# IV ROAD PROJECT PRELIMINARY DESIGN

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## 10. Design Condition

Roads in Guatemala are divided into the following four categories

a) International Road (CA1, CA2, CA9)

b) National Primary Road

c) Regional Secondary Road

d) Local Road

According to the American Road Design Standard, which is the criteria for Geometric Design of Highway and Streets (AASHTO), roads are divided into five categories as shown below;

a) Freeway

b) Rural and Urban Arterial Road

c) Minor Arterial Road

d) Collector Road

e) Local Road

The functions and characteristics of the roads in the classifications have been examined for the road network planning in the Study Area.

a) The function of the freeway and arterial roads is primarily to maintain mobility, so a high standard of road design criteria is required.

b) The function of a local road or minor road is primarily to maintain land access.

c) The function of a collector road is between that of the arterial road and local road.

Exclusive Busway

Taking the above into account as well as the conditions governing road planning, the functions and characteristics of the subject road, East West Corridor and Petapa Road, are identified as follows:

a) To the primary functional responsibility of travel service to major traffic movements

b) To provide large traffic capacity for heavy traffic volumes.

c) To enable long distance trips to be carried out at high speeds

Exclusive Busway

Other characteristics of the subject roads are to have Exclusive Busway which remains the possibility to introduce the rail transit system in future.

### 10.1 Design Standard

The proposed road design is conducted based on the premises and conditions of the design for the East West Corridor/Exclusive Busway-East West Corridor Route and Petapa Road/Exclusive Busway-FEGUA Route.

The road length of East West Corridor/Exclusive Busway-East West Corridor is about 12,200m, and the Petapa Road/ Exclusive Busway-FEGUA Route is about 17,600m.

As the result of the preliminary design, East West Corridor is to be a 4-lane dual carriageway with 2-lane Exclusive Busway, with a design speed of 60 Km/h, and to have one interchange at Anillo Periferico and three at-grade intersections at Calzada San Juan and Boulevard San Nicolas, and 30 Calle Zone 8.

Petapa Road is to be 4-lane dual carriageway. FEGUA Exclusive Busway is to be 2-lane carriageway with 19-Bus stops.

The road design is conducted to examine the following design aspects;

a) Typical cross-section

b) Alignment design

c) Cross- Section design

d) Pavement design

e) Drainage design

f) Interchange design

### 10.1.1 Typical Cross-Section

The typical cross-section is determined in consideration of the following:

a) Function and characteristics of the road.

b) Design speed of the road.

c) Design standards.

d) Related road cross-sections.

**(1) Lane Width.**

In accordance with AASHTO, a 3.50 m (12 feet) wide lane is adopted for the proposed roads.

**(2) Shoulder Width.**

In accordance with AASHTO, considering the topographical features along the route, the right and left shoulder widths of the proposed road are to be 1.0 m and 0.5 m, respectively.

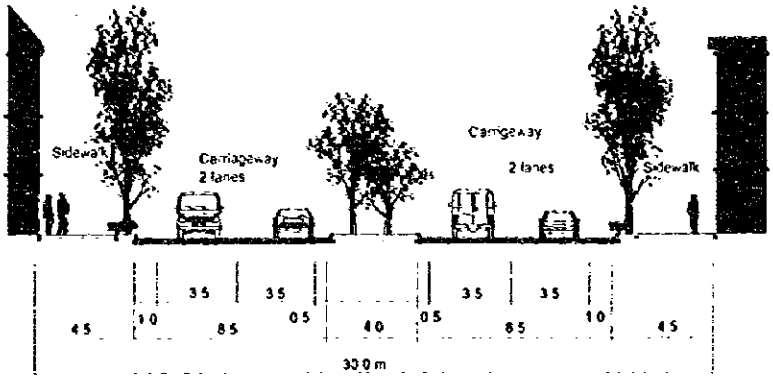
The shoulder widths of long bridges (bridge length is over 50 m) are made 0.5m. An outside shoulder width of 1.50 m is adopted for the installation of traffic signs, guardrails, information signs and for the installation of protection walls.

**(3) Median Width.**

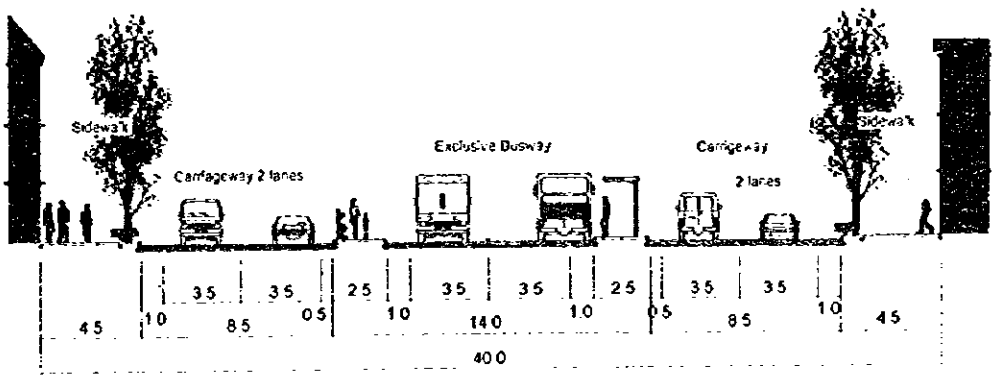
In accordance with the AASHTO, the median width is to be 4.0m.

**(4) Right of Way**

In accordance with the AASHTO, the typical right of way for the ground level 4-lane Corridor with Exclusive Busway is to be about 40m. The typical cross section is shown in Figure 10.1.




Cross Section of Petapa Road




Cross Section of East West Corridor

**Figure 10.1 Typical Cross Section**

**Table 10.1 Geometric Design Standard**

| Design Speed | | 60 km/hour | (40 miles/hour) |
|---|---|---|---|
| | (unit) | meter | feet |
| **1 Horizontal aliment** | | | |
| 1) Minimum radius (e=0.04) | | 175 | 573 |
| 2) Absolute minimum (e=0.08) | | 145 | 477 |
| For nodal crown | | 1692 | 5550 |
| For remove adverse crown | | 1747 | 5730 |
| For remove transition curve | | 2328 | 7639 |
| 3) Minimum curve length | | | |
| 2 lane | | 52 | 170 |
| 4 lane | | 76 | 250 |
| **2 Sight distance** | | | |
| 1) Minimum stopping sight distance | | 84 | 275 |
| 2) Desirable stopping distance | | 99 | 325 |
| 3) Minimum passing sight distance | | 457 | 1500 |
| **3 Vertical alignment** | | | |
| 1) With length limitation | Flat area: 7% | 152 | 500 |
| | Rolling area: 8% | 149 | 490 |
| | Hilly area: 10% | 122 | 400 |
| 2) Minimum vertical curve length | | | |
| Crest | | 1829 | 6000 |
| Sag | | 1829 | 6000 |
| 3) Desirable vertical curve length | | | |
| Crest | | 2438 | 8000 |
| Sag | | 2134 | 7000 |
| 4) Minimum vertical curve length | | 37 | 120 |

(Source: A Policy on Geometric Design of Highways and Streets, AASHTO, 1990)

### 10.1.2 Gradients of Cuttings and Embankment Slope

The gradient of cuttings and embankment slopes has been examined in consideration of soil conditions in the cuttings and embankments. The subsurface soil investigation by was conducted by boring 22 holes along the proposed road.

#### (1) Gradient of Cutting Slopes

The gradients of cutting slopes depend on the type of soil which will be excavated. Generally, the gradient of slopes has been decided with reference to Table 10.2 as well in consideration of the gradient of existing cutting slopes in surrounding areas.

**Table 10.2 Gradient of Slopes by Soil Conditions**

| Type of Soil | Cutting Height(H)(m) | Gradient (V:H) |
|---|---|---|
| Hard Rock | | 1:0.3 - 1:0.8 |
| Soft Rock | | 1:0.5 - 1:1.2 |
| Sand | | 1:1.5 - over |
| Sandy Clay High Density | H< 5m | 1:0.8 - 1:1.0 |
| | 5<H<10m | 1:1.0 - 1:1.2 |
| Low Density | H< 5m | 1:1.0 - 1:1.2 |
| | 5<H<10m | 1:1.2 - 1:1.5 |
| Sand with High Density | H< 5m | 1:0.8 - 1:1.0 |
| Gravel | 5<H<10m | 1:1.0 - 1:1.2 |
| Low Density | H< 5m | 1:1.0 - 1:1.2 |
| | 5<H<10m | 1:1.2 - 1:1.5 |
| Clay | H<10m | 1:0.8 - 1:1.2 |
| Clay with Gravel | H< 5m | 1:1.0 - 1:1.2 |
| | 5<H<10m | 1:1.2 - 1:1.5 |

From the results of subsurface investigation, the subsurface consists of two layers; one is surface soil consisting of silty clay and clayey silt with gravel, and the other is soft rock consisting of granite with an observed diameter of 40 to 50 mm.

Taking the above soil conditions into account, a 1:1.0 (V:H) slope gradient for the surface soil layer and 1:0.5 (V:H) slope gradient for the soft rock layer have been adopted. However, more subsurface investigations should be conducted when the actual slope gradients will are decided in the detailed (final) design stage.

#### (2) Gradient of Embankment Slopes

Embankments will use the materials excavated from the existing ground as the result of a comparison between the embankment and cutting volumes. The relationship between the gradient of embankment slopes and soil conditions is shown in Table 10.3.

**Table 10.3 Gradient of Embankment Slope by Type of Soil**

| Type of Soil | Embankment Height(H)(m) | Gradient (V:H) |
|---|---|---|
| Soil (Good Grading) | 0<H<6m | 1:1.5 |
| Sand with Gravel | 6<H<15m | 1:1.8 |
| Sand (Bad Grading) | 0<H<10m | 1:1.8 |
| Gravel | 0<H<10m | 1:1.5 |
| | 10<H<20m | 1:1.8 |
| Sandy Clay | 0<H<6m | 1:1.5 |
| | 6<H<10m | 1:1.8 |

As mentioned above, embankments use soft soil and silly clay in a mixture similar to mar of material excavated for the road bed. Taking the embankment materials for the proposed new highway into account, a slope gradient of 1:1.5 (V:H) has been adopted for embankments of less than 5.00 m in height and a 1:1.8 gradient for embankment of over 5.0 m in height. However, a circularship study should be carried out when the detailed design is made.

## 10.2 Horizontal and Vertical Alignment

The alignment design covers the horizontal and vertical alignment design, and is carried out to consider the harmonization of the horizontal and vertical alignment design as well as the cross section design.

### 10.2.1 Horizontal Alignment Design.

Considering the following points mainly, the route location study has been carried out using topographic maps of a scale of 1:2,000.

a) Geometric design standard of 60km/hour design speed is to be adopted.

b) Future development .

c) Existing development .

d) Environmental Conditions.

e) Alignment of existing road.

### 10.2.2 Vertical Alignment Design

In consideration of the following points, the vertical alignment design has been carried out using topographic maps of a scale of 1:2,000.

a) Geometric design standards

b) Horizontal alignment conditions

c) Geographic features

d) Access to the existing road

e) Large structures in the design

The main works of the vertical alignment design are as follows:

a) The maximum longitudinal gradient has been set as 3.0 % for future rail system and a 0.3 % gradient has been adopted for the minimum longitudinal gradient.

b) Even though, 6.0 % maximum longitudinal gradients has been adopted for rolling terrain.

c) The major function of the tunnel in Democracia Area is to protect the existing housing area, and to keep good environmental conditions.

## 10.3 Pavement

### 10.3.1 Design Standard

In Guatemala, there are no established regulations for road design regarding geometric aspects and interrelationships with ground-structures. The Direction of Planning and Designs in CAMINOS, uses the norms of AASHTO, and those of the American Asphalt Institution.

However, the types of pavements to be adopted in Guatemala are defined according to traffic volume :

| | |
|---|---|
| a) 50 to 100 (vehicle/day) | Gravel Pavement |
| b) 500 | Surface Bituminous Treatment |
| c) 1400 | Asphalt Concrete Pavement |

### 10.3.2 Pavement Type to be Adopted in this Study

The type of asphalt concrete pavement for the proposed road has been adopted in consideration of the following points.

a) In Guatemala, there has been more experience with asphalt concrete pavement than cement pavement.

b) The materials for asphalt concrete pavement can be produced in Guatemala.

c) The maintenance of cement concrete pavement is more economical than that of asphalt concrete pavement but the initial construction cost of cement pavement is high.

### 10.3.3 Pavement Thickness

**(1) Surface Thickness**

Asphalt concrete of 10cm thick has been adopted for the proposed road as the result of a calculation of pavement thickness based on the AASHTO Design of Pavement Structure.

**(2) Base Course Thickness and Materials**

The base course thickness and materials for the asphalt concrete pavement have been determined depending on the accumulated traffic volume. The base course thickness is generally determined according to the thickness of the asphalt concrete surface. For asphalt concrete surface of 20 cm thick, there is a thickness of base course, as shown below.

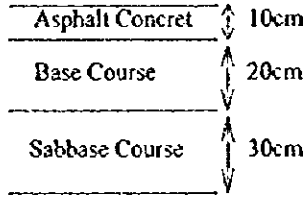



**Figure 10.2 Pavement Thickness**

## 10.4 Drainage

### 10.4.1 Drainage System

Drainage system is examined in consideration of past experience of road construction in Guatemala, the environmental aspects of soil erosion and vehicle safety. The details of the basic drainage system are as follows;

a) On the top of cutting slopes, a water channel is controlled for collecting rainwater from the surrounding area to prevent the rainwater from running into the road area.

b) At the bottom of cutting slopes, a water channel is provided for collecting the rainwater from the cutting slope area to prevent the rainwater from running onto the carriageways.

c) At the bottom of embankment slopes, a water channel is provided for collecting the rainwater from the embankment slope area.

d) Rainwater from carriageways is collected in the water channels provided at the bottom of cutting and embankment slopes.

e) Pipe culverts or box culverts are provided for the small rivers (quebrada) which cross the proposed road.

f) The bridges are to be constructed over the rivers that cross the proposed road.

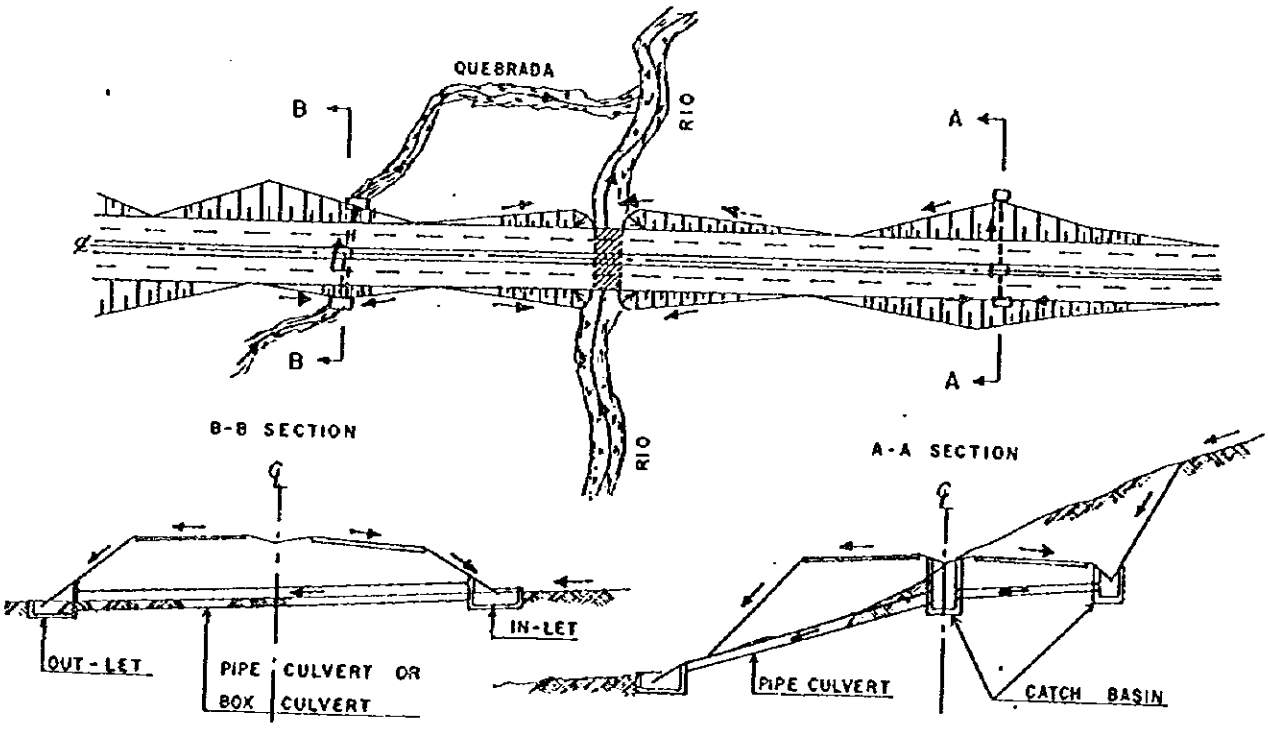



**Figure 10.3 Drainage System**

### 10.4.2 Drainage Design

The drainage design is conducted based on the selected drainage system and in consideration of the existing water flow situation and topographic conditions.

**(1) Rivers as an outlet for Rainwater**

As the result of a field reconnaissance survey along the proposed road and topographic analysis, the following rivers are selected as outlets for rainwater.

a) Rio El Naranjo (East West Corridor Route)

b) Rio La Barrance ( East West Corridor Route)

c) Rio Villalobos (FEGUA Route)

**(2) Box Culverts and Pipe**

Box culverts is to be provided at the following points, considering the topographical conditions and run-off volumes identified through the field reconnaissance survey. The minimum size adopted for the box culverts is 2.00 x 2.00 (Height x Width) considering the preserve of soil, rocks of logs in the water.

a) At small rivers (Quebrada)

b) At large embankment sections

c) At animal pashs

Pipe culverts is to be provided at small catchment-areas and the small areas of stagnant water on embankment sections. The minimum diameter of pipe culverts adopted is 1.00m, in consideration of maintenance.

## 10.5 Structure

### 10.5.1 Design Standard

The "Especiones Generales para Construction de Carreteras y Puentes de Direction General de Camions" orders that the structural design should be based on the American Standard "AASHTO". In this study, the structures shall be designed on the AASHTO basis according to this instruction. Principal design conditions are as follows:

**(1) Load**

1) Live Load

For the design live load of the road structures in Guatemala, HS20-44 of the AASHTO standard is applied. Also in this study, the structures will be designed for this live load.

2) Seismic Load

In Guatemala City a lot of earthquakes, including that of magnitude 7.6 in 1976, have occurred. In the surroundings of the city, some faults were found, and so a large seismic disaster may possibly occur in future. For the Acceleration Coefficient "A" of Guatemala City in this study, the minimum value of a category where the acceleration coefficient is highest among AASHTO's Seismic Performance Categories shall be used, when the "A" is 0.30.

**(2) Strength of Principal Materials**

The strength of principal materials is shown in Table 10.4. The strength of concrete was set in consideration of the Guatemalan conditions. The strength of steel shall be treated corresponding to the ASTM.

**Table 10.4 Strength of Materials**

| Material | Remark | Strength |
|---|---|---|
| Concrete | For Superstructure | fc=315kg/cm2 |
| | For Substructure | fc=210kg/cm2 |
| | For Prestress | fc=350kg/cm2 |
| Reinforcing bar | Grade 40 | fv=2800kg/cm2 |
| Prestressing Steel | Grade 270 | fv=161kg/mm2 |
| Structure Steel | M-183 | fu=4000kg/cm2 |

Note: fc: Specified compressive strength of concrete at 28 days
fv: Specified yield strength of reinforcement
fu: Minimum tension strength

### 10.5.2 Structure Style

The structures designed in this study are bridges, tunnels and retaining walls. Bridges are classified into large scale bridges to be constructed over deep valleys, bridges to cross a river and overbridges. A tunnel is planned to be constructed just below the Democracia Park and a retaining wall is planned in a canal near the end of the East West Corridor.

### (1) Bridge

Bridge structures shall be economical and structurally safe, and also its form should be aesthetically pleasing in harmony with the surrounding environment. In respect to the economic aspects, not only construction costs but also future maintenance costs shall be considered. The safety of bridge structures after completion as well as under construction shall be taken in consideration. The bridge structures to be constructed in a city shall be in harmony with the surrounding environment, and the splitting of communities must be avoided as much as possible.

The above mentioned aspects were considered as selection criteria for each part of the planned bridges which are divided broadly into superstructure, substructure and foundation.

1) Superstructure of Bridges

The superstructure of bridge is generally classified by type of structure into reirforced concrete (R.C.) bridge, Prestressed Concrete (P.C.) bridge and steel bridge. Applied span length for each type of bridge are shown in Table 10.5. According to the present construction situation of Guatemala City, there are some large-scale concrete plants. Therefore, cement and aggregate can be fully supplied domestically and also it is easy to obtain freshly mixed concrete and precast girders of high quality. On the contrary the steel works in Guatemala City mainly process steel shapes, reinforcement steel, etc., so as for manufacture steel girders, it is necessary to introduce foreign technology or to import the steel girders themselves. As a result of this situation, all the bridges which were recently constructed in Guatemala City are of concrete.

**Table 10.5 Bridge Type and Standard Application**

| | Type of Superstructure | Bridge Span (m) 20 40 60 80 100 120 140 160 180 200 |
|---|---|---|
| R C | R.C.Simple T-beam | |
| | R.C.Hollow Slab | |
| P C | P.C.Hollow Slab | |
| | P.C.Simple T-beam | |
| | P.C.Simple Composite I Girder | |
| | P.C.Simple Box Gireder | |
| | P.C.Cantilever erection Box Girder | |
| S | Steel Simple Composite I Girder | |
| | Steel Simple Box Girder | |
| | Steel Continuous Box Girder | |

Note: R.C.: Reinforced Concrete
P.C.: Prestressed Concrete
S : Steel

Steel bridges have some merits such as short construction time and minimizing works on site, but the construction cost will be higher in Guatemala, because of imported materials and technology. On the other hand, concrete bridges do not need re-painting, which is necessary in the case of steel bridges, and require less maintenance work. For the superstructures in this study, concrete bridges, which have the advantages in economy and maintenance, shall be introduced.

Concrete bridges are classified into R.C. bridges and P.C. bridges. The R.C. bridge is applied only to small spans and the P.C. bridge to medium and long spans. In the suburbs of Guatemala City there is a manufacturing plant of precast P.C. girders, where T-type girders for spans of under 20m and P.C. T-type girders of AASHTO for spans of 20-40m are manufactured. In almost all recently constructed bridges, these girders were used. It is possible to reduce the construction cost of bridges by using local technology to the utmost, and so these girders will be adopted for spans of under 40m in principle.

