13.3. PLANNING CONCEPT

13.3.1. FUTURE ROAD NETWORK

(1) Functional Road Classification

Project roads under study have been originally recommended by PDTU2001. Their designs must conform to the Road Design Standards (NORMA) defined by the National Department of Roads Pattern (DNER) of the Federal Government of Brazil. NORMA distinguishes four classes of roads by function, as shown below.

1) Principal Arterial Road

An (urban) principal arterial road serves the major centers of activity of urbanized areas, the highest traffic volume corridors and the longest trip desires and carries a high proportion of the total urban area travel, even though it constitutes a relatively small percentage of the total roadway network.

2) Secondary Arterial Road

A secondary arterial road interconnects with and augments the (urban) principal arterial road. It accommodates trips of moderate length at a somewhat lower level of travel mobility than principal arterials do. This road distributes to geographic areas smaller than those identified with the principal arterial road.

3) Collector Road

A collector road serves dual functions: collecting traffic between local roads and principal /secondary arterial roads and providing access to abutting properties. The collector roads link neighborhoods or areas of homogeneous land use with arterial roads.

4) Local Road

A local road provides access to a farm, residence, business or any other abutting property.

(2) Functional Classification of Project Roads

The future arterial road network as proposed in PDTU2001 consists of radial roads that center in Primeira Legua Patrimonial (the central built-up area of Belem City) and the ring roads that link these radials. The proposed network is shown by NORMA road classification in Figure 13.3-1. The figure is a conceptual presentation of the network in the Belem Metropolitan Area (BMA).

Major radial and ring roads in the BMA are designated either as principal arterials or as secondary arterials. The roads within Primeira Legua Patrimonial are functionally classified by noting continuity, road width and traffic management requirement.

The following is a description of the functionally classified future arterial road network in 2020 as proposed in PDTU2001. Figure 13.3-2 schematically maps this classification.

1) Av. Almirante Barroso and Rodovia BR-316

These roads are designated as two principal arterial roads that connect the central built-up area of Belem with suburbs and Ananindeua City. They together form a major artery of the BMA.

2) Rodovia Augusto Montenegro

The road is designated as principal arterial road that connects the center of Belem City to the Icoaraci area and serves as another major artery of the BMA.

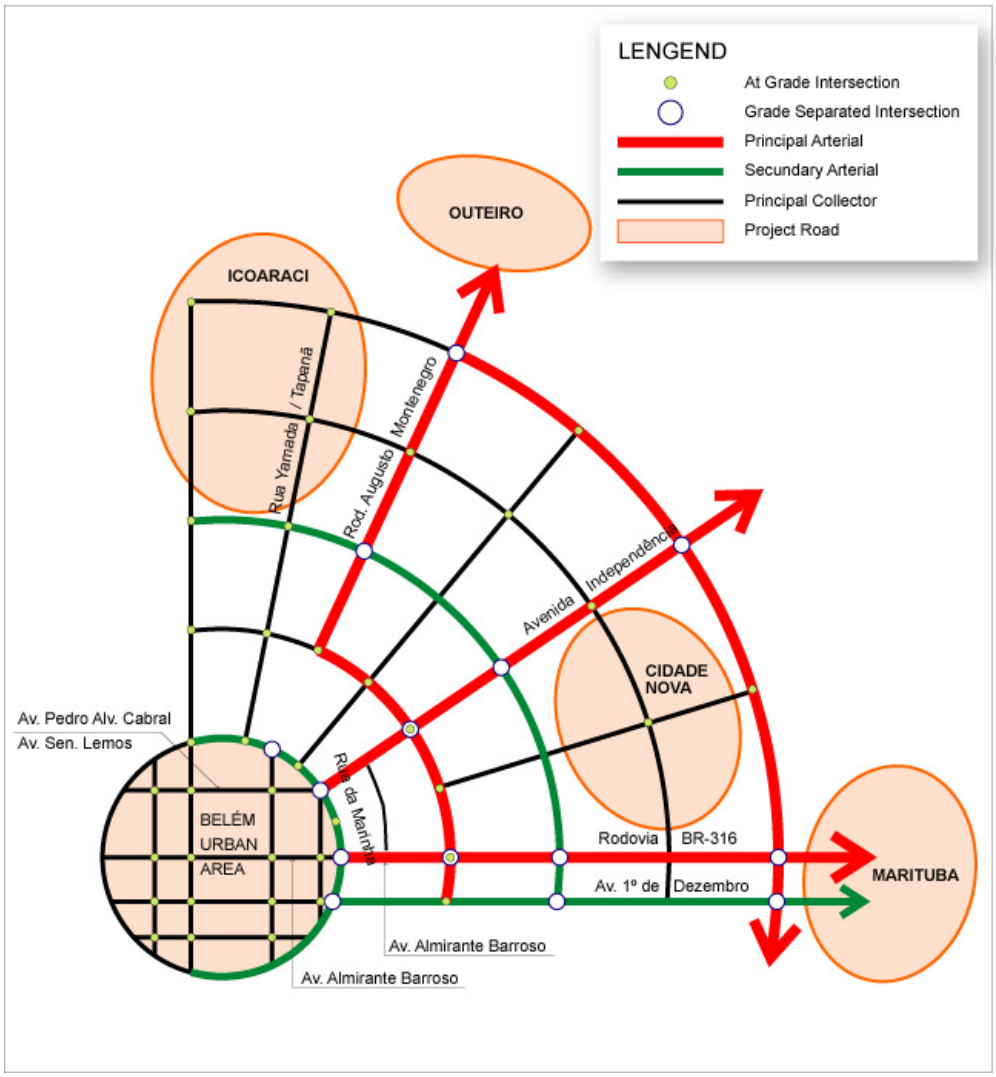


Figure 13.3-1 Concept of Functional Road Classification

3) Av. Independencia

The road is designated as principal arterial road that connects the Centro to Ciudad Nova of Ananindeua City and via Arca Viaria to the suburbs and the area beyond. It serves as another major artery of the BMA.

4) Av. Primeiro de Dezembro

The road runs parallel to Ave. Almirante Barroso and Rodovia BR-316, and serves as an alternative route to carry part of the traffic away from the two heavily traveled roads. It runs along the southern periphery of the central built-up area, and serves as the shortest link from the center of Belem City to Arca Viaria. The road is designated as secondary arterial road, because it serves as an important alternative to the major artery and provides a link from the city toward the exurbs.

5) Rua da Marinha

The road links Av. Independencia and Av. Almirante Barroso and is designated as collector road.

6) Rua Yamada

The road connects Icoaraci Area to Av. Independencia and serves as an alternative route to Rodovia Augusto Montenegro. It is defined as collector road that.

7) Avenida Mario Covas Extension

The road is designated as secondary arterial road that link the radial arterial roads.

8) Segments of Avs. Independencia, Almirante Barroso, Pedro Alvares Cabral and Senador Lemos within Primeira Legua Patrimonial

These segments are designated as collector roads that serve as local arterials within the Centro.

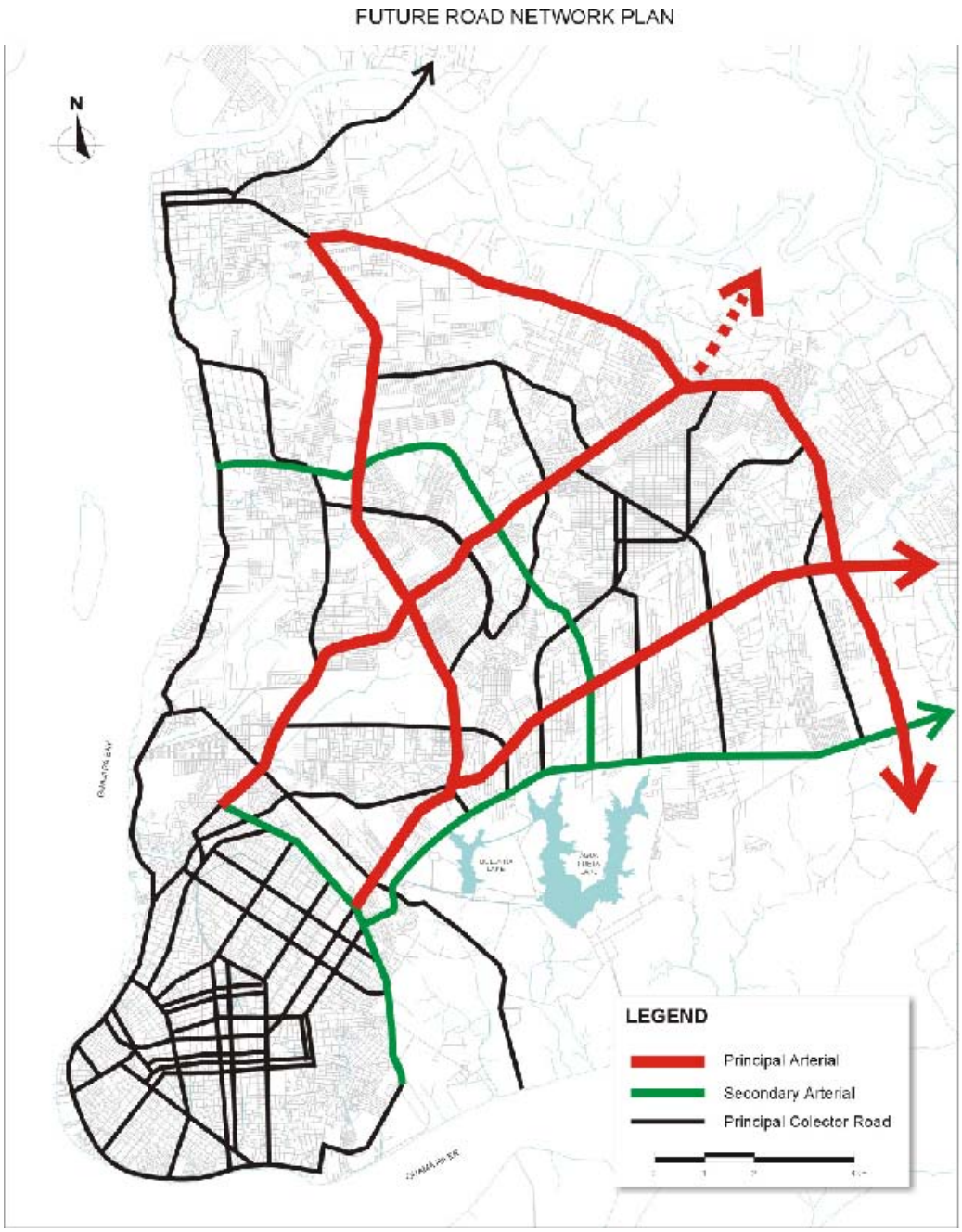


Figure 13.3-2 Functional Road Classification in 2020

(3) Future Road Network

Of the future arterial road network proposed for the year 2020, construction works are now underway on two radial roads. By the year 2007, the segment from Arca Viaria to Rodovia Augusto Montenegro will be completed on Av. Independencia, and the segment from the center of Belem City to the city limit will be completed on Av. Primeiro de Dezembro.

By 2012, the target year of the present Study, the PDTU2001-proposed arterial road network will be completed except for some segments of ring roads, as shown in Figure 13.3-3.

(4) Bicycle Road Network

Bicycle lanes are already provided, either on the road shoulder or next to the median, on Av. Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro. The Belem municipal government is currently undertaking various projects to separate the bicycle traffic from the motorized traffic within the city limit.

Recognizing the need to provide road space for the bicycle traffic, the present Study proposes bikeways in accordance with the PDTU2001-proposed bicycle road network plan. The bikeways will be provided on the right side of roadway, because they are more cyclists-friendly than those provided next to the median, which force upon cyclists the hazard of crossing the roadway. Figure 13.3-4 shows the future bicycle road network plan.

