Equipment	59	25	16	

4) Unit Construction Cost

The major unit construction cost of the work items for the project are shown in Table 16.4-5.

Table 16.4-5 Unit Construction Cost

Work Item	Unit	Unit Rate US$
1. Earth Work		
Excavation Soft Soil (Waste)	m^3	3.32
Excavation Common Soil (Waste) 0m to 2m of Depth	m^3	1.60
Excavation Common Soil (Waste) 2m to 3.5m of Depth	m^3	3.54
Borrow Material	m^3	12.72
Back Fill	m^3	23.07
Removal of Existing Drainage	m	11.70
Removal of Concrete Curb and Gutter	m	2.90
Scarification of Existing Asphalt Pavement, t = 4cm	m^2	5.70
Removal of Existing Asphalt Pavement, t = 15cm	m^2	12.06
Removal of Existing PCC Pavement with Asphalt Overlay	m^2	21.93
Geotextile	m^2	1.12
2. Aggregate Course		
Subbase Course, maximum size 40mm	m^3	37.41
Base Course, maximum size 40mm	m^3	56.62
3. Asphalt Pavements and Surface Treatment		
Asphalt Prime Coat	t	443.33
Asphalt Tack Coat	t	443.33
Hot Asphalt Concrete Pavement	t	80.40
Color Asphalt Concrete Pavement (Red Color)	t	241.20
4.Portland Concrete Cement Pavement		
Portland Concrete Cement Pavement, t = 25cm	m^3	139.40
5.Structural Embankment		
Riprap	m^2	68.93
Concrete Retaining Wall(Gravity Type), H = 2.0m	m	185.97
6.Bridge Construction		
Structural Concrete 3,000psi	m^3	170.27
Structural Concrete 5,000psi	m^3	190.93
Lean Concrete	m^3	122.98
Reinforcing Steel	t	733.40
PC Prestressing	t	3,833.47
Sheet Pile	m	98.29
Erection of Concrete Girder	m^2	162.34
Erection of Steel Girder	t	766.69
Steel Girder	t	3,639.24
Support	m^2	145.57
Cast in Place Pile 1,000mm dia	m	263.80
Pedestrian Bridge	m	680.00
Noise Barrier, H = 5.0m	m^2	500.00
7.Tunnel		
Portal and Tunnel Excavation	m	1,062.67
Ventilation, Lighting, etc.	L.S	108,800.00
8.Incidental Construction		
R.C Pipe Culvert 600mm dia.	m	47.13
R.C Pipe Culvert 900mm dia.	m	92.55
R.C Pipe Culvert 1,500mm dia.	m	198.47
Drop Inlet	each	435.97
Concrete Curb (Cast in place)	m	28.56
Concrete Boundary Block	m	22.96
Guard Rail	m	45.92
Guard Fence	m	22.93
Regulatory Traffic Sign	each	64.33
Informatory Sign	each	1,066.67
Lane Marking, Solid Line W = 10cm(White)	m^2	12.00

Note ; Applied price rate is 1US$ = 1,580 Pesos , at Nov.2 ,'98

(2) Construction Cost for Trunk Busway Facilities

Construction cost of each project is as shown in Table 16.4-6.

Table 16.4-6 Construction Cost of Trunk Busway Facilities

Road Name	Length (km) (Place)	Road Cost (M US $)	Viaduct and Flyover Cost (M US $)	Mobilization & Demobi. (M US $)	Total of Construction Cost(M US $)
Autopista Del Norte	17.240	39.244	0.000	3.924	43.168
Avenida Caracas	17.575	24.499	242.112	26.661	293.272
Avenida Suba (1)	13.150	5.479	0.000	0.548	6.027
Avenida Suba (2)	2.140	0.934	0.000	0.093	1.027
Autopista Del Sur	11.095	25.266	77.162	10.242	112.670
Central Bus Terminal	1	22.584	0.000	2.258	24.842
Suburban Bus Terminal Type 1	2	1.486	0.000	0.149	1.635
Suburban Bus Terminal Type 3	1	1.413	0.000	0.141	1.554
Suburban Bus Terminal Type 4	1	0.807	0.000	0.081	0.888
Ave. Primero De Mayo	1.090	0.371	0.000	0.037	0.408
Cra. 7a / Cra. 10	24.060	13.699	0.000	1.370	15.069
Ave. Ciudad de Quito	16.325	16.567	0.000	1.657	18.224
Calle 68 / 100	17.525	6.093	0.000	0.609	6.702
Calle 170	5.120	2.211	0.000	0.221	2.432
Suburban Bus Terminal Type 2	2	1.256	0.000	0.126	1.382
Suburban Bus Terminal Type 4	1	0.807	0.000	0.081	0.888
Total	125.320	162.716	319.274	48.199	530.188

Note : Length of Avenida Caracas Viaduct = 14.5km

(3) Construction Cost for Inner Ring Expressway

Construction cost of the inner ring way is as shown in Table 16.4-7.

Table 16.4-7 Inner Ring Expressway Construction Cost

	Length (km)	Viaduct Cost (M US $)	Mobilization Demobilization (M US $)	Total Coat (M US $)
Super Structure	15.0	217.414	21.741	239.155
Sub-structure	15.0	241.081	24.108	265.189
Total	15.0	458.495	45.850	504.344

16.4.2. LAND ACQUISITION AND COMPENSATION COST

Land acquisition and compensation cost are estimated based on the preliminary design on the trunk busway and inner ring expressway study. The affected area is classified based on the land development plan of Bogota Municipal Government. Compensation cost for the affected houses and lands by widening of road, construction of express way and bus terminals are estimated based on land prices on similar projects in the city.

Resettlement Cost for inhabitants who lose their houses to live is also calculated.

(1) Trunk Busway Facilities

The estimated land acquisition and compensation cost of trunk bus way is as shown in Table 16.4-8 to Table 16.4-11.

Table 16.4-8 Land Acquisition Cost – Trunk Busway

Road Name	Location	Area (m2)	Classification	Unit Cost (US $/m2)	Land Cost Cost (US $)
Avenida Caracas	Av.Caracas cor. Calle81 Right side	3,715	C	510	446,250
Autopista Del Sur	Av.Quito cor. Calle6 Left Side	1,900	C	320	1,600,000
Avenida Quito	km 1+840 - km 2+580 Both Side	8,880	R	475	4,218,000
Avenida Quito	km 2+580 - km 3+865 Right Side	3,855	R	475	1,831,125
Total		18,350			8,095,375

Note: Land Acquisition Cost applied from "EL VALOR DEL SUELO URBANO EN BOGOTA 1998", LONJA, DE PROPIEDAD RAIS DE BOGOTA
Land Classification: P = Pasture, A.S = Asphalt Plant, C = Commercial, R = Residential

Table 16.4-9 Compensation Cost – Trunk Busway

Road Name	Building		Affected Family			Total
	Number	Cost(US $)	Number	Inhabitant	Cost(US $)	(US $)
Avenida Caracas	17	2,108,688	23	77	73,600	2,182,288
(Resettlement)		1,362,397				1,362,397
Autopista Del Sur	7	513,000	24	79	76,800	589,800
(Resettlement)		1,362,397				1,362,397
Avenida Quito	0	0	0	0	0	0
Avenida Quito	0	0	0	0	0	0
Total	24	5,346,482	47	156	150,400	5,496,882

Table 16.4-10 Land Acquisition Cost -- Bus Terminal

Busway Route Name	Classification of Bus Terminal	Area (m2)	Classification	Unit Cost (US $/m2)	Land Cost Cost (US $)
Autopista Del Norte	Suburban, Type1	9,810	P	230	2,256,300
Avenida Caracas	Suburban, Type1	9,810	A.S	55	539,550
Avenida Suba	Suburban, Type4	9,180	P	100	918,000
Autopista Del Sur	Suburban, Type3	15,480	P	85	1,315,800
Central Bus Terminal	Central	23,750	C / R	635	15,081,250
Carrera 7a	Suburban, Type2	8,100	P	225	1,822,500
Carrera 7a	Suburban, Type4	9,180	P	90	826,200
Calle 170	Suburban, Type2	8,100	P	380	3,078,000
Total		93,410			25,837,600

Note: Land Acquisition Cost applied from "EL VALOR DEL SUELO URBANO EN BOGOTA 1998", LONJA, DE PROPIEDAD RAIS DE BOGOTA
Land Classification: P = Pasture, A.S = Asphalt Plant, C = Commercial, R =Residential

Table 16.4-11 Compensation Cost – Bus Terminal

Busway Route Name	Building		Affected Family			Total
	Number	Cost(US $)	Number	Inhabitant	Cost(US $)	(US $)
Autopista Del Norte	0	0	0	0	0	0
Avenida Caracas	0	0	0	0	0	0
Avenida Suba	0	0	0	0	0	0
Autopista Del Sur	0	0	0	0	0	0
Central Bus Terminal	69	8,348,320	133	447	425,600	8,773,920
(Resettlement)						4,743,699
Carrera 7a	0	0	0	0	0	0
Carrera 7a	0	0	0	0	0	0
Calle 170	0	0	0	0	0	0
Total	69	8,348,320	133	447	425,600	13,517,619

(2) Inner Ring Expressway

The estimated land acquisition and compensation cost for the inner ring expressway is as shown in Table 16.4-12 to Table 16.4-13.

Table 16.4-12 Land Acquisition Cost – Inner Ring Expressway

Road Name	Location	Area (m2)	Classification	Unit Cost (US $/m2)	Land Cost Cost (US $)
Cr.7a / Av. 100	Cor. of Cr.7a / Av. 100	1,888	C	635	1,198,880
Avenida Quito	Km8+ Left Side	3,125	C	320	1,000,000
Total		5,013			2,198,880

Note: Land Acquisition Cost applied from "EL VALOR DEL SUELO URBANO EN BOGOTA 1998", LONJA, DE PROPIEDAD RAIS DE BOGOTA

Land Clacification: P = Pasture, A.S = Asphalt Plant, C = Commercial, R = Residential

Table 16.4-13 Compensation Cost – Inner Ring Expressway (including express busway viaduct)

Road Name	Location	Building		Affected Family			Total
		Number	Cost(US $)	Number	Inhabitants	Cost(US $)	(US $)
Cr.7a / Av. 100	Cor. of Cr.7a / Av. 100	12	454,200	14	46	44,800	499,000
Avenida Quito	km 8+ Left Side	21	1,331,250	21	70	67,200	1,398,450
(Resettlement)			2,043,582				2,043,582
Total		33	3,829,032	35	116	112,000	3,941,032

16.4.3. ENGINEERING COST AND CONTINGENCY

Engineering cost consists of the consultancy cost required for the Detailed Design and Construction Supervision of the project implementation. The engineering cost of the detailed design is approximately 6% of the construction cost, and for the construction supervision is approximately 8%, thus total engineering cost becomes 14% of the construction cost.

Physical contingency is estimated as 10% of the construction cost and engineering cost. Price contingency for the project is not estimated at this stage.

16.4.4. PROJECT COST

(1) Trunk Busway Facilities

Summary of the project cost for each trunk busway is as shown in Table 16.4-14.

Table 16.4-14 Project Cost – Trunk Busway (including Express Bus Viaduct)

Cost Unit: Million

Road Name	Length (km)	Construction Cost (US$)	Engineering Cost (US$)		Land Acquisition (US$)	Compensation Cost (US$)	Physical Contingency (10%)	Total (US$)
			D/D	C/S				
Autopista del Norte	17.240	43.168	2.591	3.453	0.000	0.000	4.921	54.133
Avenida Caracas	17.575	26.949	1.617	2.156	0.000	0.000	3.072	33.794
Express Bus Viaduct	(14.500)	266.323	15.979	21.306	0.446	3.545	30.361	337.960
Avenida Suba 1	13.150	6.027	0.362	0.486	0.000	0.000	0.687	7.558
Avenida Suba 2	2.140	1.027	0.062	0.082	0.000	0.000	0.117	1.288
Autopista del Sur	11.095	27.792	1.668	2.223	0.000	0.000	3.168	34.851
Flyovers		84.879	5.092	6.790	1.600	1.949	9.676	109.987
Central Bus Terminal		24.842	1.491	1.987	15.081	13.518	28.320	59.751
Suburban B.T. Type 1		1.635	0.098	0.131	2.796	0.000	0.186	4.846
Suburban B.T. Type 2		1.382	0.083	0.111	4.901	0.000	0.179	6.634
Suburban B.T. Type 3		1.554	0.093	0.124	1.315	0.000	0.177	3.264
Suburban B.T. Type 4		1.776	0.106	0.142	1.744	0.000	0.202	3.971
Ave. Primero de Mayo	1.090	0.408	0.024	0.033	0.000	0.000	0.047	0.512
Cra. 7a / Cra. .10	24.060	15.069	0.904	1.206	0.000	0.000	1.718	18.897
Ave. Ciudad de Quito	16.325	18.224	1.093	1.458	6.049	0.000	2.078	28.902
Calle. 68 / 100	17.525	6.702	0.402	0.536	0.000	0.000	0.764	8.404
Calle 170	5.120	2.432	0.146	0.195	0.000	0.000	0.277	3.050
Total	125.320	530.188	31.811	42.415	33.932	19.015	60.441	717.802

Note: D/D stands for Detailed Design (6%) and C/S stands for Construction Supervision (8%)

(2) Inner Ring Expressway

Summary of the project cost for the inner ring expressway is as shown in Table 16.4-15.

Table 16.4-15 Project Cost – Inner Ring Expressway

Cost Unit: Million

	Length (km)	Construction Cost (US$)	Engineering Cost (US$)		Land Acquisition (US$)	Compensation Cost (US$)	Physical Contingency (10%)	Total (US$)
			D/D	C/S				
Superstructure	15.0	239.155	14.349	19.132	-	-	27.264	299.900
Sub Structure	15.0	265.189	15.911	21.215	2.199	3.941	30.231	338.686
Total	15.0	504.344	30.260	40.347	2.199	3.941	57.495	638.586

Note: D/D stands for Detailed Design (6%) and C/S stands for Construction Supervision (8%)

16.5. MAINTENANCE COST

Maintenance cost of the project is estimated based on the applied practice on maintenance works for similar roads and structural conditions in the city and is estimated for 20years. On the busway, it is estimated that 5% of total length will require 4cm thick of overlay every year for the first 10years. On the expressway, it is estimated that 2% of total length will require 5cm thick of overlay every year for the first 5years; and for the following 5 years, 5% of total length will require the same thickness of overlay every year. For the balance 10years, 3cm thick of overlay will be required for both busway and expressway for the whole length for one time.

(1) Trunk Bus Way Facilities

Maintenance cost of each project is as shown Table 16.5-1

(2) Inner Ring Expressway

Maintenance cost is as shown in Table 16.5-2.