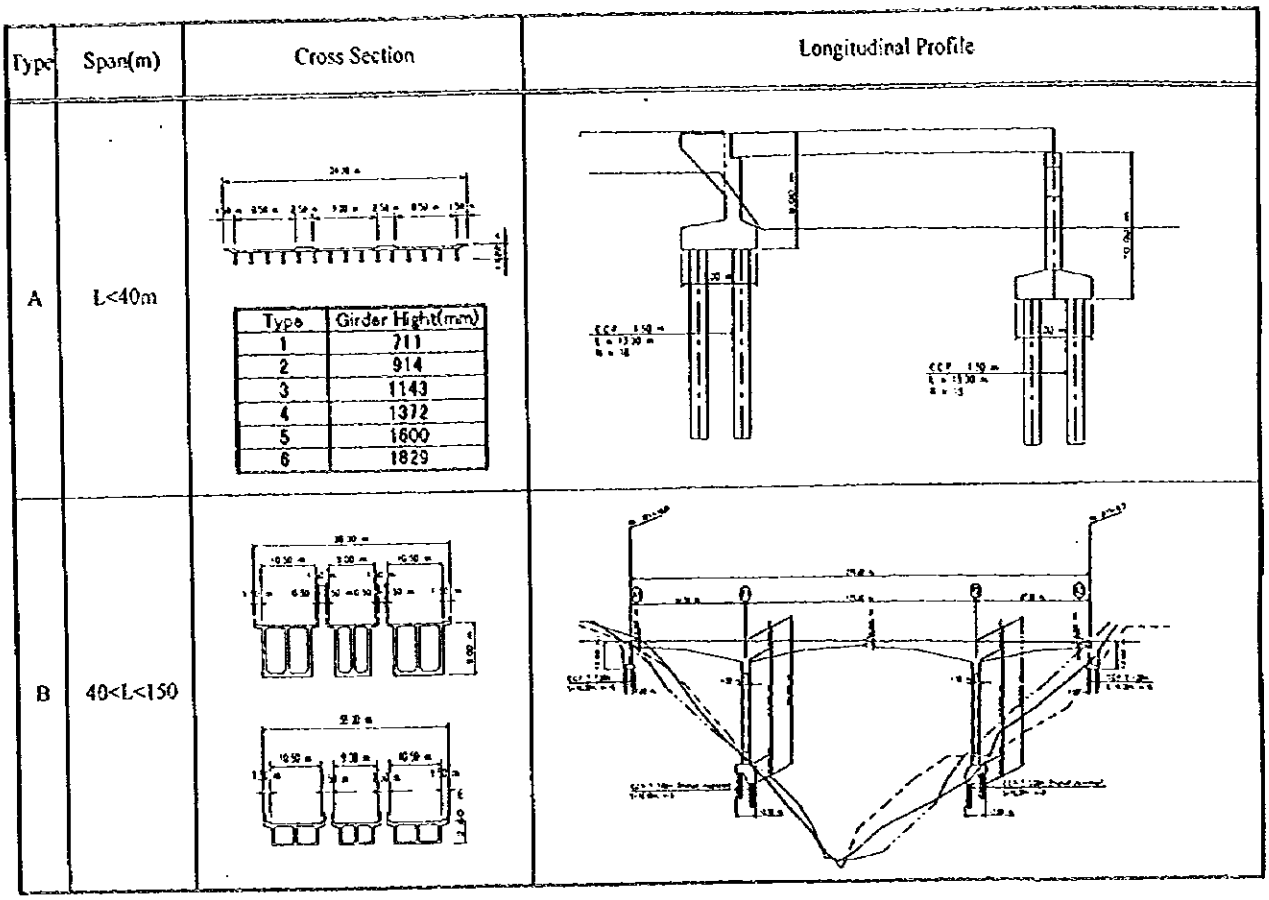


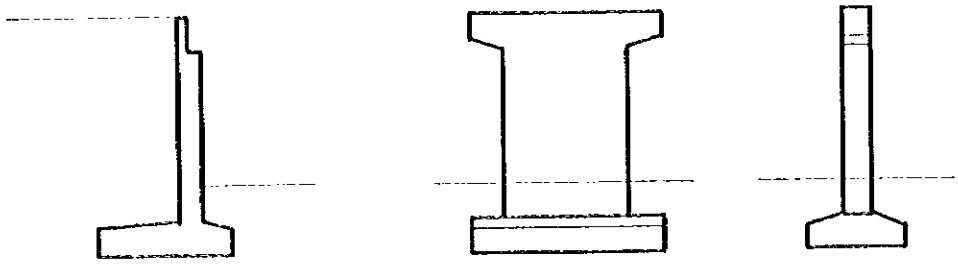

**Figure 10.4 Type of Superstructure**

All large-scale bridges with spans of over 40m, including Ircierso bridge (P.C. box girder) of Periferico in Guatemala City, were constructed by the United States more than 30 years ago. Bridge constructors in Guatemala have no experience in construction large-scale bridges. Large-scale bridges to be constructed over deep valleys, where the construction capability is an important factor in selecting bride type. In this study, the P.C. box girder cantilever erection method shall be adopted, for which there is much experience in developed countries like Japan, Europe and America and also the technical problems are less.

2) Substructure of bridge

Guatemala City has a large earthquake possibility, and so abutments and piers shall be highly aseismatic structures. For the substructure style of bridge, the reversed T-type abutment and the rectangular cantilever pier shall be adopted in principal. These styles have been experienced in developed countries with high aseismatic technology.

The substructure styles of bridge are shown in Figure 10.5.



1) Reversed T-type Abutment 2) Rectangular Cantilever Pier

**Figure 10.5 Types of Substructure**

3) Foundation of bridge

In the soil in the road planning area, a layer of 5-10 m below the surface, whose N-value is under 30, is not suitable as the bearing stratum. Foundation of a bridge requires a bearing stratum of high quality below the above mentioned layer. To select a foundation style, the boring data at the bridge construction point shall be referred to. In case that a bearing stratum exists 5m or less below the surface, the spread foundation shall be selected, and in case of 5 meter or more below the surface, the pile foundation shall be selected. Regarding the kinds of pile, the cast-in-place concrete pile shall be basically applied, and the cast-in-place pile constructed by a machine shall be adopted at site where heavy machinery can be brought, and the cast-in-place concrete pile with manual excavation shall be adopted in principle at site such as valley where machinery can not be brought.

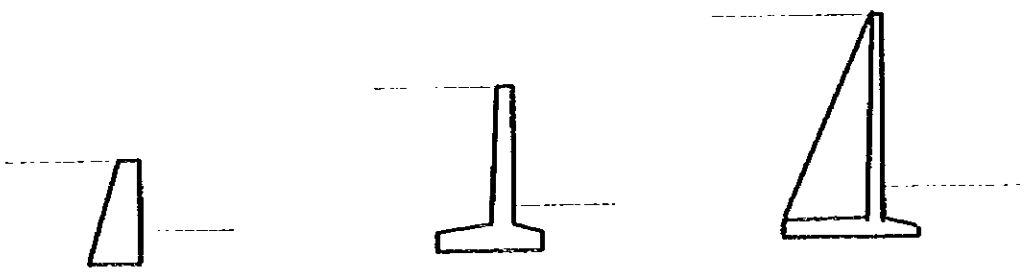
**(2) Tunnel**

For the tunnel planned to be constructed in the Parque Democracia, the open cut method shall be adopted because of little earth covering, and then the box culvert shall be applied, because of the most economical method.

**(3) Retaining wall**

Form of retaining wall depends on overall height. Gravity type, reversed T-type, and buttressed retaining wall shall be adopted in principal at an overall height of less than 3m, 3 to 12m, and more than 12m , respectively. For the foundation of retaining wall, the cast-in-place concrete pile or the spread foundation shall be adopted in the same way as the foundation of bridges.

The retaining styles of bridge are shown in Figure 10.6.



1) Gravity Type Retaining Wall 2) Reversed T-type Retaining Wall 3) Buttressed Type Retaining Wall

**Figure 10.6 Types of Retaining Wall**

## 10.6 Auxiliary Facilities

### 10.6.1 Road Lighting

Road lights are to be installed either for continuos lighting of the entire route or for spot lighting, by the criterion of road surface brightness to the driver's eye. Road sections generally subject to continuous lighting and to spot lighting are shown in Table 10.6. For the subject new road construction projects, spot lighting shall be used as principle in sections where future urban development in the roadside area is not expected and continuous lighting shall be used in all other sections.

**Table 10.6 Application of Street Lighting**

| Description | Application |
|---|---|
| Continuos lighting | Built-up area<br>Artery in residential area<br>Area where roadside is developed |
| Partial lighting | Other area<br>(at Intersection, Interchange, Pedestrian Crossing, Sharp curve, etc.) |

The foot-candle of 0.5 to 1.0 cd/m$^2$ is usually used as criterion for road light installation. In view of the relatively heavy traffic on the project roads, the criterion of 1.0 cd/m$^2$ shall be used. Typical lighting installation arrangements on Petapa Road and East West Corridor are shown in Figure 10.7.

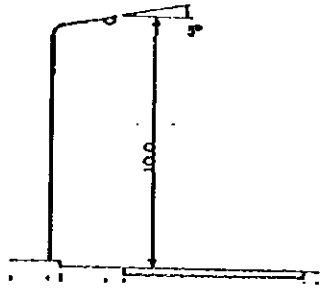


**Figure 10.7 Typical Lighting Installation**

### 10.6.2 Guardrail

In Guatemala City, almost no guardrail is installed by roads except in Villalobos (CA9) and other recently commissioned roads. However, guardrails shall be installed for traffic safety, depending on the roadside gradient or level difference, as shown in Figure 10.9. Guardrails shall be installed also in front of obstacles facing roadway such as bridge piers and handrails, as well as along a sharp curve and in sections where pedestrian crossing is to be controlled.

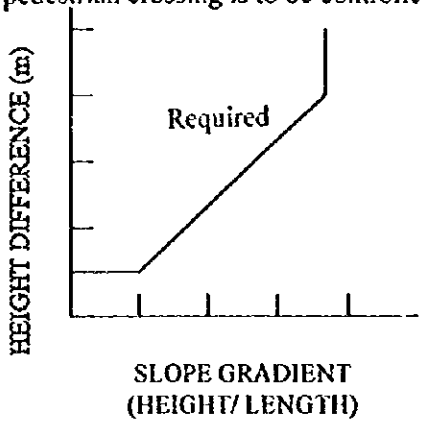



**Figure 10.8 Application of Guard Rail**

### 10.6.3 Traffic Signs

Traffic signs are classified into regulatory signs, warning signs, and guide signs. Regulatory signs indicate speed limit, no parking, no stopping, and other controls. They are installed by the Municipality upon the construction of the roads and maintained by the Municipality for the purpose of warning drivers of road alignment, road surface condition, or some unusual road side condition. Also installed and maintained by the Municipality, guide signs are to shown direction, destination, and other information to the driver.

These signs are to be by methods shown in Figure 10.9. Regulatory and warning signs usually show a symbol on a single roadside poles. While guide signs, many of which show the name of a place in writing, are either to be installed on roadside dual poles or cantilever arms, or hang overhead. In the case of 2-lane roads, road side installation is usually considered satisfactory, as the signs can be seen by drivers in either lane. However, cantilever or overhead installation should be desirable for roads with three or more lanes.

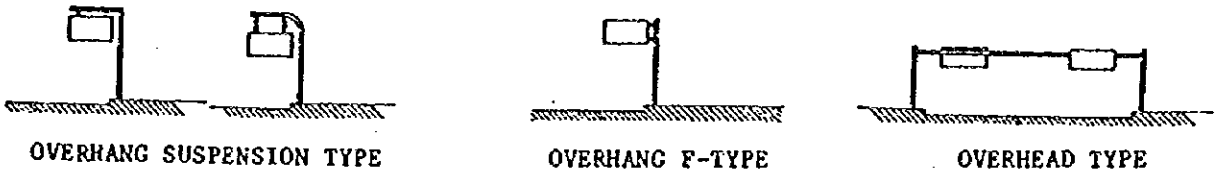



**Figure 10.9 Various Traffic Sign Mountings**

### 10.6.4 Road Markings

Types of road markings are shown in Table 10.7. These markings will make a set with traffic signs in giving an appropriate guidance to the driver at an intersection. Not only should they be marked at the time of road construction, but these markings should also be well maintained throughout the service life of the road.

**Table 10.7 Classification of Various Pavement Markings**

| | | |
|---|---|---|
| 1. Lines | a. Center line<br>b. Lane line<br>c. Pavement edge line<br>d. Stop line | |
| 2. Zone | a. Pedestrian crossing<br>b. Obstacle, no passing area,<br>c. Bus stop<br>d. No stopping zone | Diagonal and<br>Chevron marks |
| 3. Symbol | a. Lane use<br>b. Direction guide<br>c. Regulatory signs | Arrow<br>Characters<br>Speed limit, no turn,<br>Direction, restriction, etc. |
| 4. Curb | Markings for parking restriction | |
| 5. Reflector units | Studs, chatter bar, jiggle bars,<br>cats eye delineators, etc. | |

### 10.6.5 Toll Road System

Toll system of the proposed road is to be examined when the propose new roads are required to introduce the toll road system.

There are two kinds of toll system, the distance rate and open toll system. The open toll system is suggested in the Study considering for the following reasons.

a) Generally, the distance proportional system is adopted for a comparatively long road. However, the total road length of the proposed new highway, is not so long.

b) The open toll system is generally adopted for a comparatively short road or a ring road network, considering the balance between rate and distance.

c) As the proposed road is constructed by stage, the open toll system is the most flexible system.

**(1) Toll Plaza Facility**

Toll plaza facility means a facility to collect a designed toll fare from traveling vehicles and generally consists of toll gates, toll plaza, etc.

**(2) Type of Toll Plaza Facility**

Toll plaza facilities are classified into toll barrier and interchange toll plaza facility, depending on installed place. In this plan the toll barrier is applied in both of East West Corridor and Petapa Route.

**(3) Toll Fare System**

Open toll system is futher classified into an open toll system for the whole line and an open toll system by section. As the total length of each line is about 10 km in this plan, an open toll system for the whole line shall be applied, setting up toll barrier's at places where access to other roads is structurally impossible.

**(4) Consideration Points**

1) Toll barriers shall be set up not only to give a previous notice and attention at sufficiently far point for the traffic going forward with a main lane velocity, and also in order that toll gate itself can be seen from far. It is also necessary to be set up at other points, such as at the bottom of the concave longitudinal gradient alignment where the speed is apt to be higher.

2) Toll gate should not be a bottleneck of the traffic. For that reason a full number of lanes shall be provided to control the peak hour traffic volume.

3) At toll gate, vehicles shall be able to stop and start safely and easily, and also the fare shall be conveniently paid and received. Accordingly the toll plaza facility shall be designed flatly and in a straight line as much as possible.

4) In front and rear of the toll gate, concrete pavement shall be constructed because of the flowing out of oil and other materials and of the durability against being rutted.

5) Setting of number of tollgate lanes

   a) Design traffic volume (vehicle per hour) was set by using a section traffic volume at peak hour of future traffic volume (vehicle per day).

   b) Serve Time

      Supposing that eight seconds are necessary in case of open toll system, a number of necessary lanes was calculated.

   c) Outline of calculation for a rough number of necessary lanes.

      Number of necessary lanes = Peak hour traffic volume x service time/ 3,600 seconds

      East West Corridor peak traffic volume: 3,200 vehicle per hour

      Petapa Road peak hour traffic volume: 2,600 vehicle per hour

      East West Corridor = 7 lanes, FEGUA Route = 6 lanes

## 10.7 Environment Countermeasure

### (1) Resettlement

Resettlement caused by the construction of East West Corridor and Exclusive Busway FEGUA Route is a major social environmental problem in the implementation of the Project. Strict countermeasure for the resettlement should be taken to maintain good environmental condition. Some countermeasures are suggested in addition to general considerations.

Compensation is the only fundamental solution for these cases. However it should be handled with carefull considerations.

### (2) Noise Abatement

Vertical alignment against environmental impact on noise is a crucial element in the design for the structures to be constructed in Democracia area. The control point of vertical alignment for this road is the intersection with the Anillo Periferico and the surrounding residential area.

### (3) Safety and Division of Communities

To avoid these problems the following structures are required.

a) Fence/Guardrail

The Project should have fences along both sides of the Exclusive Busway to keep bus users from the Corridor to protect them against a traffic accidents. The guardrail is also useful to protecting pedestrians and drivers from accidental collision.

b) Overbridge and Underpass

Overbridge and underpass should be constructed at necessary points to avoid cutting off local communications.

### (4) Cultural Property

Although no impact on cultural property is predicted, the following considerations are suggested.

a) Undertake a preliminary reconnaissance along the route of the Project based on sampling to detect and eventually carry out an archaeological rescue effort in located sites.

b) Undertake a prospecting by monitoring at the construction phase. Monitor attempts to localize sites observed during construction of the Project, to evaluate and rescue the located sites and compare the data from the superficial reconnaissance with data from the monitoring.

### (5) Embankment

When natural conditions are modified by the construction of a road, it marks the start of a race between the appearance of erosion and growth of vegetation. Erosion problems can result from diversified causes and are the consequence of constant interaction between soil structures, climatic conditions, and water resources.

a) Stability of Slopes

Slope stability can be disturbed during the construction of road cutting or embankments. Steps of cut slope, deficiency of drainage, and modification of water flows can result in landslides. Some sensitive soils, such as shale, are known for being unstable and difficult to drain.

b) Sill-tipping of Spoil Material

Spoil material from road cutting can kill indigenous vegetation and add to erosion and slope stability problems. Large amounts of spoil can occur during construction in mountainous terrain. It is sometime difficult to keep the balance between cut and fill volumes of earth at each location, and haulage to disposal sites may be expensive. This creates a need for environmental management of tipped material.

c) Mitigation

There are wide range of techniques designed to reduce the risk of damaging the slope and to fit the project into its environment with few adverse effects. Simple techniques such as replanting will be effective in many situations. More sophisticated techniques, such as retaining walls, are to be used only in the most difficult cases.

d) Replanting

Replanting cleared areas and slope is the most important action to reduce erosion and stability problems. This should be undertaken as early as possible in the construction process, and before erosion becomes too advanced. Vegetation should be selected to serve a specific engineering function. In some cases a short-live engineering structure, such as a woven wattle fence, is to be installed, along with vegetation which can take over the function of the structure in time.

For vegetation itself specific countermeasure are not required. But general considerations are necessary during construction and maintenance. The most important consideration is to minimize felling and to maintain as much secondary forests as possible along the Project to prevent secondary impact such as soil erosion.

Reforestation will have many positive environmental benefits. It will help to stabilize slopes, prevent soil erosion and reduce water runoff, which will protect housing and croplands. There is a special need to harmonize highway alignment with the environment and visual appearance. Trees should not be planted on the edge of the road, and sight and distance should be taken into consideration when trees are planted at road crossing and the inner sides of curved roads. Tree branches should not reach the edge of the highway.

Large volumes of garbage are already dumped into streams and rivers. As population may grow due to the Project, the problem of garbage disposal in water ways will affect aquatic habitats. This negative impact can be mitigated by environmental education of the population and by an effective road cleaning program.

# 11. East West Corridor

## 11.1 Physical Condition

The East West Corridor is a new radial trunk road. The East West Corridor with the Exclusive Busway for strengthening public transportation will cope with a remarkable increase of the east-west traffic volume and mitigate the burden on Calzada San Juan Sacatepequez. The project route will connect the bus terminal in Zone 4 to the planned outer ring road, up to the crossing of Calzada San Juan. The planned outer ring road will be a widening of 49 Avenida in Colonia Montserrat and San Nicolas road.

Guatemala City and the Mixco area are connected by CA1 (6-lanes) and Calzada San Juan (4-lanes). Connecting roads such as Periferico (4-lanes), Avenida Bolivar (4-lanes), 6a Avenida (4-lanes), 7a Avenida (4-lanes) and Avenida Reforma (4-lanes with service roads) provide links to the Centro area and the other commercial centers.

In the near future Calzada San Juan will suffer from traffic congestion and the increasing traffic will not be managed. Priority should be given to public transport facilities to shift the traffic to public transportation. In these circumstances, the new 4-lane road will be constructed and the busway will be provided from the bus terminal in Zone 4 along the new road.

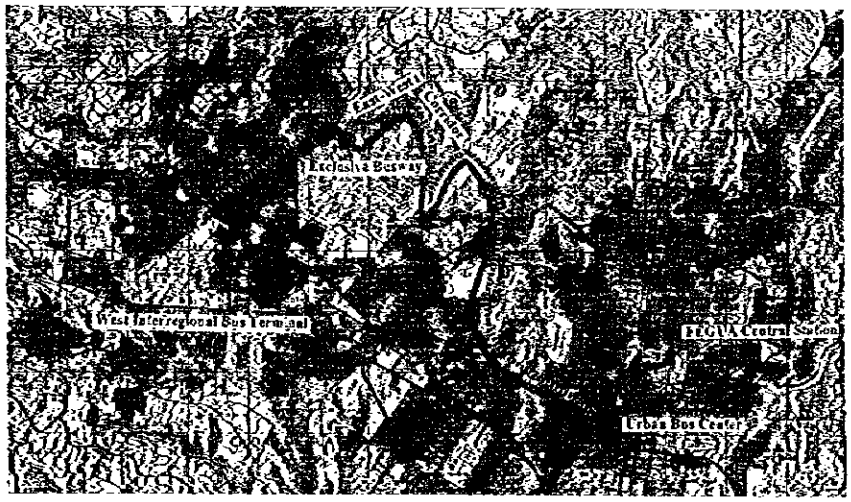



**Figure 11.1 Location Map of East West Corridor**

## 11.2 Traffic Condition

The traffic volume by section of East West Corridor can be obtained by calculation described in the chapter five. The traffic volume of passenger cars varies from section to section. However, traffic demand of 40,000 to 45,000 PCU/day are roughly expected.

The capacity volume of East West Corridor is supposed to be 48,000 PCU/day so that traffic volume of any section does not reach the capacity. Traffic volume of the section between the bus terminal and Kminaljuyu, of the section between Periferico and Naranjo are larger than that of the rest of sections.
Average trip length of traffic passing on the sections inside of Anillo Periferico is shorter than that on the sections outside of Anillo Periferico.

