CHAPTER 7
Preliminary Engineering for Trunk Busway

7. PRELIMINARY ENGINEERING FOR TRUNK BUSWAY

7.1. EXISTING PROJECT ROAD CONDITIONS

In general, the trunk busway is planned to use the central reserved space of the existing Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central. The existing road facility conditions of Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central are summarized as the results of the field reconnaissance survey and road inventory survey which was conducted by the JICA Study Team in June 2006.

The location of the Study roads, composed by Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central is shown in Figure 7.1-1 and Figure 7.1-2 respectively.

Figure 7.1-1 Location of the Trunk Busway to be Studied (Av. Venezuela Side)

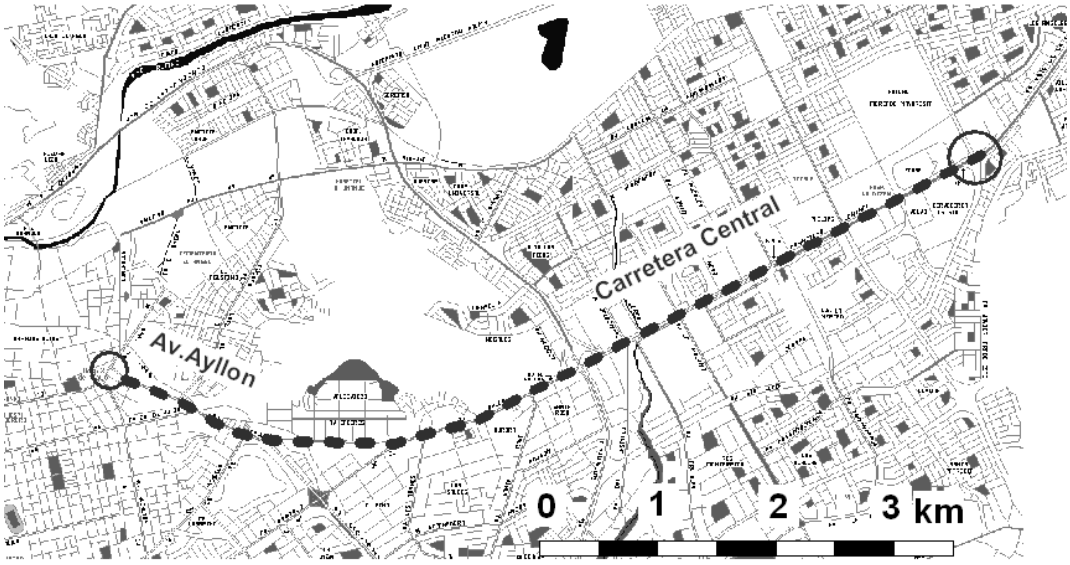


Figure 7.1-2 Location of the Trunk Busway to be Studied (Carre. Central Side)

7.1.1. EXISTING ROAD FACILITY CONDITIONS

(1) Cross Section Conditions

1) Av. Venezuela and Av. Arica

The road inventory survey along the existing Av. Venezuela and Av. Arica was conducted in May, 2006 by the JICA Study Team. Based on the results of the road inventory survey, the typical cross section of the existing Av. Venezuela and Av. Arica can be classified by the five (5) different characterized cross sections as shown in Figure 7.1-3 . The widest right of way width of the existing road was observed with about 52.0 m and the narrowest right of way width was observed with about 18.0 m near the ruins, known as the "Huaca Aramburú".

The followings conditions of the road cross section elements are pointed out on the existing Av. Venezuela and Av. Arica

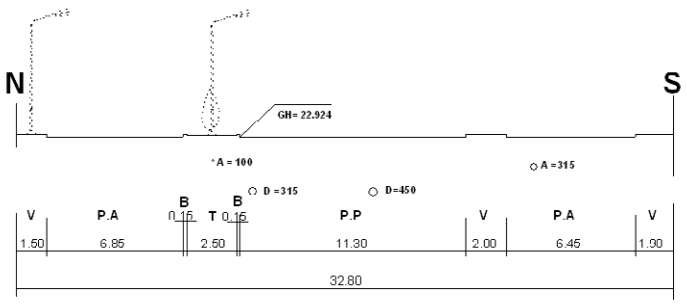
a) The right of way width of Av. Venezuela in Bellavista in the city of Callao (right side of the road at station No. 1 to No.4) is officially kept at about 52.0 m. However, actual existing right of way width is maintaining only about 32.0 m including side-walks on both sides of the road. The difference, about 20.0 m (52m-32m=20m), has been used by a private company. Therefore, the Callao municipality should negotiate with the private company. The pavement is maintained in comparatively good condition.

b) The right of way width of Av. Venezuela in the San Miguel Area in Lima City (right of road side at station No.8 and station No. 13 to 17) are officially kept at about 42.0 m to 52.0 m including side-walks on both sides of the road. However, the actual existing right of way is observed as only about 25.0 m. The difference about 17.0 m to 27.0 m has been used by a private company. Therefore, Lima municipality should negotiate with the private company. The pavement is maintained in comparatively good condition.