Table 16.5-1 Maintenance Cost for Busway

Road / Bus Terminal Name	Length (km) (Place)	Number of Bus Lane	Bus Lane Width (m)	Area of Bus Lane (m^2)	Overlay Cost (US$/$M^2$)	Open Year	Maintenance ccost	
							1st. to 10th Year (US$)	11th to 20th Year (US$)
1. Stage I								
Autopista Del Norte, 3-lane Section	7.370	2	3.5 x 2 = 7.0	51,590				
Autopista Del Norte, 5-lane Section	9.870	4	7.5 x 2 = 15.0	148,050				
Subtotal	17.240			199,640	39.54	2002.1	394,688	789,377
Avenida Caracas, Viaduct Section	14.500	2	4.5 x 2 = 9.0	130,500				
Avenida Caracas, Trunk Bus section	13.975	2	4.0 x 2 = 8.0	111,800				
Avenida Caracas, Mixed Lane section	3.600	2	3.5 x 2 = 7.0	25,200				
Subtotal	17.575			267,500	39.54	2003.7	528,848	1,057,695
Avenida Suba (1)	13.150	2	3.5 x 2 = 7.0	92,050	39.54	2001.6	181,983	363,966
Avenida Suba (2)	2.140	2	3.5 x 2 = 7.0	14,980	39.54	2002.1	29,615	59,231
Autopista Del Sur, Viaduct Section	4.700	2	4.5 x 2 = 9.0	42,300				
Autopista Del Sur, Under Viaduct Section	4.700	2	4.0 x 2 = 8.0	37,600				
Autopista Del Sur, 4-Lane Section	6.395	4	7.5 x 2 = 15.0	95,925				
Subtotal	11.095			175,825	39.54	2003.4	347,606	695,212
Central Bus Terminal	1	15,882m^2		15,882	23.18	2003.7	36,814	55,222
Suburban Bus Terminal Type 1, Apt.Note	1	3,839m^2		3,839	23.18	2002.1	8,899	13,348
Suburban Bus Terminal Type 1, Av. Caracas	1	3,839m^2		3,839	23.18	2003.7	8,899	13,348
Suburban Bus Terminal Type 3, Apt. Sur	1	7,436m^2		7,436	23.18	2003.4	17,237	25,855
Suburban Bus Terminal Type 4, Av. Suba	1	3,898m^2		3,898	23.18	2001.6	9,036	13,553
Total of Stage I	61.200			781,050			1,554,726	3,073,458
2. Stage II								
Avenida Primero De Mayo	1.090	2	3.5 x 2 = 7.0	7,630	39.54	2004.8	15,085	30,169
Carrera 7a / Avenida 10, Cr.7a Section	16.650	2	3.5 x 2 = 7.0	116,550				
Carrera 7a / Avenida 10, Av.10 Section	7.410	4	7.0 x 2 = 14.0	103,740				
Sub-total				220,290	39.54	2004.8	435,513	871,027
Avenida Ciudad de Quito	16.325	2	3.5 x 2 = 7.0	114,275	39.54	2003.4	225,922	451,843
Avenida 68 / 100	17.525	2	3.5 x 2 = 7.0	122,675	39.54	2005.7	242,528	485,057
Calle 170	5.120	2	3.5 x 2 = 7.0	35,840	39.54	2005.7	70,856	141,711
Suburban Bus Terminal Type 2,Cr. 7a	1	3,016m^2		3,016	23.18	2004.8	6,991	10,487
Suburban Bus Terminal Type 2, Calle170	1	3,016m^2		3,016	23.18	2004.8	6,991	10,487
Suburban Bus Terminal Type 4,Cr.7a	1	3,898m^2		3,898	23.18	2005.7	9,036	13,553
Sub-total	64.120			507,624			1,005,930	2,003,847
Total	125.320			1,288,674			2,560,656	5,077,306

Note: Length of Caracas Viaduct = 14.5km

Suburban Bus Terminal : Stage I - Type 1 - Apt. Nort and Av. Caracas, Type 3 - Apt. Sur, Type 4 - Av. Suba

Stage II - Type 2 - Cr.7a and Calle 170, Type 4 - Av. 10

Maintenance cost of bus terminal applied 10% of first 10years and 15% of following 10 years for asphalt overlay cost.

Thickness of aphalt overlay used 4cm for bus lane and 5cm for bus terminal.

Asphalt overlay cost included scarification, tack coat, pavement work and lane marking.

Table 16.5-2 Maintenance Cost for Inner Ring Expressway

Road Name	Length (km)	Number of Lane	Bus Lane Width (m)	Area of Bus Lane (m^2)	Overlay Cost (US$/$M^2$)	Open Year	Maintenance cost (US$ / Year)		
							1st. to 5th Year	6th to 10th Year	11th to 20th Year
Carerra 7a Section	2.50	4	8.5 x 2 =17.0	42,500	23.18	2006.1	19,703	49,258	98,515
Avenida 100 Section	1.20	4	8.5 x 2 =17.0	20,400	23.18	2006.1	9,457	23,644	47,287
Avenida Quito Section	11.30	4	8.5 x 2 =17.0	192,100	23.18	2006.1	89,058	222,644	445,288
Total	15.00			255,000			118,218	295,545	591,090

Note: Thickness of asphalt overlay applied 5cm.

Asphalt overlay cost included scarification, tack coat, pavement work and lane marking.

PART E

PROJECT EVALUATION AND CONCLUSION

CHAPTER 17
Implementation Plan

PART - E PROJECT EVALUATION AND CONCLUSION

17. IMPLEMENTATION PLAN

17.1. TRUNK BUS SYSTEM

17.1.1. IMPLEMENTATION PROGRAM AND INVESTMENT (TRUNK BUS FACILITIES)

(1) Characteristics of The Project

1) Structure

Busways:	As already described in previous chapters, bus ways for both of express and trunk bus ways will be segregated from other traffic by color pavement, and bus stops will be newly provided. There are two types of bus stop in general: bus stop at center median and bus stop at sidewalk. Bus stop at center median is connected with sidewalk by pedestrian bridge and/or pedestrian crossing for passengers to get in and out. Bus ways are classified as 10 routes as discussed earlier.
Bus Terminals:	There are two types of bus terminals namely central urban bus terminal and suburban bus terminal. Central bus terminal is a partial double deck R.C. structure with mezzanine floor in it. Both 1st and 2nd floors are asphalt paved with pedestrian bridges connecting bus bays. The 1st floor is connected with the existing two roads and the 2nd floor is connected with express bus viaduct. Shops and other facilities are accommodated on the mezzanine floor. There are four types of suburban bus terminals. They are different in size, however, the number and type of facilities are the same except for size. Bus bays are interconnected with pedestrian bridges.
Express Bus Viaduct:	Express bus viaduct has single lane dual carriageway concrete structure with single pier at standard section and twin pier rigid frame at bus stops which are located at approx. 1.5km intervals. Structure is supported by cast in situ pile of ϕ 1.0m and road surface of P.C. hollow slab deck is 11.0m above the existing road to pass over pedestrian bridges. 4.0m high transparent type noise barrier will be installed above R.C. bridge railing of 1.0m height.
Flyovers:	Flyovers for express bus are built at major intersection on Autopista del Sur. There are two types of flyovers namely flyover to pass over single intersection and flyovers to pass over multiple intersections.

Single flyover consists of R.C. columns and P.C. precast I girders supported by cast in situ piles of ϕ 1.0m.

Multiple flyover is the same type of structure as express bus viaduct.

At certain sections of multiple flyover, the same type of noise barrier as that of the express bus viaduct is installed.

2) *Construction*

As described in chapter 16, in order to avoid any interference with traffic on roads, major activities have to be carried out in nighttime except for bus terminals construction and some road works.

For structural foundation work, the road surface will be covered with temporary deck cover in order not to reduce number of traffic lanes in daytime.

Care, attention and consideration shall be taken to ensure against traffic congestion on the traffic lanes.

Some traffic has to be diverted to other roads such as Avenida 7a and Avenida Ciudad De Quito during the construction of express bus viaduct over Avenida Caracas.

Working area is to be well protected from traffic by movable safety barrier and/or fence with color blinking lights and illumination for nighttime.

(2) Basic Concept of Implementation Program

Implementation Program for trunk bus way facilities is planned for a period of 6years from the middle of 1999 to the middle of 2005.

As shown in Table 17.1-1, depending on the route, the detailed design work is to be started from the middle of 1999 and construction is to be started at the beginning of 2000 with the low cost and simple work, such as trunk bus and express bus system, at Autopista del Norte.

Detailed design and construction of express bus way viaduct and flyovers together with improvement of trunk bus system are to be started from the middle of 1999 and completed in the middle of 2003.

Central bus terminal is to be started from the middle of 2000 and completed in the middle of 2003 to accomplish express bus way system.

Land acquisition and compensation on each route has to be completed within the period of the detailed design.

Detailed design period includes invitation and selection of contractor(s).

Implementation Program of each route is to be decided based on the idea for averaging at allocation of funding at peak time.

(3) Implementation Program

As shown in Table 17.1-1, activities of each year are as follows;

1999: Detailed design work for Autopista del Norte, Avenida Caracas including express bus viaduct, Autopista del Sur including flyovers and Avenida Suba 1.

2000: Detailed design work for Avenida Caracas,Avenida Suba 1, Avenida Suba 2, Detailed design work Central Bus Terminal, Suburban Bus Terminal 1 and

Suburban Bus Terminal 3. Construction of Autopista del Norte, Avenida Caracas, Avenida Suba 1, Autopista del Sur and Suburban Bus Terminal 3.

2001: Detailed design work for Avenida Suba 2, Avenida Ciudad de Quito, Central Bus Terminal and Suburban Bus Terminal2 and 4. Construction of Autopista del Norte, Avenida Caracas, Avenida Suba 1, Avenida Suba 2, Autopista del Sur, Central Bus Terminal, Suburban Bus Terminal 1 and Suburban Bus Terminal 3.

2002: Detailed design work for Suburban Bus Terminal 2 and Suburban Bus Terminal 4. Construction of Avenida Caracas,Avenida Ciudad de Quito, Autopista del Dur, Central Bus Terminal, Bus Terminal 2 and Suburban Bus Terminal 4.

2003: Detailed design work for Avenida 7a, Avenida Primero de Mayo, Suburban Bus Terminal 5 and Suburban Bus Terminal 6. Construction of Avenida 7a, Avenida Caracas, Avenida Ciuda de Quito, Autopista del Sur, Central Bus Terminal, Suburban Bus Terminal 2, 4,5 and Suburban Bus Terminal 6.

2004: Detailed Design Work for Avenida 68-Calle100, Calle170 and Suburban Bus Terminal 7. Construction of Avenida 7a, Avenida Primero de Mayo, Avenida 68-Calle 100, Calle 170, Suburban Bus Terminal 5, 6 and Suburban Bus Terminal 7.

2005: Construction of Avenida 68-Calle 100, Calle170 and Suburban Bus Terminal 7.

Table 17.1-1 Implementation Program – Trunk Busway Facilities

Project Name and Cost M US$	Length km	1999 M US$	2000 M US$	2001 M US$	2002 M US$	2003 M US$	2004 M US$	2005 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							
3.050							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	1.413	0.438				
Suburban Bus Terminal 4								
3.264				0.726	2.075	0.463		
Suburban Bus Terminal 5								
2.689					0.009	2.201	0.479	
Suburban Bus Terminal 6								
1.939					0.013	1.311	0.615	
Suburban Bus Terminal 7								
3.945						0.015	3.519	0.411
717.802	125.320	15.775	162.634	227.227	210.698	76.662	17.884	6.922

▭ Detailed Design
■ Construction

(4) Required Investment

As shown in Table 17.1-1, investment required in each year to implement the projects is as extracted in Table 17.1-2.

Table 17.1-2 Required Investment – Trunk Busway Facilities

(Unit: Million US$)

1999	2000	2001	2002	2003	2004	2005	Total
15.775	162.636	227.227	210.698	76.662	17.884	6.922	717.802

17.1.2. DEVELOPMENT SCHEME

(1) Basic Guideline

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.

(2) Public Bus Corporation

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.

(3) Toward a Rail 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.

In order to minimize the additional investment for introducing a rail transit to the Caracas trunk bus viaduct, the followings should be taken into account when designing and constructing the viaduct.

- Alignment

  The vertical and horizontal alignment of the viaduct should be designed to allow an easy accommodation of a future rail transit system. The maximum gradient is 3.0 to 3.5% and the curvature radius should be over 100m.

- Design Load

  Live load of a rail transit is larger than that of a trunk bus by 1.2 to 2.0 times. Then, the structure should be designed to bear the load of the rail transit system.

- Station

  At a station, platforms should be extended to the total length of a train plus an allowance of 4.0 to 5.0 m in the future. Then, if the train length is over 100m, the viaduct should be designed so to make this extension possible. Platforms for trunk buses have to be lifted up to the level of the train floor.

- Car Depot

  The most difficulty to convert a trunk bus system to a rail transit system may be provision of a car depot (yard). In this case, a candidate site for the depot would be found in the quarry site along the Bogota River at the south end of Av. Caracas. The connection line from the viaduct to the depot should be planned at the early stage.

- Track, Power Line and Communication Line

  For installment of rail track, re-pavement of road surface of the viaduct will be needed by removing original asphalt pavement. Systems for power supply and communication should also be planned at the planning stage of the viaduct and the design of the viaduct for a trunk bus system should be modified, if necessary.

- For Emergency

  For an emergency case, an evacuation route should be prepared between stations. The viaduct should be facilitated with emergency exits by an emergency ladder or a direct connection with a building along the viaduct.

(4) 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.

(5) Private Financing Incentives(PFI)

As stated before, the urban bus project has a possibility for application of PFI scheme because of its high profitability. To invite private capital to a public-natured infrastructure project, a variety of schemes have been tried in the world. Table 17.1-3 summarizes them. The basic idea is common among them. Differences involve the field of private finance, the way of management and ownership of a property.

Table 17.1-3 Various Schemes of Private Financing Incentives

Abbreviation	Full Name	Contents
BOT	Built – Operate – Transfer	Private sector builds a facility and manages/operates it for a contract period and transfers ownership of the facility to the Government.
BTO	Built – Transfer – Operate	Private sector builds a facility and after completion transfers ownership to the Government and operates it.
BOO	Built – OWN – Operate	Private sector builds a facility, owns and operate it permanently. Private railway lines in Japan are under this scheme.
BLT	Built – Lease – Transfer	Private sector builds and leases a facility to a public operating agency for a certain period and after the period transfers the right of operation. This scheme is to separate ownership and operation to avoid investor's market risk.
BMT	Built – Maintain – Transfer	Private sector builds and leases a facility to a public operating agency for a certain period and transfers ownership to the agency.
AOT	Acquire – Operate - Transfer	In a subway project, for example, public sector develops infrastructure and private sector acquires rolling stock and operates the subway foe a certain period and transfers ownership of rolling stock to the Government.

17.2. INNER RING EXPRESSWAY

17.2.1. IMPLEMENTATION PROGRAM AND INVESTMENT (INNER RING EXPRESSWAY)

(1) Characteristics of The Project

1) Structure

Inner ring expressway is double lane dual carriageway viaduct 16.6km long, of which 1.6km segment at Calle6 is built under the project of Autopista del Sur.

At standard section, substructure is R.C. pile cap with R.C. column and/or rigid frame supported by ϕ 1.0m cast insitu piles and superstructure is P.C. Hollow Slab deck.

Where the viaduct is crossing over the existing flyovers, superstructure is either precast P.C. I Girder or Steel Plate Girder with R.C. slab.

Where the viaduct is passing over parallel to the existing flyover(s), substructure is R.C. pile cap with Steel Column and Beam supported by ϕ 1.0m cast insitu piles and superstructure is Steel Box Girder with R.C. slab.

Road surface of viaduct is 11.0~14.0m above the existing road.

2.0m high, transparent type noise barrier, is installed above R.C. bridge railing of 1.0m height.

2) Construction

As described in chapter 16, in order to avoid any interference with traffic on roads, major activities have to be carried out at nighttime.