**Table 11.1 Summary of Traffic Demand by Section**

| Section | Traffic Demand (PCU) | Congestion Rate | Average Trip Length (Km) |
|---|---|---|---|
| Bus Terminal - Kaminaljuyu | 45,700 | 0.95 | 11.0 |
| Kaminaljuyu - Periferico | 23,400 | 0.49 | 10.5 |
| Periferico - Naranjo | 43,900 | 0.91 | 13.7 |
| Naranjo - Montserrat | 33,100 - 39,500 | 0.69 - 0.82 | 14.5 - 14.9 |
| Montserrat - S.J.Sacatepequez | 30,800 - 39,200 | 0.64 - 0.82 | 12.3 - 15.9 |

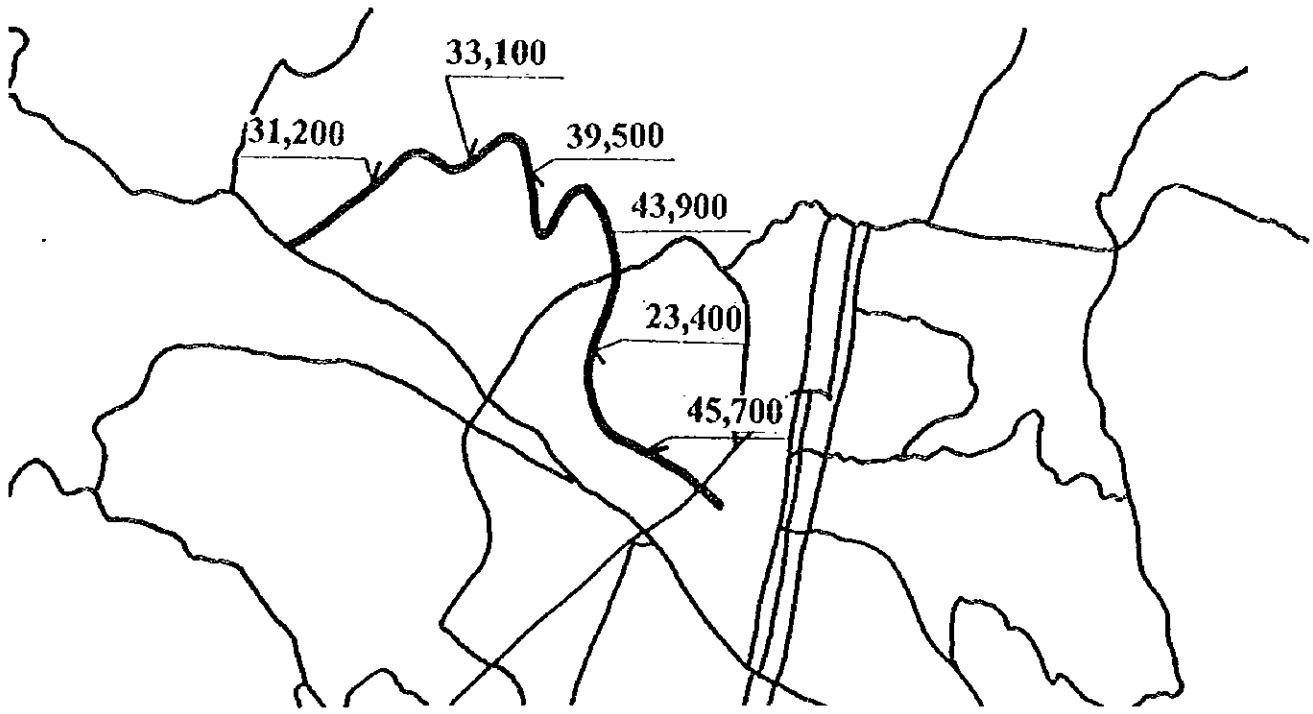



**Figure 11.2 Traffic Demand of East West Corridor**

After the analysis of traffic characteristics by section, the following findings can be obtained.

- Bus Terminal - Kaminaljuyu
  - serves the access from Zone 7 to whole area of Guatemala City.
  - serves trips from Mixco to the central Guatemala.
  - serves trips from Mixco to the southern part of the Study Area.
- Kaminaljuyu - Periferico
  - serves trips from the northern part of Mixco and Naranjo area to Zone 7.
  - serves trips from the northern part of Mixco and Naranjo area to the southern part of Guatemala City
  - serves trips from Naranjo area to the eastern part of the Study Area.
- Periferico - Montserratserves
  - trips from Mixco to the northern part of the Guatemala City and Zone 18.
  - serves trips from the northern part of Mixco to the southern part of the study area.
  - serves trips from the southern part of Mixco to the center of Guatemala City.
- Montserrat - San Juan Sacatepequezserves
  - trips from the northern part of Mixco to Guatemala City.
  - serves intra-city trips of Mixco City.

## 11.3 Geometric Design

### 11.3.1 Section between the Bus Terminal in Zone 4 and the Disposal Site of Solid Waste

**(1) Geometric**

1) Configuration

Between the bus terminal in Zone 4 and the disposal site of solid waste, Avenida Bolivar is located at the highest point and with 5% to 7% gradient descend on both sides, east- west. The disposal site has been formed reclaiming with solid waste in the gully. The depth and width of the reclaimed area is 85m and 130m, respectively. The geological features are volcanic sediments.

2) Land Use

The section from the bus terminal to the FEGUA railway is in Zone 4, from the FEGUA railway to Avenida Bolivar in Zone 8 and from Avenida Bolivar to the disposal site in Zone 3. The Zone 4 section is a commercial zone with a market, shops and bus terminal. The Zone 8 section is in mixed commercial and residential area where workshops, shops selling mechanical parts, market etc. are located. Zone 3 section is largely residential mixed with commercial and there are facilities related to the solid waste disposal. These zones are all built up with low rise buildings. The route is planned not to interfere with public facilities such as churches, and the buildings to be removed is minimized.

3) Road Pattern

The local streets have an independent system within each Zone divided by right of way of the FEGUA and Avenida Bolivar. The local streets in Zone 4 form grid pattern of the east-west and the north-south. Most streets are regulated by one-way traffic. The streets in Zone 8 are grid pattern parallel to Avenida Bolivar. Most streets are less than 7m wide and traffic is one-way. Because of the FEGUA railway and the difference of elevation, the streets of Zone 4 and Zone 8 are almost independent. The width of streets in Zone 3 is more than 12m wider than those in Zone 8 and the linked streets between the two zones are few. The streets in Zone 3 consist of a north-south and east-west grid and the streets run perpendicular to Avenida Bolivar.

Avenida Bolivar is a trunk road accessing the central district and connecting directly to CA9. Its traffic volume is large and serious traffic jams frequently occur. 2a Calle in Zone 4 connects to CA1 in the south-east of the city and functions as a trunk road in the east-west direction with 1a Calle.

**(2) Location of Selected Route**

Taking into consideration the geographical configuration, compensation for the existing facilities and the environment, the East West Corridor is a depressed road passing under Avenida Bolivar.

Based on an evaluation of future traffic demand and construction cost, relocation of existing buildings, and procurement and ease of construction, selected route is considered more advantageous. At under pass intersection with the FEGUA railway is adapted open cut of construction. The Exclusive Busway and the Corridor are constructed in open cut structure separately according to their gradient maximum 3% for future adopted railway. Bridges is required for crossing the existing local streets. Ventilation is not necessary and it is advantageous in case of accidents. The control point of vertical alignment for this road is the intersection with the FEGUA railway.

Access to the bus center of the busway, the busway is connected to the ordinary road and 2a and 3a Avenida are used for access to the bus center.

### 11.3.2 Section from the Disposal Site to Periferico

**(1) Geometric**

1) Configuration

The tributaries of the Rio La Barranca run into the residential area forming gullies with a depth of 50 to 60m.

2) Land Use

The tablelands have been urbanized and much housing is located on them. There is an archeological site (Sitio Arqueoligica) designated as a preservation area. On a long and narrow stretch of land projecting into the gullies in the shape of a peninsula, are a hospital, the facilities of the Ministry of Health, the cemetery, etc. On rather gentle slopes of the valley, some informal houses have been built. There are no buildings in the gullies. The gullies in this area have a small catchment area. To the north of the archeological site is the large Parque Democracia with a stadium and football fields.

3) Road Network

The roads in this section are local streets except for Periferico. The East West Corridor will traverse the land crossing the access roads to the tip of the 'peninsula', so some measures should be taken in order not to isolate the communities.

**(2) Location of Selected Route**

A balance between the cost of road structures and removal of existing buildings is made. Impacts on the environment are minimized.

Cutting the tableland and reclaiming the gully are to be carried out to construct a depressed road. Separation of the community can be minimized by adopting the depressed road.

Crossing of the existing road is to be by grade separation, taking into consideration securing an access road to the area near the project site on the tableland, and alleviating negative impacts on the residents and environmental problems. The reclaimed gully can be used for residential use, such as that for displaced residents.

### 11.3.3 Section from Periferico to Avenida San Nicolas (Planned Outer Ring Road)

#### (1) Geometric

1) Configuration

Periferico runs on a long and narrow tableland lying between the Rio La Barranca and the Rio El Naranjo. There are gullies on both sides of the tableland. On the western side of Periferico, rises Cerro Naranjo, 1,697m above sea level. Cerro Naranjo is composed of volcanic ash overlying the base stratum of the Paleozoic rocks.

2) Land Use

The tableland along Periferico is a residential area. Houses are constructed up to the edge of the gully. Cerro Naranjo is mostly covered with forests and farms. On the gentle slopes of the hill to the north-east are forests, where an urban development project has been carrying out. To the south of Cerro Naranjo is the upper reaches the Rio El Naranjo and a developing residential area. Small clusters of houses are distributed along the route.

3) Road Network

The unpaved roads on the northern side of Rio El Naranjo are for access to farm lands and houses. On the southern side, feeder roads have been laid out in each developed area. The private urban development project is progressing and a part of the planned road has been started. Negotiations for acquisition of land for the project are said to be almost reaching agreement.

#### (2) Location of Selected Route

Emphasis will be placed on feasibility of land acquisition and minimizing impact on the existing community. Making use of the existing development project in the north-east of Cerro Naranjo, construction of bridges is required and construction cost is higher. Acquisition of land is easier.

### 11.3.4 Section from Avenida San Nicolas to the intersection of Calzada San Juan

#### (1) Geometric

1) Configuration

This section has a comparatively flat configuration extending parallel to the Rio Guacanaya.

2) Land Use

To the south of Avenida San Nicolas is a residential area of low rise houses. To the north of San Nicolas are farms and pastures and there are residential development projects, some of which are constructed or under construction and others are only in the planning stage.

3) Road Network

Avenida San Nicolas is the trunk road accessing the north. 49a Calle has a large width and divides the residential areas but the condition of the pavement is not good. Each residential area has its own local grid road system.

**(2) Location of Selected Route**

Basically, crossings are to be at grade intersection, considering the crossing traffic volume. The route will be on the existing Avenida San Nicolas and the 49 Calle. No alternative routes are worth comparing.

## 11.4 Intersection Planning

The intersection design has been in consideration of the following points:

a) Highway classification and road network

b) Characteristics and traffic composition

c) Design Speed

d) Traffic control and toll systems

e) Economic aspects

f) Geographical features (Terrain)

g) Housing development and land acquisition

Before the intersection design, the future road network expected in the Study Area is clarified in order to consider the long-term road network configuration.

**(1) Location of Intersections**

In the location of intersections, the following points should be taken into consideration:

a) Characteristics of traffic using intersection

b) Road network and connected roads

c) Economic aspects

d) Environmental and development conditions where intersection are to be located

The layout for any specific ramp and type of traffic movement will reflect the site conditions of topography and social aspect, cost, and the degree of flexibility in traffic operation desired. The last factor should predominate in design, but the practical aspects of cost and site conditions are frequently deciding factors in the type and scope of ramps.

**(2) Type of Intersection**

Periferico IC is located at the intersection between the proposed road and the Anillo Periferico in the Febrero area. This area has been developed into housing estates and commercial areas. The land value is estimated as about Q.120 to 220/$m^2$

A four-leg interchange type is to be considered in this area, considering the land acquisition and compensation aspects, a trumpet type interchange is adopted because it requires the smallest land acquisition and compensation.

**(3) Design Criteria**

1) Design Speed

According to the AASHTO, the design speed of an interchange should be 60 km/hour, using the lower range of design speed. However, the design speed of a loop section of an interchange should be 40 km/hour considering economic aspects and the land available for the construction of the interchange.

2) Deceleration and Acceleration Length

According to the AASHTO, the minimum deceleration and acceleration lengths for one lane ramps should be 100m.

3) Cross-Section

The following cross-section dimensions have been adopted in consideration of the traffic characteristics and the function of the proposed road.

a) lane width; 3.50 m
b) right shoulder width; 1.00 m
c) left shoulder width; 0.50 m

## 11.5 Structure

In the East West Corridor, 17 bridges (5 main road bridges, 12 over bridges), one tunnel (320 meters long on main road), one retaining wall (1175 meters long on main road) are planned. Names, locations and dimensions of each structure are shown in Table 11.2.

**Table 11.2 Proposed Structure Type in East West Corridor**

| No. | Temporary Bridge Name | Station No. | Size | Type | Structure Type |
|---|---|---|---|---|---|
| 1 | PERIFERICO Bridge | No.76+08-No.76+48 | L=40m,W=40m | ov | Simple Composite PCI Girder |
| 2 | 29 AVENIDA Over Bridge | No.78+30 | L=39m,W=11m | ov | Simple Composite PCI Girder |
| 3 | DEMOCRACIA Bridge | No.79+35-No.82+35 | L=300m,W=10.5m*2 | va | Simple Composite PCI Girder |
| 4 | DEMOCRACIA PARQUE Tunnel | No.84+45-No.87+65 | L=320m,W=10.5m*2 | tn | Box Culvert |
| 5 | DEMOCRACIA PARQUE Bridge | No.89+39-No.91+10 | L=140m,W=13.5m*2 | va | 3-Span Cantilever Erection PC Box Girder |
| 6 | SAN VICENTE Bridge | No.93+80-No.95+00 | L=120m,W=13.5m*2 | va | 2-Span Cantilever Erection PC Box Girder |
| 7 | PLANGANA Bridge | No.100+29-No.101+49 | L=120m,W=13.5m*2 | va | Simple Composite PCI Girder |
| 8 | KINAL Bridge | No.102+20-No.103+40 | L=120m,W=13.5m*2 | va | 2-Span Cantilever Erection PC Box Girder |
| 9 | ZONA7 Retaining Wall | No.109+25-No.122+40 | L=1175m*2,H=1-20m | rw | Gravity Type, Reversed T-Type, Buttresed |
| 10 | 7 AVENIDA Over Bridge | No.111+18 | L=44.5m,W=20m | ov | Simple Composite PCI Girder |
| 11 | 6 AVENIDA Over Bridge | No.112+48 | L=44.5m,W=20m | ov | Simple Composite PCI Girder |
| 12 | 10 AVENIDA Over Bridge | No.120+00 | L=44.5m,W=20m | ov | Simple Composite PCI Girder |
| 13 | BOLIVAR Over Bridge | No.115+24 | L=42m,W=35m | ov | Simple Composite PCI Girder |
| 14 | 2 AVENIDA Over Bridge | No.116+24 | L=36m,W=11m | ov | Simple Composite PCI Girder |
| 15 | 3 AVENIDA Over Bridge | No.116+81 | L=36m,W=11m | ov | Simple Composite PCI Girder |
| 16 | 7 AVENIDA Over Bridge | No.117+38 | L=36m,W=11m | ov | Simple Composite PCI Girder |
| 17 | 8 AVENIDA Over Bridge | No.118+23 | L=36m,W=11m | ov | Simple Composite PCI Girder |
| 18 | 9 AVENIDA Over Bridge | No.119+18 | L=36m,W=11m | ov | Simple Composite PCI Girder |
| 19 | FEGUA .Busway Over Bridge | No.120+53 | L=37.6m,W=20m | ov | Simple Composite PCI Girder |

Note ov : over bridge
va : valley bridge
tn : tunnel
rw : retaining wall

All the five roads bridges constructed as part of the main road crossing the valley are over 100 m long. For the superstructure style, the P.C. I-girder bridge, of which Guatemala has many experiences, shall be given priority, and shall be adopted to the Democracia Bridge and Planagana Bridge where the slope of the valley declines gently in comparison. The girder erection method for both bridges shall be an erection girder method, because a truck crane method is impossible. About the other three bridges, the span shall be long and large, because the slope is steep and the valley is deep, and so a P.C. box girder cantilever erection method shall be taken. For the foundation of the bridges of the P.C. box girder, cast-in-place concrete piles with a diameter of 3.0 m shall be used because of a large load to bear.

# 12. Petapa Road

## 12.1 Physical Conditions

The Petapa Road is an intermediate corridor between the CA9 South and FEGUA Route. It attends to the south-east area of the city and the land use along the road is mixed with residential and industrial use. It is part of the secondary Route 14 and has a length of 6.5km approximately from the Municipal boundary to the Boulevard Liberation Route, CA1 near the Trébol, going through the whole Zone 12.

It serves as venting of traffic for San Miguel Petapa and a part of Villa Nueva. In the south-north direction, it is used by the traffic from Ciudad Real , Colonials of Bello Horizonte, Venezuela, Hogar and Desarrollo, Silva, Vásquez, Justo Rufino Barrios, Nimajuyú, Los Guajitos, Letrán, Morse, Eureka, San Carlos, Villa Sol, Santa Elisa, Santa Rosa, El Carmen and La Reformita, and it is also the only corridor for the industrial area, helping the southern part of the city.

The present cross section, in the south-north direction, varies from the 35.00 m to 25.00 m near San Carlos University. From the University until its intersection with Boulevard Liberación, the cross section ranges from 15.00 m to 25.00 m.

In the section described above, (USAC-Boulevard Liberación), the enlargement is almost impossible due to the residential development; this means a large quantity of expropriations (a lot of affected families) that makes a difficult acquisition of land.

At the present, the construction of a corridor is planned parallel to Petapa Road, using the both sides of the railway of FEGUA, named Calzada Atanasio Tzul, with a cross section of 10.00 m in the east and west sides.

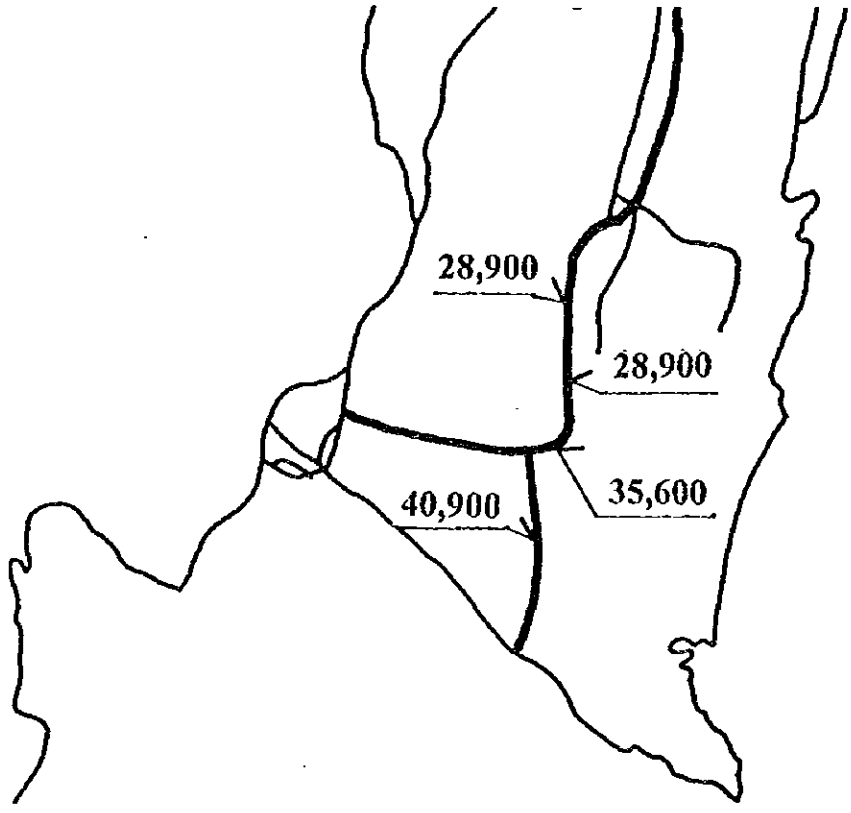
The length of this project extends from the access to Colonia Justo Rufino Barrios, Zone 21, to 13 Calle, Zone 12 approximately 4.5km. One kilometer is not going to be constructed in order to join it with Boulevard Liberación, Zone 12 near Pamplona Bridge, Zone 13. One of the problems in the construction of Calzada Atanasio Tzul is the invasion by homeless persons, who usually are migratory people of low income. The period to implement this project is from 18 to 24 months (1.5-2 years) as first stage. The next stage is in study which requires an enlargement of the Pamplona Bridge structure.

## 12.2 Traffic Demand

The summary of the traffic volume by section of Petapa Road is described in the following table. The traffic volume of the section between Ciudad Real and Rio Villa Robos are to be 28,800 to 54,700 PCU. The traffic volume of 54,700 is calculated on the partial link near Ciudad Real because all trips from Ciudad Real access to this link. Except this link, the congestion rate is appropriate so that the capacity volume has surplus.

**Table 12.1 Summary of Traffic Demand by Section**

| Section | Traffic Demand (PCU) | Congestion | Average Trip Length |
|---|---|---|---|
| Ciudad Real - Rio Villa Robos | 28,800 - 54,700 | 0.60 - 1.13 | 11.3 - 16.2 |
| Rio Villa Robos - Villa Nueva | 40,900 | 0.85 | 13.5 |




**Petapa Road**
**Unit: PCU**

**Figure 12.1 Traffic Volume of Petapa Road**

## 12.3 Geometric Design

### 12.3.1 Cross-Section Design

The cross-section design has been carried out based on the typical cross-section mentioned previously as well in consideration of future traffic conditions, the construction plan and topographic and soil conditions along the proposed road.

**(1) Number of Lanes Required**

1) Future Traffic Volume

The number of lane required has been examined based on a comparison between the projected traffic volume and lane capacity, as well as in consideration of the function and characteristics of the proposed road, and the future and existing road network configuration. The future traffic volumes on each road segment in years 2010 are shown in Table 12.2.

**Table 12.2 Future Traffic Volume**

( Unit : PCU / day )

| | Passenger Car |
|---|---|
| 1.Ciudad Real - Rio Villa Lobos | 40,900 |
| 2.Rio Villa Lobos - Petapa | 35,600 |

2) Number of Lanes Required

The traffic capacity has been calculated depending on the type of road; 2-lane road or multi-lane road, width of cross-section elements, traffic characteristics and service level of road. The vehicle capacity has been calculated based on the Highway Capacity Manual (HCM).

A 4-lane dual carriageway is adopted for the proposed road.