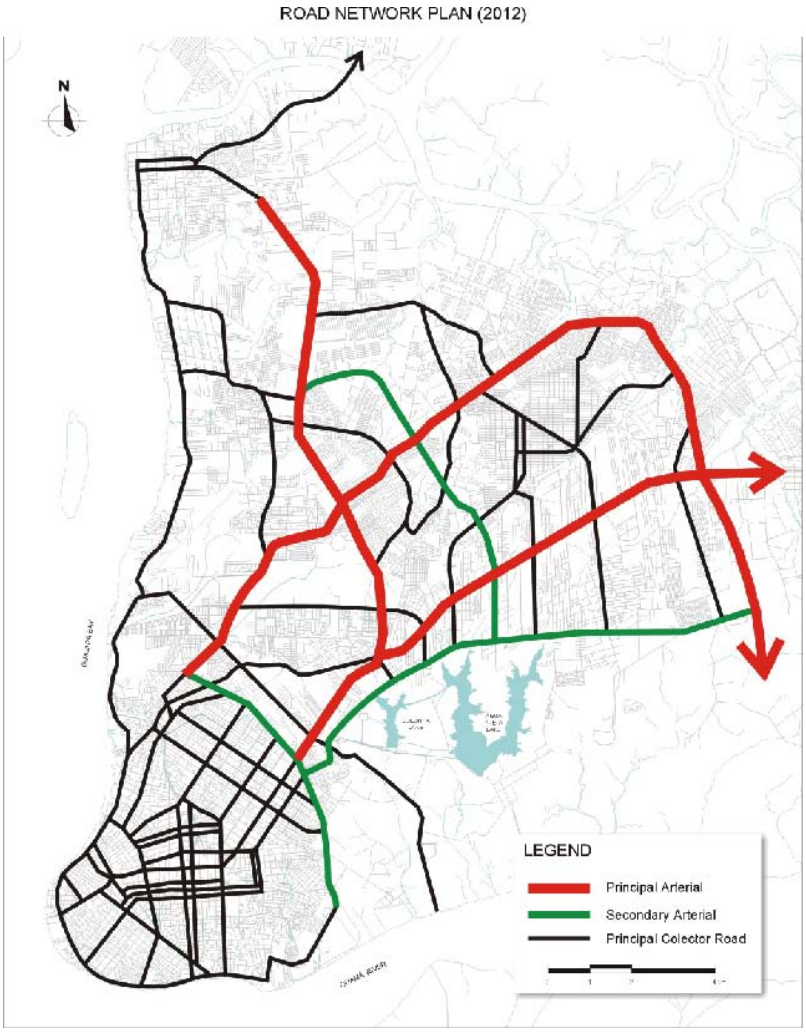


Figure 13.3-3 Future Road Network Plan for 2012

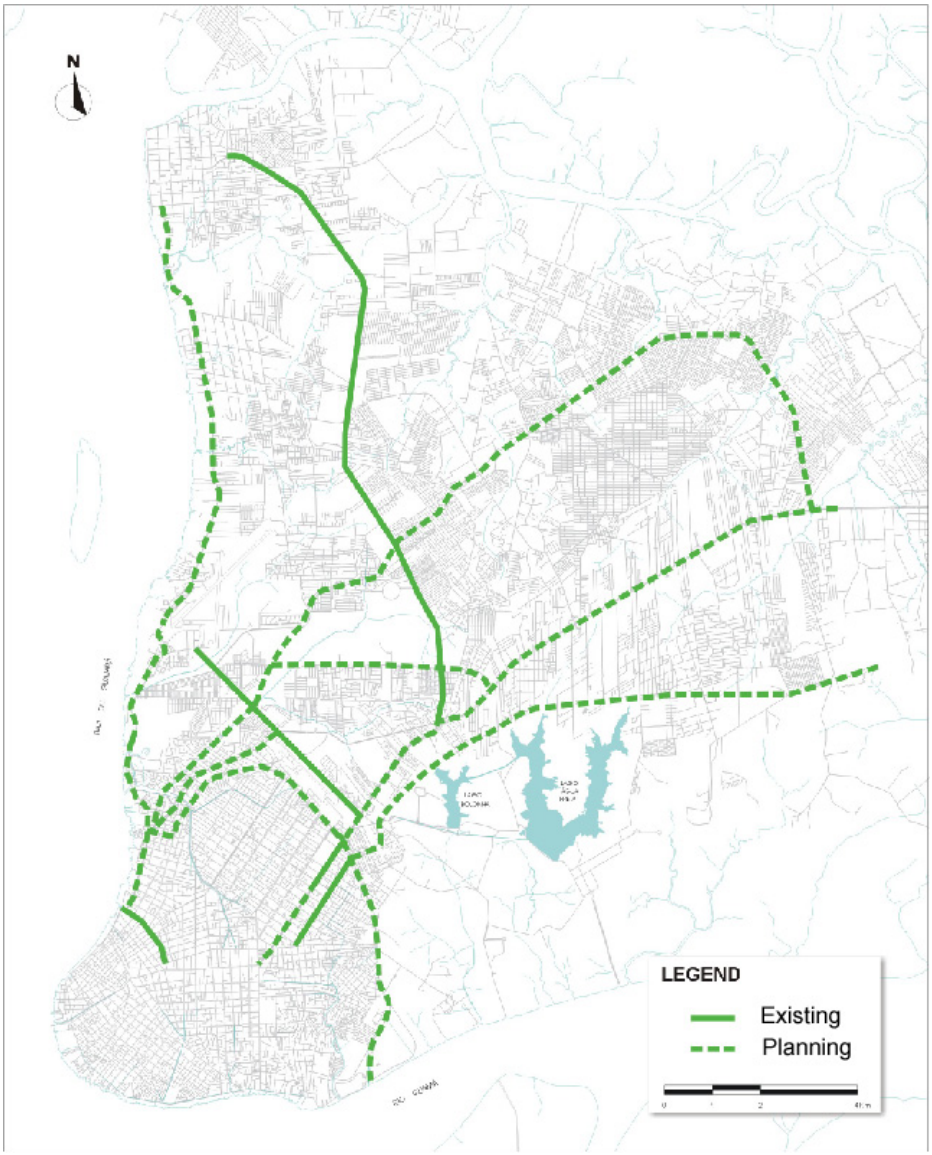


Figure 13.3-4 Bicycle Road Network in 2012

13.3.2. ROAD DESIGN STANDARD IN BRAZIL

(1) Road

1) Geometric standards

The Departamento National de Estradas de Rodagen (DNER) defines the road design standards (NORMA, for short). NORMA distinguishes several road design classes and specifies design elements for each class. It also provides a range of design elements application in accordance with different physical conditions. NORMA refers to the relationship between traffic volume and road class, but does not clarify its practical application.

Table 13.3-1 shows the application of the DNER design class and speed to the functional road classes. The figures in parentheses indicate the minimum requirements for certain physical conditions. The minimum requirements are often applied to urban roads because of densely packed roadside land use and irremovable properties.

Table 13.3-1 Road Classification and Design Class

Functional Road Classification	Applicable Road Design Class	Design Speed (km/h)
Expressway	Class 0	----
Principal Arterial	Classes 0, I and II	Classes I and II: 100 - 70 (50)
Secondary Arterial	Classes 0, I and II	Class II: 70 (50)
Collector	Classes II, III and IV	Classes III and IV: 60 (30)
Local	Classes III and IV	------

Note: Figures in parentheses indicate minimum requirements.
Source：DNER

2) Design Elements

Table 13.3-2 shows design elements for three design road classes. These design element requirements are prepared by AUSTROADS (Austroads National Office). Compared to AASHTO design standards, DNER specifies higher requirements for road alignment elements and lower requirements for cross section elements.

Table 13.3-2 DNER Design Elements by Design Class

Road Design Class	Unit	Class-II	Class-III	Class-IV
Design Speed	(km/h)	70 (50)	60 (40)	60 (30)
Minimum Radius	(m)	170 (80)	125 (50)	125 (25)
Maximum grade	(%)	4.5 (5.5)	4.5 (5.5)	4.5 (5.5)
Width of Lane	(m)	3.5 (3.3)	3.3	3.0
Width of shoulder (out)	(m)	2.5 (2.0)	2.0 (1.5)	1.3 (1.0)
Vertical Clearance	(m)	5.5 (4.5)	5.5 (4.5)	5.5 (4.5)
Lateral Clearance				
Continuous	(m)	0.5	0.3	0.3
Spot	(m)	1.5	0.5	0.5

Note: Figures in parentheses indicate minimum requirements.

Source: DNER

3) Design of Pavement Structure

The design of pavement structure conforms to the specifications of asphalt pavement (Method de projecto de Pavementos Flexiveis 1981) and those of concrete pavement (P. C. A. 1984). Structural elements of pavement, such as depth of surface, base and sub base, are determined from an axle load calculated from vehicle types and traffic volume on a given road. Concrete pavement is generally applied on the roadbeds where the possibility of land subsidence is low.

The existing arterial roads in the study area are asphalt-paved. For road surface continuity, therefore, the design standard is asphalt pavement. However, concrete pavement is provided on those roads or segments of roads that regularly bear the braking load of large motor vehicles, such as trunk busways and bus terminal access roads.

4) Bikeway

DNER specifies the design standard for bikeways. Assuming the lateral and the vertical clearance for a bicycle at 1.0m and 1.75m plus some leeway, the restriction boundary for bikeway is specified as 1.5m in width and 2.25m in height. The DNER-recommended bikeway width varies with the volume of traffic, as shown in Table 13.3-3.

Table 13.3-3 Traffic Volume and Bikeway Width

Volume of Traffic (bicycles/hour)	Width (m)
Less than 1,000	2.0 - 2.5
1,000 - 2,500	2.5 - 3.0
2,500 - 5,000	3.0 - 4.0
More than 5,000	4.0 - 6.0

Source: Ministerio dos Transportes, Manual de Planejamento Cicloviario.

(2) Bridge

1) Design Standard

DNER provides own bridge design standards; “Manual de Construcao de Obras-de arte Especiais” issued in 1995 which includes types of bridge structure, method of construction, types of foundation, method of execution, materials, etc. “Manual de Projeto de Obras-de-arte Especiais” issued in1996 also includes expansion joint, wing, drainage, shoe, method of execution, etc. Those bridge standards show the procedure of bridge planning. Since the method of detailed structure design is not shown in those manuals, AASHTO (the American design standard) is generally applied in Brazil.

2) Design Load

a) Live Load

As for the design live load of the road structure in Brazil, NB-6/82 or NBR-7188/87 of the ABNT (Associacao Brasileira de Normas Tecnicas) standard is applied. In this study, this live load will be employed for the structure design.

b) Seismic Load

Since Belem Metropolitan Area has not been experienced huge earthquake in the past, the seismic load will not be considered in the design of the structure in this study.

3) Strength of principal materials

Table 13.3-4 shows the strength of Concrete materials which is specified according to the construction conditions in Belem. The strength of steel materials will be applied according to the specification of NBR of ABNT.

Table 13.3-4 Strength of Concrete materials

Superstructure	Fck = 30 Mpa
Substructure	Fck = 25 Mpa
Prestress	Fck = 40 Mpa

Note: Fck indicates the specified compressive concrete strength at 28 days

13.3.3. ADOPTED ROAD DESIGN STANDARDS

Road designs conform to the DNER standards (Normas para projecto das estradas de rodagen, or NORMA for short).

Regarding urban roads within Belem City, NORMA serves as guidelines for application rather than as standards to keep. Different design criteria have been applied from one road to another. Different implementing agencies often keep road design standards of their own, causing this lack of uniformity.

The present Study aims to keep the uniformity of design criteria by following the DNER design standards as much as possible. Table 13.3-5 summarizes the design criteria used for road projects.

Table 13.3-5 Design Criteria and Required Facilities for Road Projects

Name of Project Road	Road Functional Classification	Design Standard	Type of Project	Design Speed (km/h)	Required Facilities for road and Cross Section Elements						Land Acquisition Conditions
					On-Road Parking	Bike Road	Sidewalks	Wide of Lane (m)	Number. of Lane	Median Strip	
1. Av. Alminante Barroso	Principal Arterial	Class-II	Trunk Busway Introduced	70	Prohibited	Provided	Provided	3.50	6	Provided	No Needed Land Acquisition
	Collector	Class-IV	Trunk Busway Introduced	60	Prohibited	Provided	Provided	3.00	6	Provided	
2. Rodovia BR -316	Principal Arterial	Class-I	Trunk Busway Introduced	100	Prohibited	Provided	Provided	3.50	6	Provided	No Needed Land Acquisition
3. Rod. August Monteneguro	Principal Arterial	Class-II	Trunk Busway Introduced	70	Prohibited	Provided	Provided	3.50	6	Provided	No Needed Land Acquisition
4. Av. Independencia	Principal Arterial	Class-II	Widening of Existing Road (4 to 6 -lane)	70	Prohibited	Provided	Provided	3.50	6	Provided	Under Construction Needed Land Acquisition Compensation
	Collector	Class-III		60	Prohibited	Provided	Provided			Provided	
5. Av. Primeiro de Dezembro	Secondary Arterial	Class-II	New Road Construction	70	Prohibited	Provided	Provided	3.50	4	Provided	Needed Land Acquisition Compensation
6. Av. Mario Covas	Secondary Arterial	Class- II	New Road Construction	60	Prohibited	N ot Provided	Provided	3.50	4	Provided	Needed Land Acquisition Compensation
7. Rua. Yamada	Collector	Class- IV	New Road Construction	40	Allowed	Not Provided	Provided	3.00	4	Provided	Needed Land Acquisition Compensation
8. Rua da Marinha	Principal Collector	Class- IV	Widening of Existing Road (2 to 4-lane)	60	Allowed	Not Provided	Provided	3.00	4	Provided	Needed Land Acquisition Compensation

13.4. ROAD AND INTERSECTION PLANNING

13.4.1. BASIC ROAD PLANNING POLICY

The following is the description of the basic planning policy for the road projects that include construction, improvement and widening.

1) The improvement on Av. Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro is done within their existing roadways, except at interchanges.
2) The widening on Av. Independencia conforms to the on-going project.
3) The improvement on Rua Yamada is done within its existing right-of-way width to the extent possible.
4) The improvement on Rua da Marinha tries to minimize its impact to the roadside residential areas.

13.4.2. BASIC INTERSECTION PLANNING POLICY

DNER provides the guidelines on interchanges by road classification, as shown in Table 13.3-5. At-grade intersections consist of those with traffic signals and those with traffic signs. Grade-separate intersections are either the diamond or the cloverleaf type.

Taking note of the guidelines in Table 13.4-1, the basic planning policy of the present Study is described as follows.

1) Intersections of two arterial roads are in principle grade-separated.

2) Intersections of an arterial and a collector, or of two collectors are either grade-separated or at grade.

3) At-grade intersections are provided between two local roads.

Table 13.4-1 Types of Intersections on Urban roads

Road Classification	Intersecting Road	Type of Intersection
Expressway	Expressway or Arterial	Direct, Cloverleaf or Diamond
Arterial	Expressway, Arterial or Collector	Diamond or Traffic Signals
Collector	Arterial, Collector or Local	Traffic Signals
Local	Collector or Local	Traffic Signs

Source：DNER, Normas para Projecto das Estradas de Rodagen 1973.

13.4.3. OUTLINE OF INTERSECTION PLANNING IN THE STUDY AREA

There are 18 major intersections in the Study Area, as shown in Figure 13.4-1, and thirteen of them require improvement of one kind or another as part of the project roads under study. The necessary improvement is identified including the appropriate type of intersection. The intersections of two arterials are in principle grade-separated. The appropriate access method to each intersection is examined vis-à-vis the volume of intersecting traffic forecast for 2012.

A circle in the Note column in the Table 13.4-2 indicates that the said intersection is part of the road projects of the present Study. More details of the improvement will be given on these intersections in the later section. An x indicates that the intersection is not included in the scope of the present Study. Some suggestion for the future is indicated on these intersections.