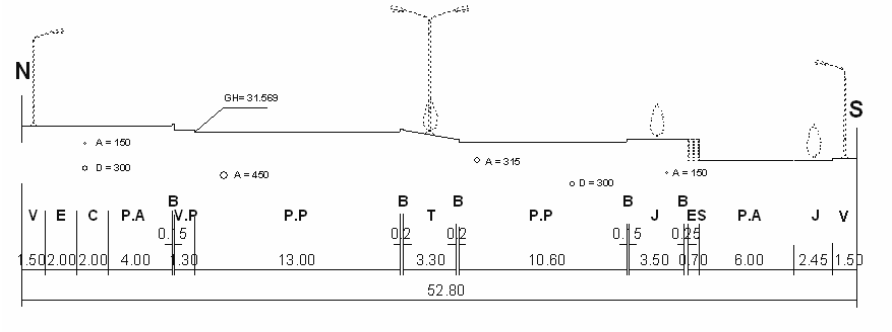
c) The right of way width of Av. Venezuela at the area of Huaca Aramburú is observed at about 18.0 m including side-walks on both sides of the road. It is very difficult to widen the existing road due to the fact that the Huaca Aramburú is a very important ruin. The pavement is maintained in comparatively good condition.

d) The right of way width of Av. Arica (station No. 34 to No 43) is observed at about 29.8 m to 34.0 m including side-walks on both sides of the road. The pavement is maintained in comparatively good condition. However, the condition of some road segments is observed as having a weak surface.

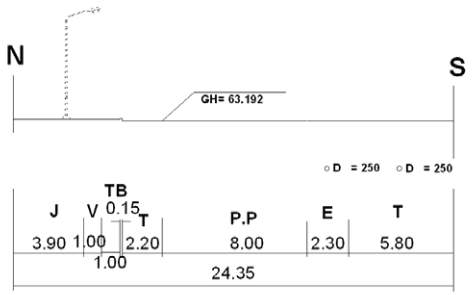
1. No.1 to No.4 and No8 (32.00m)



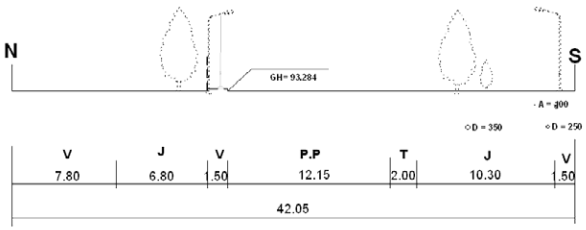
2. No.5 to No.7, No.9 to No.12 and No.20 to No.34 (52.00m)



3. No.15 to No.18 (24.35m)



4. No.20 to No.34 (42.00m)



5. No.35 to No.45 (30.00m)

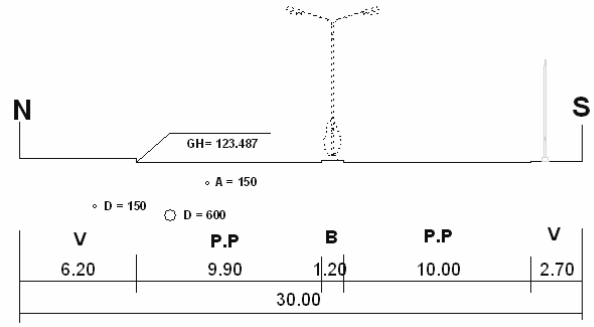


Figure 7.1-3 Typical Cross Section of Existing Av. Venezuela and Av. Arica

2) Av. Ayllon and Carretera Central

Based on the road inventory survey results, the typical cross section on the existing Av. Ayllon and Carretera Central can be classified at the four (4) characterized cross sections as shown in Figure 7.1-4 .