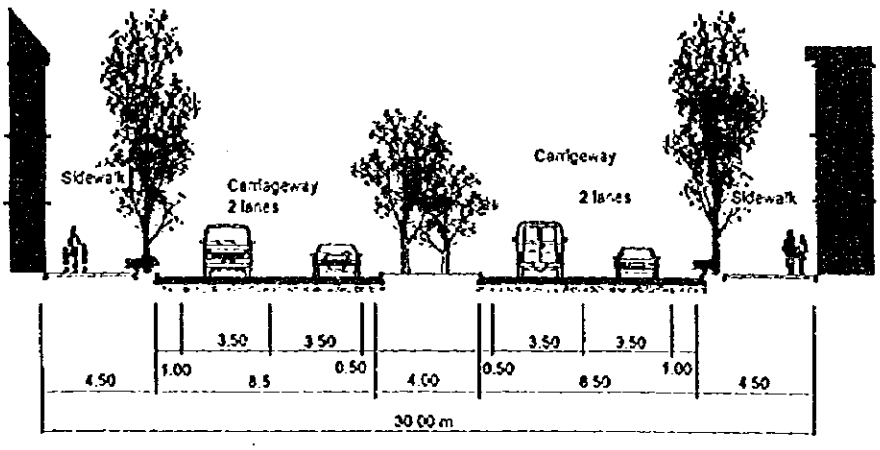



**Figure 12.2 Typical Cross Section**

**(2) Location of Selected Route**

Between Ciudad Real and Rio Villalobos, there is no alternative route because of topographical restrictions. The route is considered to cause smaller impact on social environment connected to population resettlement.

## 12.4 Intersection Planning

Before the intersection design, the future road network expected in the Study Area is clarified in order to consider the long-term road network configuration.

### (1) Design Criteria of At-grade Intersection

1) Design Speed

According to the AASHTO, the design speed of an interchange should be 60 km/hour. However, considering economic aspects and the land available for the construction of the interchange, 40 km/hour is applied as the design speed at the intersection.

2) Cross-Section

The following cross-section is adopted in consideration of the traffic characteristics and the function of the proposed road.

a) lane width; 3.65m

b) right shoulder width; 1.0m

c) left shoulder width; 0.50m

d) median width; 4.00m including a 3.00 m right turning lane

## 12.5 Structure

On the Petapa Roads, 5 bridges (4 main road bridges, 1 over bridge) are planned. There are bridges which are to cross deep valleys, and P.C - I type girder is adopted for the superstructure of all the bridges. Dimensions of each structure names and locations are shown in Table 12.3.

**Table 12.3 Proposed Structure Type in Petapa Road**

| No. | Temporary Bridge Name | Station No. | Size | Type | Structure Type |
|---|---|---|---|---|---|
| 1 | PETAPA Bridge | No.06+80 | L=32m,W=9m | ov | Simple Composite PCI Girder |
| 2 | PARAISO Bridge | No.18+82-No.18+94 | L=12m,W=11.25m*2 | rv | Simple Composite PCI Girder |
| 3 | FRUTAL Bridge | No.25+24-No.25+54 | L=30m,W=11.25m*2 | rv | Simple Composite PCI Girder |
| 4 | VILLALOBOS Bridge | No.27+20-No.32+80 | L=480m,W=11.25m*2 | rv | Simple Composite PCI Girder |
| 5 | VILLAHERMOSA Bridge | No.33+40-No.37+30 | L=390m,W=11.25m*2 | va | Simple Composite PCI Girder |

Note : ov : over bridge
rv : river bridge
va : valley bridge

Villalobos Bridge over the Villalobos river will be 30m length of P.C.- I Type girder, which can maintain a discharge capacity at river flood time, and constructed by the truck crane erection method.

Villahermosa Bridge over the small valley and FEGUA railway. At construction stage, truck crane method with P.C. I girder is considered to be difficult because of a pier of about 35m height, and so erection girder method with P.C. I-girder is planned.

# V PUBLIC TRANSPORT FACILITY PRELIMINARY DESIGN

# V. PUBLIC TRANSPORT FACILITY PRELIMINARY DESIGN

## 13. Design Conditions

### 13.1 Civil Engineering

#### 13.1.1 Design Standard

The functions and characteristics of the Exclusive Busway have been examined for the road network plan.

a) The function of the Exclusive Busway is primarily to maintain mobility, so a high standard of road design criteria is required.

b) The whole East West Corridor Route is planned at the center of the East West Corridor, and the preparation of a rail transit system is considered in this construction plan.

c) Major sections of the Route form a main radial artery and the west most section constitutes a part of the outer ring road.

d) As the result of the preliminary design, East West Corridor is a 4-Lane dual carriageway with 2-lane Exclusive Busway. Design speed is adopted as 60 Km/hour,

e) The FEGUA Route is to utilize the right of way of FEGUA for bus operation between the FEGUA Central Station and Ciudad Real and construct a new busway to Villa Nueva.

The road design is conducted to examine the following design aspects;

a) Lane Width.

In accordance with AASHTO, a 3.50m wide lane is adopted for Exclusive Busway.

b) Shoulder Width.

In accordance with AASHTO, considering the topographical features along the route, the width of the right and the left shoulder of the proposed road is set as 1.0 m and 0.5 m, respectively.

c) Right of Way

In accordance with the AASHTO, the typical right of way for a ground level 2-Lane exclusive busway is made about 10m. The typical cross section is shown in Figure 13.1.

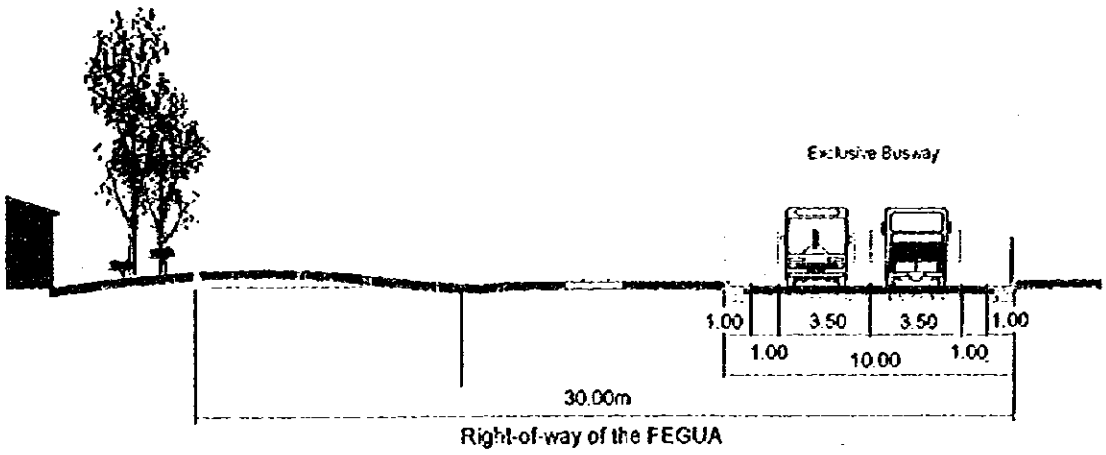



**Figure 13.1 Typical Cross Section**

### 13.1.2 Structure Style

The lane width and dimensions of bus operation space, etc., of the busways, the center and the terminals are designed to accommodate large buses of 12m long and articulated buses of 16m long.

### 13.1.3 Load

#### (1) Live Load

HS20-44 of AASHTO is applied for the design live load of the busway.

#### (2) Seismic Load

An acceleration coefficient "A" of 0.30 is applied.

## 13.2 Architecture

Guatemala has a law which is equivalent to the Building Standards Law in Japan. Prior to the actual construction of a building after its design, it is necessary to submit the drawings to the Guatemala Municipality to obtain approval prior.

This law in Guatemala sets forth various standards and rules with a view to preserving a reasonable living environment. These standards and rules include the restriction of certain types of buildings in areas specifically designated for certain purposes, the minimum distance between a building and a road as well as the boundary with a neighboring plot, the size of a car park depending on the purpose of use and size of a building, the effective open area of rooms, rules relating to evacuation at the time of fire or earthquake and other safety aspects and those applicable to schools, commercial facilities, public halls, offices and car parks, etc.

The contents of the preliminary design for public transport facilities must conform to this law and the relevant standards in Guatemala in order that the planning and design principles for such facilities are in line with the spirit of the law and standards.

Guatemala is an earthquake-prone country and there have been many occasions on which cities and/or precious historical/cultural remains have been destroyed by a large earthquake. Facing the likelihood of further earthquakes in the years to come, the Government of Guatemala has introduced seismic design standards. Considering the past record of earthquakes and the findings of various surveys, the country is divided into 3 zones with the application of a specific seismic force (horizontal force) factor for each zone.

This design seismic force (horizontal force) is calculated as V = A.D.B.Q.W and is determined by multiplying the weight of each floor of a building by the factor, in turn determined by such parameters as the strength of past earthquakes in the zone in question, height, rigidity distribution, vibration characteristics and shape of the building, etc.

The Ultimate Strength Design Method is adopted as the structural design method, following the example of the Uniform Building Code (UBC) of the US and the design of a building based on the UBC should prove safe.

As the subject facilities of the present F/S, i.e. Urban Bus Center and Inter-Regional Bus Terminals, etc., are public transport facilities where many, unspecified people will gather day and night, they must be strong enough to ensure the safety of such people vis-a-vis earthquakes.

In regard to basement rooms and the central core section which are enclosed by walls and ceilings, a mechanical ventilation system or sufficient openings must be provided to ensure a constant inflow of fresh air from outside. The introduction of an air-conditioning system (for both heating and cooling) is unnecessary for these facilities given the average monthly temperature and the conditions of the building services of existing public buildings. However, lifts and/or slopes should be introduced for the exclusive use of the physically handicapped, the elderly and pregnant women to make the facilities easily accessible.

In addition to functioning as bus terminals, the planned facilities will also provide shopping opportunities at the commercial facilities to be constructed adjacent to them and will provide areas for relaxation while waiting for buses. It is essential that such areas are conceived as being cheerful and pleasant. Consequently, the luminous intensity for passenger waiting areas and shops in the shopping area will be at least 400 lux, as in the case in Japan, while the luminous intensity for the bus terminal, passageways and staircases, etc. will be a minimum of 200 lux to prevent a feeling of dimness.

The Urban Bus Center and the North, West and South Inter-Regional Terminals will become the key facilities for the public transport network of Guatemala City and its satellite cities and their functions must be maintained throughout the day except for late at night. Accordingly, the installation of an emergency power generating unit is desirable.

## 13.3 Bus Design Specifications

### (1) Target Buses

At present, a huge variety of buses in terms of model and size are operating in Guatemala City. The current presence of more than 20 different types/sizes of buses will, however, decline with the gradual increase of the bus size. The bus berth and pedestrian deck design specifications are as follows.

- Length (L) : 12.0 m
- Width (W) : 2.5 m
- Height (H) : 3.2 m
- Wheelbase (Wb) : 5.8 m

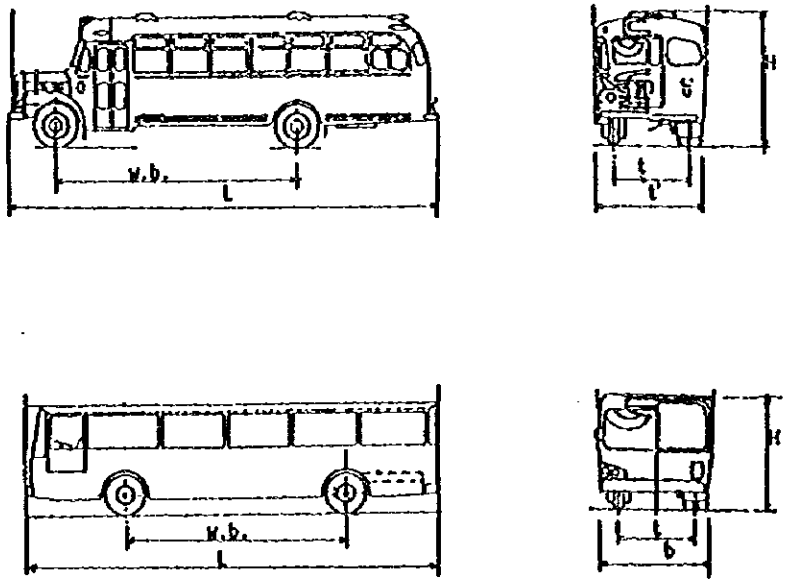



**Figure 13.2 Dimension of Buses**

**(2) Pedestrian Deck**

The standard pedestrian deck design is shown in Figure 13.3. Clearance under the girder is set at 4 m. As the girder height varies between 0.50 m and 1.50 m depending on the type of structure, the floorboard height will accordingly vary between 4.50 m and 5.50 m. The staircase will have a step height of 30 cm and a slope of 1 - 2 m with a 2 m wide landing area halfway up.

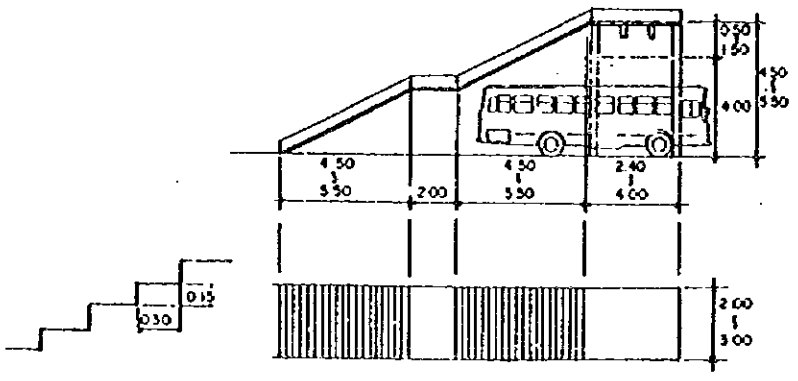



**Figure 13.3 Standard Design of Pedestrian Bridge**

# 14. Exclusive Busway

## 14.1 Planning Concept

### (1) Objectives

Exclusive bus ways are to make the most use of buses along trunk routes. In the Master Plan, they were introduced along two routes, namely the east-west route and the FEGUA route. The major objective is to serve commuters from population centers in the western and southern suburbs to the central business district (CBD) of the metropolitan area. It is expected that the busways promote use of the bus services and contribute a lot to reducing congestion in the directions of the busways.

### (2) Bus Routes to Operate on Exclusive Busways

Bus routes to operate on exclusive busways are planned by modifying the routing in the Master Plan. Twenty one (21) routes including 2 routes operating on both busways. They consist of:

| | |
|---|---|
| Key routes connecting western suburb to CBD | (5) |
| Key routes connecting southern suburbs to CBD | (5) |
| Key route connecting northern suburbs to CBD | (1) |
| Routes connecting western suburbs to southern suburbs | (4) |
| Southern or eastern inter-regional bus routes | (5) |
| Other route | (1) |

In general, each route has express services and ordinary services. Most of these routes are supplemented by feeder buses to serve branch routes and inside CBD areas. Access points are identified at locations where entrance and exit of the buses to/from the busways are planned.

### (3) Bus Station System

The average bus station interval is approximately 1,100m on the East West Route and 800 m on the FEGUA Route. Their types of bus stations are planned according to the expected roles of each location.

1) Special Stations (100% buses stop.)
- Urban Bus Center at Zone 4
- FEGUA Central Station
- Villa Nueva North Station
- Calzada San Juan Sacatepequez Station

2) Major Stations (~75% buses stop)
(4 berths/one-way, 65 m, platform=3m wide)
- 6-th and 7-th Avenue Station
- USAC Station
- Ciudad Real Station
- Bethania Station

3) Minor Stations (~50% buses stop)
(3 berth/one-way, 50 m, platform=3m wide)

### (4) Transformation into a Rail Transit System

The busways are designed in such a way as to be transformed into a railway transit system except for some sections such as the steep section, in the southern part of Ciudad Real..

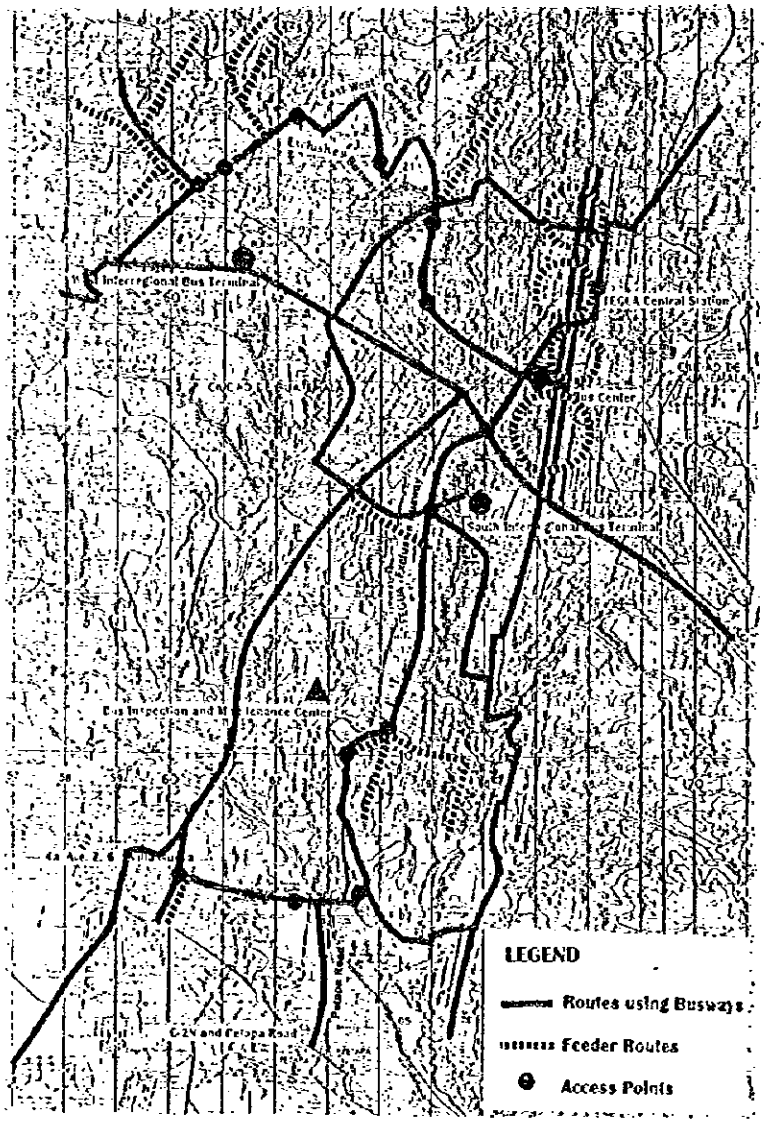



**Figure 14.1 Bus Service Network Operating on Exclusive Busways**

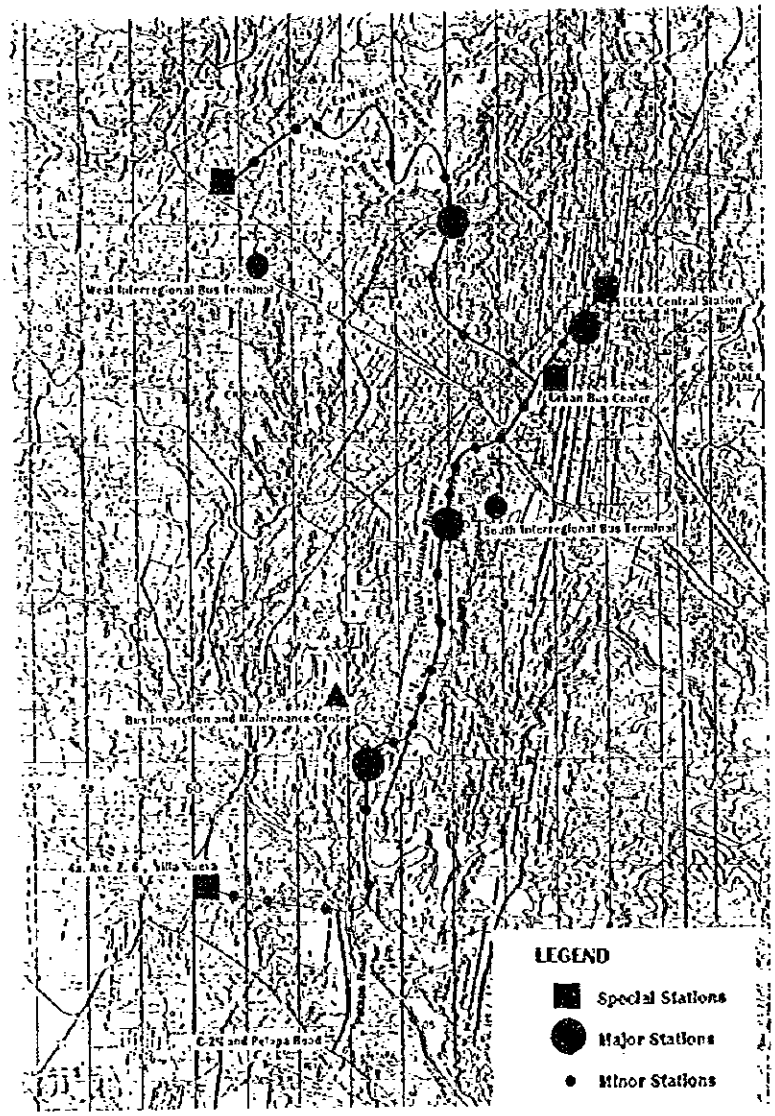



**Figure 14.2 Location of Bus Stations**

**Table 14.1 Bus Routes Operating on Exclusive Busways**

| Route No. | Type | % of Buses assigned to the Busway | Route |
|---|---|---|---|
| 1 | Key Route | 100 | Z19-BW(EW)-Peri-FC Station-BW(FEGUA)-UBC |
| 2 | Key Route | 100 | Z19-BW(EW)-UBC-CBD |
| 3 | Key Route | 100 | Mixco-CA1W-Peri-FC Station-BW(FEGUA)-UBC |
| 4 | Key Route | 50 | Mixco-CA1W-Liberacion-BW(FEGUA)-UBC-FC Station |
| 5 | Key Route | 50 | Mixco-Outer Ring-BW(EW)-UBC-CBD |
| 6 | Key Route | 50 | Villa Nueva-CA9S-Liberacion-BW(FEGUA)-UBC-FC Station |
| 8 | Key Route | 100 | Villa Nueva-BW(FEGUA)-UBC-FC Station |
| 9 | Key Route | 100 | Petapa-Petapa Rd-BW(FEGUA)-UBC-FC Station |
| 10 | Key Route | 50 | Villa Canales-DR1-Villa Hermos-DR14-BW(FEGUA)-UBC-FC Station |
| 12 | Ordinary | 50 | Villa Canales-DR1-Liberacion-BW(FEGUA)-UBC-FC Station |
| 23 | Ordinary | 100 | Jocotales-DR15-FC Station-BW(FEGUA)-UBC |
| 29 | Ordinary | 100 | Z19 North-BW(EW)-Peri-CA9 S-Villa Nueva |
| 30 | Ordinary | 100 | Z19 North-BW(EW)-Peri-BW(FEGUA)-Petapa Rd-Petapa |
| 31 | Ordinary | 100 | Z19 North-BW(EW)-Peri-DR1-Boca del Monte |
| 33 | Inter-regional | 100 | Mixco-CA1 W Peri-BW(FEGUA)-Petapa Rd-Petapa |
| 59 | Inter-regional | 100 | Z19-BW(EW)-Tierra Nueva-Hipodromo-Av Elena-Av Cementerio-7 Av-CA1W |
| 73 | Inter-regional | 100 | CA9S-Villa Nueva-BW(FEGUA)-Peri Tramo -S Terminal |
| 74 | Inter-regional | 100 | DR8-Villa Canales-DR2-Petapa-Petapa Rd-BW(FEGUA)-Peri Tramo-S Terminal |
| 75 | Inter-regional | 100 | CA1E-Liberacion-BW(FEGUA)-UBC |
| 76 | Inter-regional | 100 | Fraijanes-NR2-CA1E-Liberacion-BW(FEGUA)-UBC |
| 77 | Inter-regional | 100 | San Jose Pinula-NR18-CA1E-Liberacion-BW(FEGUA)-UBC |