Table 13.4-2 Main Intersections in the Study Area

No.	Name of Road	Main Crossing Road	Type of Intersection	Condition	Note	Remarks
1	Av. Independencia	Av. Senador Lemos	At grade	One way	○	
2	- Do -	Av. P. Alvares Cabral	At grade	One way	○	
3	- Do -	Av. Julio Cesar	Diamond		○	
4	- Do -	Rua Marinha	At grade		○	
5	- Do -	Rua Yamada	Trumpet		○	
6	- Do -	Rod. A. Montenegro	Full cloverleaf		○	
7	- Do -	Av. Mario Covas	At grade		×	
8	- Do -	Rod. BR-316	Diamond		○	On-going
9	Av. Almirante Barroso	Av. Fraitas	Flyover		×	Existing
10	- Do -	Av. Julio Cesar	At grade, rotary		×	Existing
11	- Do -	Rod. A. Montenegro	Rotary and diamond		○	On-going

12	Rodovia BR-316	Rua Marinha	At grade		○	
13	- Do -	Av. Mario Covas	Full cloverleaf		○	
14	Rodovia A. Montenegro	Rua Marinha	At grade		○	
15	- Do -	Av. Mario Covas	At grade		×	
16	Rua Yamada	Av. Mario Covas	At grade		×	
17	Av. Primeiro de Dezembro	Av. Mario Covas	At grade		○	
18	- Do -	Arca Viaria	At grade		○	

Note : ○:Studied Intersection; × : Outside the scope of the Study

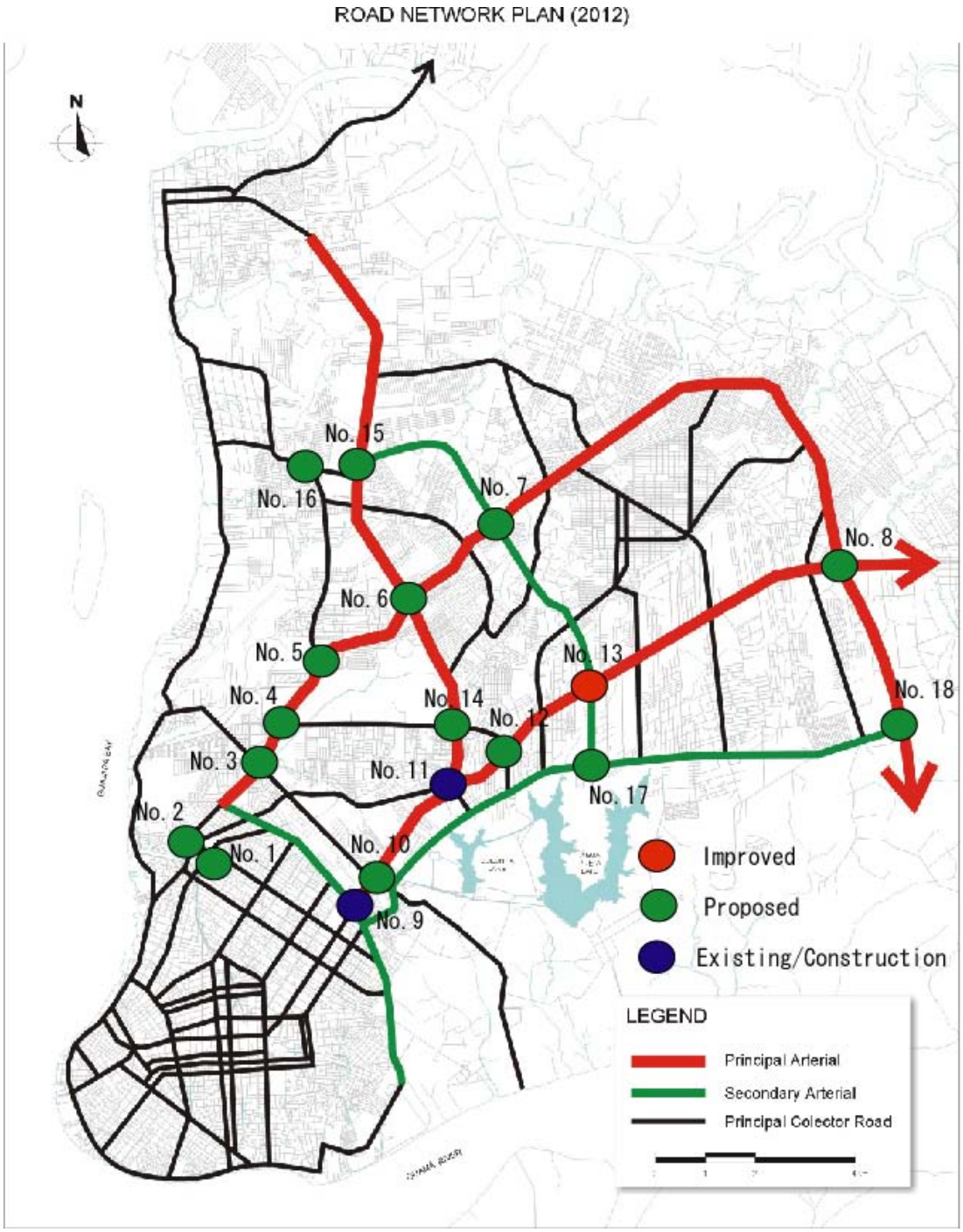


Figure 13.4-1 Location of Major Intersections under Planning

13.4.4. INTERSECTIONS PROPOSED ON PROJECT ROADS

(1) Intersections Crossing Av. Independencia

Av. Independencia utilizes the right of way of the high tension transmission line. The road was planned as a two-way four-lane road and the construction works have been underway for some time. The present Study proposes the widening of the road to six lanes to meet the future traffic demand and the planned introduction of the exclusive trunk bus lane. The planning has to take into consideration the potential hazards of the transmission line and steel pylons.

No.1: Intersection with Av. Senador Lemos

Av. Senador Lemos is a principal collector road and the at-grade intersection is suitable. The road is expected to function as a northbound one-way road in the future plan.

No.2: Intersection with Av. Pedro Alvares Cabral

Av. Pedro Alvares Cabral is a principal collector road and the at-grade intersection is suitable. The road is expected to function as a southbound one-way road in the future plan.

No.3: Intersection with Av. Julio Cesar

Av. Julio Cesar is a principal collector road and the intersection could be at grade. However, the road is expected to function as an important access via Av. Independencia to the airport. Therefore, the grade-separate intersection will be suitable. In addition, the road is integral part of the ring road inside the Primeira Legua Patrimonial, and as such carries large traffic.

The planning must remember the canal and the transmission pylons nearby. It is also necessary to remember that the water supply and sewage pipes are installed under the median. The proposed design is a diamond-type interchange passed over Av. Julio Cesar.

No.4 Intersection with Rua da Marinha

Rua da Marinha is a principal collector road and the at-grade intersection is suitable. Given the expected traffic congestion at the Entroncamento Interchange, the increased traffic from Icoaraci is likely to pass this road via Rodovia Augusto Montenegro.

No.5: Intersection with Rua Yamada

Rua Yamada is a principal collector road and the intersection could be provided at grade. However, the road will function as an alternative route to Rodovia Augusto Montenegro, and presently carries substantial traffic because of the growing development activities along its route. Specifically, factories and other business establishments have begun to dot the area along the road, generating the traffic to and from the Centro. Accordingly, a grade-separate intersection will be provided at this site. The proposed design is a trumpet-type interchange to allow full traffic access. Because of the site location on the high terrace and the necessary clearance from the transmission line running parallel to Av. Independencia, Rua Yamada will be the underpass.

No. 6: Intersection with Rodovia Augusto Montenegro

Rodovia Augusto Montenegro is a principal arterial road crossing Av. Independencia, also an arterial. Therefore, the intersection will be grade separated.

Because of the heavy traffic into and out of the intersection, the design will be a full-access cloverleaf interchange.

To keep adequate clearance from the transmission line, Rod. Augusto Montenegro will be the overpass at the intersection. Major design conditions are described below.

- Given the present elevation of road surface, Rodovia Augusto Montenegro has more than enough clearance from the transmission line. Its road surface can be elevated by two meters and still stays clear of the transmission line.
- The planned height of drainage for Av. Independencia is the control point of the design. An allowance of under-girder height of 0.5m and the girder height of 2.0m will be added to the restriction boundary of 4.5m for Av. Independencia.
- The ramp alignment for Rodovia Augusto Montenegro is designed to stay clear of a large supermarket located in the west of the intersection site.

No.7: Intersection with Avenida Mario Covas

Avenida Mario Covas is a secondary arterial road and the at-grade intersection is suitable. The Centro-bound and the Cidade Nova-bound traffic are estimated to increase sizably by 2012, but the proposed improvement on Avenida Mario Covas will lighten the traffic to the extent that the at-grade intersection can handle. No improvement is planned for this intersection.

No.8: Intersection with Rodovia BR-316

The Para State Government is formulating a plan for this intersection. The present Study will accept this plan.

(2) Intersections Crossing Av. Almirante Barroso and Rodovia BR-316

Five intersections with either a principal arterial or a secondary arterial are examined regarding Av. Almirante Barroso and Rodovia BR-316.

No.9: Intersection with Av. Fraitas

The intersection is already partly grade-separated. The present Study proposes no improvement for this intersection.

No.10: Intersection with Av. Julio Cesar

Av. Julio Cesar is a principal collector road and the present at-grade intersection is provided with U-turn lanes. The intersection will easily handle the future increase of traffic and there is no need of improvement. The present Study proposes no plan for the intersection.

No.11: Intersection at Entroncamento

The improvement works are in progress at this intersection and the present Study will accept the on-going improvement project.

No.12: Intersection with Rua da Marinha

Rua da Marinha is a principal collector road and the at-grade intersection is suitable. Because the intersection is located next to the Entroncamento Interchange, it will handle the traffic that diverts from the heavy congestion expected at Entroncamento.

No.13: Intersection with Avenida Mario Covas

The existing intersection is a three-leaf clover type of grade separation. The intersection will turn into a full-access four-leaf clover, when the southbound extension of Avenida Mario Covas is implemented.

(3) Intersections Crossing Rodovia Augusto Montenegro

Two intersections with a principal arterial and a secondary arterial are examined regarding Rodovia Augusto Montenegro, itself a principal arterial road.

No.14: Intersection with Rua da Marinha

Rua da Marinha is a principal collector road and the at-grade intersection is suitable. Because the intersection is located next to the Entroncamento Interchange, it will handle the traffic that diverts from the heavy congestion expected at Entroncamento.

No.15: Intersection with Avenida Mario Covas

Avenida Mario Covas is a secondary arterial road and the at-grade intersection is suitable. The Centro-bound traffic is expected to increase through 2012, but the at-grade intersection will be able to handle the intersecting traffic, when the improvement of Avenida Mario Covas is implemented. The present Study proposes no plan for this intersection.

(4) Intersection Crossing Rua Yamada

No.16: Intersection with Avenida Mario Covas

Avenida Mario Covas is a secondary arterial road and the at-grade intersection is suitable. The intersection will be able to handle the expected traffic growth through 2012. The present Study proposes no plan for this intersection.

(5) Intersections Crossing Av. Primeiro de Dezembro

No.17: Intersection with Avenida Mario Covas

Avenida Mario Covas is a secondary arterial road intersecting Av. Primeiro de Dezembro, also a secondary arterial. The at-grade intersection will be able to handle the expected traffic increase through 2012.

No.18: Intersection with Arca Viaria

Arca Viaria is a principal arterial road and intersects at grade with Av. Primeiro de Dezembro, a secondary arterial. This intersection is the access point to the Centro for the inbound traffic from exurbs traveling on Arca Viaria. The present intersection will be able to handle the expected traffic increase through 2012.

13.5. TYPICAL CROSS SECTIONS

The cross sectional planning has been carried out by taking into account the design road classification and the design speed described in Section 13.3.3 and the roadside conditions of the project roads. The number of lanes has been determined by modifying the proposals of PDTU2001 vis-a-vis the traffic demand projections.

13.5.1. BUSWAY

(1) Trunk Busway

The trunk busway is provided in the right of way of the existing arterial roads. It consists of two lanes, one on each side of the median. Accordingly, the arterial roads must have the

width from 42m to 45m and six or more lanes. Figure 13.5-1 shows the typical cross section on the trunk busway.

The arterial roads are characterized by the intensive roadside development for commercial and residential purposes. Assuming the intensive utilization of the frontage road, the trunk busway is provided in the central part of road space, and segregated by the curb from the through traffic lanes. Other motor vehicles are not allowed to use the trunk busway. To deal with occasions of bus breakdowns, the curb should not be made too high for buses to drive over.

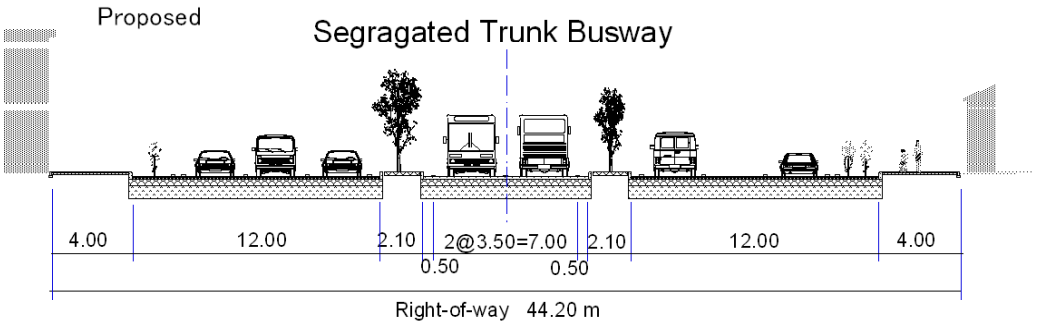


Figure 13.5-1 Typical Cross Section on Trunk Busway

(2) Exclusive Trunk Bus Lane

The exclusive trunk bus lanes are introduced only on Av. Independencia. As with the trunk busway, the exclusive lanes are provided next to the median. To prevent other motor vehicles from entering, they are segregated by the chatter bar from the through traffic lanes. Figure 13.5-2 shows the typical cross section on the exclusive trunk bus lane.

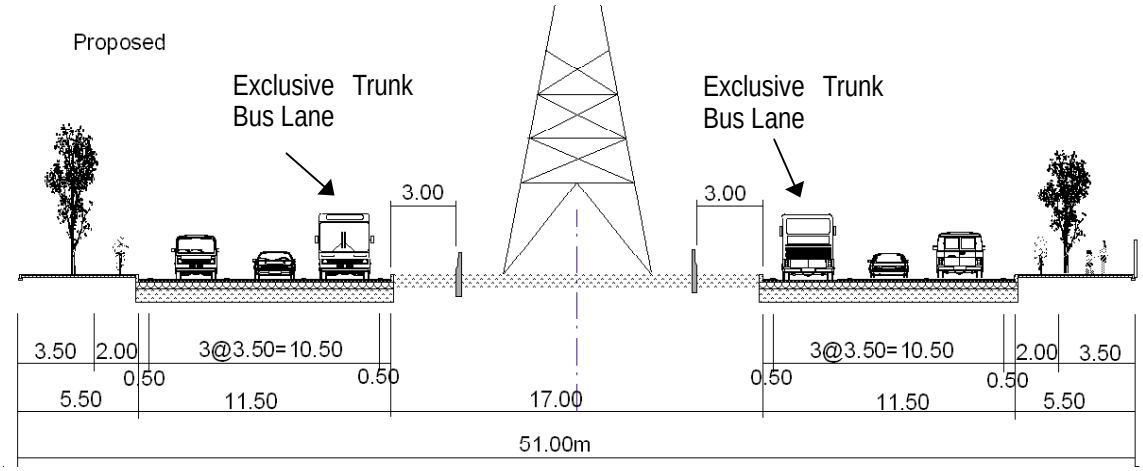


Figure 13.5-2 Typical Cross Section on Trunk Bus Exclusive Lane

(3) Trunk Bus Priority Lane

The right side lane of the existing roads is used as trunk bus priority lane. The lane is marked by the colored pavement to warn off other motorized traffic during the bus priority hours. The lane is open to the regular traffic off priority hours. Figure 13.5-3 shows the typical cross section on the trunk bus priority lane.