The following are pointed out as the results of the survey.

a) The existing right of way width of Av. Ayllon at near Av. Grau (station No. 1 to No. 4) is observed at about 23.0 m to 25.0 m including side-walks on both sides of the road. The road is paved with hot-mixed asphalt concrete, however, the pavement

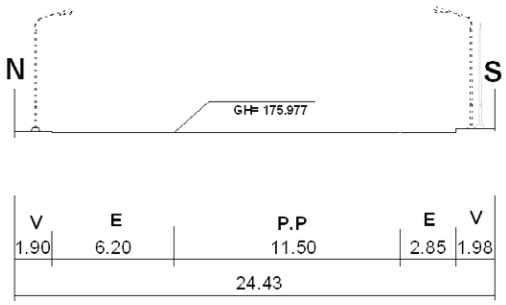
conditions are very weak. When the trunk busway is constructed, the pavement should be reinforced.

b) In addition to the above, a lot of small housing has been developed on both sides of the road. It is very difficult to widen the existing road in this area. Therefore, when the trunk busway is constructed, reduction of cross section elements will be required.

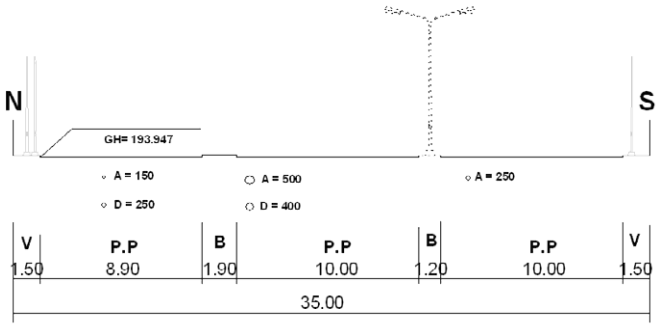
c) The existing right of way width of Av. Ayllon at the San Luis (station No. 11 to No. 16) is observed at about 33.0 m to 35.0 m including side-walks on both sides of the road. The pavement is maintained in comparatively good condition. However, conditions of some road segments are observed as having a weak surface. When the trunk busway is constructed, the pavement should be reinforced in the weak pavement areas.

d) The existing right of way width of Av. Ayllon after the intersection between Av. Venezuela and Evitamiento (station No.17 to 45) is observed at 42.0 m to 52.0 m including side-walks on both sides of the road. The frontage roads are developed on both sides of the road. The pavement is maintained in comparatively good condition. However, conditions of some road segments are observed as having a weak surface. When the trunk busway is constructed, the pavement should be reinforced the weak pavement areas.