**Table 14.2 Bus Routes Planned in the Master Plan**

| Route No. | Type | Route |
|---|---|---|
| 1 | Key Route | Z19-EW Corridor-Peri-CBD |
| 2 | Key Route | Z19-EW Corridor-CBD |
| 3 | Key Route | Mixco-CA1N-Peri-CBD |
| 4 | Key Route | Mixco-CA1N-CBD(Bolivar) |
| 5 | Key Route | Mixco-CA1N-CBD(6&7 Av) |
| 6 | Key Route | Villa Nueva-CA9S-CBD(Bolivar) |
| 7 | Key Route | Villa Nueva-CA9S-CBD(6&7 Av) |
| 8 | Key Route | Villa Nueva-Ciudad Real-FEGUA-CBD |
| 9 | Key Route | Petapa-DR14-Ciudad Real-FEGUA-CBD |
| 10 | Key Route | Villa Canales-DR1-11AV-7AV-CBD(Bolivar) |
| 11 | Key Route | Villa Canales-DR1-11Av-7Av-CBD(6&7 Av) |
| 12 | Key Route | Villa Canales-DR1-Av Las Americas-CBD(Bolivar) |
| 13 | Key Route | Villa Canales-DR1-Av Las Americas-CBD(6&7 Av) |
| 14 | Key Route | San Jose Pinula-NR18-CA1E-CBD(Bolivar) |
| 15 | Key Route | San Jose Pinula-NR18-CA1E-CBD(6&7 Av) |
| 16 | Key Route | Paraiso-CA9N-Inner Ring E-CBD(Bolivar) |
| 17 | Key Route | Paraiso-CA9N-Inner Ring E-CBD(North) |
| 18 | Key Route | Paraiso-CA9N-Inner Ring-E-CBD(South 6&7 Av) |
| 19 | Key Route | Maya-CA9N-Inner Ring E-CBD(Bolivar) |
| 20 | Key Route | Maya-CA9N-Inner Ring E-CBD(North) |
| 21 | Key Route | Maya-CA9N-Inner Ring E-CBD(South 6&7 Av) |
| 22 | Key Route | Jocotales-DR15-CBD(Bolivar) |
| 23 | Key Route | Jocotales-DR15-CBD(6&7 Av) |
| 24 | Ordinary | Amparo-Peri-CBD(Bolivar) |
| 25 | Ordinary | Amparo-Peri-CBD(6&7 Av) |
| 26 | Ordinary | CBD(North)-Diagonal14-CBD(Bolivar) |
| 27 | Ordinary | Diagonal14-CBD(South)-CBD(North)-Diagonal14 |
| 28 | Ordinary | Diagonal14-CBD(North)-CBD(South)-Diagonal14 |
| 29 | Ordinary | Z19-EW Corridor-Peri-CA9S-Villa Nueva |
| 30 | Ordinary | Z19-EW Corridor-Peri-FEGUA-Ciudad Real-DR14-Petapa |
| 31 | Ordinary | Z19-EW Corridor-Peri-DR1-Boca del Monte |
| 32 | Ordinary | Mixco-CA1W-Peri-CA9S-Villa Nueva |
| 33 | Ordinary | Mixco-CA1W-Peri-FEGUA-Ciudad Real-Petapa |
| 34 | Ordinary | Mixco-CA9W-Peri-DR1-Boca del Monte |
| 35 | Ordinary | Paraiso-Ca9N-Peri-Boca del Monte |
| 36 | Ordinary | Maya-CA9N-Peri-Boca del Monte |
| 37 | Ordinary | Ciudad Nueva-10&11 Av-2 Ca-Vista Hermosa |
| 38 | Ordinary | Ciudad Nueva-10&11 Av-2 Ca-URL |
| 39 | Ordinary | Hipodromo-Ca9N-Av Elena -Av Cementerio-7 Ca-5 Av-Av Mariscal-B1 San Cristobal-18 Av |
| 40 | Ordinary | Hipodromo-Ca9N-Av Elena-Av Cementerio-7 Ca-5 Av-Av Mariscal-Comunidad-Mixco |
| 41 | Ordinary | Mixco-B1 San Cristobal-CA9S |
| 42 | Ordinary | San Cristobal-B1 Balcones-CA9S |
| 43 | Ordinary | San Cristobal-B1 Sur-Ca9S |
| 44 | Ordinary | Barcenas-Villas Nueva-NR2-Villa Canales |
| 45 | Ordinary | Milagro-NR5-7 Ca-Av Cementerio-13 Ca |
| 46 | Ordinary | 1 de Julio-Nr5-7 Ca-Av Cementerio-13 Ca |
| 47 | Ordinary | Ciudad Real-DR14-Av Bolivar-Av Cementerio-Av Elena-CA9N(UMG) |
| 48 | Ordinary | Maya-CA9N-10&11 Av-Av Reforma-Av Americas |
| 49 | Ordinary | Maya-CA9N-10&11 Av-Av Reforma-Av Americas |
| 50 | Ordinary | Amparo-Peri-USAC |
| 51 | Ordinary | Amparo-Peri-NR5-DR14-Ciudad Real |
| 52 | Ordinary | Amatitlan-CA9S-CBd |
| 53 | Ordinary | Amatitlan-CA9S-Villa Nueva |
| 54 | Ordinary | Amatitlan-Lago Road Villa Canales |
| 55 | Ordinary | North Terminal-CA9N-Los Ocotes-San Jose Pinula |
| 56 | Ordinary | Canalitos-URL-2 Ca-11 AV-CA9N-Canalitos |
| 57 | Ordinary | Canalitos-CA9N-10 Av-2 Ca-URL-Cana;otps |
| 58 | Ordinary | Santa Catarina Pinula-20 a-Av Reforma-10&11 Av-Ciudad Nueva |
| 59 | Ordinary | Z19-Tierra Nueva-Hipodromo-CA9N-Av Elena-Av Cementerio-7 Av-CA1W |

(to continue)

| Route No. | Type | Route |
|---|---|---|
| 60 | F-KR1,2 | Amparo |
| 61 | F-KR1,2 | Z19(North)-1 de Julio |
| 62 | F-KR1,2 | Z19(South)-Milagro |
| 63 | F-KR6,7 | CA9S-Mezquital |
| 64 | F-General | CA9S-USAC-DR14-FEGUA |
| 65 | F-KR8,9 | Ciudad Real-Nimajuyu-Justo Rufino Barrios |
| 66 | F-KR14,15 | CA1E-Samta Catarina Pinula |
| 67 | F-KR16~21 | Inner Ring E-Santa Rosita |
| 68 | F-KR16~21 | North Terminal-Lomas del Norte |
| 69 | F-KR16~21 | Paraiso-Maya |
| 70 | Extra U. | West Terminal-NR5-PT60 |
| 71 | Extra U. | West Terminal-CA1W-PT43-PT62-PT61 |
| 72 | Extra U. | West Terminal-CA1W-PT43-PT62-PT63 |
| 73 | Extra U. | South Terminal-CA9S-PT64 |
| 74 | Extra U. | Zone 4 Terminal- Av Castellana-Liberacion-Av Las Americas-DR1-PT65 |
| 75 | Extra U. | Zone 4 Terminal-Castellana-Liberacion-CA1E-PT66 |
| 76 | Extra U. | Zone 4 Terminal-Castellana-Liberacion-CA1E-Fraijanes |
| 77 | Extra U. | Zone 4 Terminal-Castellana-Liberacion-CA1E-NR18-PT66 |
| 78 | Extra U. | North Terminal-CA9N-PT67 |
| 79 | Extra U. | Zone 1 Terminal-10&11 Av-8&9 Ca-15 Av-Diag13-Chinautla-PT59 |

## 14.2 East West Route

### 14.2.1 Traffic Demand

The traffic of East West Corridor Route is estimated as shown in the following table. Maximum traffic demand is estimated as 18,800 PCU which is equal to 370 thousands person trips. It is supposed that the capacity of a busway is 18,900 PCU. Traffic demand of each section is within the capacity.

All sections serve long distance trips whose average trip length is calculated as 18.0 km, except the section between the Urban Bus Center and Kaminaljuyu. Namely, the role of the busway is as arterial road that serves long distance trips.

**Table 14.3 Summary of Traffic Demand by Section**

| Section | Traffic Demand (PCU) | Congestion | Average Trip Length |
|---|---|---|---|
| Urban Bus Center - Kaminaljuyu | 18,800 | 0.99 | 15.9 |
| Kaminaljuyu - Periferico | 14,400 | 0.76 | 18.0 |
| Periferico - Naranjo | 17,800 | 0.94 | 17.7 |
| Naranjo - Montserrat | 16,700 | 0.88 | 18.0 |
| Montserrat - S.J.Sacatepequez | 9,600 - 9,800 | 0.52 | 16.8 - 18.1 |

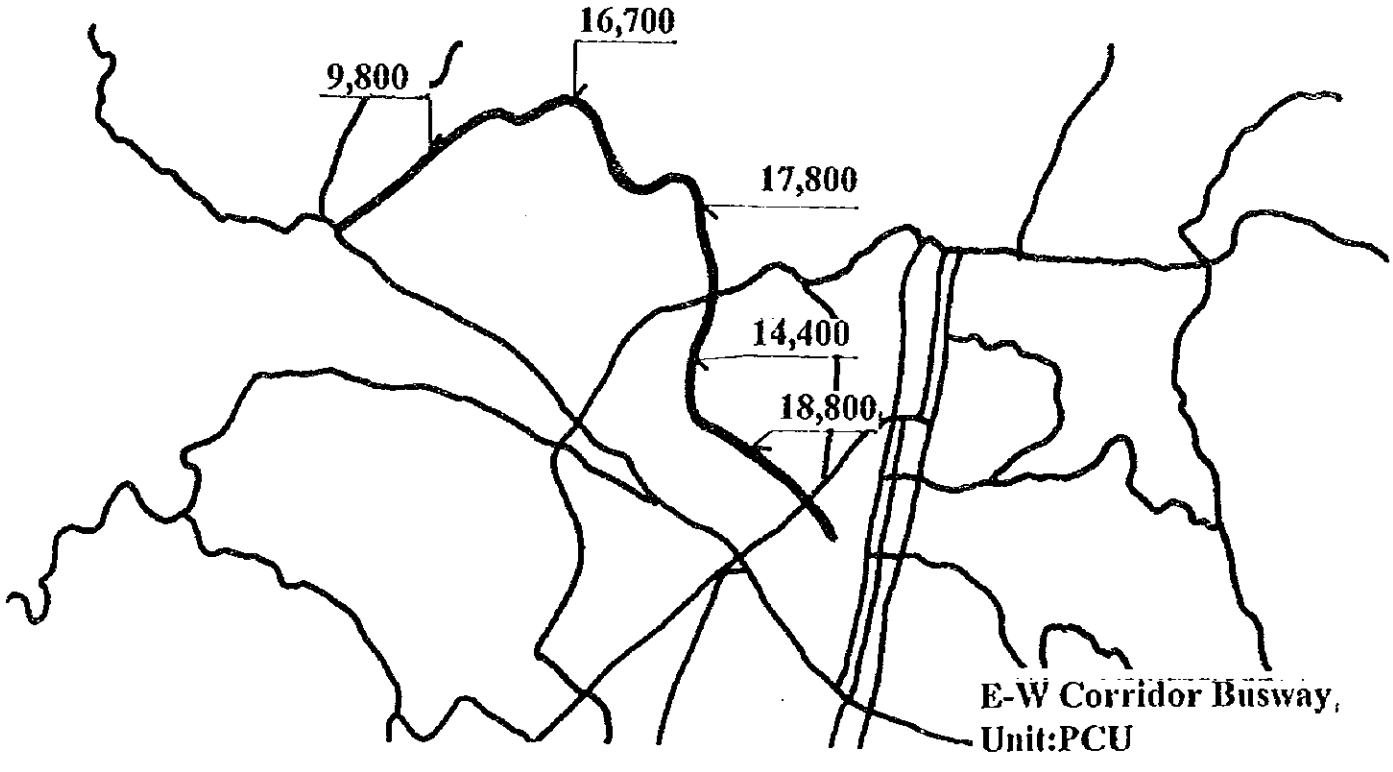



**Figure 14.3 Traffic Demand of E-W Corridor Busway**

### 14.2.2 Site Condition

East West Route is established inside the right of way of the East West Corridor. Six bridges of over 100 meters long crossing deep valleys and one tunnel are planned. For these bridges and tunnel, the same style as the East West Corridor shall be adopted, and they are constructed most economically because of the same time execution.

### 14.2.3 Preliminary Design

Names, locations and dimensions of each structure are shown in Table 14.3. Dimension and styles of structures are the same as the East West Corridor. NARANJO Bridge is included in another road plan, and so only the busway is considered in this Study. Pedestrian bridges are planned at the crossing point of Periferico and at the bus stop of Parque Democracia.

**Table 14.4 Proposed Structure Type in East-West Corridor Busway**

| No | Temporary Bridge Name | Station No. | Size | Type | Structure Type |
|---|---|---|---|---|---|
| 1 | NARANJO Bridge | No.72+80-No.75+50 | L=270m,W=10m | va | 3-Span Cantilever Erection PC Box Girder |
| 2 | DEMOCRACIA Bridge | No.79+35-No.82+35 | L=300m,W=10m | va | Simple Composite PCI Girder |
| 3 | DEMOCRACIA PARQUE Tunnel | No.84+45-No.87+65 | L=320m,W=10m | tn | Box Culvert |
| 4 | DEMOCRACIA PARQUE Bridge | No.89+30-No.91+10 | L=140m,W=10m | va | 3-Span Cantilever Erection PC Box Girder |
| 5 | SAN VICENTE Bridge | No.93+80-No.95+00 | L=120m,W=10m | va | 2-Span Cantilever Erection PC Box Girder |
| 6 | PLANGANA Bridge | No.100+29-No.101+49 | L=120m,W=10m | va | Simple Composite PCI Girder |
| 7 | KINAL Bridge | No.102+20-No.103+40 | L=120m,W=10m | va | 2-Span Cantilever Erection PC Box Girder |
| 8 | Pedestrian Bridge | No.76+50, No.90+50 | L=42m+10m*2,W=5m | pd | Simple PCT Girder |

Note : va : valley bridge
: tn : tunnel
: pd : pedestrian bridge

## 14.3 FEGUA Route

### 14.3.1 Traffic Demand

The traffic demand of FEGUA Route busway can be calculated as shown in the following table. Traffic volume is almost full of the capacity on any section so that the congestion rate is from 0.88 to 1.10. Compared with the characteristics of traffic on East West Corridor Route, average trip length is much longer. It suggests that this busway is important as a trunk road and serves long distance trips of inter-city. The section between FEGUA and the Urban Bus Center serves short distance trips such as inter-zonal trip in the Central Guatemala.

**Table 14.5 Summary of Traffic Demand by Section**

| Section | Traffic Demand (PCU) | Congestion Rate | Average Trip Length (km) |
|---|---|---|---|
| FEGUA Central Station - Urban Bus Center | 8,300 - 19,800 | 0.44 - 1.05 | 15.8 - 17.8 |
| Urban Bus Center - CA1 | 18,400 | 0.97 | 19.7 |
| CA1 - Periferico | 19,100 - 20,700 | 1.01 - 1.10 | 21.5 - 21.6 |
| Periferico - Ciudad Real | 19,600 | 1.04 | 22.0 |
| Ciudad Real - Rio Villalobos | 16,700 - 19,500 | 0.88 - 1.03 | 20.3 - 24.4 |
| Rio Villalobos - Villa Nueva | 16,700 | 0.88 | 20.3 |

The trip characteristics by section are summarized as follows.

- FEGUA Station - Urban Bus Center
  trips from Zone 1 to Mixco and Villa Nueva
  trips from the north-eastern area to the southern area, such as Villa Nueva and Petapa, of the Study Area
- Urban Bus Center - CA1
  trips from the northern part of Guatemala City to the southern part of the city
  trips from the north-eastern area to southern part of the Study Area
- CA1 - Ciudad Real
  trips from Zone 12 to the Central Guatemala
  trips from Ciudad Real, Villa Nueva and Petapa, to the Central Guatemala
  trips from Ciudad Real to Mixco
- Ciudad Real - Rio Villalobos
  trips from Villa Nueva and Petapa to the Central Guatemala
  trips from Villa Nueva and Petapa to Mixco
- Rio Villalobos - Villa Nueva
  trips from Villa Nueva and Amatitlan to the Central Guatemala

### 14.3.2 Site Condition

Bus way FEGUA Route is planned to run from Villa Nueva to El Frutal, from El Frutal to Pamplona in parallel with Petapa Road, and from Pamplona to the Central Station in parallel with FEGUA. The section between Villa Nueva and El Frutal is Bus way's own road, and at the slowly descending section a bridge of 300 meters long is planned.

In the parallel section with FEGUA a Viaduct is planned, because this section crosses with a heavy traffic road. Besides, FEGUA and RUTA 2 cross now on the same level, but the RUTA 2 is planned to underpass.

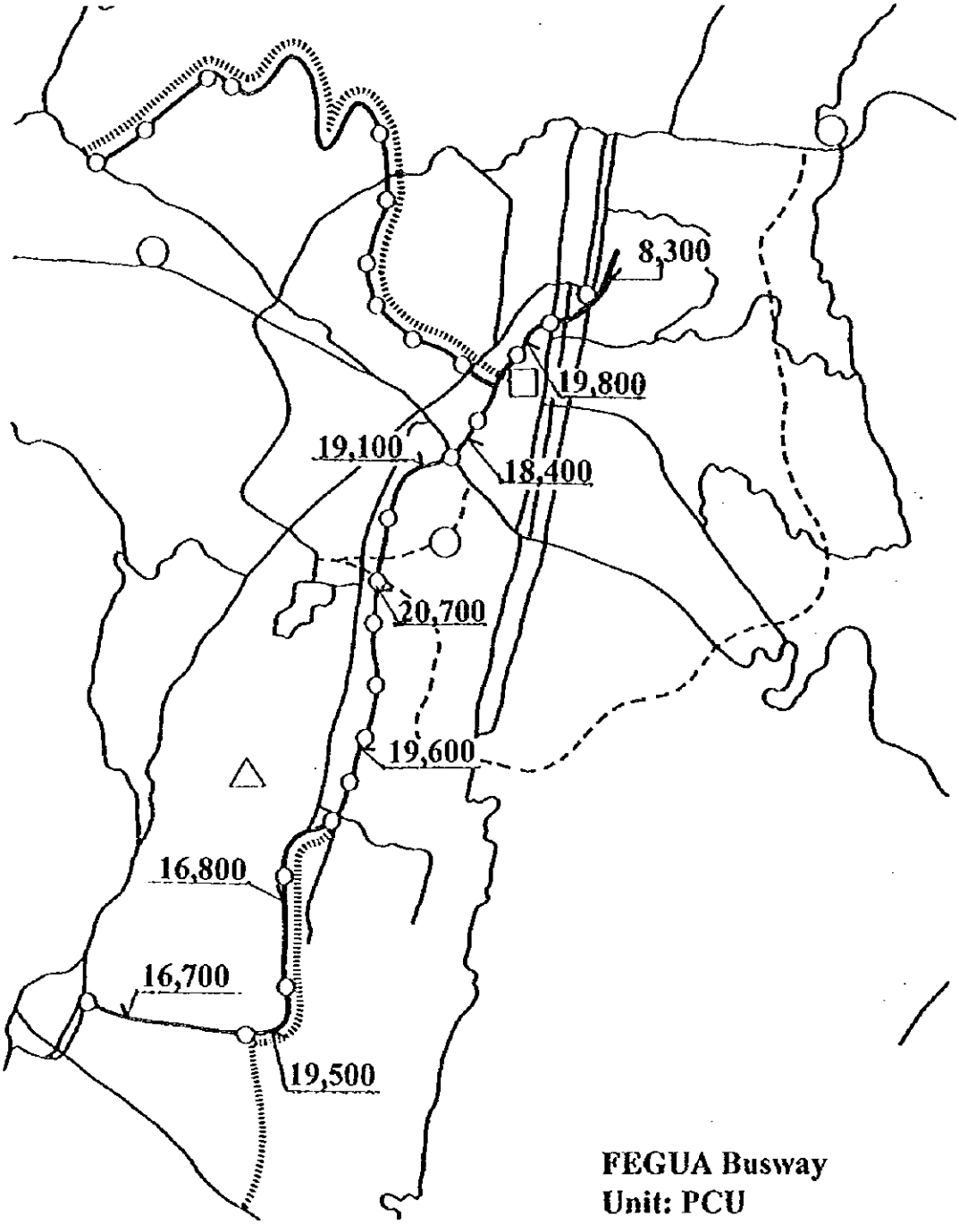



**Figure 14.4 Traffic Demand of FEGUA Route**

### 14.3.3 Preliminary Design

Names, Locations and dimension of each structure are shown in Table 14.6.

**Table 14.6 Proposed Structure Type in FEGUA Route**

| No. | Temporary Bridge Name | Station No. | Size | Type | Structure Type |
|---|---|---|---|---|---|
| 1 | MARIANITA Bridge | No.09+78-No.12+78 | L=300m,W=12m | va | 3-Span Cantilever Erection PC Box Girder |
| 2 | JUST RUFINO BARRIOS Bridge | No.77+45 | L=40m,W=22m | ov | Simple Composite PCI Girder |
| 3 | 18 CALLE Bridge | No.124+84-No.125+05 | L=21m,W=10m | vd | Simple Composite PCI Girder |
| 4 | ZONA12 Retaining Wall | No.123+60-No.138+60 | L=501m,H=1-6m | rw | Gravity Type, U-Type Retaining Wall |
| 5 | ZONA12 Viaduct | No.127+20-No.136+60 | L=1480m,W=10m | vd | Simple Composite PCI Girder |
| 6 | BOULEVER Bridge | No.140+31-No.140+81 | L=50m,W=14.5m | vd | Simple Composite PCI Girder |
| 7 | ZONA 4 Retaining Wall | No.156+24-N0.165+24 | L=900m,H=4m | rw | Reversed T-Type |
| 8 | RUTA2 Bridge | No.165+24-No.165+46 | L=25m,W=20m | vd | Simple Composite PCI Girder |
| 9 | 6 AVENIDA Bridge | No.167+34-No.167+74 | L=40m,W=13-17m | vd | Simple Composite PCI Girder |
| 10 | 7 AVENIDA Bridge | No.168+98-No.169+32 | L=34m,W=17m | vd | R.C. Concrete Arch |
| 11 | Pedestrian Bridge | No.58+20, No.67+80 | L=42+10*2m,W=5m | pd | Simple PCT Girder |

Note : va : valley bridge
ov : over bridge
rw : retaining wall
vd : viaduct
pd : pedestrian bridge

Regarding Marianita Bridge, the foundation is constructed at a densely built-up area in the valley, and therefore the P.C. box girder cantilever erection method with a long span is adopted. On the slope area of the valley, the P.C. I girder erection method is applied. Villalobos, Villa Hermosa Bridges shall have the same style as Petapa Road.