For structural foundation work, road surface is covered with temporary deck cover in order not to reduce number of lanes in daytime.

Care, attention, and consideration shall be taken to ensure against traffic congestion in the traffic lanes.

Working area is to be well protected from traffic by movable safety barrier and/or fence with color blinking lights and illumination for nighttime.

(2) Basic Concept on Implementation Program

Implementation Program for inner ring expressway is planned for the period of five and half years from the middle of 2000 to the end of 2005.

In order to avoid starting the IRE work at the same time of Avenida Caracas project, construction is planned to start one and half years (from 2002) after the start of Avenida Caracas since some traffic will be diverted are from Aenida Caracas to Avenida Ciudad de Quito which causes traffic congestion on the road as previously mentioned.

Land acquisition and compensation on the route has to be completed within the period of the detailed design.

Detailed design period includes invitation and selection of contractor(s).

(3) Implementation Program

As shown in Table 17.2-1, activity of each year is as follows;

1) 2000~2001 : Detailed design.

2) 2002~ 2005: Construction.

Table 17.2-1 Implementation Program – Inner Ring Expressway

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$
Inner Ring Expressawy	15.000		▭	▭	■	■	■	■
Total 638.586			11.122	26.081	67.965	205.587	205.586	122.236

▭ Detaile Design
■ Construction

(4) Required Investment

As shown in Table 17.2-1, investment required in each year to implement the project is as presented in Table 17.2-2

Table 17.2-2 Required Investment – Inner Ring Expressway

Unit: M US$

2000	2001	2002	2003	2004	2005	Total
11.122	26.081	67.965	205.587	205.586	122.236	638.586

17.2.2. DEVELOPMENT SCHEME

(1) Basic Guideline

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.

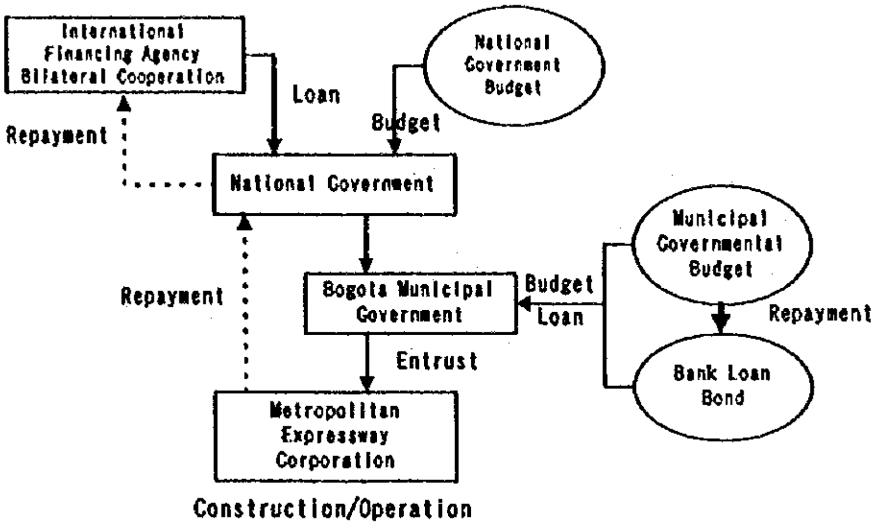
(2) Development Scheme and Fund Source

As the FIRR of the project is 4.9%, the problem is whether to take a subsidy policy or not. If not, the Government cannot expect private capital to come in, in which case the majority of the required fund needs to depend on a loan. In this case, an ordinary commercial loan is not applicable. If the interest rate is higher than 10%, the Government has to subsidize anyway in order to pay interest. A soft loan from IDA or bilateral loan is desirable. Also as for the grace period, the longer, the better. Because in the long future revenue will increase sufficiently to repay the interest of an ordinary loan.

If the Government decides to take a subsidy policy, private financing will become possible. Since it is assumed that the Government does not have the sufficient funds to disburse at one time, the PFI scheme of "Build, Lease and Transfer (BLT)" may be suitable in this case, rather than "BT". (see Chapter 17.1.2.). Toll revenue cannot cover the lease charge and the deficit has to be covered by the subsidy from the Government.

For those two cases, the development schemes are schematically shown in Figure 17.2-1. In the alternative 1, the land acquisition and compensation cost of the initial investment is shouldered by the Government. However the amount is small.

If there are no specific financial resources like an objective tax for subsidies, the subsidy policy will make an additional financial burden on the budget of the Government. Therefore, the alternative 2 is not recommendable.


Alternative 1: Development by Public Works

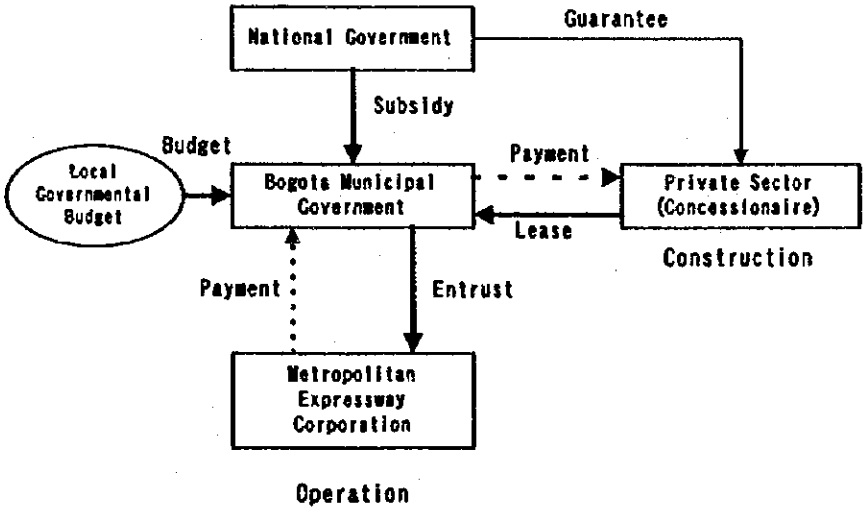

Alternative 2:Semi-Private Finance(BLT)

Figure 17.2-1 Development Scheme of Inner Ring Expressway

17.2.3. INSTITUTIONAL ARRANGEMENT

The urban expressway will need new organizations 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

Here, the organization is called tentatively the Bogota Metropolitan Expressway Corporation or simply the Corporation. Main equity holder is the Central Government or the Municipal Government. If necessary, the governmental banks can join. The Corporation is a quasi governmental agency.

The main role of the Corporation is to maintain and operate the urban expressway in Bogota. If the expressway network is going to expand in the future, the Corporation will also study, plan, contract and supervise a construction project. The roles and functions of the corporation are:

- Operation of urban expressway
- Maintenance of urban expressway
- Management of new urban expressway project
- Survey and Study on urban transportation and expressway

Therefore, the organization of the Corporation would be as shown in Figure 17.2-2. Figures in the parenthesis is the number of staff as a rule of thumb. In Figure 17.2-3, the function and activities of the Corporation are shown in detail.

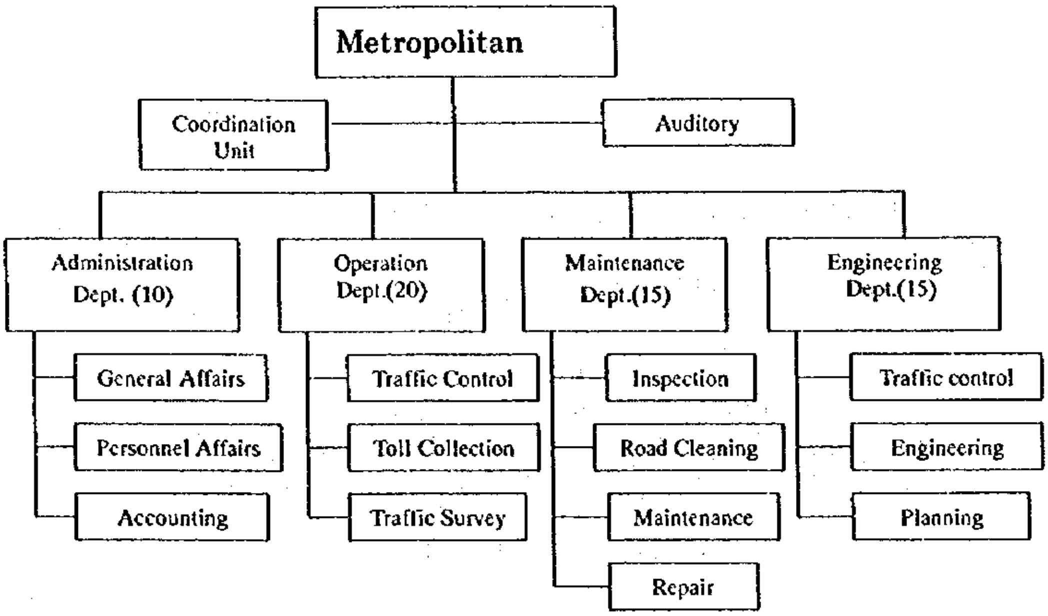
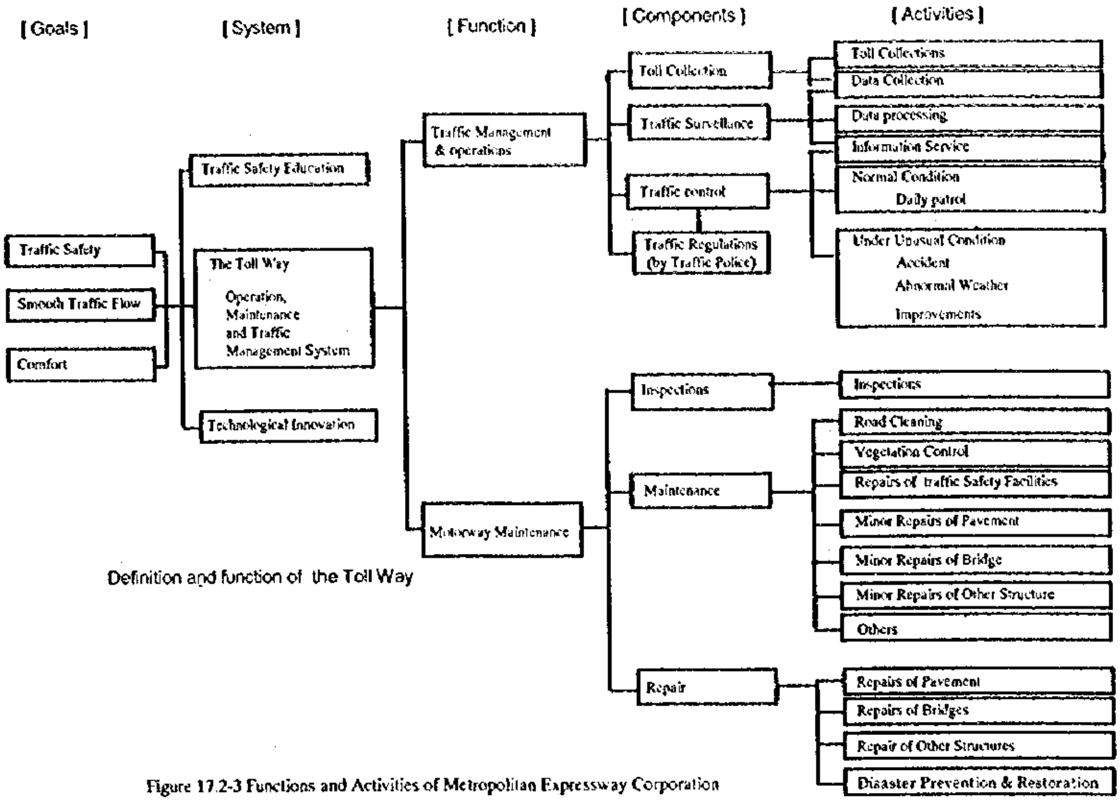


Figure 17.2-2 Sample Organization of Metropolitan Expressway Corporation

The number of staff will depend upon whether some works such as toll collection, road cleaning, accident treatment and so on are done internally or entrusted to an external agency on contract basis. Here, the number of staff is estimated based on the latter condition.



Definition and function of the Toll Way

Figure 17.2-3 Functions and Activities of Metropolitan Expressway Corporation

Figure 17.2-3 Functions and Activities of Metropolitan Expressway Corporation

CHAPTER 18
Economic and Financial Evaluation

18. ECONOMIC AND FINANCIAL EVALUATION

The trunk bus system project and the inner-ring expressway project are both evaluated in this chapter, from the economic and financial viewpoints. The economic evaluation is to examine the economic viability of the projects by comparing economic cost of the projects and economic return (benefits) to be generated in the regional or national economy after execution of the projects. The financial evaluation is to analyze if the projects are profitable or not to an operating agency through comparison of revenue and expenditure.

The two projects are independently executable, although they will mutually affect the demand. In the evaluation analysis, they are treated separately and the results are stated in a different section. When one is evaluated, implementation of the other is preconditioned along with other on-going or fixed projects such as the subway project, the Cundinamarca road project and others..

18.1 ECONOMIC EVALUATION

18.1.1. APPROACH AND ASSUMPTIONS

In this section, the trunk bus system project and the inner-ring expressway project are evaluated from the economic viewpoint, following a cost-benefit analysis. To measure and compare a cost and a benefit of the projects in economic price, the procedure shown in Figure 18.1-1.

Economic cost is a monetary expression of goods and services to be really consumed for a project implementation. Then, all the transfer cost (tax and subsidy) will be deducted from the cost measured in market price. In addition, shadow wage rates (SWRs) are applied to unskilled labor costs included in the project cost. The same process is taken to estimate unit cost of vehicle operation which is used to estimate economic benefits, by excluding all taxes and applying the SWRs to labor cost of mechanics and crews.

The implementation program shown in the previous chapter is preconditioned to identify the year when the project cost is generated or the benefit starts to accrue. Therefore, the evaluation results will be affected by a change in the implementation program

Economic benefit is defined as the amount saved in travel costs due to a project. Travel costs consist of two components, vehicle operating cost (VOC) and travel time cost (TTC). These are the benefits most direct and comparatively easy to quantify. It is obvious that there exist other benefits of a transportation project than those direct benefits, such as safety improvement and acceleration of urban development as well as mitigation of traffic congestion. In this feasibility study, however, those kinds of benefits are difficult to measure and are neglected in order to exclude an arbitrary evaluation.

Benefit of a project is measured through so-called "with" and "without" comparison. Using the results of traffic assignment to a network with the project in question and also to the same network but without the project, total VOC and TTC of each case are calculated. And then, the benefit is obtained as the difference between "with" and "without cases.