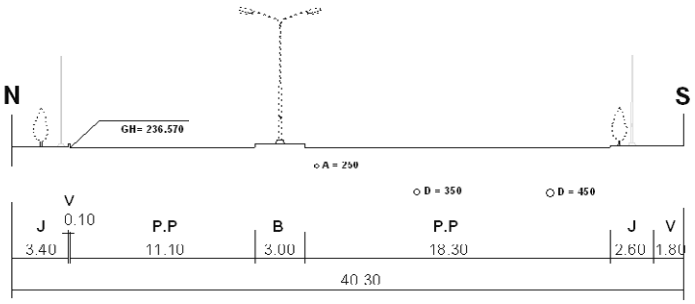
1. No.2 to No.5



2. No.11 to No.16



3. No.17 to No.42



4. No.43 to No.45

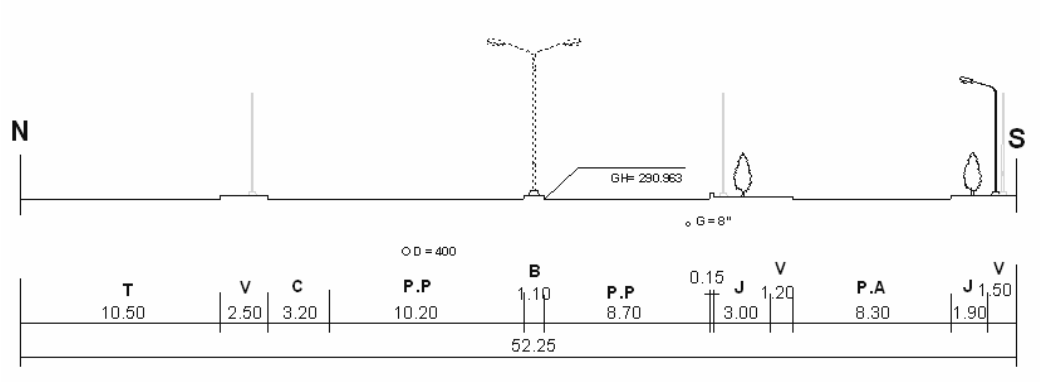


Figure 7.1-4 Typical Cross Section of Existing Av. Ayllon and Carretera Central

(2) Pavement Structure on Project Road

1) Av. Venezuela and Av. Arica

In general, the existing Av. Venezuela and Av. Arica are paved by a 20.0 cm depth of cement concrete pavement, however, the road surface on the road segments which are poor cement concrete pavement are covered by hot mixed asphalt concrete pavement with 5.0 cm depth. The pavement surface is maintained in comparatively good condition. Cross Section Survey". Each pavement layer thickness of the existing typical pavement structure covered by asphalt concrete pavement is shown in Figure 7.1-5.

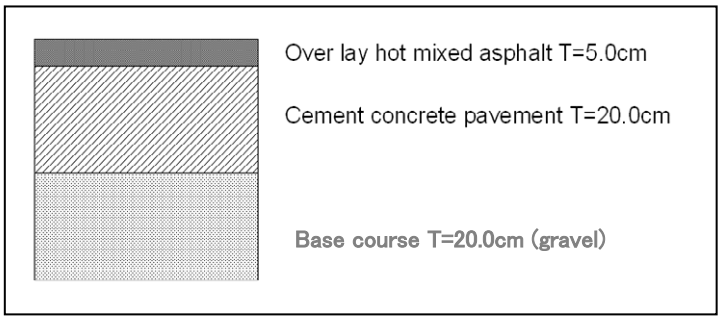


Figure 7.1-5 Thickness of Existing Cement Concrete Pavement Layers

2) Av. Ayllon and Carretera Central

The existing Av. Ayllon and Carretera Central are paved with hot mixed asphalt concrete. However, the pavement conditions of the Manzanilla area are very poor. The pavement surfaces of other road sections or segments are maintained in comparatively good conditions. The pavement layer thickness of each existing typical pavement structure is shown in Figure 7.1-6.

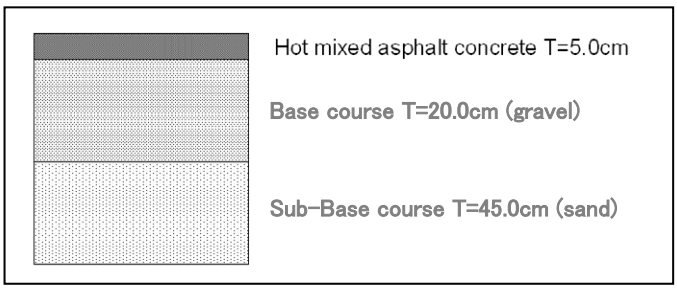


Figure 7.1-6 Thickness of Existing Asphalt Concrete Pavement Layers

(3) Drainage Conditions

The average monthly precipitation in the dry season during October to April is observed at about 0.6 mm to 0.9 mm, and in the rainy season during May to September is observed at about 1.2 mms to 2.0 mms. The maximum monthly precipitation during the period from 1974 to 1996 was observed at 12 mm. The annual precipitation is observed at 12.6 mm in the Lima and Callao metropolitan area.

Considering precipitation conditions in the Study area, the drainage conditions of Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central are constructed as minimum drainage structures of both sides of the road.

(4) Intersection Conditions

There are many intersections on the Av. Venezuela, Av. Arica, Av. Ayllon and Carretera Central. Traffic signals have been installed at the major intersections, and the other intersections are non-signalized. Almost all intersections are developed as at-grade intersections, and the intersection between Carretera Central and Av. Evitamiento is constructed by the grade separated intersection. The types of the major intersections of Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central are shown in Table 7.1-1.