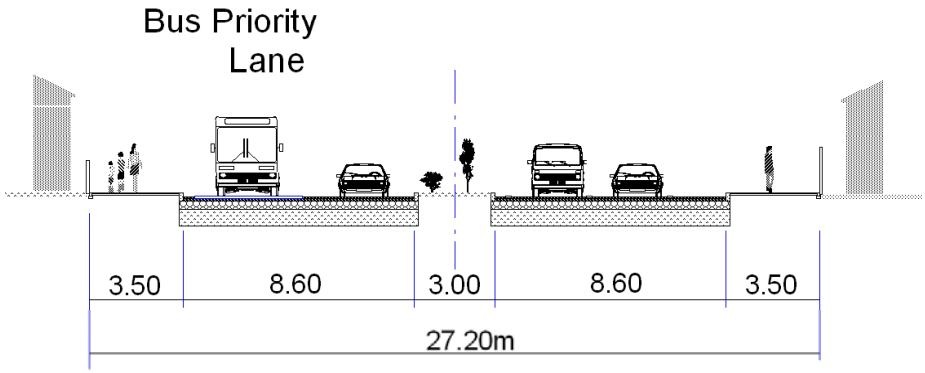


Figure 13.5-3 Typical Cross Section on Trunk Bus Priority Lane

13.5.2. SIDEWALK

The planned width of sidewalk ranges from 2.0m to 3.5m. The sidewalk of more than 3.5m in width will be provided with a tree belt for roadside beautification.

13.5.3. BIKEWAY

The bikeway is 2.0m wide in accordance with the DNER design standards. It will be placed either on the right side of the roadway or on the sidewalk to provide the convenience of roadside access.

In commercial areas, the bikeway is placed on the right side of the roadway. Many pedestrians are found on sidewalks in the commercial areas. It is thought important to separate cyclists from the sidewalks to avoid the collision with these pedestrians.

In the suburbs, the roadways are usually constructed with higher design speed. To protect cyclists from traffic accidents on the roadways, the bikeway is placed on the sidewalk. A tree belt is provided on the sidewalk to separate cyclists from pedestrians.

13.5.4. ON-STREET PARKING SPACE

On-street parking space is planned in the right side of traffic lane along commercial and residential areas to easily access to facilities. Figure 13.5-4 shows the typical cross section on On-street parking space.

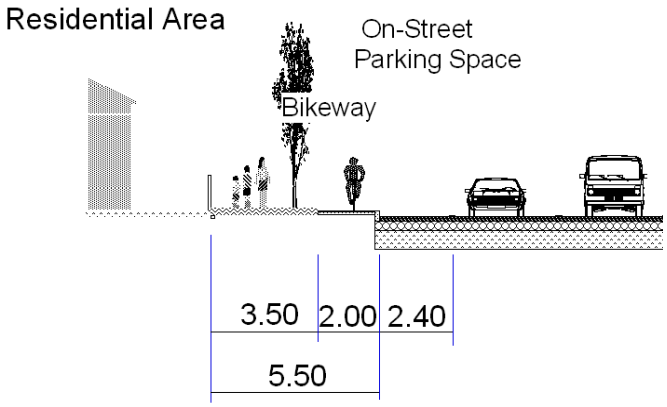


Figure 13.5-4 Typical Cross Section on On-Street Parking Space

13.5.5. CROSS SECTION PLANNING

(1) Avenida Almirante Barroso

Av. Almirante Barroso is a principal arterial road that runs from the intersection with Av. Jose Bonifacio to the Entroncamento Interchange. The width ranges from 42.2m to 45.0m. The road is a two-way eight-lane road and the right-side lane, or the frontage road, is mainly used for bus traffic. The roadside land use consists of well-developed commercial activities.

The position of the existing sidewalk curb is used as the control point for cross sectional planning, because water supply and sewage pipes and other public utility facilities are buried underneath the sidewalks.

The planned cross section of the road consists of four components: the existing sidewalk of 3.6m to 4.0m, the bikeway of 2.0m, the roadway of three 3m lanes and the trunk busway. The cross section structure is shown in Figure 13.5-5. The bikeway is currently provided on both sides of the median. It is necessary to move the bikeway onto the sidewalk, when the trunk busway is introduced next to the median.

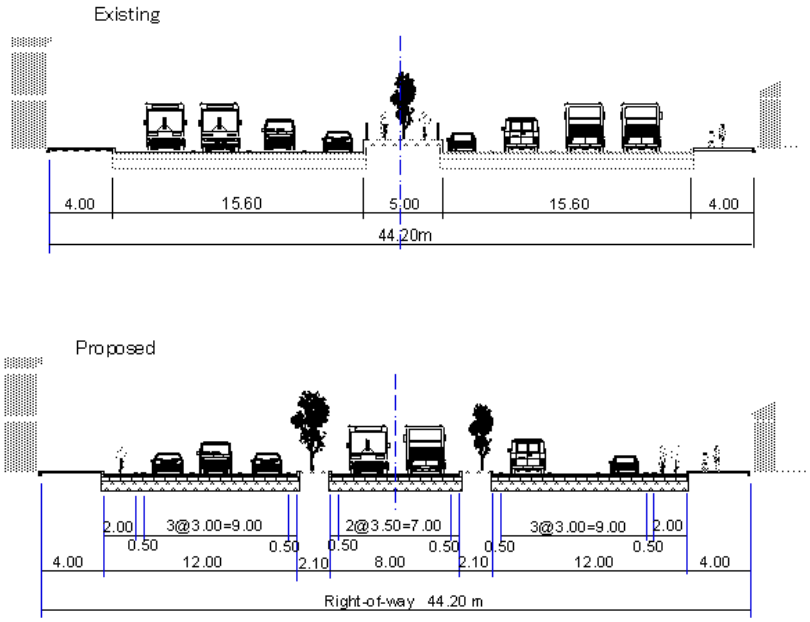


Figure 13.5-5 Typical Cross Section on Av. Almirante Barroso

(2) Rodovia BR-316

Rodovia BR-316 is the outbound extension of Av. Almirante Barroso in the Centro. It is a principal arterial road that runs from the Entroncamento Interchange through Marituba City. It serves as one of the inter-city arteries. The present road width is around 50.0m. The road has six lanes and the right side lane is mainly used for bus traffic. The roadside is dotted with large supermarkets, and its land use can be characterized as semi-commercial and semi-industrial.

The position of the existing sidewalk curb is used as the control point for cross sectional planning, because water supply and sewage pipes and other public utility facilities are buried underneath the sidewalks. The planned cross section consists of four components: the existing sidewalk of 5.7m, the bikeway of 2.0m, the roadway of three 3.5m lanes and the trunk busway. The cross section structure is shown in Figure 13.5-6.

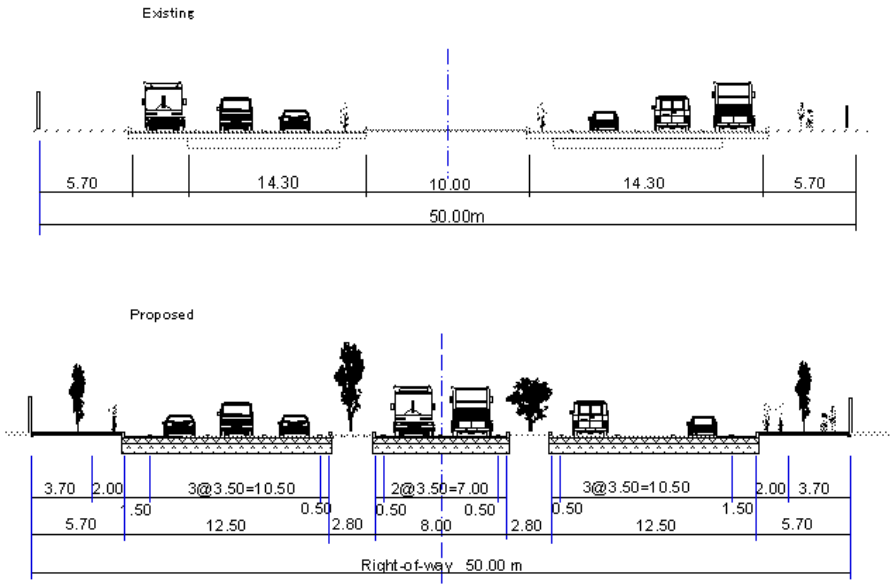


Figure 13.5-6 Typical Cross Section on Rodovia BR-316

(3) Rodovia Augusto Montenegro

Rodovia Augusto Montenegro is a principal arterial road that runs from Icoaraci City to Av. Almirante Barroso. The road width is 45.0m. The median used to be the railway. The bikeway is provided on both sides of the median. The road has six lanes and the right side lane is mainly used for bus traffic. The roadside land use is mainly residential.

The cross sectional planning takes the existing sidewalk as given. The planned cross section consists of four components: the existing sidewalk of 5.5m, the bikeway of 2.0m, the roadway of three 3.5m lanes and the trunk busway. The bikeway is currently provided on both sides of the median. As is the case with Av. Almirante Barroso, the bikeway will be moved to the sidewalk to ensure the safety of cyclists. The cross section structure is shown in Figure 13.5-7.

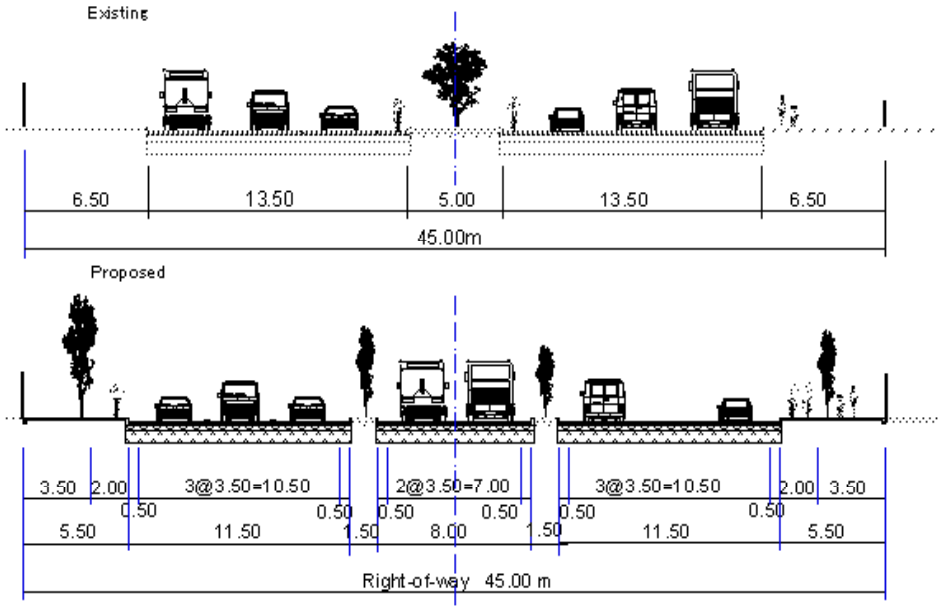


Figure 13.5-7 Typical Cross Section on Rodovia Augusto Montenegro

(4) Avenida Independencia

Av. Independencia is a principal arterial road that radially extends from the eastern edge of the Centro northeastward to Ananindeua City where it becomes part of the outer ring road. The road is currently under construction utilizing the right of way of the high-tension transmission line. The planned road width is 40.0m with four lanes. The roadside land use is chiefly residential.

The steel pylons in the median and the on-going canal project in the area are the control points for cross sectional planning. The roadway must be distanced about three meters away from the high-tension transmission pylons. The planned cross section consists of four components: the sidewalk of 3.5m, the bikeway of 2.0m, the roadway of two 3.5m lanes and the exclusive trunk bus lane. The exclusive bus lane provided next to the median is segregated by the chatter bar from the through traffic lane. The cross section structure is shown in Figure 13.5-8.

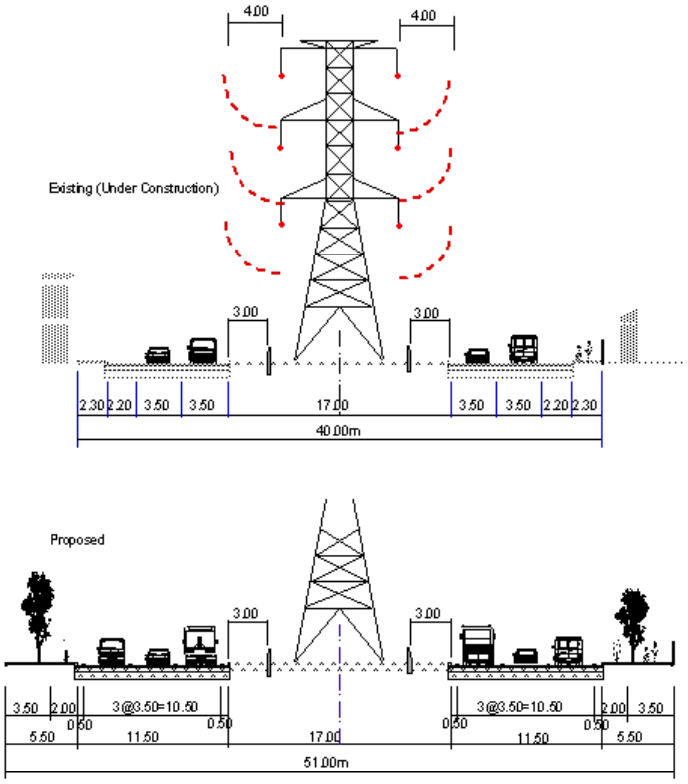


Figure 13.5-8 Typical Cross Section on Av. Independencia

(5) Avenida Primeiro de Dezembro

Av. Primeiro de Dezembro is a new secondary arterial road that runs parallel to Rodovia BR-316 on the south. The road will serve as the alternative route to take part of the heavy traffic load on Rodovia BR-316. It is the shortest route to connect, via Arca Viaria, the rapidly growing southeastern residential areas to the Centro. The roadside land use is largely residential.

The cross sectional planning aims at minimizing the possible impact on the reservoir in the south of the planned road. The planned road width is 40.0m. The four-lane road segment from the eastern fringe of the Centro toward the city center is now under construction by the municipal government. The planned cross section consists of three components: the sidewalk of 5.5m, the bikeway of 2.0m and the roadway of two 3.5m lanes. The planned road has the total right of way of 40.0m in width, and reserves space worth two lanes next

to the median to be prepared for the widening needed in the future. The cross section structure is shown in Figure 13.5-9.