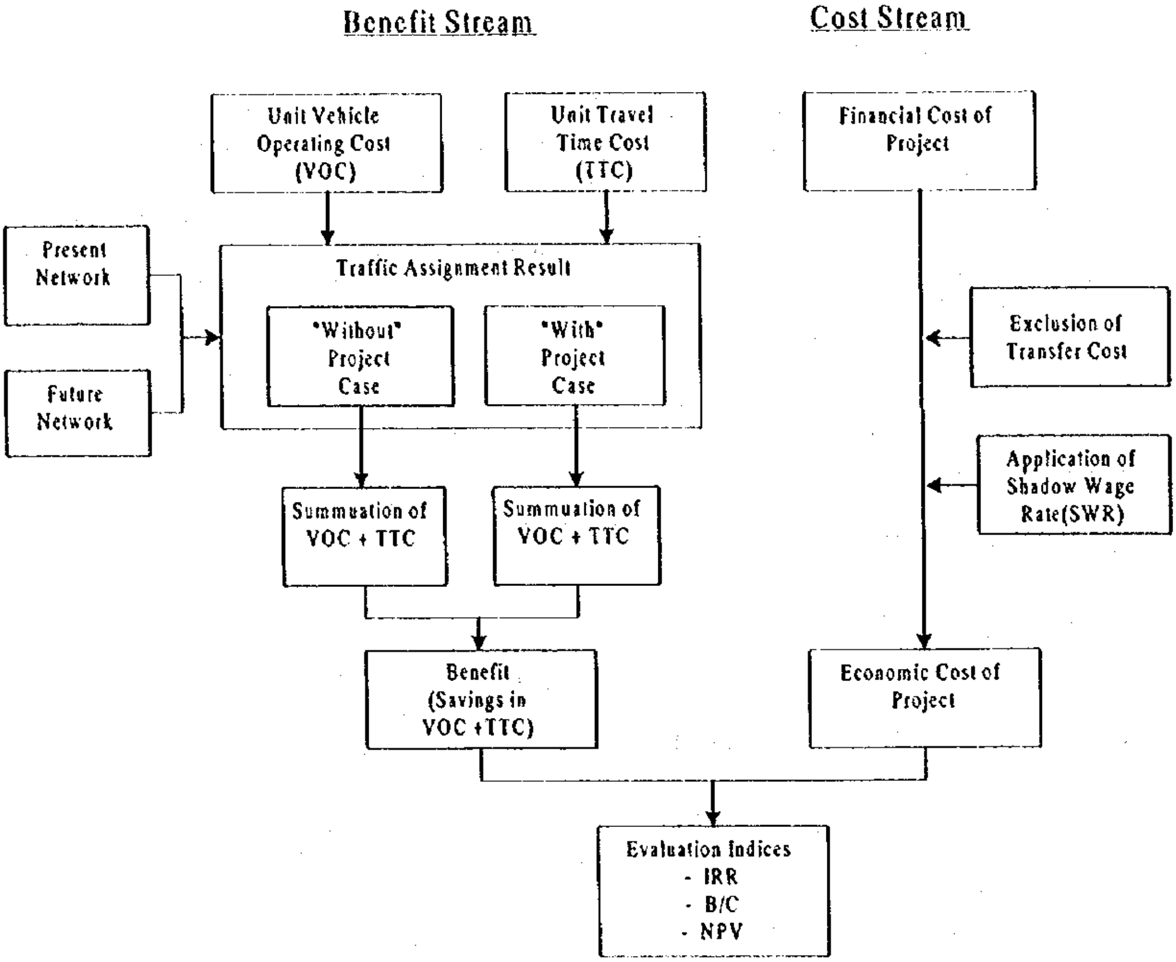


Figure 18.1-1 Work Flow for Economic Evaluation

Economic cost and benefit are compared through a discount cash flow analysis. The discount rate (DR) is 12% which is widely used in Colombia as an economic interest rate. The same rate is used in estimation of capital opportunity cost of VOC. As evaluation indicators, internal rate of return (IRR), benefit/cost ratio (B/C) and net present value (NPV) are calculated. They are defined as below:

- Internal Rate of Return(IRR): r satisfying: $\sum \frac{B_n}{(1+r)^n} = \sum \frac{C_n}{(1+r)^n}$
- Net Present Value(NPV) = $\sum \frac{B_n - C_n}{(1+DR)^n}$
- B/C Ratio(B/C) = $\sum \frac{B_n}{(1+DR)^n} \div \sum \frac{C_n}{(1+DR)_n}$

Pro-forma cash flow of a project to be evaluated is prepared for the period of 1999 to 2020. Although a physical life of an infrastructure project is 50 to 60 years long, economic life is assumed to be 25 years, taking future rapid urban growth and changes of socioeconomic conditions into consideration. Then, every investment is not completely depreciated within the analytical period until 2020. Therefore, residual value of each project in 2021 is calculated and added to the benefit stream.

18.1.2. ECONOMIC COST

Project costs estimated in Chapter 16 are expressed in the financial price and they are converted into economic cost, taking the process shown in Figure 18.1-3. The points are:

1) Construction cost is broken down into three cost items: material cost, equipment cost and labor cost.
2) Out of material and equipment cost, import duties and value added tax are deducted. The tax rate is in the range of 16 to 25%. Assumed average rate is 25% for the goods to be imported and 22% for the domestic ones.
3) Assuming 60 to 80% of labor cost is for unskilled labor, a shadow wage rate (SWR) is applied. According to data of DANE, unemployment rate in Bogota has been in the range of 10 – 15% (Figure 18.1-2). Assuming 10% of the rate in average for the long term up to 2020, the SWR is estimated at 75% according to Haveman's formula:

SWR = (Wage rate in market) x (1.25 – Unemployment Rate / 0.2)

= (Wage Rate in market) x 0.75

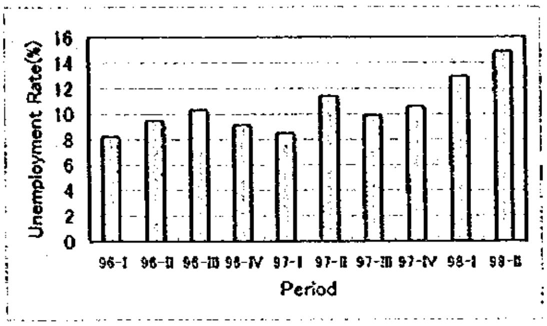


Figure 18.1-2 Unemployment Rate in Bogota

Table 18.1-1 shows the resultant economic cost of the Study projects. Economic Costs of the inner-ring expressway and the bus ways and lanes correspond to 87% of their financial costs. Total economic cost of terminals is 93% of the financial costs because they include much land acquisition and compensation cost on which no adjustment was made. Total economic cost of the Study project is US$ 2,310 million while the financial cost is US$ 2,634 million. Additionally, other related trunk bus projects require US$ 265 million at the economic price, for which the financial cost is US$ 363 million. Those projects are not included in this Study but they are treated as preconditions for this study and then included in the evaluation analysis. Some proposed trunk bus lines take routes partly on a Study road and partly on those preconditioned roads. And then, an individual evaluation is almost impossible.

The residual value of the Study projects is US$ 584 million, 25% of the total investment amount at the economic price. This amount is added to the cash inflow in the year 2021.

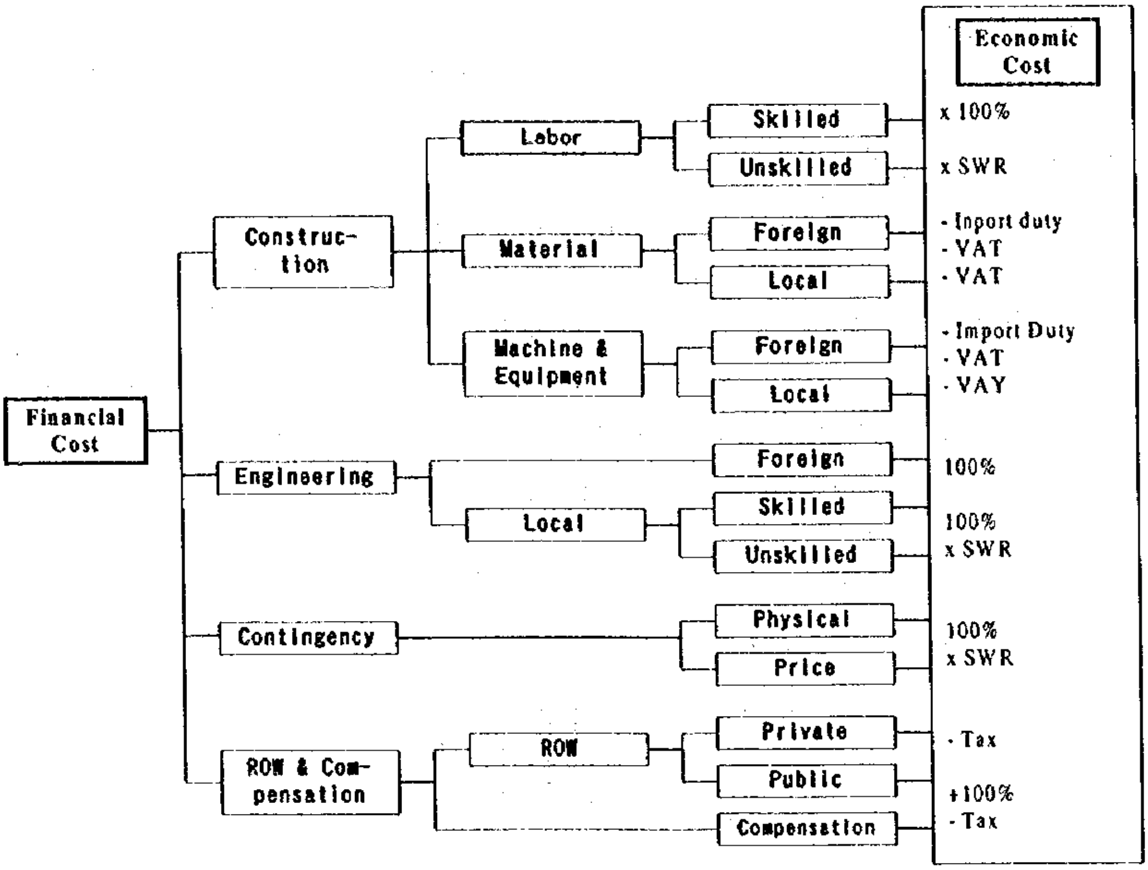


Figure 18.1-3 Conversion from Financial Cost to Economic Cost

Table 18.1-1 Financial Cost and Economic Cost of Project

(unit: US$1,000)

No.	Project	Opening Year	Project Cost		Residual Value in 2020	
			Financial	Economic	Financial	Economic
1	Expressway	2005	638,533	559,201	180,583	158,371
2	Cr. 7a.	2004	18,897	16,361	4,535	3,927
3	Apt. Norte	2001	54,133	46,966	6,496	5,636
4	Av. Caracas	2003	371,755	325,215	74,821	65,514
5	Av. 1 de Mayo	2004	512	443	123	106
6	Av. Suba(1)	2001	7,558	6,544	907	785
7	Av. Suba(2)	2001	1,288	1,115	155	134
8	Av. Quito	2004	28,901	25,835	11,534	10,798
9	Apt. Sur	2003	144,840	126,936	30,680	27,099
10	Call. 68/100	2005	8,404	7,269	2,353	2,035
11	Call. 170	2005	3,050	2,641	854	740
	Subtotal		1,277,872	1,118,527	313,041	275,144
1	Central Terminal	2003	59,752	55,296	23,085	22,194
2	Terminal Atp Norte	2001	3,281	3,146	2,379	2,363
3	Terminal Av. Caracas	2003	1,565	1,429	745	718
4	Terminal Av. Suba(1)	2001	2,031	1,882	1,052	1,034
5	Terminal Av. Sur	2003	3,265	3,007	1,706	1,654
6	Terminal Cr. 7a	2004	2,688	2,574	2,030	2,003
7	Terminal Av. 10a	2004	1,940	1,790	1,093	1,058
8	Terminal Call. 170	2005	3,944	3,829	3,320	3,288
	Sutotal		78,466	72,954	35,411	34,311
	Study Project Total	–	2,634,209	2,310,008	661,493	584,599
Related Trunk Bus Projects						
1	Calle 80	2005	90,125	78,846	31,724	28,882
2	Trv. 48(South Rail)	2005	38,872	34,007	13,683	12,457
3	Av. de las Americas	2005	39,558	34,607	13,924	12,677
4	Av. Boyaca	2005	45,523	39,826	16,024	14,588
5	Av. Centenario	2005	89,372	78,187	31,459	28,640
	Subtotal		303,450	265,473	106,814	97,244

18.1.3. VEHICLE OPERATING COST

Vehicle operating cost (VOC) is one of the main sources of economic benefit. The operating cost per unit distance is estimated by type of vehicle, such as passenger car, taxi, light truck, heavy truck, bus, large bus and articulated bus. The last two do not exist at present in Bogota but were added for this project.

VOC is composed of the following components:

a) Fuel cost
b) Oil cost
c) Tire cost
d) Repair cost
e) Depreciation cost
f) Capital opportunity cost
g) Crew and overhead cost

In Colombia, the Ministry of Transport has been periodically updating VOC data in order to use an input to the HDM Model which is developed by IBRD for the appraisal of highway development and maintenance projects. The VOC estimates in this Study depend on the basic information and assumptions of the MOT's data.

The HDM Model is mostly applied, however, to inter-municipal or inter-regional highway projects where a key factor affecting VOC is surface conditions of a road, especially in terms of roughness. On the other hand, unit VOC needed for this project are those applicable to urban road which are mostly paved and where the key factor is not roughness but operating speed. Therefore, unit VOC of each component from (a) to (e) is expressed as a function of operating (travel) speed. A part of item (e) and the others (item (f) and (g)) are not directly affected by operating speed but by travel time.

Unit costs of each item are estimated at market price and then are converted into economic cost. VOC varies by road surface conditions. However, unit VOCs are investigated only for paved road because the roads examined in this Study are mostly in the urban area of Bogota which are paved.

(1) Characteristics of Representative Vehicles

Although there are many vehicles of different makes and models actually running in Bogota and unit VOC varies by makes/models and also changes by vehicle age, several popular models are selected as representative ones and their VOCs are studied and aggregated by taking an average.

Table 18.1-2 Characteristics of Representative Vehicles

		Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articula-ted Bus (200pax.)	Light Truck	Heavy Truck
1	Representative Model	Matsuda Ford Toyota Daewoo	Chevrolet Mazda Hyndai Ford	Chevrolet Hyndai Iveco	Chevrolet International Dina Iveco	Volvo Mercedes Scania	Volvo Mercedes Scania	Chevrolet Isuzu	Inter-national Isuzu
2	Price(US$)								
	(1) Financial	17,800	13,437	36,595	53,797	140,000	198,000	22,595	58,340
	(2) Economic	11,784	11,585	31,544	46,377	120,690	170,690	15,280	49,242
3	No. of Tires	4	4	4	6	6	10	4	6
4	Fuel Type	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel	Gasoline	Diesel
5	Annual Operation	25000	60000	70000	70000	80000	90000	35000	35000
6	Average Speed	25	25	20	20	25	30	30	30
8	Annual using hours	1000	2400	3500	3500	3200	3000	1167	1167

The economic cost of each representative vehicle is the market price less taxes. Table 18.1-2 shows average cost and characteristics such as tire type, fuel type, operating distance and hours.

(2) Fuel Cost

Colombia produces and refines crude oil, but production of gasoline is not enough to meet the domestic demand and 10 to 15% of total consumption depends on import. Retail price of regular gasoline is US$ 0.273/liter, of which 13% corresponds to taxes. Deducting this tax amount from the financial price, economic price of regular gasoline is estimated to be US$ 0.241/liter. In the same way, Economic price of super gasoline is US$ 0.418, diesel oil US$ 0.239 (On diesel, no tax is imposed).

Table 18.1-3 shows composition of fuel consumption by type of vehicles, which was estimated based on MOT's data and interviewing survey of major gas stations in Bogota. Making averages of fuel prices weighted by these consumption rates, fuel costs of each vehicle were estimated as indicated in the table.