Table 7.1-1 Types of Intersection on the Project Roads

Name of Intersection	Location Distance(km)	Type of Intersection	Signal	Crossing Type
On Av. Venezuela				
Av. Venezuela---Av. De la Marina	0.0	Separation Roundabout	Signalized	6-leg
---Av. Haya de la Torre	1.2	At-grade	Signalized	4-leg
---Av. Insurgentes	1.7	At-grade	Signalized	4-leg
---Av. Elmer Faucett	2.4	At-grade	Signalized	4-leg
---Av. Universitaria	4.4	At-grade	Signalized	4-leg
---Av. Arica	6.9	At-grade	Signalized	4-leg
Av. Arica ---Av. Ugarte	8.4	Roundabout	Signalized	4-leg
Av. Ugarte ---Av. Grau	8.9	Roundabout	Signalized	4-leg
On Carretera Central---				
Av. Grau --- Av. N Ayllon	0.0	At-grade	Signalized	4-leg
Av. N Ayllon ---Av. 28 de Julio	1.0	At-grade	Signalized	4-leg
- --Av. México	1.5	At-grade	Signalized	4-leg
--- Av. Circunvalación	1.8	At-grade	Signalized	4-leg
---Av. Arriola	3.0	At-grade	Signalized	3-leg
---Av Las Torres	3.3	At-grade	Signalized	4-leg
---Av. Robles	4.9	Separation Interchange	Non Signalized	4-leg
--- Av. La Molina	6.2	At-grade	Signalized	4-leg
Carr. Central-- Av. 22 de Julio	9.5	At-grade	Signalized	3- leg

(5) Pedestrian Bridge Conditions

Three (3) pedestrian bridges are located on the existing Carretera Central, however, many pedestrians cross the existing road without using the pedestrian bridges. On the other hand, there is no pedestrian bridge on the existing Av. Venezuela, Av. Arica , and Av. Ayllon.

(6) Condition of Bus Stop Facilities

The existing bus stops are located near to the intersection between the project roads and the major crossing roads, however, almost all the bus stop facilities are not developed, and

many buses stop at any place on the road. At present, the Urban Transport Management (Gerencia de Transporte Urbano -GTU) of Lima has planned the following bus stops.

1) Av. Nicolas Ayllon------27 bus stops

2) Carretera Central--------51 bus stops

3) Av. Venezuela--------32 bus stops

7.1.2. UNDERGROUND SOIL CONDITIONS

In the previous studies, there is a lot of underground soil investigation data from the Av. Venezuela, Av. Ayllon, and Carretera Central. Some typical soil data from the project roads are attached.

1) Estudio Definitivo de Ingeniería Corredor Vial : Av. Venezuela – Av. Arica(1997)
2) Intercambio Vial Av. Riva Aguero – Av. 28 de Julio- Av. Nicolas Ayllon (1996)
3) Estudio Definitivo de Ingeniería, Paso a Desnivel Carretera Central – Av. La Molina
4) Estudio Definitivo de Ingeniería, Paso a Desnivel Carretera Central – Av. Hermilo Valdizan
5) Estudio Definitivo de Ingeniería, Paso a Desnivel Carretera Central – Av. Separadora Industrial

According to this soil investigation data, the following soil conditions are observed along the project roads.

1) The surface layer is covered by clay and sand with a depth of about 50cm.
2) Below 50 cm from existing ground level is a foundation of clay, sand, and gravel.
3) The CBR under the existing roads were observed at about 20% to 30% in weak soil condition layers and about 60% to 80 % were observed in strong soil condition layers.
4) Density of soil was observed at 2.0 (gr/m3) to 2.1 (gr/m3).
5) The percentage of moisture content of soil was observed at about 7.0 % to 8.0%.

REGISTRO DE EXCAVACIONES

PROYECTO : Estudio Definitivo de Ingeniería, Corredor Vial
Av. Venezuela - Av. Arica
Tramo: Av. Elmer Faucett - Plaza Bolognesi