The viaduct in the Zone 12 overpasses the 18$^{th}$ Calle, 13$^{th}$ Calle and 8$^{th}$ Calle of heavy traffic. The planned Periferico road is designed to overpass the busway, so the point of 18$^{th}$ Calle becomes a smoothing section to the actual ground of the viaduct. Therefore the surface level of 18$^{th}$ Calle which now crosses with FEGUA railway at the same level shall be lowered, and 18$^{th}$ Calle shall be planned to underpass the FEGUA. P.C. I-girder with a span of 35-40 meters long shall be adopted to the superstructure of the Viaduct.

For the bridges which overpass Bolivar, Ruta 2 and 6$^{th}$ Avenida, P.C. I girder is adopted. However, the existing bridge overcrossing 7$^{th}$ Avenida is an arch bridge, matches with the surrounding scene and produces a good environment. Accordingly, newly widened bridges shall be arch bridges of the same style as the existing bridges. To execute this bridge, the case-in-place method with all staging shall be applied. First, the half of the bridge shall be completed by shutting the half traffic of the 7$^{th}$ Avenida, and then the another half of the bridge shall be finished, being used the newly finished side to the traffic.

# 15. Urban Bus Center

## 15.1 Roles and Functions

The center is located at the junction of the two busways and can be a hub of major urban bus routes for smooth transfer among them. It is also a new urban center to integrate various urban functions (Figure 15.1).

Major functions are as follows:

**(1) Public Transport Center Functions**

- Exclusive Busway - FEGUA Route
- Exclusive Busway - East West Route
- Other urban bus routes including feeder buses
- Inter-regional bus routes via CA1 East
- Taxis

**(2) Urban Center Functions**

- Commercial, business, service and cultural centers including a retail market
- Urban amenity such as a plaza

## 15.2 Traffic Demand

The center receives 9 urban bus routes and 3 inter-regional bus routes via the Exclusive Busway - FEGUA Route and 11 urban bus routes via the exclusive Busway - East West Route and ordinary roads such as the sixth and the seventh Avenues.

The peak hour urban bus traffic is estimated to be approximately 480 urban buses in each direction of the FECUA Route and the East West Corridor Route.

Based on the traffic estimation and grouping similar destinations, the required capacity of the center is estimated to be 43 berths. Therefore, 50 berths are planned considering 7 extra berths.

- Exclusive Busway FEGUA Route (major urban routes) = 15 berths
- Exclusive Busway FEGUA Route (inter-regional via CA 1 East) = 10 berths
- Exclusive Busway East West Route (major urban route) = 6 berths
- Other urban bus routes to/from 6th and 7th Avenues = 12 berths

It is noted that for smooth boarding and alighting, a new ticketing system should be introduced, for example, a system in which passengers buy tickets outside the buses before boarding.

The total number of urban bus passengers is estimated to be approximately 244,000 according to the simulation and inter-regional passengers to be approximately 31,000.

## Table 15.1 Number of Berths of Urban Bus Center

| Destination | Route type | Route number | Use of busway | Daily frequency | Frequency peak hour | % to visit UBC | No. of visi trip | No. of visits peak hour | Combined no. of visits | Stoppage minutes | No. of berths |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Via FEGUA Route | | | | | | | | | | | |
| Zone 19 | Key route | 1 | Short use | 502 | 50 | 100 | 1 | 50 | 50 | 1.5 | 2 |
| Mixco | Key route | 3 | Short use | 643 | 64 | 100 | 1 | 64 | 99 | 1.5 | 4 |
| Mixco | Key route | 4 | Short use | 350 | 35 | 50 | 2 | 35 | | | |
| Villa Nueva | Key route | 6 | Short use | 586 | 59 | 50 | 2 | 59 | 156 | 1.5 | 4 |
| Villa Nueva | Key route | 8 | Long use | 488 | 49 | 100 | 2 | 98 | | | |
| Petapa | Key route | 9 | Long use | 340 | 34 | 100 | 2 | 68 | 68 | 1.5 | 2 |
| Villa Canales | Key route | 10 | Long use | 293 | 30 | 50 | 2 | 30 | 66 | 1.5 | 2 |
| Villa Canales | Key route | 12 | Short use | 358 | 36 | 50 | 2 | 36 | | | |
| Joyotales | Key route | 23 | Short use | 363 | 36 | 100 | 1 | 36 | 36 | 1.5 | 1 |
| CAI East | Inter-regional | 25 | Short use | 49 | 5 | 100 | 1 | 5 | 26 | 15 | 10 |
| CAI East | Inter-regional | 26 | Short use | 141 | 14 | 100 | 1 | 14 | | | |
| CAI East | Inter-regional | 27 | Short use | 67 | 7 | 100 | 1 | 7 | | | |
| Sub-total | Urban | | | 3928 | 393 | | | 476 | 476 | | 15 |
| | Inter-regional | | | 257 | 26 | | | 26 | 26 | | 10 |
| Via EW Route or roads | | | | | | | | | | | |
| Zone 19 | Key route | 2 | Long use | 657 | 66 | 100 | 2 | 131 | 131 | 1.5 | 4 |
| Mixco | Key route | 5 | Long use | 774 | 77 | 50 | 2 | 77 | 77 | 1.5 | 2 |
| Villa Nueva | Key route | 7 | Roads | 658 | 66 | 50 | 2 | 66 | 66 | 1.5 | 2 |
| Villa Canales | Key route | 11 | Roads | 228 | 23 | 50 | 2 | 23 | 52 | 1.5 | 2 |
| Villa Canales | Key route | 13 | Roads | 289 | 29 | 50 | 2 | 29 | | | |
| San Jose Pinula | Key route | 15 | Roads | 190 | 19 | 50 | 2 | 19 | 19 | 1.5 | 2 |
| Paraiso | Key route | 18 | Roads | 233 | 23 | 50 | 2 | 23 | 51 | 1.5 | 2 |
| Maya | Key route | 21 | Roads | 281 | 28 | 50 | 2 | 28 | | | |
| Amparo | Ordinary | 25 | Roads | 452 | 45 | 50 | 2 | 45 | 45 | 1.5 | 2 |
| Diagonal 14 | Ordinary | 27 | Roads | 254 | 25 | 50 | 1 | 13 | 39 | 1.5 | 2 |
| Diagonal 14 | Ordinary | 28 | Roads | 529 | 53 | 50 | 1 | 26 | | | |
| Sub-total | Urban | | | 4545 | 455 | | | | 481 | | 18 |
| Total | Urban | | | 8473 | 847 | | | | 957 | | 33 |

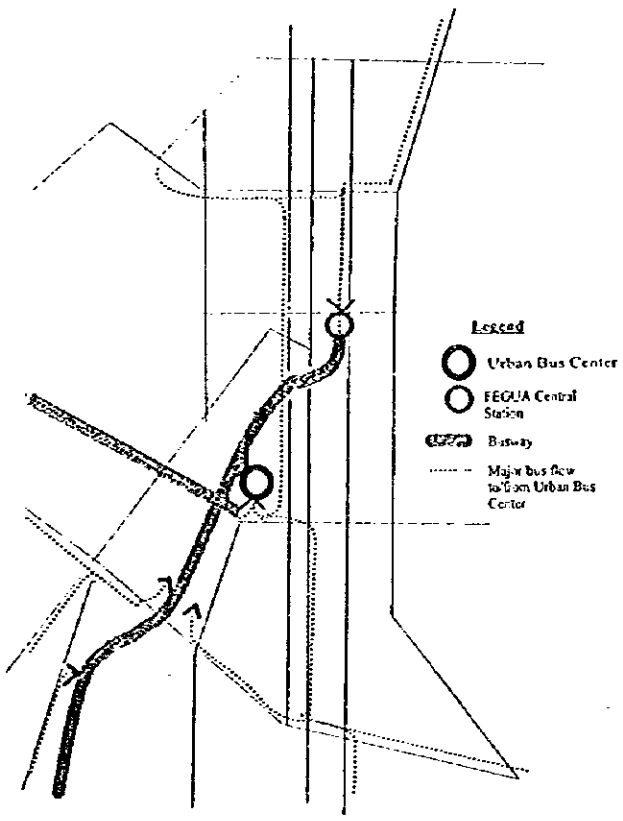



**Figure 15.1 Location of Urban Bus Center in Transport Network of CBD**

## 15.3 Site Conditions

The planned construction site for the Urban Bus Center consists of the existing bus terminal and wholesale market in Zone 4, located at the center of the old city quarter, and the adjacent site which currently houses a market (to be relocated). This site is adjacent to the future Exclusive Busway (FEGUA route) which traverses Guatemala City in the north-south direction and is strategically placed to play a central role in the city's bus transport system.

Some 2,000 buses and more than 1,000 trucks and passenger cars currently use the existing bus terminal and market every day. The planned site is, therefore, a major supply and procurement base for daily necessities for the people of Guatemala City with more than 100,000 people using the facilities daily.

The relocation of the function of the central wholesale market to the CENMA, where buildings to serve large wholesalers and large retailers have already been constructed, is planned and business operation on the site is expected to commence shortly. As far as smaller retailers are concerned, the Guatemala Municipality plans their relocation to another new market, thus paving the way for the construction of the new Urban Bus Center at the present market site.

The planned site for the Urban Bus Center has an irregular rectangular shape, which is more of a trapezium shape, with a shorter side of some 280 m, a longer side of some 385 m and a depth of some 200 m. The total area is approximately 6.6 ha and the four sides are bordered by roads.

## 15.4 Preliminary Design

The Urban Bus Center will consist of a terminal for the transfer of bus passengers and a commercial center for bus passengers and the general public to enjoy shopping and/or light meals, etc.

It is planned that the bus terminal building will be a circular building with a basement floor and two floors above ground. A reinforced concrete, rigid frame structure will be employed while a bearing wall structure will also be used for some parts. Use of the basement as a chargeable car park with spaces for some 800 passenger cars is planned to serve shoppers using the commercial center to be constructed adjacent to the terminal building and people working at or visiting the CBD.

The terminal for the future Exclusive Busway (East-West Route) will be located on the first floor while the transfer terminal for passengers using the other Exclusive Busway (FEGUA Route) will be located on the second floor. The functions of the Urban Bus Center after its completion will be closely related to the opening of the Exclusive Busway (FEGUA Route) which will be simultaneously constructed. The timing of the work commencement and completion for these two projects should, therefore, be carefully decided, taking the various conditions of the projects into consideration.

The terminal at the Urban Bus Center will have 25 berths on the first floor for the East West Route of the busway and 25 berths on the second floor for the FEGUA Route of the busway based on the traffic demand forecast for the year 2010. The building will have a circular shape with a radius of some 80 m. Extension of the center will be possible by widening the bus road sections to meet a demand increase in the distant future.

An octangular space will be provided at the core of this circular-shaped terminal building and facilities for transfer passengers, such as an information desk, ticket counter, waiting room, administration office, rest room for drivers and conductors, cafeteria, shops, emergency medical treatment room and toilets, will be provided in this central space.

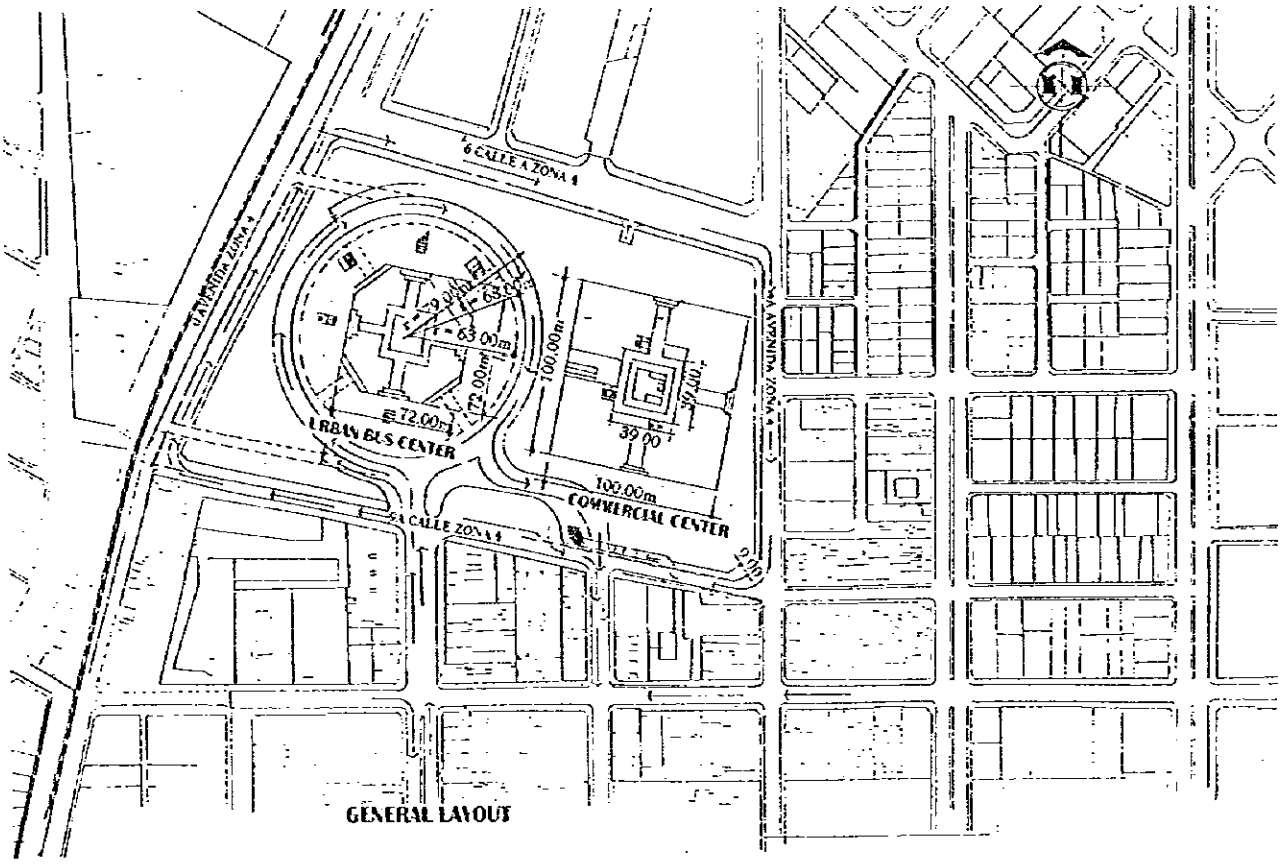



**Figure 15.2 General Layout of Urban Bus Center**

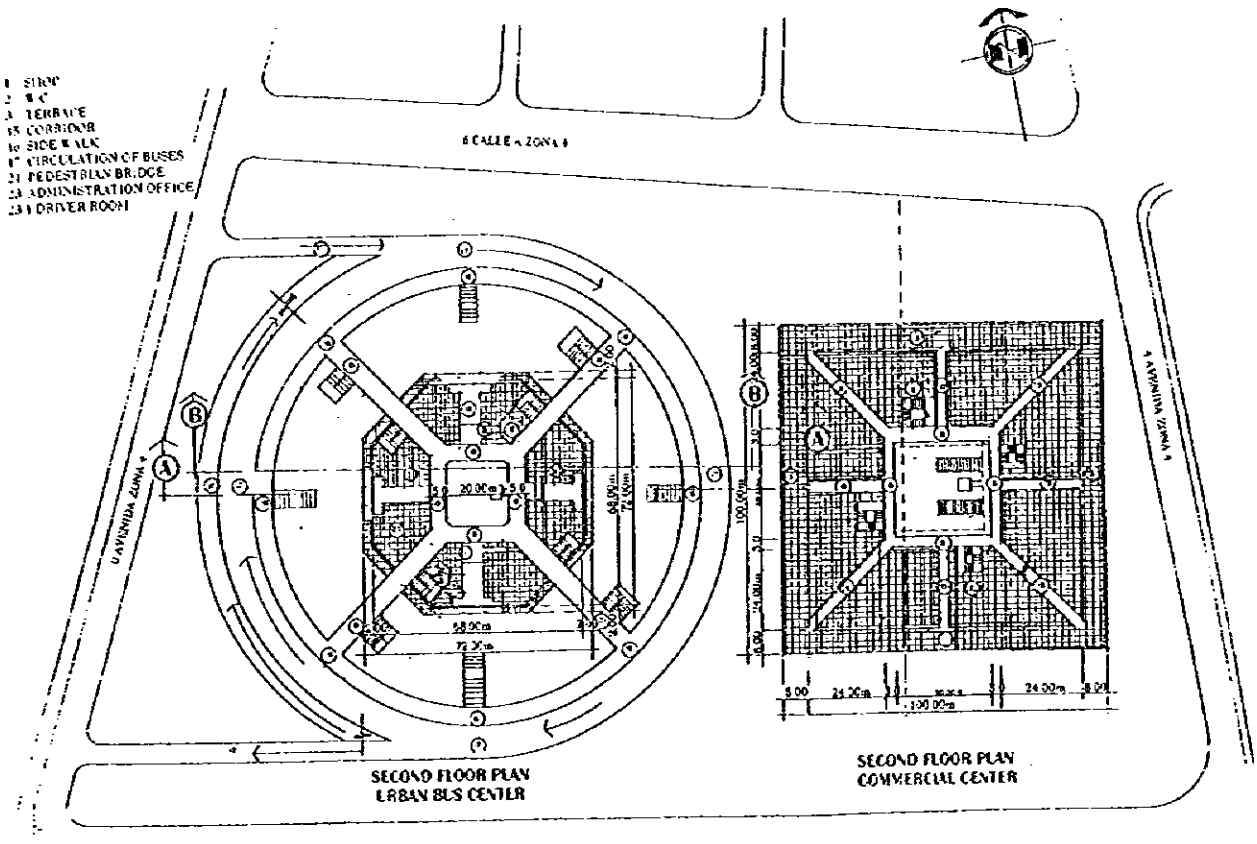



**Figure 15.3 Second Floor Plan of Urban Bus Center and Commercial Center**

It is planned that the terminal building of the Urban Bus Center will be bright and comfortable and that it will be easy to navigate by all, including aged people and children. As Guatemala is an earthquake-prone country, the necessity for the building to have a seismic design cannot be over-emphasized. The adoption of a reinforced concrete rigid frame structure with a sufficient wall area for each of the 3 floors of this 15 m tall building should be sufficient to resist a large earthquake.

Because of the location of an information desk, waiting room and shops, etc., for transfer passengers, the core section will form a space surrounded by pillars, walls and ceiling, etc. In contrast, the bus terminal section, i.e., the berths, will have an open structure with pillars, beams and a slab floor and without external walls for lighting and ventilation purposes. A mechanical ventilation system will be installed for the central core section to circulate fresh outside air in addition to the provision of wide openings for natural ventilation purposes. The survey findings on other buildings in Guatemala City suggest that it is unnecessary to install an air-conditioning system for heating and cooling for the shops and passenger facilities inside the Urban Bus Center.

Maximum building openings are planned for lighting and ventilation purposes to ensure day-time brightness and to reduce the power consumption. One priority of the lighting plan is for the waiting room for passengers and for the shops to be as bright as possible throughout the terminal's operating hours, including the early morning and late night. The minimum luminous intensity for the main rooms and spaces is as follows.

a) Shops : 400 lux

b) Administration office; information desk : 400 lux

c) Waiting room : 400 lux

d) Passageways; staircases : 200 lux

e) Bus berths : 200 lux

f) Toilets; storage rooms, etc. : 100 lux

A lift for the exclusive use of the physically handicapped, elderly and pregnant women will be installed at the central core to assist their movement between the first floor and second floor to make the Urban Bus Center a friendly facility for the physically impaired.

As the Urban Bus Center will be a key facility of the public transport network linking Guatemala City with its satellite cities, its function must be fully maintained from 6 o'clock in the morning until 11 o'clock in the evening. The Center will be provided by an emergency power generating unit (one 500 KVA diesel generator) to provide emergency back-up in the case of a power cut due to lightning, etc.

# 16. Interregional Bus Terminal

## 16.1 Role and Functions

### (1) Background and Objectives

Traffic congestion in the CBD and the bus terminal in Zone 4 is becoming a serious bottleneck for buses and other vehicles. Congestion on Calle Marti (CA9 North) is also chronic and still worsening. An efficient extra-urban bus system to alleviate congestion and improve the service level is required. The inter-regional bus terminals will alleviate the traffic volume going to the CBD and make bus transfer more efficient and comfortable. Also it will contribute to decentralization of concentrated urban functions and will serves for the residents in the vicinity.

### (2) Functions

The existing extra-urban buses should be reclassified into suburban buses and inter-regional buses. The former should become a part of the urban bus system of the metropolis. The latter should have new terminals on the periphery of the city center area. These terminals should have the following functions:

- Turning points of inter-regional buses
- Connections between inter-regional buses and the dense urban bus network
- New urban center functions such as market, commercial, business, cultural functions, etc.

In the Master Plan, terminals at the north, west and south were recommended. Regarding the east direction, it was recommended that inter-regional buses to/from the east use the Urban Bus Center in Zone 4 for the time being instead of building an east terminal because of insufficient demand and no major traffic problems compared to other arteries such as Calle Marti.

## 16.2 Traffic Demand

The required number of berths and the terminal area are preliminarily estimated as follows:

**Table 16.1 Traffic Demand for three Interregional Bus Terminals**

| | CA9 North | CA1 West | CA9 South |
|---|---|---|---|
| 12 hour one-way traffic of inter-regional buses in 1996 | 190 | 350 | 290 |
| Ratio of number of cargo to number of passengers of inter-regional buses in 1996 | 8 % | 15 % | 9 % |
| Number of buses corresponding to passengers without cargo | 175 | 298 | 264 |
| Preliminarily estimated future demand | 263 | 447 | 396 |
| Number of buses in a peak hour (Peak ratio = 15%) | 39 | 67 | 59 |
| Number of buses based on 30 minutes parking | 20 | 34 | 30 |
| Net area requirement ($330m^2$/berth) = S | approx. 0.7 ha | approx. 1.1 ha | approx. 1.0 ha |
| Design site area (S x 1.2) | approx. 0.8 ha | approx. 1.3 ha | approx. 1.2 ha |

Use of buses for cargo transportation is decreasing. The required number of buses specially used for cargo transport is estimated to be some 200 per day. Assuming 15 % of the peak ratio and 30 minute parking,15 berths are required at CENMA. Therefore the existing 28 berths are regarded to be sufficient.