Table 18.1-3 Composition of Fuel Type and Average Fuel Cost by Type of Vehicle

(%, US$/liter)

Fuel Type	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Regular Gasoline	55	80	20	20			80	10
Super Gasoline	45	20						
Diesel			80	80	100	100	20	90
Total	100	100	100	100	100	100	100	100
Av. Financial Cost(US$/liter)	0.34	0.30	0.25	0.25	0.24	0.24	0.27	0.24
Av Economic Cost(US$/liter)	0.30	0.27	0.24	0.24	0.24	0.24	0.24	0.24

Fuel consumption rate of vehicle varies according to its running speed. The most economical speed is 45 to 50 km/hr for passenger car, and 50 to 60 km/hr for medium and large vehicles. Based on the MOT's data concerning the fuel consumption rate by running speed, fuel costs/km are tabulated by type of vehicle, as shown in Table 18.1-4.

(3) Oil Cost

Retail price of lubricant oil is US$ 2.33 /liter and after deducting tax, economic cost is US$ 1.86 /liter. According to a general experimental data, the relations between oil consumption and running speed are as shown in Table 18.1-5. From this information, economic oil cost can be calculated by running speed.

(4) Tire Cost

Table 18.1-6 presents type of tire, market price and economic price by type of vehicle. Under the condition of average speed of 35 mile/hr (56 km/hr) on paved roads, average tire life can be assumed to be 45,000 km for passenger car and 50,000 km for heavy vehicle.

Table 18.1-4 Fuel Consumption Rate and Cost by Type of Vehicle

	Operating Speed (Km/hr)	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Fuel Consumption Rate (Liter/100Km)	5	212.6	212.6	337.2	672.7	975.4	1210.9	605.2	1210.4
	10	138.6	138.6	215.8	430.4	624.1	774.7	387.3	774.5
	20	100.2	100.2	156.0	311.2	451.2	560.2	280.0	560.0
	30	87.0	87.0	122.2	284.2	412.1	511.6	235.0	412.0
	40	80.2	80.2	107.9	264.5	383.5	476.1	225.0	342.0
	50	78.4	78.4	101.4	284.2	412.1	511.6	220.0	314.0
	60	81.0	81.0	97.5	326.1	472.8	587.0	225.0	303.0
	70	85.7	85.7	98.2	380.9	552.3	685.6	230.0	314.0
	80	92.7	92.7	102.0	438.1	635.2	788.6	250.0	340.0
	90	102.4	102.4	112.7	483.9	701.7	871.0	276.2	375.6
Financial Fuel Cost (US$/100km)	5	71.6	64.0	82.9	165.3	233.2	289.4	160.9	293.4
	10	46.7	41.7	53.0	105.8	149.2	185.2	103.0	187.7
	20	33.7	30.2	38.3	76.5	107.9	133.9	74.4	135.7
	30	29.3	26.2	30.0	69.8	98.5	122.3	62.5	99.9
	40	27.0	24.1	26.5	65.0	91.7	113.8	59.8	82.9
	50	26.4	23.6	24.9	69.8	98.5	122.3	58.5	76.1
	60	27.3	24.4	24.0	80.1	113.0	140.3	59.8	73.4
	70	28.8	25.8	24.1	93.6	132.0	163.9	61.2	76.1
	80	31.2	27.9	25.1	107.7	151.9	188.5	66.5	82.4
	90	34.5	30.8	27.7	118.9	167.7	208.2	73.4	91.0
Economic Fuel Cost (US$/100km)	5	63.3	56.6	80.8	161.1	233.2	289.4	145.7	289.6
	10	41.3	36.9	51.7	103.1	149.2	185.2	93.3	185.3
	20	29.8	26.7	37.4	74.5	107.9	133.9	67.4	134.0
	30	25.9	23.2	29.3	68.1	98.5	122.3	56.6	98.6
	40	23.9	21.4	25.8	63.3	91.7	113.8	54.2	81.8
	50	23.4	20.9	24.3	68.1	98.5	122.3	53.0	75.1
	60	24.1	21.6	23.3	78.1	113.0	140.3	54.2	72.5
	70	25.5	22.8	23.5	91.2	132.0	163.9	55.4	75.1
	80	27.6	24.7	24.4	104.9	151.9	188.5	60.2	81.3
	90	30.5	27.3	27.0	115.9	167.7	208.2	66.5	89.9

Thus, tire consumption rates per 1,000 km are 8.9% and 12.0%, respectively. On the other hand, it is empirically known that this consumption rate becomes larger when average running speed rises. An IBRD report ("Quantification of road user savings", IBRD Occasional Paper No.2, 1966) shows the relationship as in Table 18.1-7. Based on this information, economic tire cost per km can be obtained as shown in the same table.

Although some vehicles use re-treaded tire, they are neglected for the reasons that the market share is not significant and that the life of re-treaded tire is shorter than brand new tire even if its price is lower, so that there is no big difference in economic price per kilometer between the two.

Table 18.1-5 Oil Consumption Rate and Cost by Type of Vehicle

	Speed (Km/hr)	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Oil Consumption Rate(Liter/1000Km)	5	3.48	3.48	4.10	8.01	11.61	16.02	6.86	8.01
	10	2.24	2.24	2.63	5.14	7.45	10.28	4.40	5.14
	20	1.54	1.54	1.81	3.53	5.12	7.06	3.03	3.54
	30	1.27	1.27	1.49	2.92	4.23	5.84	2.50	2.92
	40	1.13	1.13	1.33	2.68	3.89	5.36	2.22	2.68
	50	1.10	1.10	1.29	2.58	3.74	5.16	2.08	2.58
	60	1.09	1.09	1.28	2.36	3.42	4.72	1.80	2.36
	70	1.07	1.07	1.26	2.14	3.10	4.28	1.68	2.14
	80	1.00	1.00	1.18	1.87	2.71	3.74	1.52	1.87
	90	0.90	0.90	1.06	1.68	2.44	3.36	1.37	1.68
Financial Oil Cost (US$/1000km)	5	8.1	8.1	9.5	18.6	27.0	37.3	16.0	18.6
	10	5.2	5.2	6.1	12.0	17.3	23.9	10.2	12.0
	20	3.6	3.6	4.2	8.2	11.9	16.4	7.0	8.2
	30	3.0	3.0	3.5	6.8	9.8	13.6	5.8	6.8
	40	2.6	2.6	3.1	6.2	9.0	12.5	5.2	6.2
	50	2.6	2.6	3.0	6.0	8.7	12.0	4.8	6.0
	60	2.5	2.5	3.0	5.5	8.0	11.0	4.2	5.5
	70	2.5	2.5	2.9	5.0	7.2	10.0	3.9	5.0
	80	2.3	2.3	2.7	4.3	6.3	8.7	3.5	4.3
	90	2.1	2.1	2.5	3.9	5.7	7.8	3.2	3.9
Economic Oil Cost (US$/1000km)	5	6.5	6.5	7.6	14.9	21.6	29.8	12.8	14.9
	10	4.2	4.2	4.9	9.6	13.9	19.1	8.2	9.6
	20	2.9	2.9	3.4	6.6	9.5	13.1	5.6	6.6
	30	2.4	2.4	2.8	5.4	7.9	10.9	4.7	5.4
	40	2.1	2.1	2.5	5.0	7.2	10.0	4.1	5.0
	50	2.0	2.0	2.4	4.8	7.0	9.6	3.9	4.8
	60	2.0	2.0	2.4	4.4	6.4	8.8	3.3	4.4
	70	2.0	2.0	2.3	4.0	5.8	8.0	3.1	4.0
	80	1.9	1.9	2.2	3.5	5.0	7.0	2.8	3.5
	90	1.7	1.7	2.0	3.1	4.5	6.3	2.5	3.1

Table 18.1-6 Financial Economic Cost of Tire

Item	Unit	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
No. of Tires	No./set	4	4	4	6	6	10	4	6
Type of Tire		175-70-R13	175-71-R14	750-16	900-20 1000-20	900-20 1000-20	900-20 1000-20	750-16	950-200
Financial Cost (Market Price)	US$/Set	425.66	425.66	552.10	3209.56	3209.56	5349.26	896.00	2485.22
Tax	US$/Set	98.23	98.23	127.41	740.67	740.67	1234.44	206.77	573.51
Economic Cost	US$/Set	327.43	327.43	424.70	2468.89	2468.89	4114.82	689.23	1911.71
Tire Life	Km	45,000	45,000	45,000	50,000	50,000	50,000	45,000	50,000
Tire Consumption Rate	% /1000km	2.2	2.2	2.2	2.0	2.0	2.0	2.2	2.0

Table 18.1-7 Tire Consumption Rate and Cost by Type of vehicle

	Speed (Km/hour)	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Tire Consumption Indices (56km/hr =100)	5	53	53	53	53	53	53	53	53
	10	56	56	56	56	56	56	56	56
	20	60	60	60	60	60	60	60	60
	30	67	67	67	67	67	67	67	67
	40	78	78	78	78	78	78	78	78
	50	92	92	92	92	92	92	92	92
	56	100	100	100	100	100	100	100	100
	60	107	107	107	107	107	107	107	107
	70	125	125	125	125	125	125	125	125
	80	151	151	151	151	151	151	151	151
	90	180	180	180	180	180	180	180	180
Financial Tire Cost (US$/1000km)	5	5.0	5.0	6.5	34.0	34.0	56.7	10.6	26.3
	10	5.3	5.3	6.9	35.9	35.9	59.9	11.2	27.8
	20	5.7	5.7	7.4	38.5	38.5	64.2	11.9	29.8
	30	6.3	6.3	8.2	43.0	43.0	71.7	13.3	33.3
	40	7.4	7.4	9.6	50.1	50.1	83.4	15.5	38.8
	50	8.7	8.7	11.3	59.1	59.1	98.4	18.3	45.7
	60	10.1	10.1	13.1	68.7	68.7	114.5	21.3	53.2
	70	11.8	11.8	15.3	80.2	80.2	133.7	24.9	62.1
	80	14.3	14.3	18.5	96.9	96.9	161.5	30.1	75.1
	90	17.0	17.0	22.1	115.5	115.5	192.6	35.8	89.5
Economic Tire Cost (US$/1000km)	5	3.9	3.9	5.0	26.2	26.2	43.6	8.1	20.3
	10	4.1	4.1	5.3	27.7	27.7	46.1	8.6	21.4
	20	4.4	4.4	5.7	29.6	29.6	49.4	9.2	22.9
	30	4.9	4.9	6.3	33.1	33.1	55.1	10.3	25.6
	40	5.7	5.7	7.4	38.5	38.5	64.2	11.9	29.8
	50	6.7	6.7	8.7	45.4	45.4	75.7	14.1	35.2
	60	7.8	7.8	10.1	52.8	52.8	88.1	16.4	40.9
	70	9.1	9.1	11.8	61.7	61.7	102.9	19.1	47.8
	80	11.0	11.0	14.3	74.6	74.6	124.3	23.1	57.7
	90	13.1	13.1	17.0	88.9	88.9	148.1	27.6	68.8

(5) Repair Cost

Calculating annual maintenance cost based on MOT's VOC data, the rate of annual maintenance cost to the vehicle price is estimated to be 4.2% for passenger car, and small truck and 7.4% for other commercial vehicles with large annual running distance. By assuming annual running distance, maintenance cost per kilometer can be calculated as shown in Table 18.1-8.

According to the same IBRD report referred to in the tire cost estimation, the relationship between maintenance cost and running speed shows that maintenance cost becomes lowest at around 50 km/hr of speed. Using these conversion rates, maintenance cost can be obtained at different speeds (Table 18.1-9).

Table 18.1-8 Assumptions for Repair Cost Estimation

	Unit	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Vehicle Cost									
Financial	US$	17,800	13,437	36,595	53,797	140,000	198,000	22,595	58,340
Economic	US$	11,784	11,585	31,544	46,377	120,690	170,690	15,280	49,242
Tire Cost									
Financial	US$	426	426	552	3,210	3,210	5,349	896	2,485
Economic	US$	327	327	425	2,469	2,469	4,115	689	1,912
Vehicle Cost w/o Tire									
Financial	US$	17,374	13,012	36,043	50,588	136,790	192,651	21,699	55,855
Economic	US$	11,456	11,258	31,119	43,908	118,221	166,575	14,591	47,330
Annual Repair Cost									
% of Vehicle Cost	%	4.0	8.0	8.0	8.0	8.0	8.0	6.0	8.0
Financial	US$	695	1,041	2,883	4,047	10,943	15,412	1,302	4,468
Economic	US$	458	901	2,490	3,513	9,458	13,326	875	3,786
Annual Operation.	Km	25,000	60,000	70,000	70,000	80,000	90,000	35,000	35,000
Average Speed	Km/Hr	25	25	20	20	25	30	30	30
Repair Cost at Average Speed									
Financial	US$	27.8	17.3	41.2	57.8	136.8	171.2	37.2	127.7
Economic	US$	18.3	15.0	35.6	50.2	118.2	148.1	25.0	108.2

(6) Depreciation Cost

Depreciable amount is defined as the vehicle economic cost (without tire cost) less salvage cost after usage during vehicle life. In Colombia, where market for secondhand vehicles and spare parts is well developed, salvage value rate should be assumed at rather high rate, namely, 25% for passenger car, 20% for small truck and 15% for others (Table 18.1-10).

Vehicles are devaluated through their use in proportion to running kilometers, while their value will decrease as they become old, even without usage. Particularly, a passenger car loses its value rapidly as time passes. Therefore, the proportion of depreciation subject to use, and depreciation subject to time may be assumed as follows: 50:50 for passenger car and 70:30 for others.

Depreciation subject to use is furthermore subdivided into two parts. It is assumed that one third of this cost depends on the number of driven distance and two thirds are affected by running speed, in the same way as maintenance cost. Costs of use-related depreciation and time-relate depreciation are shown in Table 18.1-11 and Table 18.1-12, respectively.

Time related depreciation in the table presents daily depreciation cost which is depreciable amount divided by number of days during life period. This cost is independent from driven distance and from running speed. Therefore, this cost shall be calculated separately based on the number of vehicles in the region and added to the other cost which is affected by running speed. The same thing can be said to the capital opportunity cost, crew cost and overhead cost.