UBICACION : Tramo: Av. Elmer Faucett - Plaza Bolognesi

FECHA : Enero de 1996

CALICATA : C-1

PROF.(m) : 1,20

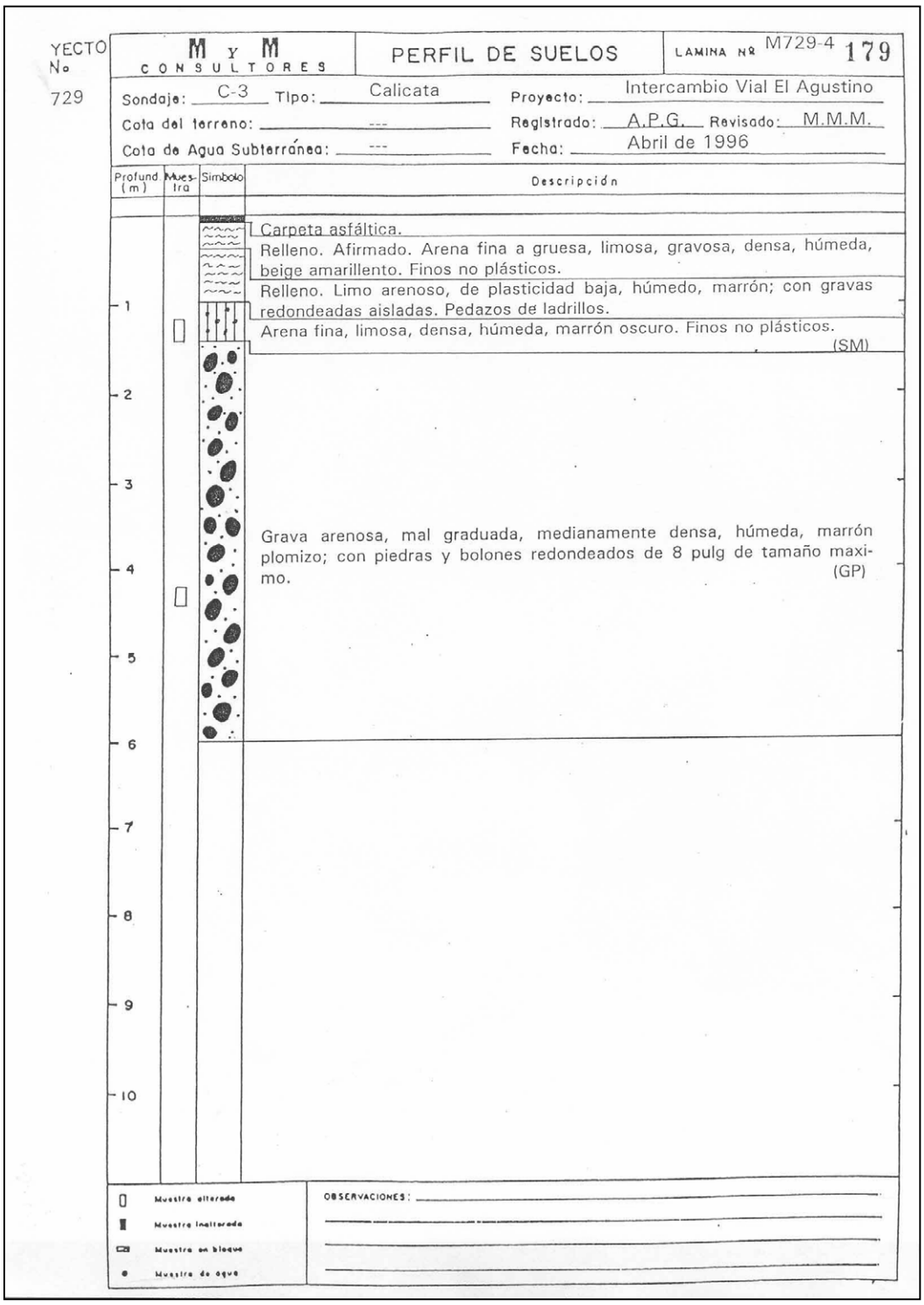
COTA : -

NIVEL FREATICO : N.P.

PROF. (m.)	TIPO DE EXCAV.	MUESTRA	SIMB.	DESCRIPCION	CLASIF. SUCS
0,20	EXCAVACION A CIELO ABIERTO			Losa de Concreto Portland	
0,90		M-1		Arcilla limosa, color marrón oscuro, de regular humedad, en estado semi-compacto. Presenta restos de huaco color rojo.	CL-ML
1,20		M-2		Arena limosa, con gravas redondeadas a subredondeadas, en forma aislada, color beige claro, en estado semi-compacto y semi húmedo.	SM

OBSERVACIONES

No se presentó Nivel Freático.



YECTO No 729

M y M CONSULTORES

PERFIL DE SUELOS

LAMINA Nº M729-4 179

Sondaje: C-3 Tipo: Calicata Proyecto: Intercambio Vial El Agustino

Cota del terreno: --- Registrado: A.P.G. Revisado: M.M.M.