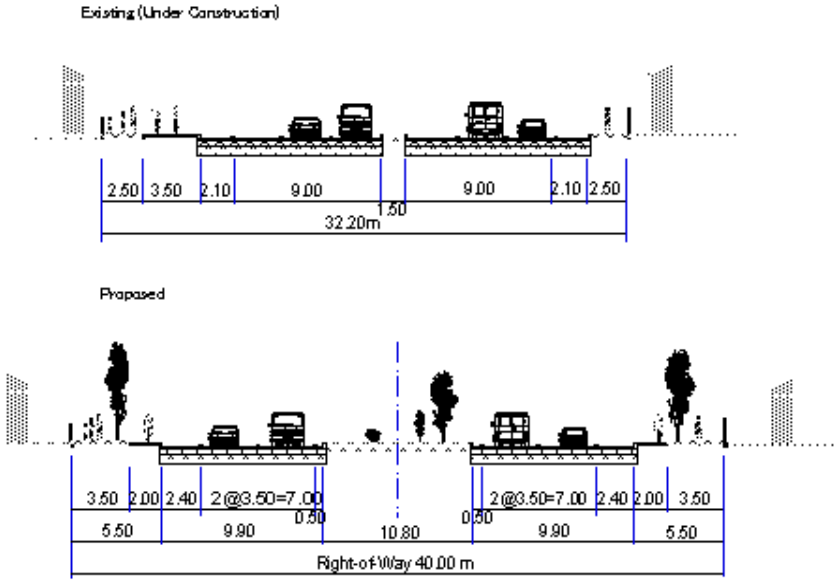


Figure 13.5-9 Typical Cross Section on Av. Primeiro de Dezembro

(6) Rua da Marinha

Rua da Marinha is a collector road that connects Av. Independencia and Av. Almirante Barroso. The planned right of way is 30.0m in width. The land use on the south side of the road is chiefly residential and the north side is taken up by the Navy Fusillade Training Center.

The boundary of the residential areas on the south side of the road is taken as fixed for cross sectional planning and the width of 30.m is secured by utilizing part of the naval property. The planned cross section consists of four components: the sidewalk of 2.4m, the bikeway of 2.0m, the road surface parking space of 2.1m and the roadway of two 3m lanes. A left-turn lane of 3.0m is reserved next to the median. The cross section structure is shown in Figure 13.5-10.

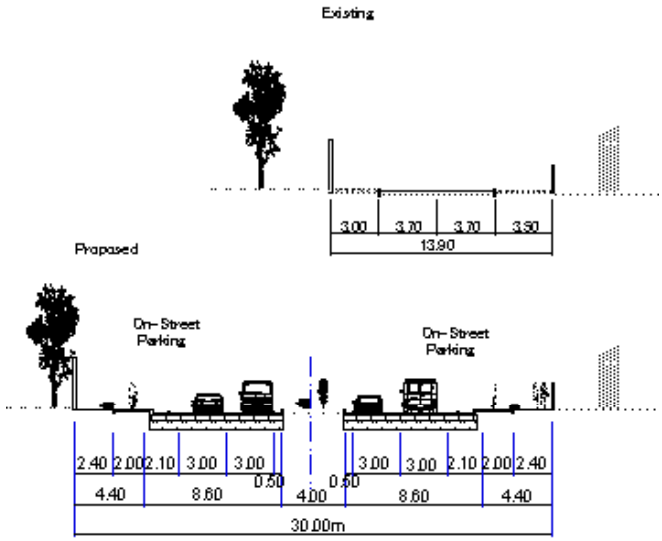


Figure 13.5-10 Typical Cross Section on Rua da Marinha

(7) Rua Yamada

Rua Yamada is a collector road that connects the Icoaraci area to Av. Independencia. It runs parallel to Rodovia Augusto Montenegro and serves as the alternative route to the latter. The right of way is 14.60m wide and has two lanes. The roadside land use is residential and semi-commercial.

Based on the traffic demand forecast, it is considered necessary to double the lanes into four on this road. The required right of way is 27.2m wide. The planned cross section consists of three components: the sidewalk of 3.50m, the road surface parking space of 2.10m and the roadway of two 3m lanes. A left-turn lane of 3.0m is reserved next to the median. The cross section structure is shown in Figure 13.5-11.

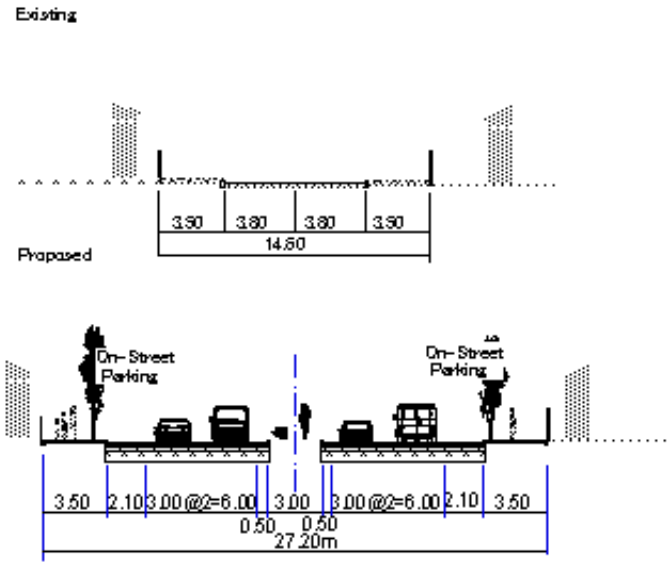


Figure 13.5-11 Typical Cross Section on Rua Yamada

PART D

PRELIMINARY ENGINEERING DESIGN OF TRUNK BUSWAY AND ROAD PROJECTS

CHAPTER 14
Preliminary Design For Facilities Of Trunk Busways

PART-D PRELIMINARY ENGINEERING DESIGN OF TRUNK BUSWAY AND ROAD PROJECTS

14. PRELIMINARY DESIGN FOR FACILITIES OF TRUNK BUSWAYS

14.1. GENERAL

As proposed in Chapter 8, the trunk busway is introduced to three arterial roads of Avenida Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro and the exclusive trunk bus lane to Avenida Independencia (Figure 14.1-1). The trunk bus priority lane is provided on the selected arterial roads within the Centro and the built-up area of Icoaraci. This chapter prepares the preliminary designs of road facilities necessary for the trunk bus system in the manner proposed in the conceptual plan of Chapter 8 and the cross section design standards suggested in Chapter 13. A complete set of preliminary designs is annexed to the report.

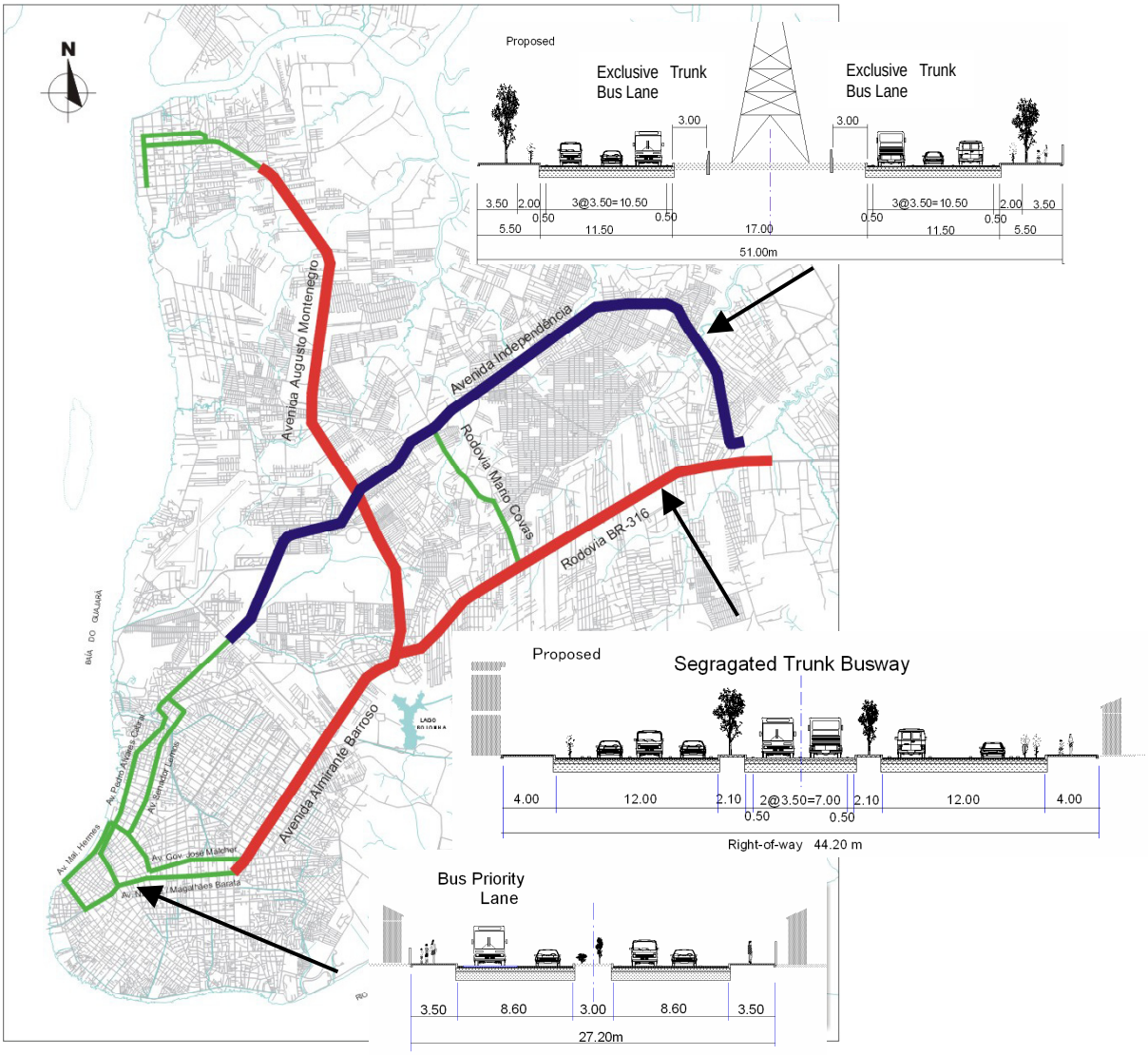


Figure 14.1-1 Road Network for Trunk Bus System

14.2. PRELIMINARY DESIGN OF TRUNK BUSWAY

14.2.1. ASSUMPTION

The trunk busway is constructed on the existing road space, because the arterial roads selected for its introduction are located in the midst of dense urban land use for commerce, business and housing. The possibility of widening these roads is extremely limited. The two-lane trunk busway is constructed by utilizing the existing median.

14.2.2. ALIGNMENT DESIGN

(1) Horizontal Alignment

Because the busway is built on the median of the existing roads, its horizontal design follows the respective alignments of these roads.

1) Avenida Almirante Barroso

Avenida Almirante Barroso extends 6.0km from the intersection with Av. Jose Bonifaciokous to Entroncamento Interchange. Its horizontal alignment is mostly straight, with occasional curves of some 2,000m in radius. Accordingly, the busway design adopts the straight alignment with insertions of 2,000m-radius curves. The design speed is 70km per hour with minimum radius requirement of 200m for curves. Therefore, the adoption of the present horizontal alignment of the avenue more than satisfies the geometric structure standards.

2) Rodovia BR-316

Rodovia BR-316 extends 12.75km from Entroncamento Interchange to Marituba. Its horizontal alignment is mostly straight, with the S-curve of 450m and 600m radius each near Entroncamento. The busway design follows this alignment. The design speed is 100km per hour with minimum radius requirement of 400m for curves. Therefore, the adoption of the present horizontal alignment of the road satisfies the geometric structure standards.

3) Rodovia Augusto Montenegro

Rodovia Augusto Montenegro extends 13.635km from Entroncamento Interchange to Icoaraci. Because the right of way used to be the railway track, the horizontal alignment is gently curved except around the intersection with Pass. Sao Francisco where it curves with a radius of 550m and also around the intersection with Rua Brasilia where it curves with a radius of 400m. The busway follows the same alignment, with the shortest radius of 400m among its curved sections. Given the design speed of 70km per hour and the minimum radius requirement of 200m, this satisfies the geometric structure standards.

(2) Vertical Alignment

The vertical design follows the respective alignments of three arterial roads since the busway is constructed with their respective horizontal alignments. Three roads are built on flat ground with the steepest longitudinal slope of less than 1.0%. Therefore, the steepest slope of the busway is also less than 1.0%. The design speed of 100km per hour requires the minimum longitudinal slope of 3% to 4%. Therefore, the vertical alignment adopted for the busway more than satisfies the geometric structure standards.

14.2.3. CROSS SECTION DESIGN

(1) Avenida Almirante Barroso (Class II, Design Speed of 70km/h)

The right of way of the avenue varies from 42.2m to 45.0m in width, with four lanes each way segregated by the median. As shown in Figure 14.2-1, four center lanes with the median in the middle are for long through trips, and four side lanes, two each way, are for short trips. The sidewalk of 4.0m wide is provided on both sides of the avenue. The bikeway is provided on the median. Conventional buses are operated on the lane next to the sidewalk. Underneath the sidewalk are buried pipelines of water supply and sewage, power transmission lines, drainpipes for road surface water and so on. The basic planning policy is to keep the cross section design within the present width of the right of way and to leave the sidewalks undisturbed. Table 14.2-1 and Figure 14.2-1 compare the cross section elements of Av. Almirante Barroso before and after the busway construction.

Table 14.2-1 Cross Section Elements of Avenida Almirante Barroso:

Before and After Busway Construction:

Cross Section Element	Before	After	Remarks
Width of Right of Way (m)	42.2	42.2	Unchanged
Width of Right-side Sidewalk (m)	4.0	4.0	Unchanged
No. of Right-side Lanes	4	3	Reduced by one
Width of Right-side Outer Busway Divider (m)	0	2.1	Used to build trunk bus stops
Width of Right-side Roadway (m)	15.6	10.0	Reduced to 3 lanes of 3m each
Width of Right-side Bikeway (m)	2.0	2.0	Moved from the median next to the sidewalk
Width of Trunk Busway (m)	0	8.0	Two lanes of 3.5m each, with lane divider
Width of Median (m)	1.0	0	Used for the busway
Width of Left-side Bikeway	2.0	2.0	Moved from the median next to the sidewalk
Width of left-side Roadway (m)	15.6	10.0	Reduced to 3 lanes of 3m each
Width of Left-side Outer Busway Divider (m)	0	2.1	Used to build trunk bus stops
No. of Left-side Lanes	4	3	Reduced by one
Width of Left-side Sidewalk (m)	4.0	4.0	Unchanged

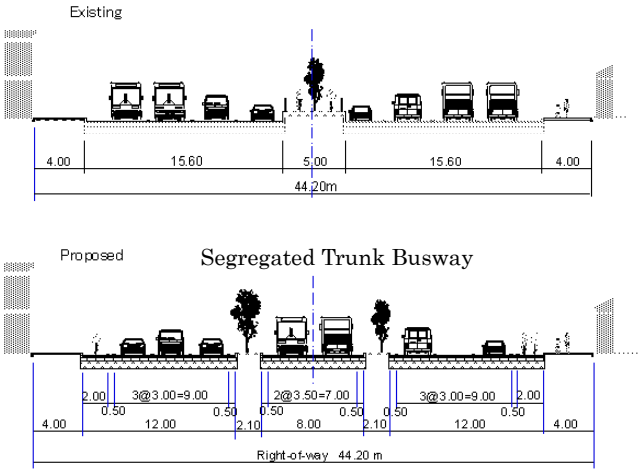


Figure 14.2-1 Cross Section of Av. Almirante Barroso: Before and After

(2) Rodovia BR-316

The right of way has the width of 50.0m from Entroncamento Interchange through Alca Viaria. The busway is constructed within the present width. Table 14.2-2 and Figure 14.2-2 compares the cross section elements of Rodovia BR-316 before and after the busway construction.