(7) Capital Opportunity Cost

This cost is not affected by use but accrues only as time passes and is determined by vehicle price, life period, salvage value rate and interest rate, using the following formula:

Table 18.1-9 Financial and Economic Repair Cost by Type of Vehicles

	Speed (km/hr)	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Repair Cost Rate by Speed	5	141	141	142	142	142	142	134	159
	10	133	133	131	131	131	131	126	147
	20	118	118	111	111	111	111	113	124
	30	105	105	89	89	89	89	100	100
	40	95	95	74	74	74	74	94	83
	50	94	94	72	72	72	72	93	81
	60	100	100	79	79	79	79	100	88
	70	108	108	88	88	88	88	107	98
	80	115	115	100	100	100	100	114	112
	90	122	122	112	112	112	112	120	125
Financial Repair Cost (US$/1000km)	5	39.2	24.5	58.6	82.2	194.5	243.5	49.8	203.2
	10	37.0	23.1	54.0	75.8	179.3	224.5	46.9	187.2
	20	32.8	20.5	45.8	64.2	152.0	190.3	41.9	158.5
	30	31.0	19.3	41.2	57.8	136.8	171.2	39.5	143.1
	40	29.2	18.2	36.6	51.4	121.6	152.2	37.2	127.7
	50	27.8	17.3	33.6	47.2	111.7	139.9	36.1	117.0
	60	26.4	16.5	30.7	43.0	101.8	127.5	35.0	106.4
	70	26.1	16.3	29.7	41.8	98.8	123.7	34.7	103.2
	80	27.8	17.3	32.5	45.6	107.9	135.1	37.2	111.7
	90	30.0	18.7	36.2	50.7	120.1	150.3	39.7	124.5
Economic Repair Cost (US$/1000km)	5	25.8	21.2	50.6	71.4	168.1	210.6	33.5	172.2
	10	24.4	20.0	46.6	65.8	155.0	194.1	31.6	158.7
	20	21.6	17.7	39.5	55.8	131.4	164.5	28.2	134.3
	30	20.4	16.7	35.6	50.2	118.2	148.1	26.6	121.3
	40	19.2	15.8	31.6	44.6	105.1	131.6	25.0	108.2
	50	18.3	15.0	29.0	41.0	96.5	120.9	24.3	99.2
	60	17.4	14.3	26.5	37.4	88.0	110.2	23.6	90.2
	70	17.2	14.1	25.7	36.2	85.4	106.9	23.3	87.4
	80	18.3	15.0	28.1	39.6	93.3	116.8	25.0	94.7
	90	19.8	16.2	31.2	44.0	103.8	130.0	26.7	105.5

Table 18.1-10 Assumptions for Depreciation Cost Estimation

	Unit	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articula-ted Bus (200pax.)	Light Truck	Heavy Truck
Vehicle Cost									
Financial	US$	17,800	13,437	36,595	53,797	140,000	198,000	22,595	58,340
Economic	US$	11,784	11,585	31,544	46,377	120,690	170,690	15,280	49,242
Tire Cost									
Financial	US$	426	426	552	3,210	3,210	5,349	896	2,485
Economic	US$	327	327	425	2,469	2,469	4,115	589	1,912
Vehicle Cost w/o Tire									
Financial	US$	17,374	13,012	36,043	50,588	136,790	192,651	21,699	55,855
Economic	US$	11,456	11,258	31,119	43,908	118,221	166,575	14,591	47,330
Salvage Value									
% of Vehicle Cost	%	25.0	10.0	15.0	15.0	20.0	20.0	20.0	15.0
Financial	US$	4,344	1,301	5,406	7,588	27,358	38,530	4,340	8,378
Economic	US$	2,864	1,126	4,668	6,586	23,644	33,315	2,918	7,100
Annual Operation.	Km	25,000	60,000	70,000	70,000	80,000	90,000	35,000	35,000
Average Speed	Km/Hr	25	25	20	20	25	30	30	30
Vehicle Life	Year	12	10	10	12	12	12	12	12
% of Dep. of Use & Time									
Subject to use	%	50	50	70	70	70	70	70	70
Subject to time	%	50	50	30	30	30	30	30	30
Depreciable Amount									
Financial									
subject to use	US$	6,515	5,855	21,445	30,100	76,603	107,884	12,151	33,234
subject to time	US$	6,515	5,855	9,191	12,900	32,830	46,236	5,208	14,243
Total	US$	13,031	11,711	30,636	43,000	109,432	154,121	17,359	47,477
Economic									
subject to use	US$	4,296	5,066	18,516	26,125	66,204	93,282	8,171	28,162
subject to time	US$	4,296	5,066	7,935	11,197	28,373	39,978	3,502	12,069
Total	US$	8,592	10,132	26,451	37,322	94,577	133,260	11,673	40,231

$$C = P\,(1 - r)\,F - P\,/\,n + i\,r\,P$$

$$F = i\,(1 + i)^n\,/\,(\,(1 + i)^n - 1)$$

Where,

C: Capital opportunity cost
P: Economic cost of vehicle
F: Capital recovery factor
r: Salvage value rate
i: Interest rate
n: Durability (Vehicle life)

Table 18.1-11 Financial and Economic Depreciation Cost subject to Use

	Speed (Km/hour)	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articula-ted Bus (200pax.)	Light Truck	Heavy Truck
Indices for Depreciation Cost subject to Use (Av. Speed = 100)	5	136	136	119	131	131	131	126	146
	10	130	130	114	123	123	123	121	137
	20	119	119	104	108	108	108	110	119
	30	108	108	96	92	92	92	100	100
	40	100	100	91	81	81	81	96	86
	50	100	100	91	80	80	80	95	85
	60	104	104	96	84	84	84	100	90
	70	110	110	100	91	91	91	106	98
	80	116	116	105	99	99	99	111	109
	90	121	121	109	109	109	109	116	120
Financial Depreciation Cost subject to Use (US$/1000km)	5	29.6	13.3	36.4	46.9	104.4	130.7	36.6	115.6
	10	28.3	12.7	34.8	44.2	98.3	123.1	34.9	108.0
	20	25.8	11.6	31.9	38.7	86.3	108.0	31.8	94.3
	30	24.7	11.1	30.6	35.8	79.8	99.9	30.4	86.7
	40	23.5	10.6	29.4	32.9	73.3	91.8	28.9	79.1
	50	21.7	9.8	28.1	29.1	64.7	81.0	27.8	68.8
	60	21.7	9.8	27.9	28.9	64.3	80.5	27.7	68.1
	70	21.7	9.8	27.8	28.7	63.8	79.9	27.5	67.4
	80	22.6	10.2	29.4	30.2	67.3	84.2	28.9	71.6
	90	24.0	10.8	30.6	32.5	72.5	90.7	30.6	77.8
Economic Depre-ciation Cost subject to Use (US$/1000km)	5	19.5	11.5	31.4	40.7	90.2	113.0	24.6	98.0
	10	18.6	11.0	30.0	38.3	85.0	106.4	23.5	91.5
	20	17.0	10.0	27.6	33.6	74.6	93.4	21.4	79.9
	30	16.3	9.6	26.5	31.1	69.0	86.4	20.4	73.5
	40	15.5	9.1	25.3	28.6	63.4	79.4	19.5	67.1
	50	14.3	8.4	24.2	25.2	55.9	70.0	18.7	58.3
	60	14.3	8.4	24.1	25.0	55.5	69.6	18.6	57.7
	70	14.3	8.4	24.0	24.9	55.2	69.1	18.5	57.1
	80	14.9	8.8	25.3	26.2	58.2	72.8	19.5	60.6
	90	15.8	9.3	26.5	28.2	62.6	78.4	20.6	65.9

Table 18.1-12 Financial and Economic Depreciation Cost subject to Time

	Unit	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articula-ted Bus (200pax.)	Light Truck	Heavy Truck
Financial Cost									
Daily Cost	US$/Day	1.49	1.60	2.52	2.95	7.50	10.56	1.19	3.25
Hourly Cost	US$/Hr	0.54	0.24	0.26	0.31	0.85	1.28	0.37	1.02
Economic Cost									
Daily Cost	US$/Day	0.98	1.39	2.17	2.56	6.48	9.13	0.80	2.76
Hourly Cost	US$/Hr	0.36	0.21	0.23	0.27	0.74	1.11	0.25	0.86

Interest rate is 12% which is the same rate as the discount rate used when calculating evaluation indices. Table 18.1-13 presents daily capital opportunity cost.

Total capital opportunity cost in the study area is the product of this daily cost and total number of vehicles existing in the area. Therefore, in a with and without comparison for project evaluation, this cost will be cancelled if in both cases the number of vehicles is the same.

Table 18.1-13 Capital Opportunity Cost by Type of Vehicle

Unit	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articula-ted Bus (200pax.)	Light Truck	Heavy Truck
US$	17,800	13,437	36,595	53,797	140,000	198,000	22,595	58,340
US$	11,784	11,585	31,544	46,377	120,690	170,690	15,280	49,242
US$	426	426	552	3,210	3,210	5,349	896	2,485
US$	327	327	425	2,469	2,469	4,115	689	1,912
US$	17,374	13,012	36,043	50,588	136,790	192,651	21,699	55,855
US$	11,456	11,258	31,119	43,908	118,221	166,575	14,591	47,330
%	25.0	25.0	15.0	15.0	15.0	15.0	20.0	15.0
US$	4,344	3,253	5,406	7,588	20,519	28,898	4,340	8,378
US$	2,864	2,814	4,668	6,586	17,733	24,986	2,918	7,100
Km	25,000	60,000	70,000	70,000	80,000	90,000	35,000	35,000
Km/Hr	25	25	20	20	25	30	30	30
Year	12	10	10	12	12	12	12	12
	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
US$/Day	3.57	2.67	6.81	9.56	25.86	36.42	4.28	10.56
US$/Hr	0.63	0.16	0.36	0.60	1.42	1.77	0.54	1.32
US$/Day	2.35	2.31	5.88	8.30	22.35	31.49	2.88	8.95
US$/Hr	0.41	0.14	0.31	0.52	1.22	1.53	0.36	1.12

(8) Crew Cost and Overhead Cost

Also, this cost is not affected by driven distance but is proportional to time. According to information from hearing to vehicle owners, average annual wage of a bus driver is about US$ 6,500 while that of a taxi and buseta driver is lower than this amount approximately by 15%. Average wage of a truck driver is in the same level as bus driver's. (Table 18.1-14)

Most of buses are owned by individual persons in Bogota, not by enterprise. One owner possesses one or few bus fleet and rents them to his driver. Under these circumstances, therefore, much overhead cost is not needed. Bus owner's profit is not regarded as economic cost, and overhead cost of truck transport business is about 30% of crew cost.

Table 18.1-14 Crew Cost and Overhead Cost by Type of Vehicle

	Unit	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articula-ted Bus (200pax.)	Light Truck	Heavy Truck
Annual Crew Cost									
Financial	US$	0	5,850	5,200	6,500	7,150	7,150	0	6,500
Economic	US$	0	4,388	3,900	4,875	5,363	5,363	0	4,875
Annul Overhead Cost								-	
Financial	US$	0	1,170	1,040	1,950	2,145	2,145	0	1,300
Economic	US$	0	878	780	1,463	1,609	1,609	0	975
Daily Crew and OH Cost								-	
Financial	US$	0.00	19.23	17.10	23.15	25.47	25.47	0.00	21.37
Economic	US$	0.00	14.42	12.82	17.36	19.10	19.10	0.00	16.03
Hourly Crew and OH Cost								-	
Financial	US$	0.00	1.17	0.89	1.45	1.39	1.24	0.00	2.67
Economic	US$	0.00	0.88	0.67	1.09	1.05	0.93	0.00	2.01

(9) Aggregate VOC

Aggregate units VOCs are summarized as shown in Table 18.1-15. To calculate total VOC in a network, firstly, running speed of each link must be obtained from the traffic assignment result, secondly, total distance-related cost is calculated by summing up the cost in each link and finally, time-related cost calculated separately using total number of vehicles is added to the distance-related cost.

Table 18.1-15 Aggregate VOC by Type of Vehicle

(1) VOC subject to Use (US$/1000Km)

	Speed (Km/hour)	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Financial Cost	5	153.5	114.9	193.9	347.1	593.1	757.6	273.9	657.2
	10	122.4	88.0	154.8	273.6	480.2	616.6	206.2	522.8
	20	101.6	71.5	127.6	226.2	396.5	512.8	167.1	426.6
	30	94.2	65.9	113.5	213.3	367.9	478.7	151.5	369.8
	40	89.7	62.9	105.2	205.6	345.7	453.7	146.6	334.7
	50	87.2	62.0	100.9	211.2	342.7	453.6	145.6	313.7
	60	87.4	62.6	97.8	221.7	351.3	466.2	146.6	303.1
	70	89.3	64.5	97.7	237.7	370.6	491.9	148.6	304.9
	80	95.8	69.6	105.0	268.1	413.6	550.3	161.0	332.2
	90	104.8	76.7	115.5	303.0	462.9	618.6	177.1	372.2
Economic Cost	5	119.0	99.7	175.4	314.2	539.3	686.4	224.7	594.9
	10	92.6	76.1	138.5	244.4	430.7	551.0	165.1	466.5
	20	75.7	61.7	113.5	200.1	352.9	454.3	131.8	377.7
	30	69.8	56.7	100.4	187.9	326.7	422.7	118.5	324.3
	40	66.4	54.1	92.6	180.0	305.9	399.0	114.7	291.9
	50	64.7	53.1	88.7	184.5	303.4	398.6	113.9	272.6
	60	65.2	53.6	85.8	194.3	312.3	411.2	115.0	263.0
	70	66.9	55.2	85.6	209.2	331.2	435.9	116.7	264.6
	80	71.8	59.5	91.8	235.9	370.0	488.0	126.6	287.9
	90	78.8	65.5	100.9	265.9	413.2	547.1	139.5	322.1

(2) VOC subject to Time ($/Hour)

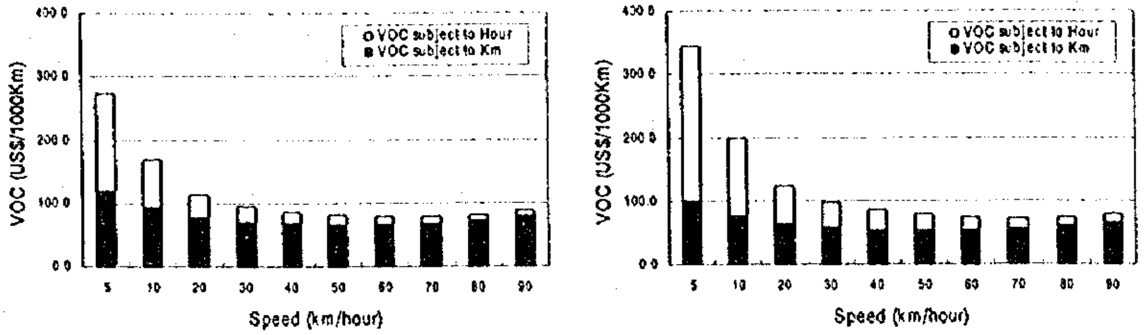
	Car	Taxi	Buseta	Bus (60 pax.)	Large Bus (100 pax.)	Articulated Bus (200pax.)	Light Truck	Heavy Truck
Financial Cost								
Depreciation	0.543	0.244	0.263	0.307	0.855	1.284	0.372	1.017
Capital Opportunity Cost	0.625	0.163	0.355	0.598	1.416	1.772	0.536	1.321
Crew and Overhead Cost	0.000	1.170	0.891	1.449	1.394	1.239	0.000	2.674
Total	1.168	1.577	1.509	2.354	3.665	4.296	0.908	5.013
Economic Cost								
Depreciation	0.358	0.211	0.227	0.267	0.739	1.110	0.250	0.862
Capital Opportunity Cost	0.412	0.141	0.307	0.519	1.224	1.532	0.360	1.120
Crew and Overhead Cost	0.000	0.878	0.669	1.086	1.046	0.930	0.000	2.006
Total	0.770	1.229	1.202	1.872	3.008	3.572	0.610	3.988

Figure 18.1-4 illustrates the vehicle operating cost by type of vehicle and by operating speed. At very low speed of 5 km per hour, the time-related cost is higher than the distance related cost of all types of vehicles except light truck. Most economical speed is around 60 to 70 km per hour. Comparing a car with a taxi, the distance-related cost of a taxi is lower than that of a car due to longer annual operating distance of taxi and on the contrary, taxi's time related cost is higher than that of a car because of taxi driver's wage.