## 16.3 North Interregional Bus Terminal

### 16.3.1 Site Conditions

The planned construction site for the North Inter-regional Bus Terminal is located along CA9, some 8 km northeast to the city center. A private developer is currently constructing a suburban shopping center with a car park some 500 m away from the road. As of September, 1996, the facilities which have been completed and are in operation include a building with shops selling such fresh foodstuffs as vegetables, meat, etc., a building with shops selling clothes, electrical goods and miscellaneous goods and a cafeteria and other resting facilities.

This private developer plans to construct a provisional bus terminal at the same premises and the site for the North Inter-Regional Bus Terminal planned under the F/S is a plot of some 9,000 $m^2$ adjacent to this provisional bus terminal which will be voluntarily constructed by the said private developer and which will be leased to the Guatemala Municipality until the North Inter-regional Bus Terminal is constructed by the Municipality or a third sector.

There is an existing access road of Alvaro Aruz Street to the planned terminal site for urban buses. New stops for the urban buses are to be constructed on this access road side, inter-regional buses and urban buses can transfer their passengers without any mix up. It is likely that the private road section, providing access to the commercial facilities and the bus terminal, will be donated to the Municipality free of charge.

### 16.3.2 Preliminary Design

Commercial facilities constructed by a private developer are in operation at the site adjacent to the planned North Inter-regional Bus Terminal. In view of this, no new shopping facilities will be constructed as part of the Project and only the bus terminal building and auxiliary facilities will be constructed.

With its rectangular plot shape of some 80 m x 110 m, the Terminal will be planned as a parallel platform type terminal.

Inter-regional buses traveling on the CA9 towards Guatemala City from the north-east will enter the Terminal via the access road on the southern side of the Terminal and will move straight and turn on after unloading and loading passengers to the access road on the west side and then back to the CA9 via Alvaro Arzu Street.

As the site will allow 7 berths along one platform, 3 platforms with 21 berths are initially planned. It will be possible to introduce additional 2 platforms with a total of 10 berths in the future using the land remaining at the site.

Several facilities (buildings) to support the operation and maintenance of the Terminal will be required and will be constructed on the northern section of the site. These facilities will include an administration office, information desk, waiting room, rest room for drivers and conductors, emergency medical treatment room and kiosk, etc.

Passengers arriving at the Terminal will leave their buses, walk up the stairs and cross a footbridge to the information desk, berth of a connecting bus or neighboring commercial center. As this commercial center has shops selling all daily necessities, including such fresh foodstuffs as vegetables and meat, clothes, miscellaneous goods and electrical goods, etc., it should be unnecessary for bus passengers from suburban areas to transfer to urban buses to conduct their daily shopping in the city center.

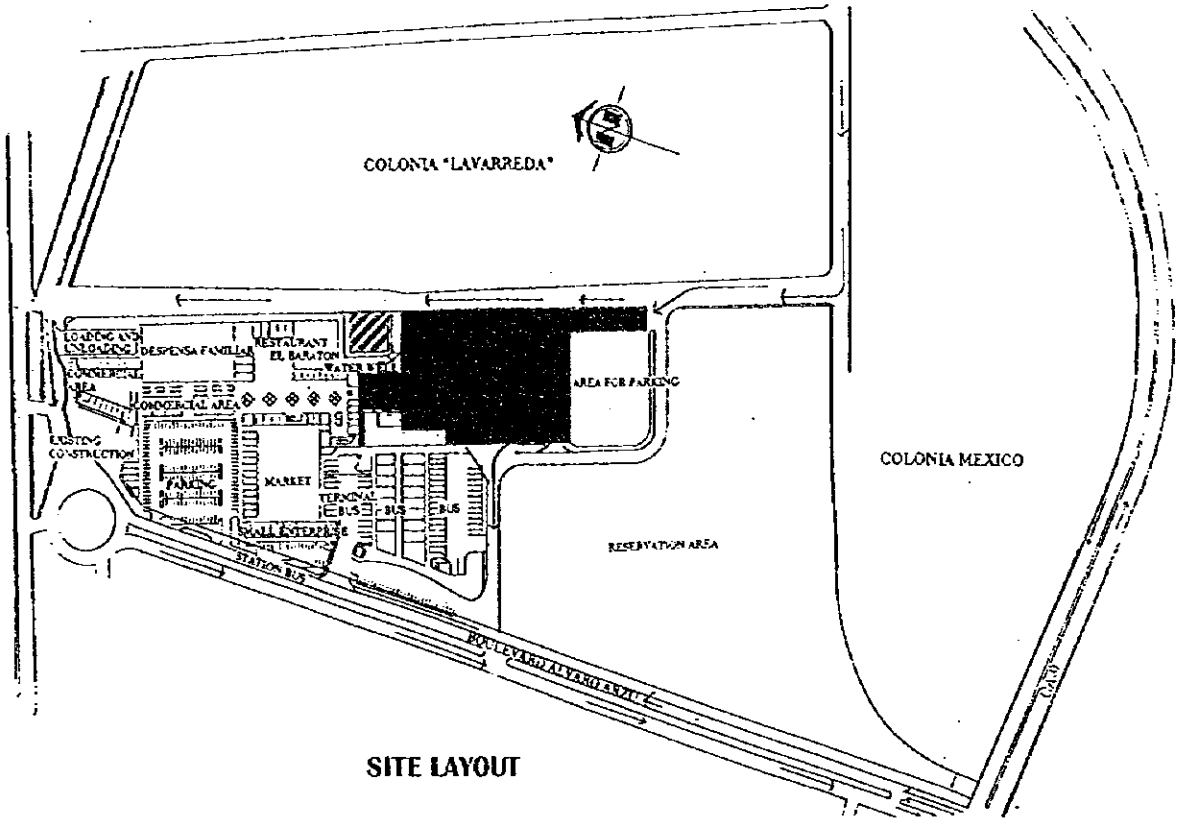



**Figure 16.1 General Layout of North Interregional Bus Terminal**

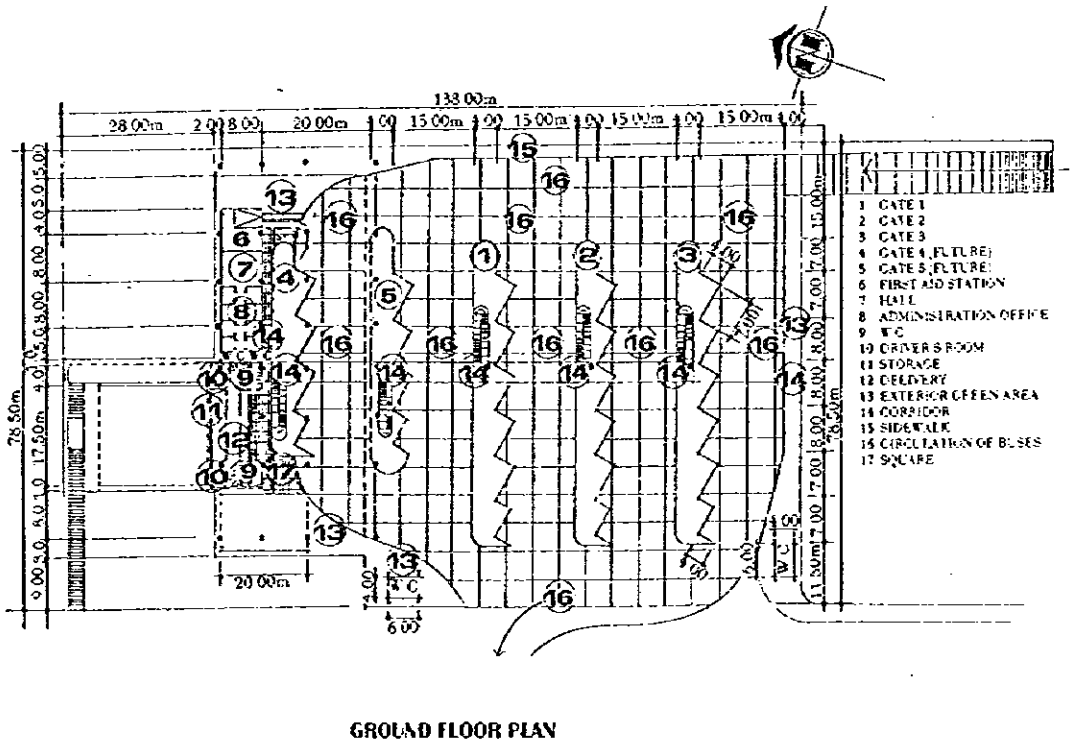



**Figure 16.2 Ground Floor Plan of North International Bus Terminal**

## 16.4 West Interregional Bus Terminal

### 16.4.1 Site Conditions

The planned site for the West Inter-regional Bus Terminal has an area of approximately 1.5 ha (some 100 m x 150 m) and is located along Calzada Roosevelt (CA1) on the border between Guatemala City and Mixco City. At the back of the site runs 2a Calle parallel to Calzada Roosevelt.

One drawback to the site is the presence of more than 10 houses on the site, the ground level of which is some 2 - 4 m below Calzada Roosevelt. The site is located one block within the Mixco City side of the border between Guatemala City and Mixco City and, therefore, is in the administrative area of Mixco City.

The fact is that more than 50 people are actually living on the site. Careful handling of such sensitive issues as land expropriation and the relocation of residents will be required with the cooperation of both the Guatemala and Mixco City authorities concerned.

### 16.4.2 Preliminary Design

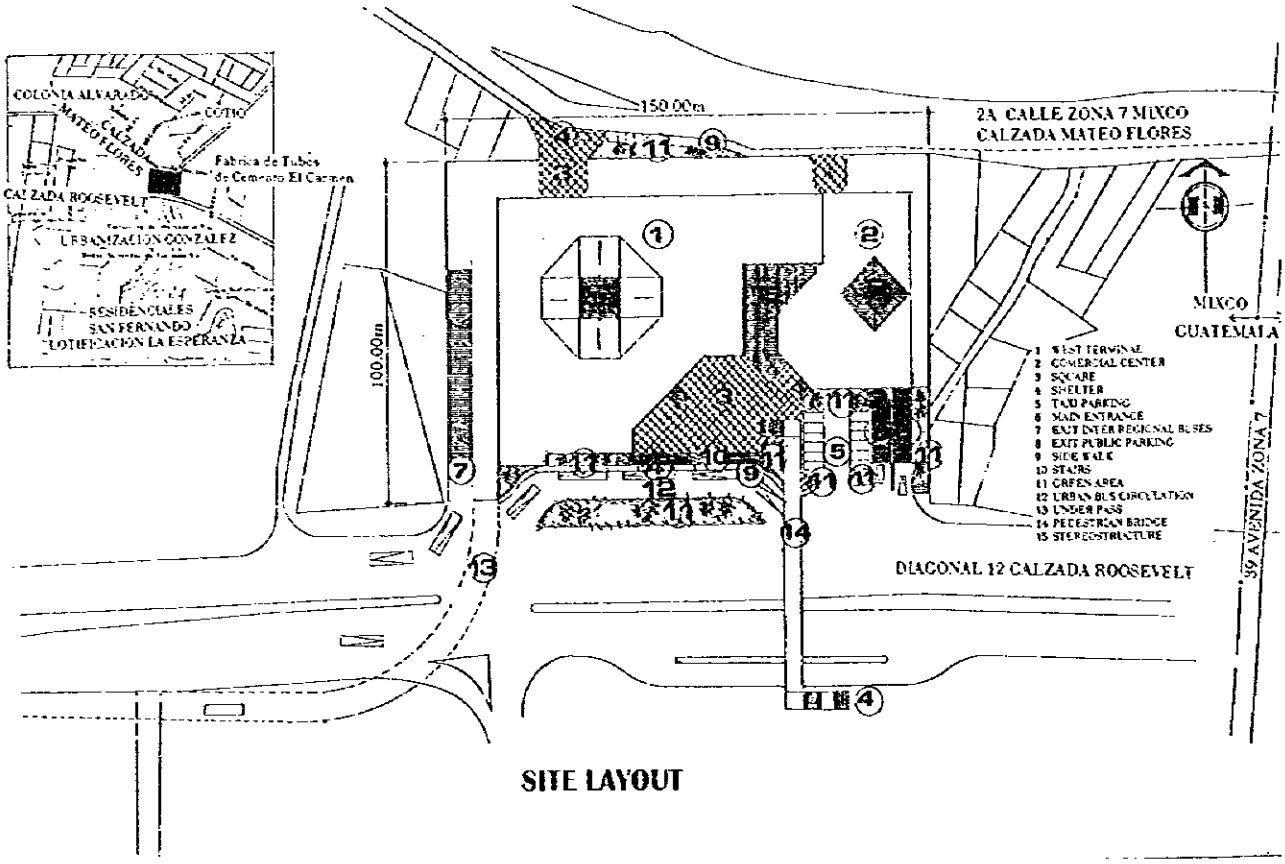
Inter-regional buses traveling towards Guatemala City through Mixco City will leave the main road some 200 m before the planned terminal site along Calzada Roosevelt to enter the Terminal's access road and will then gradually go down to cross the highway via tunnel to reach the Terminal.

The Terminal will have parallel type berths. A total of 9 platforms with 4 berths each will make up the required 36 berths. As shown in the cross-section of the Drawings, the elevational difference between the front road and the planned site is accepted as a design condition. The bus terminal will be constructed on the basement floor with a commercial center constructed above it.

The commercial center will be planned within a rectangular site of some 75 m x 130 m and will incorporate the operation and maintenance facilities for the bus terminal which will be constructed on the basement floor. The commercial center will have a total floor area of slightly less than 10,000 $m^2$ and will be classified as a medium size commercial center.

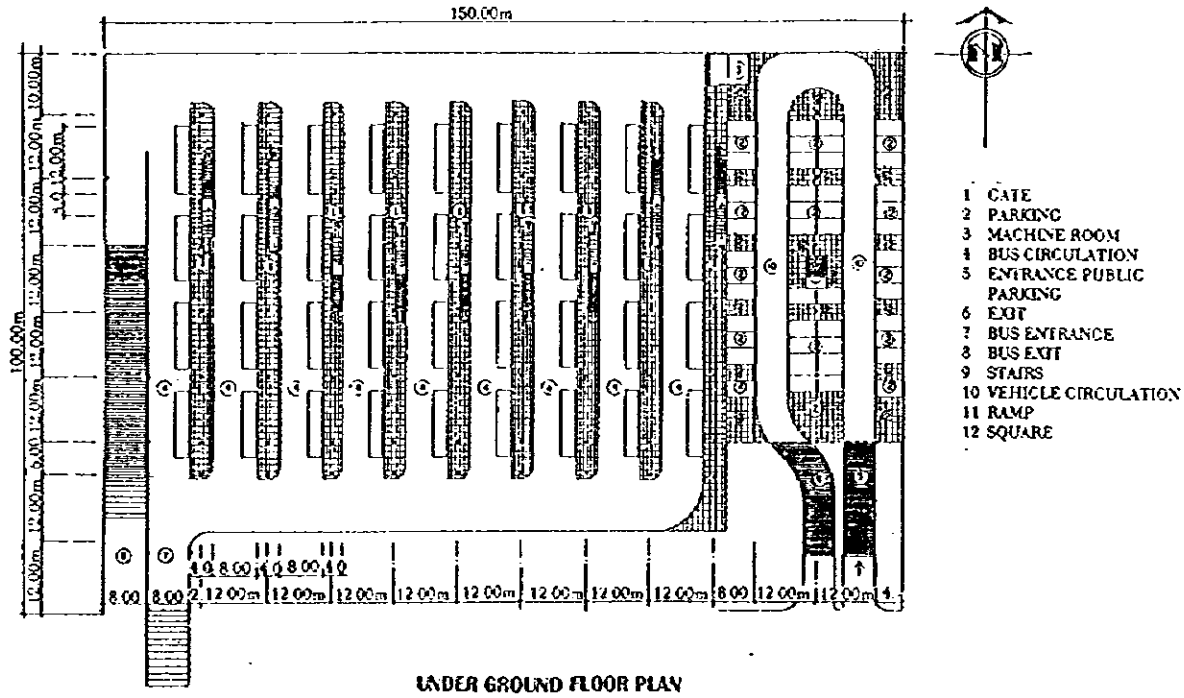
The operation and maintenance facilities will include an administration office, information desk, ticket counter, waiting room, rest room for drivers and conductors, toilets, emergency medical treatment room and storage rooms, etc., and will be planned so as to create a convenient and comfortable bus terminal for passengers.

The commercial center will house kiosks, shops selling clothes, miscellaneous goods and electrical goods, etc., fast food comer, restaurant, cafeteria, fruit market and vegetable market in order to generally meet the daily shopping requirements. The kiosk and restaurant, etc., which are expected to generate a profit, should be allocated in order to maximize the tenancy income from the commercial center.




SITE LAYOUT

**Figure 16.3 General Layout of West Interregional Bus Terminal**




UNDER GROUND FLOOR PLAN

**Figure 16.4 Ground Floor Plan of West Interregional Bus Terminal**

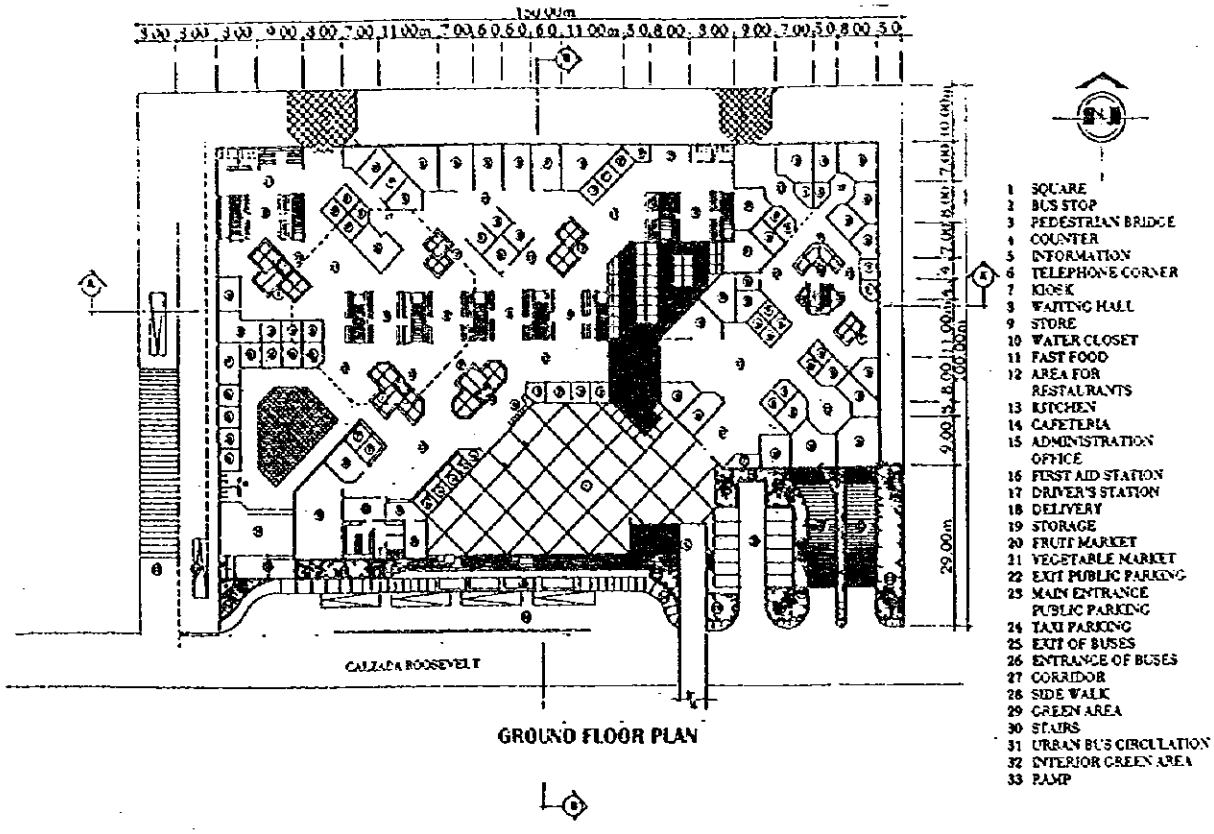



**Figure 16.5 First Floor Plan of West Interregional Bus Terminal**

## 16.5 South Interregional Bus Terminal

### 16.5.1 Site Conditions

The planned site for the South Inter-regional Bus Terminal is a rectangular vacant site of some 80 m x 220 m (approximately 1.8 ha) next to a bull-fighting stadium and a bicycle racing stadium located some 4 km south of the city center. The land is owned by the Central Government and no specific problem is anticipated regarding land use.

This site is also connecting to Periferico-Tramo Road, the design of which is currently in progress by the Guatemala Municipality with a view to commencing construction work in the near future.

### 16.5.2 Preliminary Design

The South Inter-regional Bus Terminal will comprise the southern gateway to Guatemala City linking Guatemala City to cities lying to the south and south-west of the capital. Inter-regional bus services heading for the capital travel on CA9 from the southern port town of Puerto San Jose and Escuintla and from Retalhuleu and Mazatenango on CA2 lying in the south-western part of Guatemala. It is estimated that the South Inter-regional Bus Terminal will require 30 berths to serve these buses based on the traffic demand forecast results.

Buses reaching the Terminal via a slip road of the planned Periferico-Tramo Road will circulate a large rectangular island of 50 m x 200 m in a clockwise direction to find vacant berths. This rectangular island will, in fact, be largely divided into 2 sections to reduce the distance for buses to reach the designated berths and the path line for buses inside the Terminal will be systematized into 2 routes. Buses arriving at the Terminal from the CA9 direction will be guided to a larger section with 17 berths while those arriving from the CA2 direction will be guided to a smaller section with 13 berths for clear identification of the general destinations to prevent passengers from catching the wrong bus.

Inside this rectangular island of 50 m x 200 m, operation and maintenance facilities will be provided on the first floor and a commercial center for shopping will be introduced on the second floor.

The facilities on the first floor, i.e., level with the berths, will include an administration office, information desk, ticket counter, waiting rooms, rest room for drivers and conductors, toilets, emergency medical treatment room and storage rooms, etc. All the facilities should be arranged in view of easy monitoring and control by the entity responsible for bus operation and the collection of paid fares. From a passenger's point of view, these facilities, including the Terminal itself, should be easy to find and comfortable.

The commercial center will have a total floor area of some 10,000 $m^2$ and will be constructed for those people traveling from suburban areas to buy daily necessities, etc. The commercial center will have shops selling meat, vegetables, fruit, clothes, miscellaneous goods and small electrical goods to cater for the daily needs of the public so that not all shoppers from suburban areas will have to travel further to the city center for shopping.