Table 14.2-2 Cross Section Elements of Rodovia BR-316:

Before and After Busway Construction:

Cross Section Element	Before	After	Remarks
Width of Right of Way (m)	50.0	50.0	Unchanged
Width of Right-side Sidewalk (m)	5.7	5.7	Unchanged
No. of Right-side Lanes	3	3	Unchanged
Width of Right-side Roadway (m)	13.0	12.5	Lane width reduced to 3.5m
Width of Right-side Outer Busway Divider (m)	0	2.8	Used to build trunk bus stops
Width of Right-side Bikeway (m)	1.3	2.0	Moved from the median next to the sidewalk
Width of Median (m)	10.0	0	Used for the busway
Width of Trunk Busway (m)	0	8.0	Two lanes of 3.5m each, one lane each way
Width of Left-side Bikeway	1.3	2.0	Moved from the median next to the sidewalk
Width of Left-side Outer Busway Divider (m)	0	2.8	Used to build trunk bus stops
Width of left-side Roadway (m)	13.0	12.5	Lane width reduced to 3.5m each
No. of Left-side Lanes	3	3	Unchanged
Width of Left-side Sidewalk (m)	5.7	5.7	Unchanged

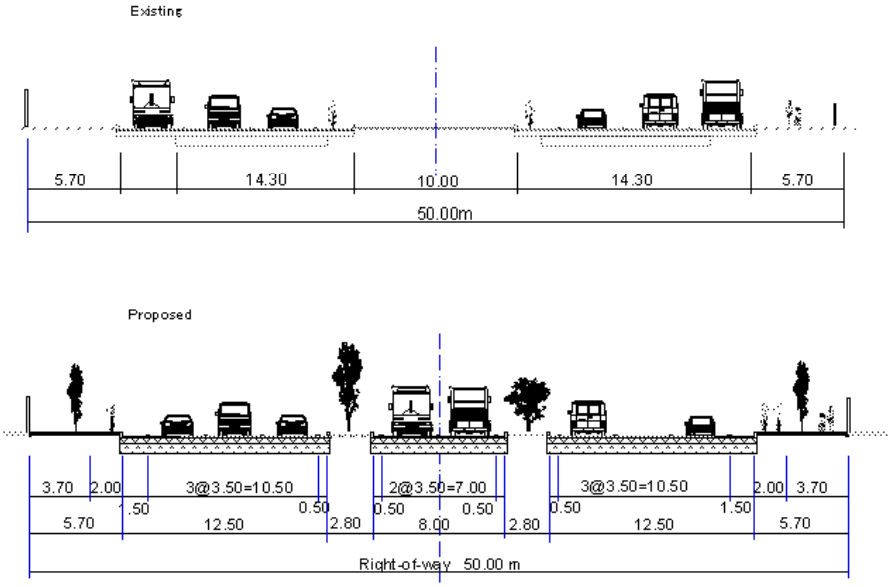


Figure 14.2-2 Cross Section of Rodovia BR-316: Before and After

(3) Rodovia Augusto Montenegro (Class II, Design Speed of 70km/h)

The road width varies by segment: viz., 45.0m from Entroncamento Interchange to Rua Augusto Cohen, from 36.2m to 37.5m around Entroncamento Interchange and 30.2m near the intersection with Pass. Alacid Nunes. Because the design has to conform to the available width of the right of way, the right-side lane is used as trunk bus priority lane around Entroncamento Interchange. The bikeway on the median is moved next to the sidewalk. Table 14.2-3 and Figure 14.2-3 compare the cross section elements of Rodovia Augusto Montenegro before and after the busway construction.

Table 14.2-3 Cross Section Elements of Rodovia BR-316:

Before and After Busway Construction:

Cross Section Element	Before	After	Remarks
Width of Right of Way (m)	45.0	45.0	Unchanged
Width of Right-side Sidewalk (m)	6.5	5.5	Reduced by 1.0m
No. of Right-side Lanes	3	3	Unchanged
Width of Right-side Roadway (m)	12.5	12.5	Lane width of 3.5m each
Width of Right-side Outer Busway Divider (m)	0	1.5	Used to build trunk bus stops
Width of Right-side Bikeway (m)	1.0	2.0	Moved from the median next to the sidewalk
Width of Median (m)	5.0	0	Used for the busway
Width of Trunk Busway (m)	0	8.0	Two lanes of 3.5m each, one lane each way
Width of Left-side Bikeway	1.0	2.0	Moved from the median next to the sidewalk
Width of Left-side Outer Busway Divider (m)	0	1.5	Used to build trunk bus stops
Width of left-side Roadway (m)	12.5	12.5	3 lanes of 3.5m each
No. of Left-side Lanes	3	3	Unchanged
Width of Left-side Sidewalk (m)	6.5	5.5	Reduced by 1.0m

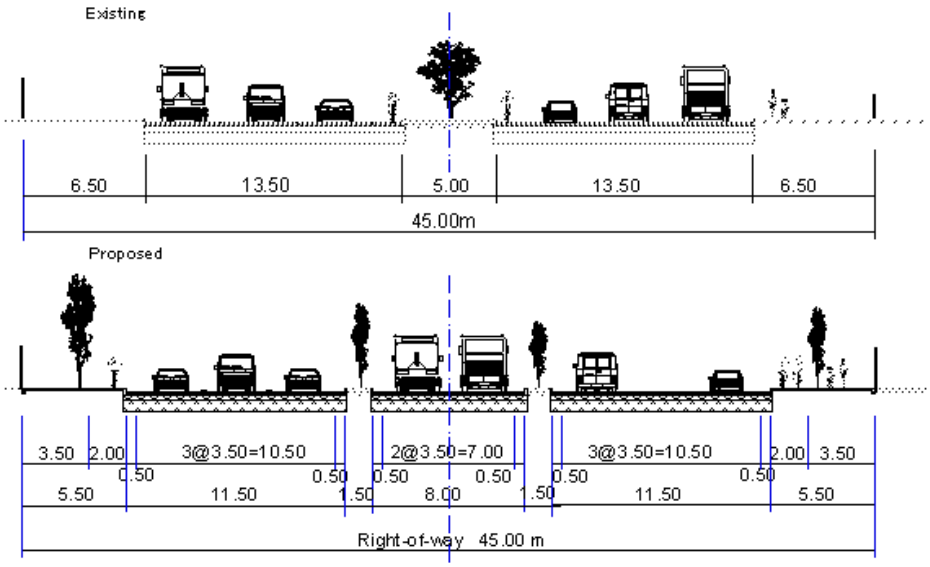


Figure 14.2-3 Cross Section of Rodovia Augusto Montenegro: Before and After

14.2.4. PAVEMENT DESIGN

(1) Pavement Type

The proposed trunk busway is paved by slabs of concrete cement, for the following reasons.

1) Heavy load of large-bodied trunk buses during driving, at starting and braking to stop
2) Heavy stationary load of trunk buses at bus stops
3) High temperature in the Study Area
4) Lower operation and maintenance costs

(2) Pavement Layers

By taking into account the local paving practices and in consultation with the counterparts, the concrete pavement has sub-ground layers shown in Figure 14.2-4.

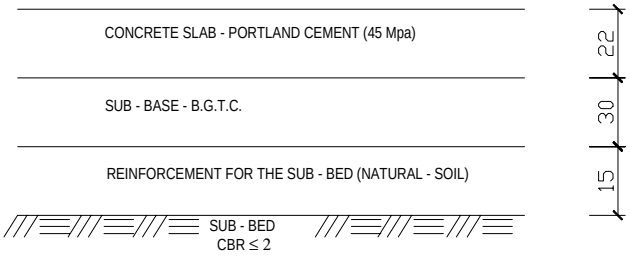


Figure 14.2-4 Pavement Layers of Trunk Busway

14.2.5. FACILITIES AND APPURTENANCES REQUIRING RELOCATION OR REMOVAL

The trunk busway is constructed in the center part of three arterial roads. This requires relocation or removal of some existing facilities and appurtenances along the way, such as tree lines, street lampposts, pedestrian bridges and bikeway. Table 14.2-4 summarizes the relocation and removal requirements on three roads.

Table 14.2-4 Relocation and Removal Requirements

Road	Tree Size			Pedestrian Bridges	Lamp Posts	Traffic Signals	Others		
	Small	Medium	Tall				Electric Posts	Monument	Bikeway on Median
Av. Almirante Barroso	296	21	186	4	143	10		1	3500m
Ro. BR-316	102	288	23	4	141	4			
Rod. Augusto Montenegro	44	995	104	3	298	5	1700m		

14.3. PRELIMINARY DESIGN OF EXCLUSIVE TRUNK BUS LANES (AV. INDEPENDENCIA)

14.3.1. GENERAL

The exclusive trunk bus lane each way is introduced to Avenida Independencia. As with the trunk busway, two lanes are provided on the center part of the avenue. Each lane is segregated by chatter bars from the roadway for other through traffic.

Two exclusive lanes are built on the segment from Av. Julio Cesar to Marituba. The segment from Av. Julio Cesar to Av. Pedro Alvares Cabral is flanked by the canal on its left, allowing no room to provide trunk bus stops. Accordingly, the trunk bus priority lane is provided on both sides of this segment.

14.3.2. ALIGNMENT DESIGN

(1) Horizontal Alignment

The design follows the horizontal alignment of the on-going and the planned construction of Avenida Independencia. Around the nature conservation area, the alignment is designed to skirt around the area.

The following control points are adopted to design the horizontal alignment of the exclusive lanes.

1) Given the high-voltage transmission lines passing above the centerline of the avenue, the control point for horizontal alignment is the distance of 3.0m from the steel pylons.
2) The alignment around the intersection with Rua da Marinha is designed to avoid the nature conservation area on the east of the avenue.
3) The minimum requirement of curve radius is 300m. However, S-curves of 200m in radius are designed for some sections to skirt around the pylons.

(2) Vertical Alignment

As with the horizontal alignment, the design conforms to the vertical alignment of the on-going and the planned construction of Avenida Independencia. The avenue runs on the flat ground, with the steepest longitudinal slope of 2.4%.

The following control points are adopted to design the vertical alignment of the exclusive lanes.

1) The design conforms to the vertical alignment of the canal embankment road.
2) Av. Independencia is the overpass at the intersection with Av. Julio Cesar. The steepest longitudinal slope is 4.0%.
3) Rua Yamada is the underpass at the intersection with Av. Independencia. Because the altitude in the area is relatively high at 16.0m, the underpass is naturally drained off eastward to the planned canal.
4) Av. Independencia is the underpass at the intersection with Rod. Augusto Montenegro. The control point for vertical alignment is the natural drainage height of the avenue. By taking into account the respective height of catch-basins and drainpipes, the road surface of the avenue is designed to have the height of 11.5m, relative to the planned canal bed of 9m high.

5) The design of the segment after the intersection with Rod. Augusto Montenegro follows the vertical alignment of the planned construction of Av. Independencia. The steepest longitudinal slope is 2.43%.

14.3.3. CROSS SECTION DESIGN

Av. Independencia now under construction uses the 40m-wide right of way of high-voltage transmission lines. The avenue under construction has four lanes. The roadside land use is mostly residential. The cross section design must consider the transmission pylons in the median and the planned channel of the canal project. The cross section elements consist each way of the sidewalk of 3.50m, the bikeway of 2.0m, the roadway of two 3.5m-wide lanes and the exclusive trunk bus lane. Figure 14.3-1 compares the cross section elements before and after the introduction of the exclusive bus lanes for the segments with steel pylons in the median. Figure 14.3-2 does the same for the segments located away from the transmission lines. Figure 14.3-3 compares the cross section elements before and after in the segment that runs on the embankments of the planned channel of the canal project.