At the operating speed of 20 km per hour, total cost of large bus with the capacity of 100 passengers is about US$ 500 per 1,000 km, 1.7 times of ordinary bus and the capacity is also about 1.7 times. On the other hand, the cost of an articulated bus is about 2.2 times of an ordinary bus while its capacity is about 3.3 times. Then, the articulated bus is more cost effective than the ordinary bus as long as their loading factors are equal.

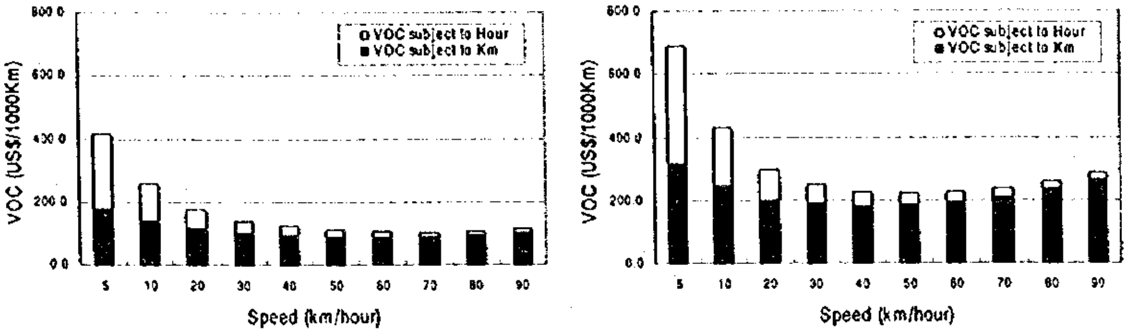
(1) Car

(2) Taxi



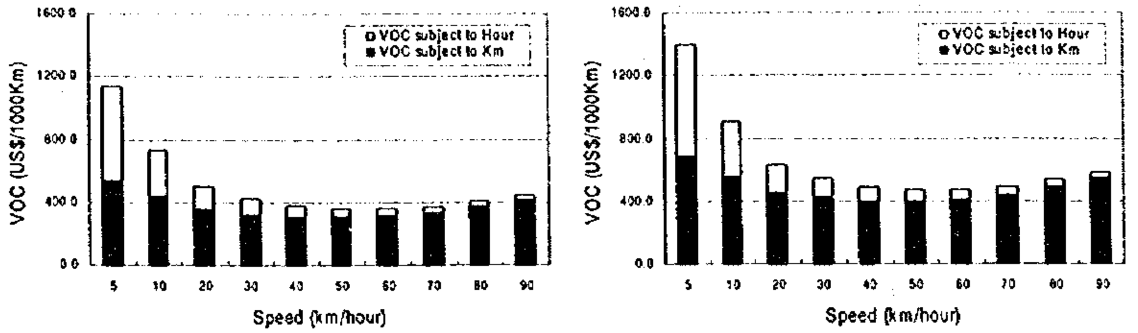
(3) Buseta

(4) Bus



(5) Large Bus (100 passengers)

(6) Articulated Bus (200



(7) Light Truck

(8) Large Truck

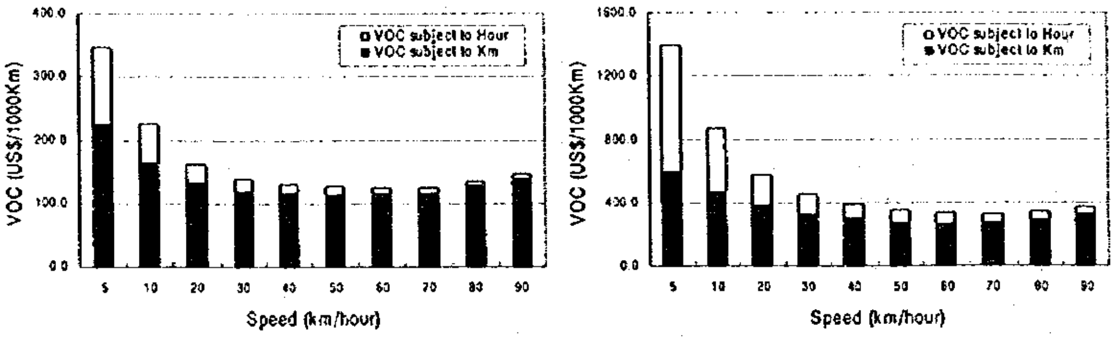


Figure 18.1-4 Economic Vehicle Operating Cost by Speed

18.1.4. TRAVEL TIME VALUE

Travel time of car users and bus passengers is converted to money term using unit time value. Their time values are estimated based on their income which reflects their productivity. According to the data of our home interview person trip survey in 1995, the average monthly household income as of March 1998 was C$ 353,024 for non-car owning families and C$ 923,518 for car owning families. Assuming monthly working hours of 160 hours, the value of one hour at work is estimated at C$ 2,078 for non-car owner (i.e. public transport passenger) and C$ 4,892 for car owner (i.e. car user) in 1999. (Table 18.1-16)

All trips with "business" purpose are regarded as productive activities and therefore time spent for a "business" trip is given the said value. The share of "business" trip is 7.5%. "To work" trips (with a share of 14.6%) and "to home" trips from work are assumed to have a half of the time value "at work" while other trips have no time value. (Table 18.1-17)

Time value will change by year. The higher people's productivity rises, the larger the time value becomes. Then, it may be reasonable to assume the time value will rise at the same rate as GRDP per capita growth. According to the framework assumed in the Master Plan Study of JICA in 1995, GRDP per capita index (year 1995=100) will grow to 113 in 2000, 132 in 2005 and 197 in 2015 (Table 18.1-18).

Total TTC is estimated by multiplying these unit time values by the aggregate passenger-hours by mode calculated from assigned traffic in a network.

Table 18.1-16 Hourly Income by Car Ownership

Car Ownership	Family Income (C$/mon.)		No. of Earners (person/HH)	Working Hours (Hours/mon.)	Houly Income in '99 (C$/hr/person)
	1995	1999			
Car-Owning 31%	923,518	1,565,363	2.0	160	4,892
Non Car-Owning	353,024	598,376	1.8	160	2,078
Average	521,914	898,142	1.9	160	2,954

Table 18.1-17 Travel Time Cost

Item	Unit	Car User	Public Trans-portation User	Average
1) Hourly Income	C$/hr/person	4,892	2,078	2,954
2) Time Value				
a. Business Trip (x 1.0)	C$/hr/person	4,892	2,078	2,954
b. To work trip (x 0.5)	C$/hr/person	2,446	1,039	1,477
c. Home trip fm work(x 0.5)	C$/hr/person	2,446	1,039	1,477
3) Trip composition				
a. Business Trip	%	7.5	7.5	7.5
b. To work trip	%	14.6	14.6	14.6
c. Home trip from work	%	14.6	14.6	14.6
4) Weighted average Travel Time Value	C$/hr/person	1081	459	653

Table 18.1-18 Future Travel Time Value

(C$/Hour)

Car Ownership	1999	2000	2005	2015
Car Owning Household Member	1081.1	1107.8	1462.3	2880.8
Non Car Owning Household Member	459.2	470.5	621.1	1223.6

18.1.5. TRUNK BUS SYSTEM

(1) Economic Benefit

The aggregate amount of the vehicle operating cost (VOC) and the travel time cost (TTC) means economic expenditure to support people's social and economic activity in a city. Figure 18.1-5 illustrates the future increase of the amount in Bogota. The upper part of each bar is the difference of the total transport cost in case the trunk bus system is introduced and in case it is not introduced, and therefore represents, the benefit of the project.

Without the project, total cost will increase from US$ 4,000 million in 2001 to US$ 9,900 million in 2015. If the project is implemented, the annual cost in 2015 will be reduced to US$ 8,600 million. Therefore, US$ 1,300 is the benefit to accrue in the single year of 2015. In the same way, the first year benefit is US$ 360 million in 2001.

The total transport cost will drop down in 2006 to the level of two thirds of the previous year. This is because many transport projects such as an urban railway, urban expressway, the Cundinamarca toll road are scheduled to open in that year.

The trunk bus system consists of three components: construction of exclusive bus way/lane, rearrangement of bus routes and introduction of large buses. According to the result of simulation works, approximately one-third of the benefit is attributed to the construction of bus way and lanes.

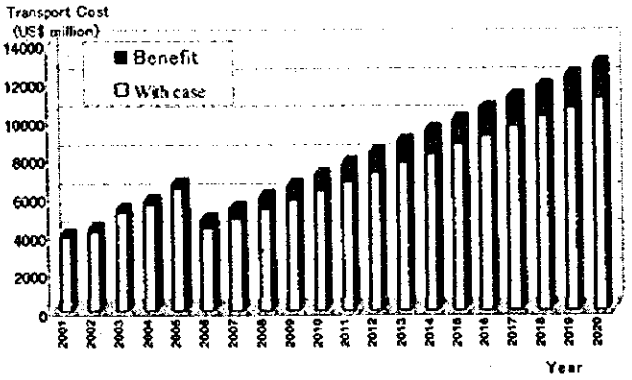


Figure 18.1-5 Daily Transport Cost and Benefit of Trunk Bus System

Table 18.1-19 shows the economic benefit by source. About 40% of the benefit is generated by savings in VOC and 60% by savings in TTC. In the early stage after the trunk bus project starts, private car users will get negative benefit by this project. But in the long run, when road transport conditions become worse, they will also become beneficiaries.

Table 18.1-19 Economic Benefit of Trunk Bus System Project by Source

(Million US$/Year)

Benefit (Savings in)	Tranport Mode	Year		
		2000	2005	2015
VOC subject to Distance	Private	-12.6	-21.0	24.8
	Public	32.0	100.2	164.5
	Total	19.3	79.3	189.3
VOC subject to Time	Private	-37.4	-97.5	64.8
	Public	61.9	170.8	291.8
	Total	24.5	73.3	356.5
Travel Time Cost (TTC)	Private	-26.7	-47.4	81.9
	Public	79.5	254.4	677.8
	Total	52.7	207.0	759.8
Total	Private	-76.8	-165.9	171.5
	Public	173.3	525.5	1,134.1
	Total	96.5	359.6	1,305.6

Table 18.1-20 shows the change in average travel speed by mode. Comparing the private mode and the public mode, the former will lose or maintain speed by the project while the latter will maintain or gain speed. However, the difference is not remarkable. More important thing is that, in the long-term trend of decreasing speed, trunk bus and express bus will keep a high speed.

Table 18.1-20 Average Speed Change by Trunk Bus System Project

Mode	Year 2000		Year 2005		Year 2015	
	W/o	W/	W/o	W/	W/o	W/
Car	14.9	14.2	14.6	13.9	10.7	10.7
Taxi	12.9	12.7	12.9	12.0	9.8	9.7
Truck	17.5	17.4	18.2	16.9	12.5	12.5
Bus	13.8	13.8	13.3	15.2	9.9	12.0
Trunk Bus	-	28.5	0.0	25.3	-	19.0
Express Bus	-	30.0	0.0	30.0	-	30.0
Average	14.5	14.2	14.3	14.1	10.6	10.9

(2) Economic Evaluation Result

As the cost-benefit cash flow of the project is shown in Table 18.1-21, the economic viability of the project is extremely high showing 44.6% of IRR and US$ 3,031 million of NPV. This high IRR is because the trunk bus system project implies a so-called software component of rationalization of bus route. In fact, unless the route rearrangement and large introduction are executed, IRR of only bus infrastructure construction is 23.7 %, which is still high.

Table 18.1-21 Economic Cash Flow of Trunk Bus System Project

(US$ 1000)

Year	Cash Flow			Discounted Cash Flow		
	Cost	Benefit	B-C	Cost	Benefit	B-C
1999	14,888	0	-14,888	14,888	0	-14,888
2000	146,060	0	-146,060	130,411	0	-130,411
2001	198,064	108,036	-90,028	157,895	86,126	-71,769
2002	224,840	119,560	-105,280	160,037	85,101	-74,936
2003	121,800	159,894	38,094	77,406	101,616	24,210
2004	108,967	177,180	68,213	61,831	100,537	38,706
2005	87,580	211,752	124,173	44,371	107,280	62,910
2006	3,587	454,212	450,625	1,623	205,463	203,840
2007	3,587	548,807	545,220	1,449	221,654	220,205
2008	3,587	643,402	639,815	1,294	232,017	230,724
2009	3,587	737,997	734,410	1,155	237,615	236,460
2010	3,587	832,592	829,005	1,031	239,350	238,319
2011	4,384	927,187	922,803	1,125	237,986	236,861
2012	4,922	1,021,782	1,016,860	1,128	234,166	233,038
2013	4,922	1,116,377	1,111,455	1,007	228,433	227,426
2014	5,718	1,210,972	1,205,253	1,045	221,240	220,195
2015	6,318	1,305,567	1,299,249	1,031	212,966	211,936
2016	7,126	1,400,161	1,393,035	1,038	203,926	202,888
2017	7,126	1,494,756	1,487,630	927	194,378	193,451
2018	7,126	1,589,351	1,582,225	827	184,535	183,707
2019	7,126	1,683,946	1,676,820	739	174,569	173,831
2020	7,126	1,778,541	1,771,415	660	164,621	163,962
Residual	-248,329	0	248,329	-20,523	0	20,523
Total	733,699	17,522,074	16,788,375	642,392	3,673,578	3,031,185

IRR(%)	44.6
B/C	5.72
NPV	3,031,185

(3) Evaluation by Trunk Bus Road

Here, the trunk bus system is evaluated by road group, one by one. To do this, some assumptions and a different approach are taken as described below.

a. "With and without" comparison is made between the "do all project" case and the case of "do all except a road to evaluate". That means the benefit of the trunk bus system on the road to evaluate is defined as the diseconomy accruing due to that the system is missing solely on the road.

b. In both cases above, planned bus rerouting and introduction of large buses are assumed. Large sized buses are hypothetically operated on ordinary lanes together with cars and trucks. In this sense, the result is, strictly speaking, not the evaluation of trunk bus system on the road, but of the economic effect of segregated bus lanes to the subject road.

c. Economic cost is the sum of the trunk bus lane/road cost and the terminal cost. The cost of the central terminal is allocated to each roads in proportion to the number of buses using the central terminal.

Table 18.1-22 Economic Evaluation of Trunk Bus System by Road

Bus Priority Artery	IRR (%)	B/C	NPV (US$1000)
1. Av. Caracas, Apt. Norte	17.3	1.9	273,215
2. Av. Quito, Apt. Sur, Av. 1° de Mayo	29.7	4.9	455,398
3. Cra. 7ª, Cra. 10ª	13.7	1.3	4,975
4. Calle 68/100	62.9	54.1	434,061
5. Av. Suba	33.3	11.1	131,882
6. Calle170	32.9	6.8	41,673

The evaluation result is shown in Table 18.1-22. Every road is judged economically feasible, showing each IRR higher than 12%. The highest IRR of 63% is estimated for Calle 68/100 which will have heavy bus traffic while the cost is comparatively low. Although Av, Caracas, Autopista Norte and Sur will also have a huge number of bus passengers, their IRRs are moderate due to the high construction cost of elevated structures for a busway and flyovers.

For Cra.7ª and 10ª, low-cost bus priority lanes are planned. The priority will be given to buses only in morning and evening peak time. Then, 30 percent of daily benefit is taken account for this project. Consequently, its IRR is the lowest. Av. Suba is also facilitated with the bus priority lanes but it shows high IRR of 33% because the bus traffic volume on Av. Suba is much larger than Cra 7ª.