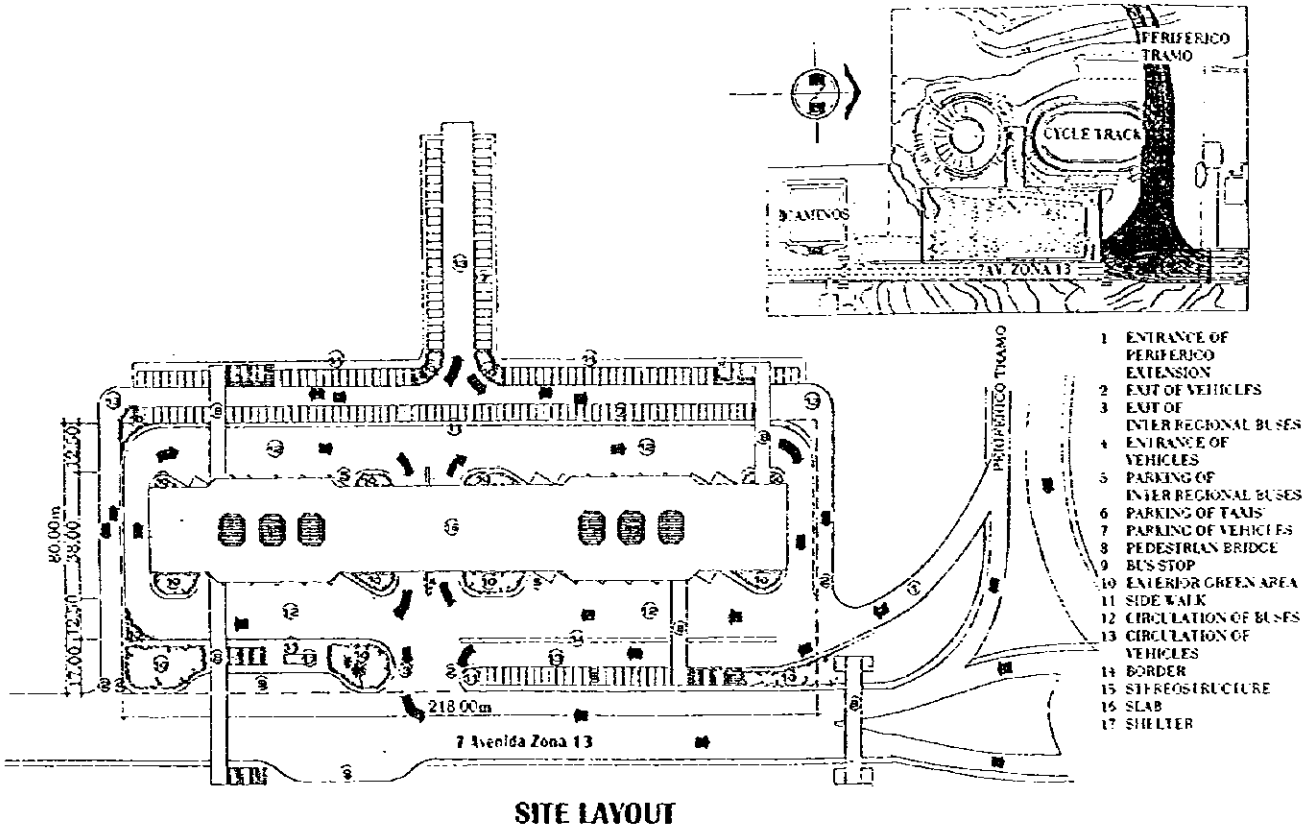



**Figure 16.6 General Layout of South Interregional Bus Terminal**

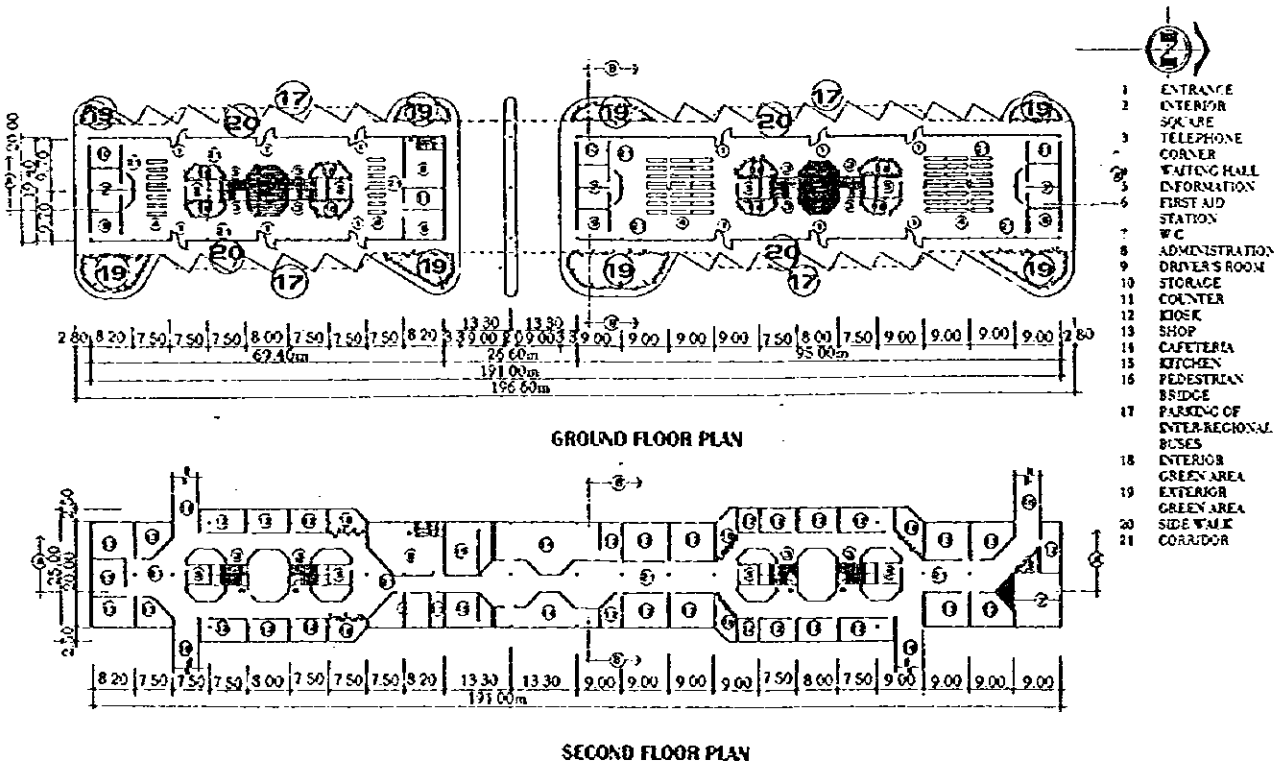



**Figure 16.7 Ground and Second Floor Plan of South Interregional Bus Terminal**

# 17. Bus Inspection and Maintenance Center

## 17.1 Roles and Functions

### 17.1.1 Roles and Objectives

Deterioration of mechanical conditions of buses causes problems of passenger service, operation efficiency, traffic and urban environment. The existing bus inspection system and introduction of the preferential bus system have limited results for improvement of mechanical conditions of buses.

The role of the center is to improve mechanical conditions of the urban buses of the Guatemala Metropolitan Area to achieve the following objectives.

- Secure traffic safety
- Improve urban environment
- Improve operational efficiency

**(1) Traffic Safety**

By improving mechanical conditions of the buses, traffic accidents caused by functional problems of buses will be reduced and safety conditions of passengers will be improved. Traffic problems caused by buses on other vehicles are also to be reduced.

**(2) Urban Environment**

By improving mechanical conditions, especially exhaust gas equipment as well as engines, urban pollution and nuisance such as air pollution, noise and vibration will be reduced.

**(3) Operational Efficiency**

By improving the mechanical conditions, buses become free from breakdown and the operating costs can be reduced resulting in increase of the operation efficiency. For passengers, reliability and comfort will be improved.

In a longer run, demonstration effects of the urban bus inspection and maintenance system will contribute to expansion of the system to cover other buses such as inter-regional buses and general vehicles and to eventually realize a general vehicle inspection system.

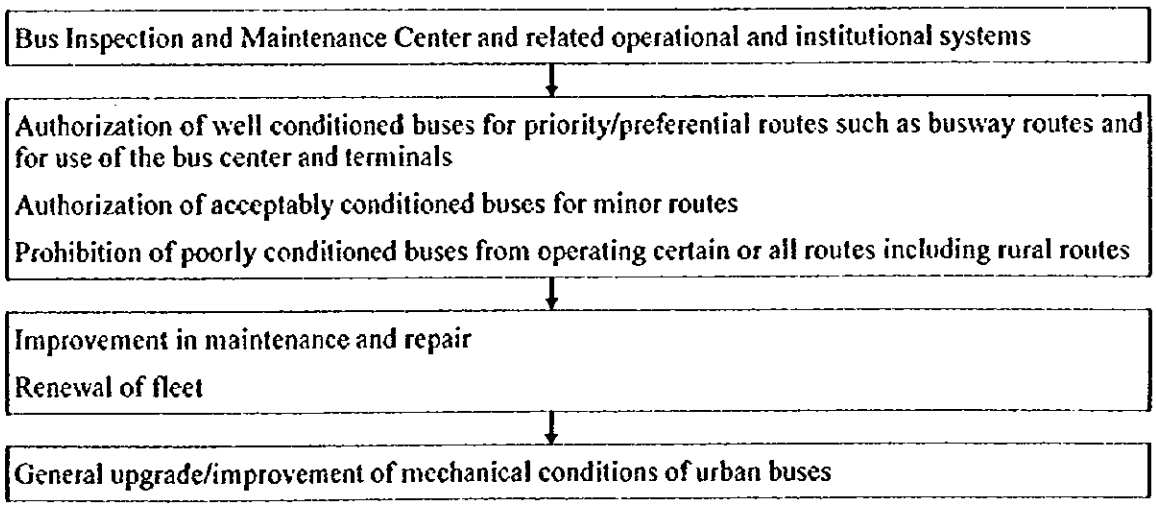



**Figure 17.1 Approach of Bus Inspection and Maintenance Center**

### 17.1.2 Functions

#### (1) Target buses

Some 3,000 urban buses will be inspected annually including 50 articulated buses. The total fleet will be increased to some 4,300 in 2010.

**Table 17.1 Target Buses**

| | 1996 | | 2010 |
|---|---|---|---|
| | Operating units | Registered units | Estimated units |
| Number of urban buses | 2,311 | 3,677 | --- |
| Number of sub-urban buses | 1,183 | --- | --- |
| Total | 3,494 | --- | 4,300 |

According to the Master Plan, the operation area of the urban buses of Guatemala City will be expanded. Therefore, reorganization of urban and extra-urban bus operators will be necessary based on coordination between the Guatemala Municipality and the Public Transport Directorate of Ministry of Communications, Transport and Public Works.

#### (2) Functions

The center will have the following three major functions.

- Inspection
- Maintenance and repair with emphasis on improvement of the urban environment
- Training and campaign

#### (3) Legal framework

In coordination with the new environmental law, regulations to govern the urban bus inspection and maintenance systems should be elaborated based on the regulations of the urban public transport services.

#### (4) Expected Effect of the Project

The planned Bus Inspection and Maintenance center is for improvement of mechanical conditions of buses by establishing a better inspection system and enforcing the sufficient maintenance standard. It is necessary to encourage mechanical improvement and discourage buses in poor mechanical conditions. Preferential buses or buses operating on busways shall be required to fulfill higher standards. Such integration of the inspection system with bus support measures will be effective. Moreover, strict bus inspection will be a good example to control other vehicles in poor conditions.

## 17.2 Site Condition

The planned site for the Bus Inspection and Maintenance Center is located in the same area of the project of CENMA. The CENMA project involves some 70 ha, of which some 36 ha has already developed as a new market for fresh food and other good.
The planned site for the Bus Inspection and Maintenance Center is a rectangular land of 100m by 172m neighboring on the southern side of the CENMA. As there is no specific development plan for this site owned by the Guatemala Municipality, this plot has been designated as a possible construction site for the Bus Inspection and Maintenance Center.

The site is located some 10 km south to the city center along a branch of Aguilar Batres Road and there are no buildings, such as schools, hospitals and office blocks, requiring special environmental consideration in the vicinity. The site is, therefore, deemed highly appropriate as the location for the proposed Bus Inspection and Maintenance Center.

## 17.3 Preliminary Design

The Bus Inspection and Maintenance Centre will consist of vehicle inspection lines to check the physical conditions of buses, a maintenance workshop for maintenance and repair, an environment training center, an administrative office building, garage, rest facilities for staff, security guard post, vehicle washing line and car park, etc.

### (1) Vehicle Inspection Lines

The vehicle inspection lines will be equipped with a diesel smoke meter, CO/HC gas analyzer, axle load meter to weigh buses, side slip tester to check whether or not a bus runs straight in a stable and safe manner, break tester, speed meter tester and headlight tester to check the optical axis and luminous intensity of the headlights to ensure a satisfactory maintenance standard for public transport buses.

The inspection capacity of these lines is calculated based on the assumption that, given the likely work efficiency in Guatemala, the inspection of each bus will take less than 60 minutes, the daily working hours are 8 hours and there are 20 working days/month. The inspection capacity of the Centre will, therefore, be as follows.

10 hours/day x 240 days/year = 2,400 buses/year

In short, one vehicle inspection line will be able to inspect some 2,400 buses/year. For some 4,300 public transport buses, two inspection lines will be sufficient to inspect all the buses once a year.

Following inspection of the essential functions for safe driving at a vehicle inspection line, those buses which pass certain standards for emission gas and external appearance will be given a vehicle inspection certificate which must always be carried during operation. In addition, a vehicle inspection sticker will be issued for display on the front windscreen for instant visual recognition. Buses with functional defects or bad exterior damage will be instructed to undergo repair or improvement in view of their re-inspection within a specified period.

### (2) Workshop

Most private vehicle workshops in Guatemala City are poorly equipped and are unable to perform satisfactory inspection, maintenance and repair. The exceptions are those workshops run by foreign vehicle manufacturers.

In view of these circumstances, the introduction of a bus workshop along with the inspection lines is planned in order to provide a bus inspection, maintenance and repair service, on payment of a fee, for those bus owners which lack the means to conduct, maintenance and repair themselves. This workshop will be equipped so as to conduct the maintenance and repair of the chassis, engine, body, instrumentation and lubrication systems, electrical installation system, parts machining equipment, tires and paint work. The workshop will have 8 bays and its annual work capacity is calculated as follows.

8 bays x 240 days/year / 3 bay day/bus = 640 buses/year

In short, the workshop will be able to handle the repair of some 600 buses/year. The introduction of the workshop will clearly improve the maintenance level of buses operating in the Metropolitan Area.

### (3) Environment Training Center

The emission gas data measured at the vehicle inspection line will be obtained under conditions which differ from the actual road driving conditions. Given the increasing awareness of the general public of the importance of environmental issues, including noise and emission gas, the center will be equipped with advanced instruments to conduct the strict checking of noise and emission gas, etc. in order to act as a key center dealing with environmental issues through the accumulation of measurement data.

The instruments to be installed at the environment training center will include a chassis dynamometer, CO/HC gas analyzer and noise meter to conduct various measurements and analysis. The chassis dynamometer is a highly advanced meter capable of conducting various environmental measurements by creating different driving modes, such as high speed, acceleration and strong braking for immediate stoppage, while keeping the bus on the same spot. This meter will be used to conduct various measurements on buses of 10 years of age or more as well as new buses with a view to collecting data for the establishment of environmental standards governing noise and emission gas, etc.

### (4) Other Buildings

In addition to the three above-mentioned buildings, the Bus Inspection and Maintenance Center will also have a vehicle washing line, car park, administration office building and security guard post, etc. to ensure the smooth operation and administration of the Center.

### (5) Environmental Measures

The waste water from the bus inspection lines, workshop, environment training center and vehicle washing line, etc. will contain oil and, therefore, must not be discharged to the sewerage system without prior treatment due to environmental implications. For those facilities consuming a large quantity of water, such as the vehicle washing line, a water recycling system will be installed to separate oil and water for the repeated use of neutralized water after filtering and absorption by activated charcoal, etc. It will, therefore, be unnecessary to use clean drinking water for vehicle washing purposes, etc. The introduction of such a water treatment system will reduce the consumption of municipal water, the supply of which is already insufficient in the city, and will provide adequate environmental protection.

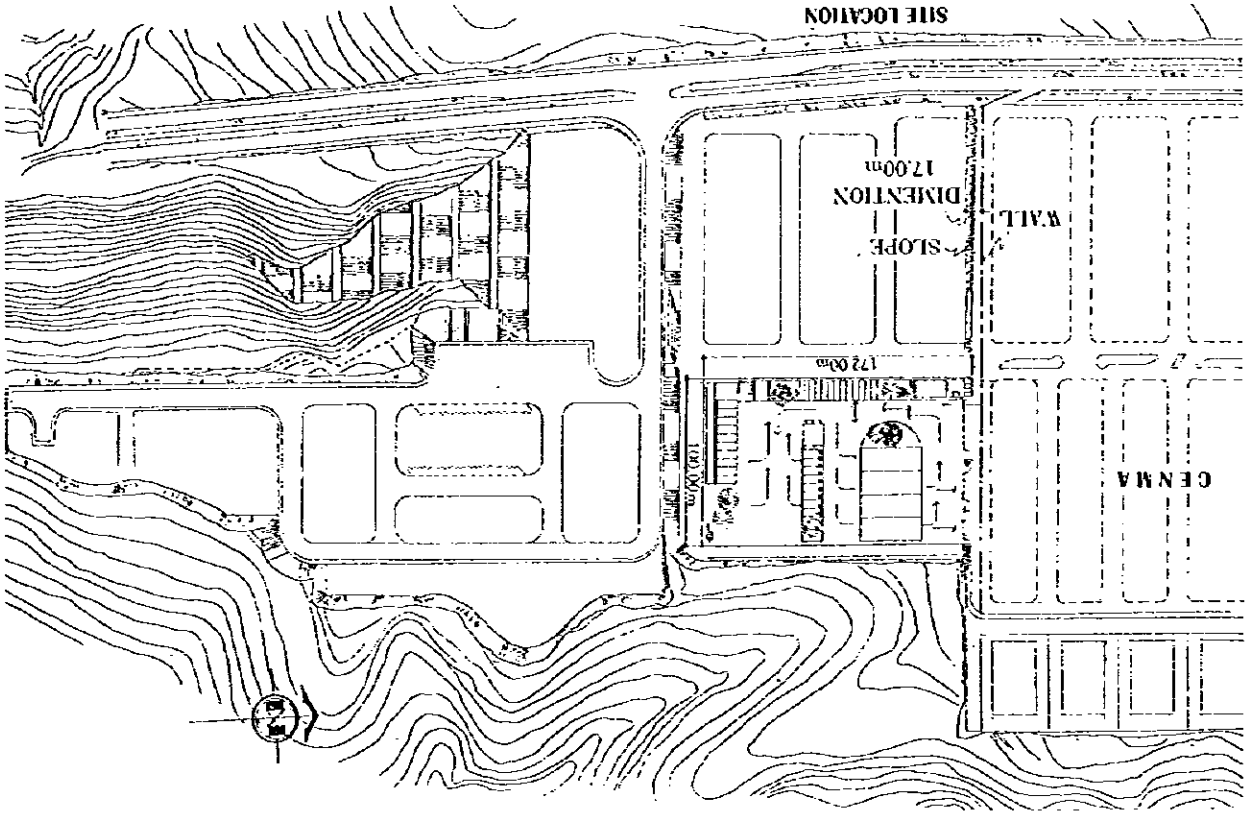



**Figure 17.2 General Layout of Bus Inspection and Maintenance Center**

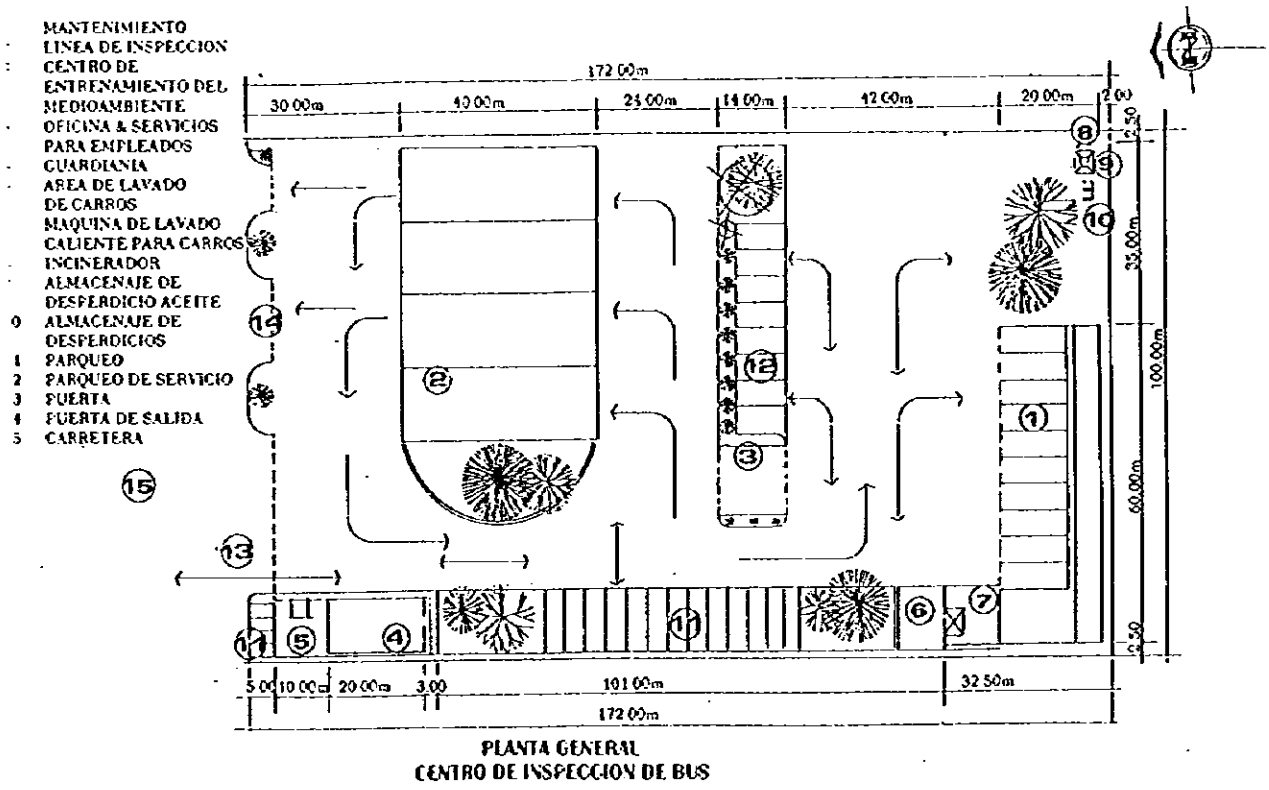



**Figure 17.3 Layout of Each Building for Bus Inspection and Maintenance Center**