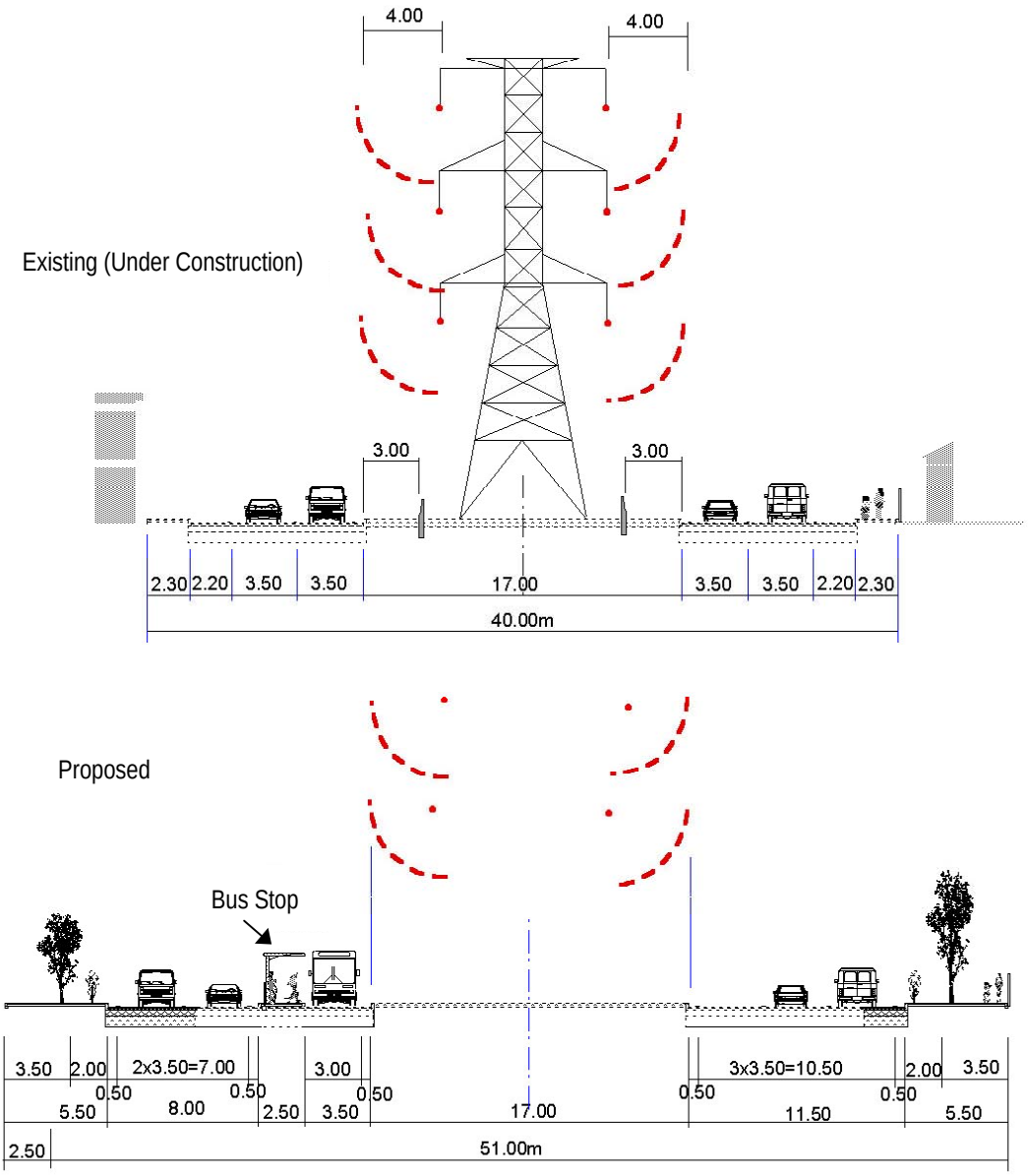


Figure 14.3-1 Cross Section of Av. Independencia with Steel Pylons: Before and After

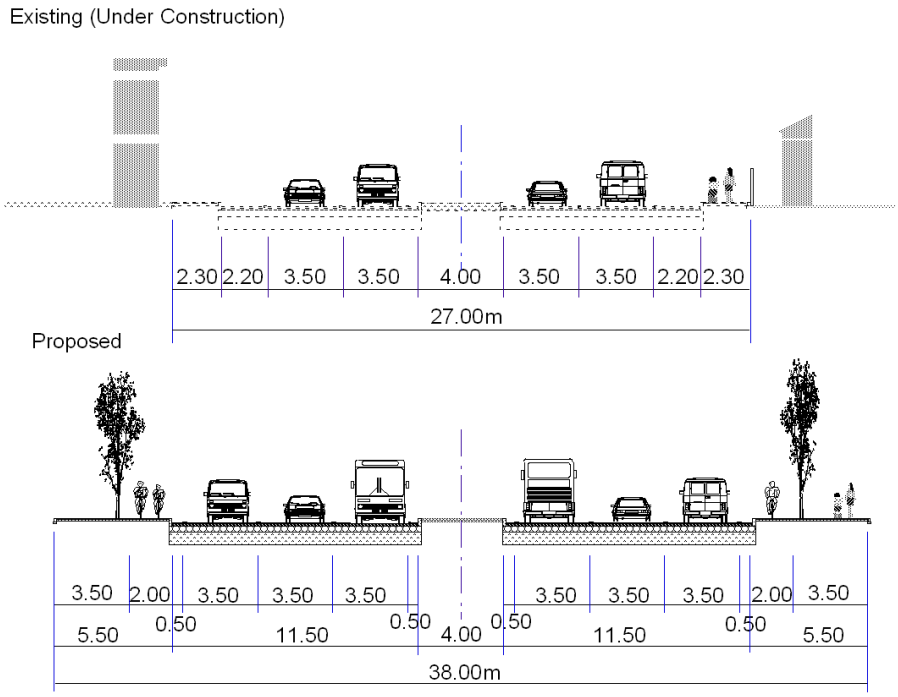


Figure 14.3-2 Cross Section of Av. Independencia without Steel Pylons: Before and After

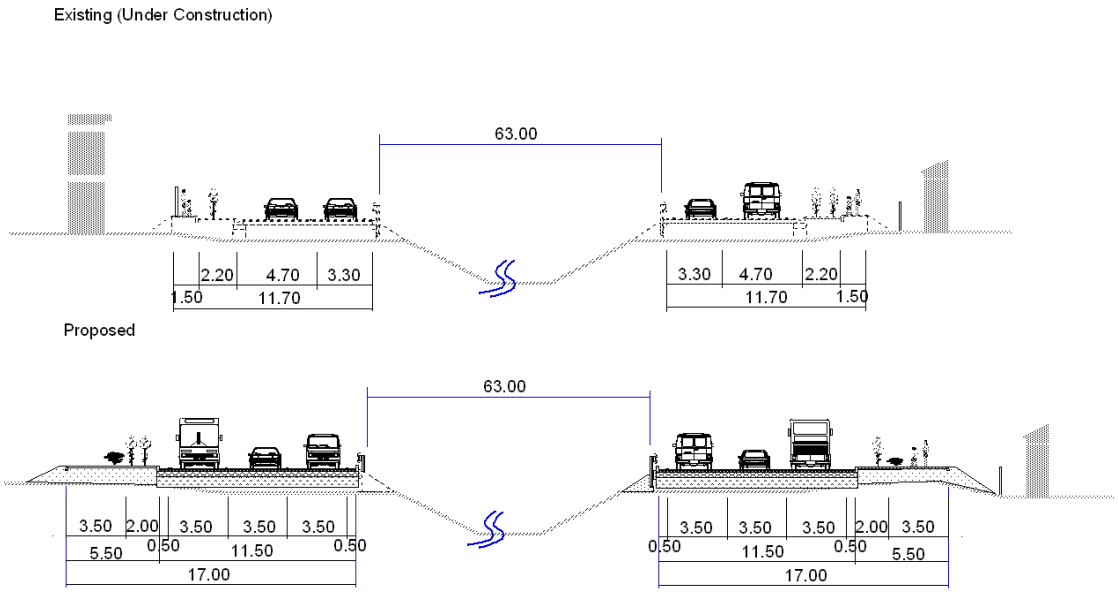


Figure 14.3-3 Cross Section of Av. Independencia on Canal Embankments: Before and After

14.3.4. INTERSECTION DESIGN

Av. Independencia is a principal arterial. Accordingly, its intersection with another principal arterial is grade-separated. In addition to the intersection with Rod. Augusto Montenegro, a principal arterial, the grade separation is provided at the intersections with Av. Julio Cesar and Rua Yamada that are principal collectors.

Av. Independencia crosses two more major roads, namely, Rua da Marinha (principal collector) and Avenida Mario Covas (secondary arterial). Because through traffic on Av. Independencia is not heavy on these roads, the intersections are at grade with traffic signals.

(1) Av. Julio Cesar

Av. Julio Cesar is a principal collector, and the at-grade intersection would have been suitable as stipulated by the planning policy. However, this avenue provides Av. Independencia with an important access to the airport. In addition, the avenue is part of the ring road in the Primeira Legua Patrimonial and has heavy through traffic. Therefore, the grade separate intersection is judged suitable.

It is necessary to design the intersection with sufficient clearance from the planned channel of the canal project and the transmission pylons. It is also necessary to consider the water supply pipelines buried underneath the median.

Given the topographic and land use conditions around the site, the proposed design is a diamond interchange with Av. Independencia flying over Av. Julio Cesar.

(2) Rua Yamada

Av. Rua Yamada is a principal collector, and the at-grade intersection would have been suitable as stipulated by the planning policy. However, the road is expected to serve as an alternative route to Rod. Augusto Montenegro, with concomitant growth of traffic in the future. With its roadside already dotted with modern factories and other places of employment, Rua Yamada is expected to grow into one of the important links to the Centro.

The design requirement is to provide enough clearance from the transmission lines above Av. Independencia.

The site is located high on the terrace, and constrained overhead by the high-voltage transmission lines. Accordingly, the proposed design is a full-access trumpet interchange, with Rua Yamada as its underpass.

(3) Rod. Augusto Montenegro

Rodovia Augusto Montenegro is a principal arterial, and therefore its intersection with Av. Independencia is grade-separated in accordance with the planning policy. Given the heavy traffic through the intersection, the proposed design is a full-access cloverleaf interchange.

The design must secure the clearance limit of Rod. Augusto Montenegro vis-à-vis the transmission lines above Av. Independencia. The design conditions are as follows.

1) The present road surface of Rod. Augusto Montenegro can be raised by 2 meters to keep enough clearance from the transmission lines above Av. Independencia.
2) The drainage structures proposed for Av. Independencia are the control point.
3) The road surface height of Rod. Augusto Montenegro relative to the road surface of Av. Independencia is the sum of the clearance limit of the latter avenue, the allowance of 0.5m below the girder and the girder height of 2.0m.
4) The improvement of vertical alignment on Rod. Augusto Montenegro at the intersection reaches down to the ramp nose.
5) The horizontal alignment of the ramps is designed to avoid a large supermarket located to the west of the site.

14.3.5. STRUCTURE DESIGN

Structures proposed for Avenida Independencia are eight bridges and one box culvert. The following is the description of these structures.

(1) Bridge across Una Channel

The vertical alignment of the road on the existing bridge is terrible and obstructs the motorized traffic. The cause is the subsidence of road surface, despite the unchanged original vertical alignment of the bridge itself. A new bridge is proposed to replace the antiquated bridge.

The existing bridge is a concrete bridge of 30m in length. A new bridge has the lower girder height with two 15m spans. The superstructure uses PCI girders. The bridge site is located in the built-up area. The drill-and-drive technique that uses steel piles is selected for the foundation works, because it is less noisy and more vibration free.

(2) Bridge across Sao Joaquim Channel

The segment from Avenida Julio Cesar to Avenida Visconde de Souza Franco flanks the right bank of Sao Joaquim Channel. Therefore, it is necessary to cross the channel to go toward the Centro. The horizontal alignment of the segment is sharply curved with a radius of 120m. Cast-in-place concrete piling of PC hollow slabs is suitable to cope with the curve. The bridge is a 3-span continuous girder bridge, with span length of 30m.

The cast-in-place technique requires the timbering for the superstructure of the bridge. It is necessary to do the construction works, including the substructure and the foundation as well as the superstructure, when the water level of the channel is low.

The drill-and-drive technique is selected for the foundation works. Two piers are proposed to support the eccentricity of the curved superstructure. Piers have a round cross section to resist the flow of the channel. Figure 14.3-4 shows the cross section of the proposed bridge.

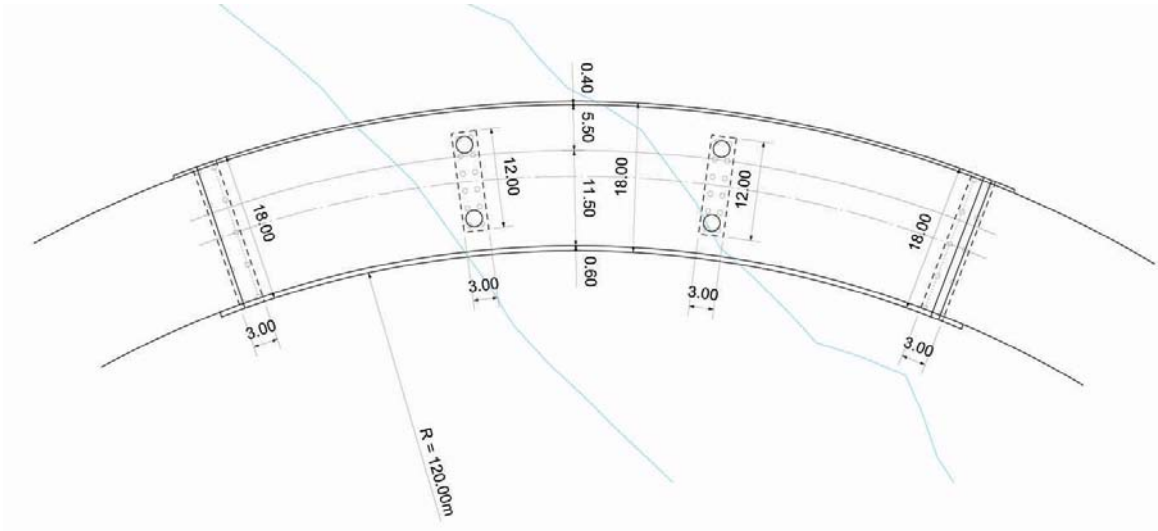


Figure 14.3-4 Cross Section of the Proposed Bridger over Sao Joaquim Channel

(3) Interchange with Avenida Julio Cesar

Avenida Independencia flies over Avenida Julio Cesar at the proposed interchange. For the roadway from Rodovia BR-316 toward Avenida Visconde de Souza Franco, it is necessary to raise the surface height of Avenida Independencia to give the clearance limit to Avenida Julio Cesar. The design longitudinal slope is 4.0%, and the flyover bridge is 360m long. For the roadway from Avenida Visconde de Souza Franco toward Rodovia BR-316, the flyover bridge is 450m long, because it has to cross Sao Joaquim Channel as well as to give the clearance limit to Avenida Julio Cesar. Because the on-ramp to this roadway also crosses Sao Joaquim Channel, a bridge of 180m in length is proposed for the ramp.

Because these bridges have curved horizontal alignment in some part, their superstructures use PC hollow slabs that are easier to adjust to a curve. The span length is 30m, the most economical length for normal bridges. Because the proposed superstructures require the timbering, it is necessary to do the construction works when the water level of the channel is low. It is also necessary to place the height control on the motorized traffic (restriction on large vehicles) during the construction. Piers have a round cross section to resist the flow of the channel.

(4) Interchange with Rua Yamada

Avenida Independencia flies over Rua Yamada at the proposed interchange. Because the road width of Rua Yamada is relatively narrow, the box culvert is proposed for the interchange.

(5) Interchange with Rodovia Augusto Montenegro

At the proposed interchange, the road surface of Rodovia Augusto Montenegro is raised to allow enough clearance to Avenida Independencia below. The proposed bridge is a 2-span continuous girder bridge of 60m in length. PC hollow slabs are used for girders. The roadways are grade separated by traffic direction. Because the firm sub-ground of rock is found in shallow depth at the site, the foundation is built directly upon the rock base. Triads of piers are provided to support the wide superstructure.