(4) Sensitivity Analysis

1) Changes in Cost and Benefit

By changing estimated cost and benefit, sensitivity analysis was made as shown in Table 18.1-23. The economic viability is quite stable even against an extreme cost increase or benefit decrease. Only 20% of the estimated benefit can make the project feasible (In such a case, IRR is 13.6%). The feasibility of the project will be lost only when more than 80% of benefit is not realized and in addition cost overrun is more than 20 %.

Table 18.1-23 Sensitivity Analysis of Cost and Benefit Change

Benefit Decrease	Cost Increase				
	Base Case	20%up	40% up	60% up	80% up
Base Case	44.6	39.1	35.0	31.9	29.4
20% down	38.0	33.4	30.0	27.3	25.1
40% down	31.0	27.3	24.5	22.2	20.4
60% down	23.3	20.4	18.1	16.3	14.7
80% down	13.6	11.4	9.7	8.2	7.0

2) Change of Bus Fare

In this study, fare rate of trunk bus and express bus is set at C$ 600 per ride. However, if the bus fare rises over 600 pesos per ride, the number of passengers will decrease and then IRR will become lower. Another analysis is made on the basis of increase of passengers' payment and the proper fare system which is stated in Chapter 18.3. Here, the sensitivity of IRR to a change of bus fare rate was examined. The result is shown in Table 18.1-24 and Figure 18.1-6.

As the resultant figure shows, IRR is not so sensitive to the fare rate unexpectedly. When the rate exceeds C$ 1,000, IRR decreases remarkably. At 2,000 pesos per ride, IRR drops down to 16.6%. Two reasons are considered on this dull sensitivity. One is the future income level of passengers. As stated in the future time value, income level is assumed to become 1.7 times of the present in 2015, and therefore, passenger's willingness to pay will also become 1.7 times. The other reason is abolishment of existing bus lines competing with new trunk bus lines explained in Chapter 9. By doing this, some passengers have no other way but to take a trunk bus, no matter how much the fare is.

Table 18.1-24 Sensitivity Analyses by changing Bus Fare

Fare Level	Benefit in 2015	Economic Evaluation Indicators		
(Peso/Ride)	(Million US$)	IRR(%)	B/C	NPV(M.US$)
430	1,420.7	46.4	6.03	3,230.4
600	1,305.6	44.6	5.72	3,031.1
800	1,286.8	43.5	5.53	2,910.6
1,000	1,234.8	41.4	5.16	2,671.0
1,500	1,001.7	31.0	3.67	1,714.9
2,000	769.9	16.6	1.77	492.0

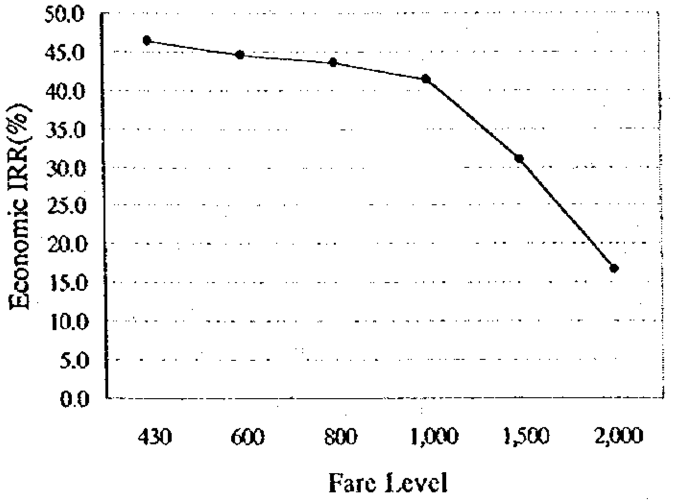


Figure 18.1-6 Economic IRR of Trunk Bus System Project by different Fare

3) *Influence of Inner-Ring Expressway*

As explained at the beginning of this Chapter, the trunk bus system project was evaluated with the precondition that the inner-ring expressway opens as scheduled in 2006. If this condition is denied, IRR of the trunk bus system project is as shown Table 18.1-25. The influence of the expressway project is negligible, with the evaluation indicators slightly improved.

Table 18.1-25 Influence of Inner-Ring Expressway on Trunk Bus System Project

Item	Expressway exists (Base Case)	Expressway does not exist
Benefit in 2005	211.7	211.8
Benefit in 2015	1305.5	1,320.2
IRR(%)	44.6	45.4
B/C	5.72	5.86
NPV(Million.US$)	3031.1	3,120.2

18.1.6. INNER-RING EXPRESSWAY

(1) Economic Benefit

The project cost is estimated to be US$ 638.5 millions at the market price corresponding to US$ 559.2 million at the economic price. The toll rate is assumed at 2,000 pesos at the opening of the expressway in 2006 and gradually increases, according to the rise of car users' paying capacity, to 3,000 pesos in 2015.

Under the conditions above, the first year benefit of the expressway project is US$ 51 million and reaches US$ 178 million in 2015 (see Figure 18.1-7). This benefit is approximately 1.3 to 1.5 % of total transport cost.

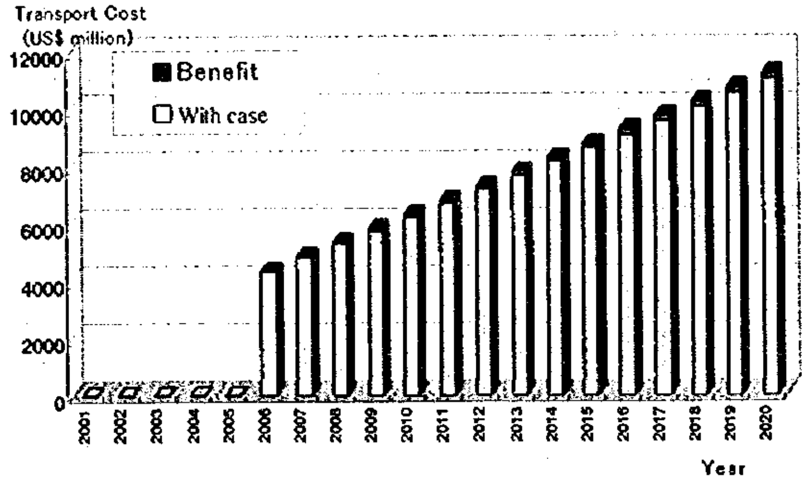


Figure 18.1-7 Total Transport Cost and Economic Benefit of Expressway Project

Table 18.1-26 shows the benefit by source. Approximately 55% is due to savings in VOC and 45% in TTC. In the opening year, the distance-related benefit of private vehicles is negative. This is because some drivers take a detour route in order to take a route of the expressway. Although public transport vehicles cannot take the expressway, they will have almost no disadvantages by this project. On the contrary, they will get benefit in the long term.

Changes of the average speed are shown by mode in Table 18.1-27. Differences between "With" case and "Without" case are minimal. Speed improvement is only a small percent on the average. This is because the traffic volume on the expressway is not significant in terms of vehicle-kilometer while the total extension is still short. Another reason is the tendency of traffic toward an equilibrium. If a car can freely run on the expressway, many cars will take the expressway route. Consequently, average speed on the expressway goes down.

Table 18.1-26 Economic Benefit of Inner-Ring Expressway Project by Source

(Million US$/Year)

Benefit (Savings in)	Tranport Mode	Year 2006	Year 2015
VOC subject to Distance	Private	-5.3	16.0
	Public	0.3	0.9
	Total	-5.0	16.8
VOC subject to Time	Private	23.2	81.0
	Public	0.8	1.1
	Total	23.9	82.1
Travel Time Cost (TTC)	Private	18.2	74.3
	Public	-0.5	4.8
	Total	17.7	79.0
Total	Private	36.1	171.2
	Public	0.5	6.7
	Total	36.6	178.0

(2) Evaluation Result

Economic cash flow of the Inner-ring Expressway is analyzed as shown in Table 18.1-28. Small amounts of cost appear after 1005. This is the maintenance and operation cost of the expressway.

IRR of the expressway project is estimated at 14.7% and the net present value (NPV) is US$ 89 million. As the IRR is over the discount rate of 12%, the project is judged economically feasible. However, the value of IRR is not so high and then sensitivity analysis becomes important. Especially, as car users are sensitive to the toll charge, sensitivity to a change in toll rate is of significance.

Table 18.1-27 Average Speed Change by Inner-Ring Expressway Project

Mode	Year 2005		Year 2015	
	W/o	W/	W/o	W/
Car	13.5	13.9	10.4	10.7
Taxi	11.8	12.0	9.4	9.7
Truck	16.7	16.9	12.2	12.5
Bus	15.1	15.2	11.9	12.0
Trunk Bus	25.7	25.3	19.0	19.0
Express Bus	30.0	30.0	30.0	30.0
Average	13.8	14.1	10.6	10.9

Table 18.1-28 Economic Cost Benefit Cash Flow of Inner-Ring Expressway

(US$ 1000)

Year	Cash Flow			Discounted Cash Flow		
	Cost	Benefit	B-C	Cost	Benefit	B-C
1999	0	0	0	0	0	0
2000	10,482	0	-10,482	9,359	0	-9,359
2001	24,809	0	-24,809	19,778	0	-19,778
2002	59,834	0	-59,834	42,589	0	-42,589
2003	178,727	0	-178,727	113,584	0	-113,584
2004	178,727	0	-178,727	101,415	0	-101,415
2005	106,622	0	-106,622	54,018	0	-54,018
2006	104	50,746	50,642	47	22,955	22,908
2007	104	64,880	64,776	42	26,204	26,162
2008	104	79,014	78,910	37	28,493	28,456
2009	104	93,148	93,044	33	29,991	29,958
2010	104	107,282	107,178	30	30,841	30,811
2011	259	121,416	121,157	66	31,164	31,098
2012	259	135,550	135,291	59	31,065	31,005
2013	259	149,684	149,425	53	30,628	30,575
2014	259	163,818	163,559	47	29,929	29,882
2015	259	177,952	177,693	42	29,028	28,986
2016	518	192,086	191,568	75	27,976	27,901
2017	518	206,220	205,702	67	26,817	26,749
2018	518	220,354	219,836	60	25,585	25,525
2019	518	234,488	233,970	54	24,309	24,255
2020	518	248,622	248,104	48	23,012	22,964
2021	-158,371	0	158,371	-13,088	0	13,088
Total	405,231	2,245,257	1,840,026	328,416	417,996	89,580

IRR(%)	14.7
B/C	1.27
NPV	89,581

(3) Sensitivity Analysis

1) Change of Cost and Benefit

As IRR of the expressway project is not so high, it is sensitive to a change of cost and benefit. Table 18.1-29 presents the result of a sensitivity analysis. Assuming the threshold value of IRR for being feasible, the project is still feasible against 20% decrease of the benefit or 20% increase of the cost. However, If both of 10% decrease of the benefit and 20% increase of the cost happens, IRR will be less than 12%. The same is true to the condition of 20% decrease of the benefit and 10% increase of the cost.

Table 18.1-29 Change of Cost and Benefit of Inner-Ring Expressway Project

Benefit Change	Cost Change				
	20% less	10% less	Base Case	10% up	20% up
20% up	20.0	18.4	17.0	15.8	14.7
10% up	18.8	17.2	15.9	14.7	25.1
Base Case	17.6	16.1	14.7	13.6	12.6
10% less	16.2	14.8	13.5	12.4	11.4
20% less	14.8	13.4	12.2	11.1	10.2

2) Change of Toll Rate

Proposed toll rate is C$ 2,000 in 2006 and C$ 3,000 in 2015. If this toll rate is changed, IRR of the project will naturally be affected. A higher toll rate discourages car users from using the expressway and if users decrease, the economic IRR will be lower. Table 18.1-30 and Figure 18.1-8 shows the change of IRR under various toll rates. If the toll is as cheap as C$ 500, IRR is 21.2%. As the toll rises up, IRR becomes lower and at the toll rate between C$ 5,000 to C$ 5,500, IRR falls below the threshold. From the economic point of view, a lower toll rate is desirable. However, the project cannot be financially feasible at a low toll rate.

Table 18.1-30 Effect of Toll Rate of Inner-Ring Expressway Project on Benefits and IRR

Fare Level (Peso/Ride)	Benefit in 2015 (Million US$)	Economic Evaluation Indicators		
		IRR(%)	B/C	NPV(M.US$)
500	114.0	21.2	1.67	221.50
1,000	107.0	18.2	1.52	188.50
1,500	121.5	17.0	1.43	170.20
2,000	149.6	16.5	1.38	130.20
2,500	162.9	16.0	1.30	122.10
3,000	178.0	15.0	1.25	94.00
3,500	175.9	14.0	1.21	69.30
4,000	179.2	13.5	1.17	44.50
4,500	207.9	13.0	1.11	39.00
5,000	201.3	12.6	1.07	21.40
5,500	185.3	11.6	0.96	-14.20
6,000	173.0	10.9	0.88	-40.60
7,000	152.6	9.5	0.74	-84.40
8,000	133.5	8.2	0.62	-124.40
9,000	122.1	7.3	0.55	-148.30
10,000	113.9	6.7	0.50	-165.60

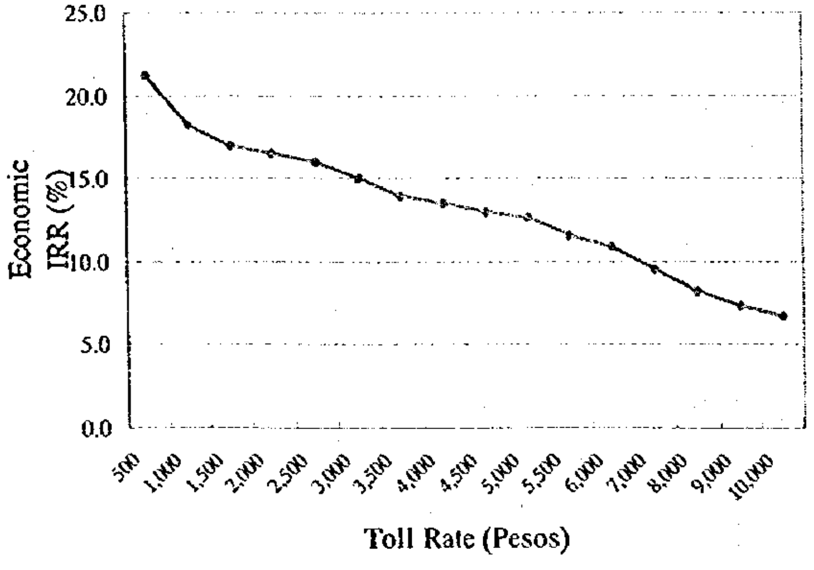


Figure 18.1-8 Relationship between Economic IRR and Expressway Toll Rate

3) *Influence of Trunk Bus System Project*

The inner-ring expressway project was evaluated with the precondition that the trunk bus system project is implemented as scheduled during 2000 to 2005. If this condition is not met and the trunk bus system is never realized, IRR of the expressway will be changed as shown in Table 18.1-31. The influence of the trunk bus project is significant. IRR will increase by 2.8 points and NPV will be almost double.

Table 18.1-31 Influence of Trunk Bus System Project on IRR of Expressway Project

Item	Trunk bus exists (Base Case)	Trunk bus does not exist
Benefit in 2006	50.7	90.1
Benefit in 2015	178.0	192.6
IRR(%)	14.7	17.5
B/C	1.27	1.54
NPV(Million US$)	89.6	178.4