(6) Bridge across Ariri River

The roadway from Rodovia BR-316 to Avenida Visconde de Souza Franco is already provided with a steel girder bridge. The foundation for another bridge is already completed for the roadway from Avenida Visconde de Souza Franco to Rodovia BR-316. The existing bridge for the traffic from Rodovia BR-316 to Avenida Visconde de Souza Franco is too narrow to provide the sidewalk and the bikeway. Accordingly, a new steel girder bridge for bicycles and pedestrians is constructed at the site fiver meters away from the bridge.

Regarding the other direction of traffic, the superstructure of a steel girder bridge is proposed on the completed foundation. A new steel girder bridge for bicycles and pedestrians is also constructed near the bridge.

(7) Bridge across 40 Horas River

40 Horas River has the appearance of a retarding basin and the proposed bridge is 30m long. The superstructure uses PCI girders, because it is possible to move them by the truck crane parked at the back of the abutment.

(8) Bridge across Icui Guajara River

The proposal is the same as the bridge for 40 Horas River.

(9) Bridge across Maguariacu River

The proposed bridge is 60m in length, twice longer than those proposed across 40 Horas and Icui Guajara Rivers, because Maguariacu River has larger discharge of water. The superstructure is 2-span PCI girders, with span length of 30m.

14.3.6. DESIGN OF ACCESS ROADS

(1) Traffic management plan around Ave. Pedro Cabral and Ave. Senador Lemos

The alignment plan at the beginning section on Av. Independencia is revised for the following reasons:

1) Problem of new bridge construction with high cost;
2) Difficulty of road widening due to the heavily developed area along the alignment; and
3) Difficulty of traffic management at a complicated 5-way intersection between Av. Pedro Alvares Cabral and Rod. Arthur Bernardes.

The revised alignment is planned to connect to a pair of one-way streets, Ave. Pedro Cabral (southbound) and Ave. Senador Lemos (north bound), at the north side of Canal do Una. Therefore, it is necessary to change and improve the traffic management including the existing one-way system in the surrounding area of these two roads.

Following are the basic considerations for the study of traffic management in this area:

1) To improve the existing road network and space. Minor improvement is also allowed such as partial road widening, except for new road construction;
2) To avoid the heavy traffic concentration on particular road segments;
3) To introduce a simple traffic management plan to avoid confusing drivers driving in this area; and
4) To avoid the decline of urban activity such as commercial and business activity.

The outline of the proposed traffic management plan in this area is as follows:

1) Av. Independencia is connected to Av. Pedro Alvares Cabral (southbound) and Av. Senador Lemos (north bound), which are changed to a one-way traffic system from two-way. (Refer to green line in Figure 14.3-5).
2) Two counterclockwise one-way circulation systems are proposed using Av. Pedro Alvares Cabral, Trv. Cel. Bentes, Av. Senador Lemos and Av. Doutor Freitas, and using Tra. Rosa Moreira, Rua do Una, Tra. Djalma Dutra, Rua Municipalidade and Av. Visconde de Souza Franco. The inside area of these roads would also be developed to a one-way system (refer to red lines in Figure 14.3-5).
3) Traffic management system for other roads remains as is (refer to blue shaded mark in Figure 14.3-5), except for the above-mentioned roads. Traffic management using the two-way traffic system along main roads is shown as blue shaded marks in Figure 14.3-5. Figure 14.3-7 shows the one-way traffic system in both the current one-way system and the proposed management system.

Traffic assignment is done in two alternative cases of “without” and “with” the improved road network for the 2012 daily traffic demand. Figure 14.3-6 shows the traffic volumes in

this area forecast by the assignment method. The traffic assignment in the road network with the proposed one-way system is well balanced in traffic volume within this area.

(2) Bus flow movement plan of busway at Entroncamento

Entroncamento intersection between Av. Almirante Barroso, Rodovia Augusto Montenegro and Av. Pedro Alvares Cabral, is the busiest intersection in traffic volume in the study area. An underpass on Av. Almirante Barroso at the Entroncamento intersection is under construction. Busways on Av. Almirante Barroso and Rodovia Augusto Montenegro merge at the Entroncamento intersections. The bus operation on the trunk busway at this intersection is more complicated. Therefore, it is necessary to establish a plan for minimizing the traffic congestion and smoothing the trunk bus operation on the trunk busway at this intersection.

The proposed bus flow plan on the trunk busway at the Entroncamento intersection is summarized below and shown in Figure 14.3-8.

1) On the underpass section on Av. Almirante Barroso, it is difficult to construct a segregated busway due to the limited width of the underpass. This section must become a bus priority lane instead of segregated busway. (Refer to red line in Figure 14.3-8).

2) Taking into account the weaving length into the priority and the mixed lanes from the segregated busway, the segregated busway ends before reaching the Entroncamento intersection on both Av. Almirante Barroso and Rodovia Augusto Montenegro (Refer to green line in Figure 14.3-8).

3) The trunk busway inside the Entroncamento intersection on Rodovia Augusto Montenegro is changed to an ordinary traffic lane in which the trunk buses operate with ordinary vehicles. This is because it is impossible to install a bus priority lane in this section, which is the weaving area in the Entroncamento (Refer to blue line in Figure 14.3-8).

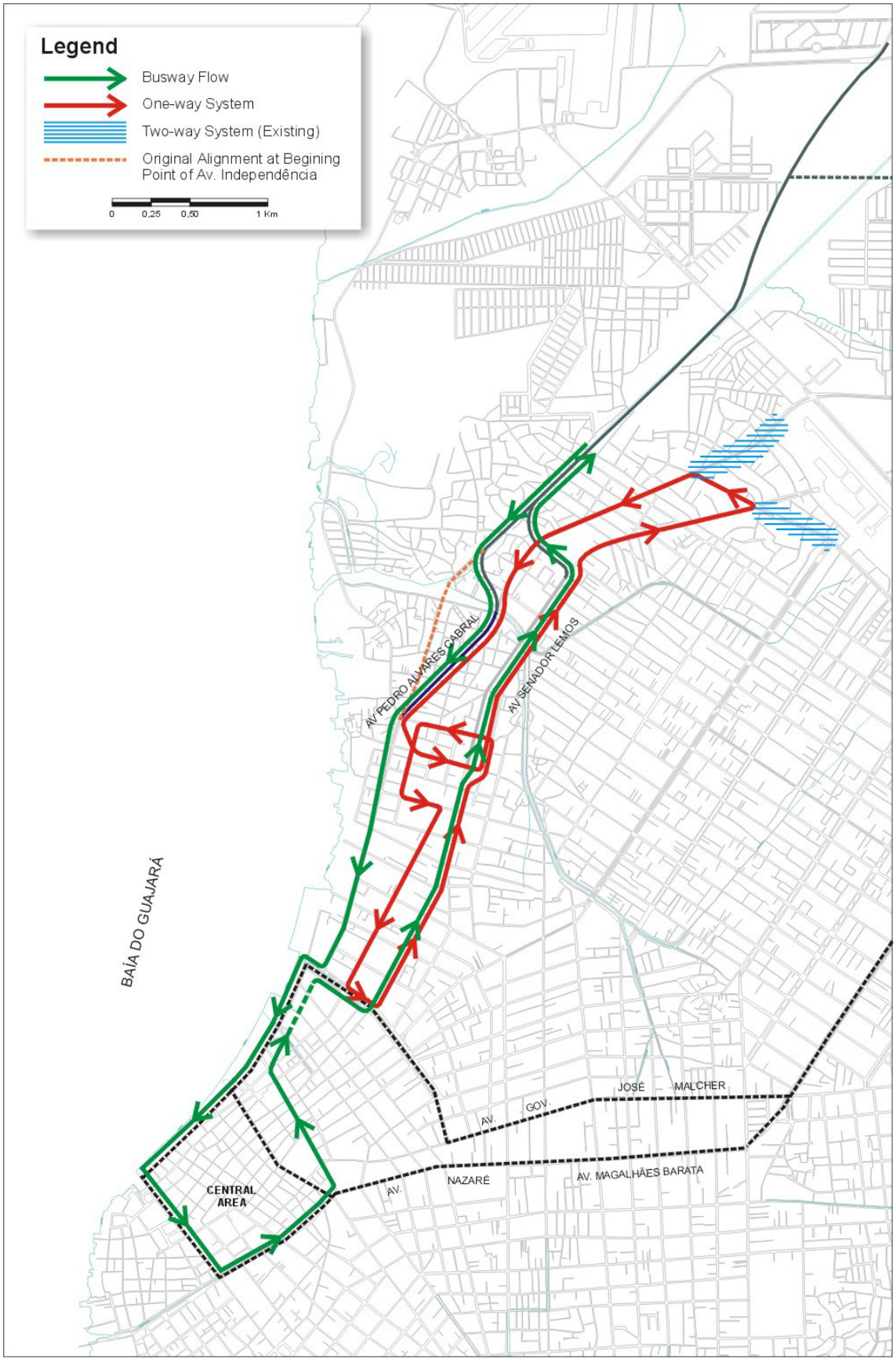
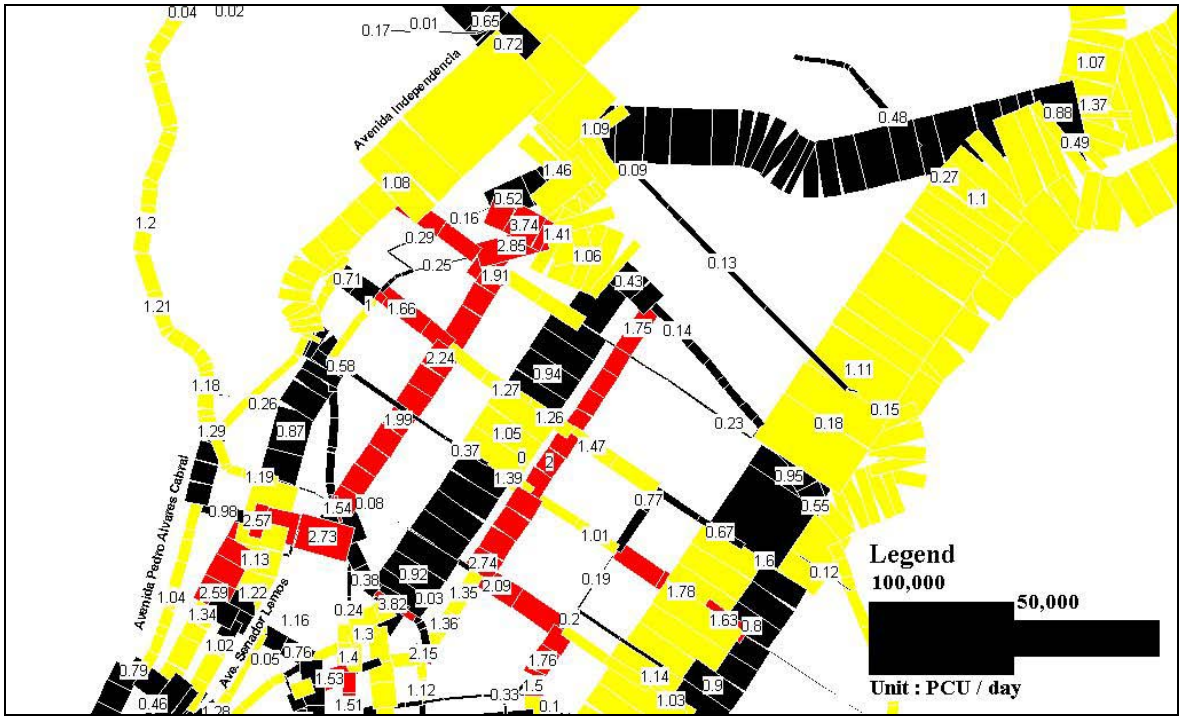


Figure 14.3-5 Proposed One-way Traffic System near the Beginning Point of Avenida Independencia

"Without" Case



"With" Case

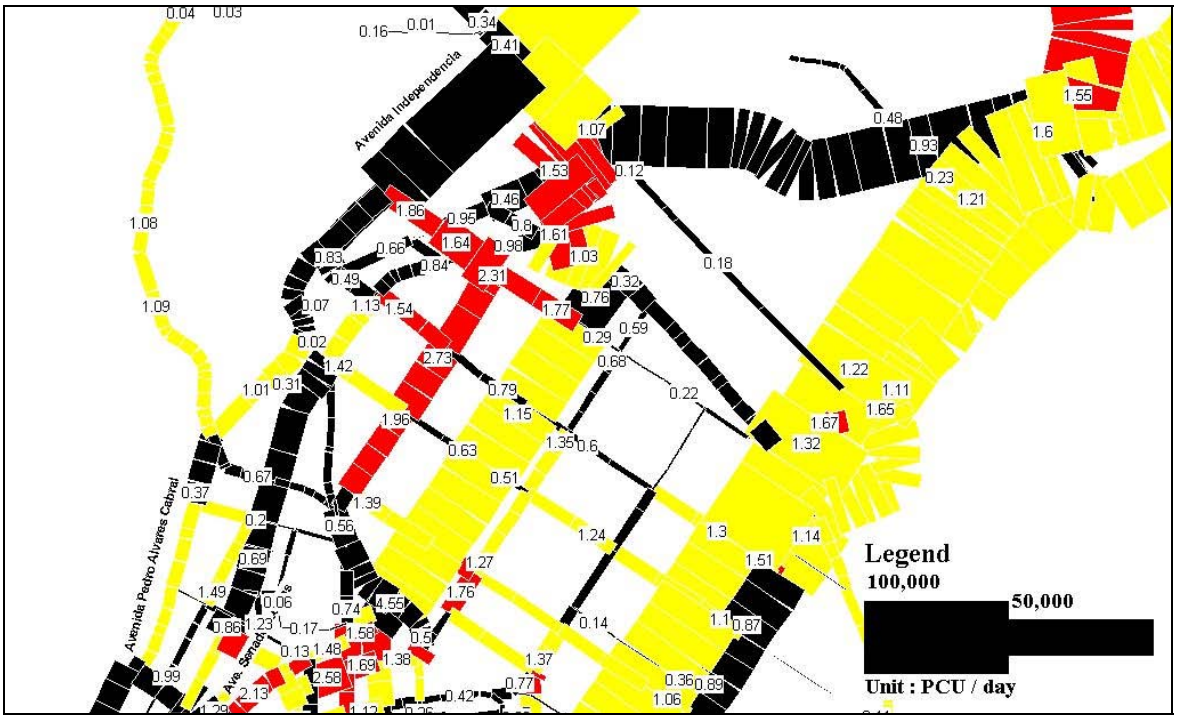


Figure 14.3-6 Traffic Volumes on "Without" and "With" Improvement Cases in 2012