Cota de Agua Subterránea: --- Fecha: Abril de 1996

Profund (m)	Muestra	Simbolo	Descripción
			Carpeta asfáltica.
			Relleno. Afirmado. Arena fina a gruesa, limosa, gravosa, densa, húmeda, beige amarillento. Finos no plásticos.
1			Relleno. Limo arenoso, de plasticidad baja, húmedo, marrón; con gravas redondeadas aisladas. Pedazos de ladrillos.
			Arena fina, limosa, densa, húmeda, marrón oscuro. Finos no plásticos. (SM)
2			
3			
4			Grava arenosa, mal graduada, medianamente densa, húmeda, marrón plomizo; con piedras y bolones redondeados de 8 pulg de tamaño maximo. (GP)
5			
6			
7			
8			
9			
10			

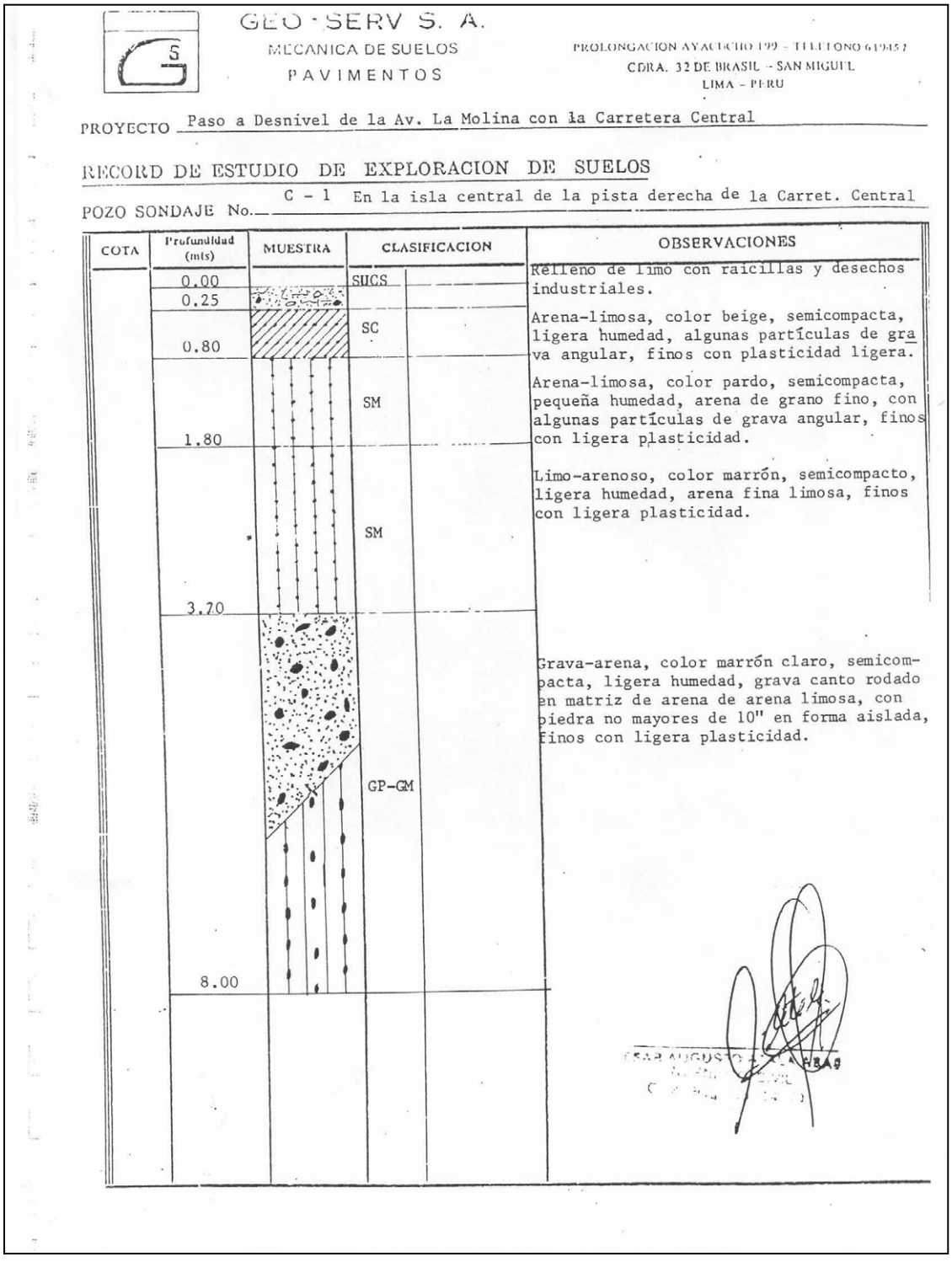
Muestra alterada

Muestra inalterada

Muestra en bloque

Muestra de agua

OBSERVACIONES:



GEO-SERV S. A.
MECANICA DE SUELOS
PAVIMENTOS

PROLONGACION AYACUCHO 199 - TELEFONO 619457
CDRA. 32 DE BRASIL - SAN MIGUEL
LIMA - PERU

PROYECTO Paso a Desnivel de la Av. La Molina con la Carretera Central

RECORD DE ESTUDIO DE EXPLORACION DE SUELOS

POZO SONDAJE No. C - 1 En la isla central de la pista derecha de la Carret. Central

COTA	Profundidad (mts)	MUESTRA	CLASIFICACION SUCS	OBSERVACIONES
	0.00			Relleno de limo con raicillas y desechos industriales.
	0.25		SC	Arena-limosa, color beige, semicompacta, ligera humedad, algunas partículas de grava angular, finos con plasticidad ligera.
	0.80		SM	Arena-limosa, color pardo, semicompacta, pequeña humedad, arena de grano fino, con algunas partículas de grava angular, finos con ligera plasticidad.
	1.80		SM	Limo-arenoso, color marrón, semicompacto, ligera humedad, arena fina limosa, finos con ligera plasticidad.
	3.70		GP-GM	Grava-arena, color marrón claro, semicompacta, ligera humedad, grava canto rodado en matriz de arena de arena limosa, con piedra no mayores de 10" en forma aislada, finos con ligera plasticidad.
	8.00			

CESAR AUGUSTO [illegible]

REGISTRO DE EXCAVACIONES

PROYECTO : Estudio Definitivo de Ingeniería, Corredor Vial
Av. Venezuela - Av. Arica
Tramo: Av. Elmer Faucett - Plaza Bolognesi

UBICACION : Tramo: Av. Elmer Faucett - Plaza Bolognesi

FECHA : Enero de 1996

CALICATA : C-3

PROF.(m) : 1,20

COTA : -

NIVEL FREATICO : N.P.

PROF. (m.)	TIPO DE EXCAV.	MUESTRA	SIMB.	DESCRIPCION	CLASIF. SUCS
0,20	EXCAVACION A CIELO ABIERTO			Losa de Concreto Portland	
0,40				Se observa un vacío.	
0,50		M-1		Arena con matriz limo-arcilloso, color marrón, con presencia de gravas redondeadas en forma aislada, en estado semi-suelto y semi-húmedo. En la Berma se encontró relleno con restos de plásticos, gravas redondeadas, desmonte, restos de ladrillos, pajas.	SM-SC
1,00					
1,20					

OBSERVACIONES

No se presentó Nivel Freático.

7.1.3. UNDERGROUND FACILITY CONDITIONS

The major underground facilities are classified as the water supply pipe and sewage pipe. Generally, the water supply pipe lines (Diameter of pipe (D) =100mm to 150mm) are located at both sides of existing roads. The major sewage pipe lines with D=450mms to 600 mms are located at the center of the existing roads, and the sub-sewage pipe lines which are connected from the main sewage pipe to houses with D=250 mm to 450 mm are located under both side walks. Major sewage pipes are connected to each house by a connection pipe with D=100 mm. The water supply and sewage pipes are located at a depth of about 2.0 m to 3.0 m under the existing road surface level. The detailed water supply pipe and sewage pipe systems are presented in Technical Report "Water Supply and Sewage System". These data and information are obtained from Servicio de Agua Potable y Alcantarillado de Lima (SEDAPAL).

7.1.4. PAST RELATED PLANS AND STUDIES

The following numerous plans and studies were prepared by the Lima and Callao municipalities and related authorities.

1) Metropolitan Road Plan, 1971, approved by Supreme Resolution No. 063-70VI, December 15th 1970.
2) Transport Plan, 1989(Transurb-Class, for MML)
3) Metropolitan Road Plan, 1990, put in validity by Mayorship Decree No. 127-92-MML (Lima –Callao Metropolitan Development Plan 1990-2010)
4) Urban Master Plan of Callao 1995-2010 (IMP for Corde Callao, 1995)
5) Metropolitan Road System Map, approved by Decree No. 127-MML September 29th 1997.
6) Strategic Plan of Urban Transport- Metropolitan Projects(ST-CTLC August 2001)
7) Update of the Metropolitan Road System, approved by Decree No. 341-MML December 6th 2001, It is effective to the date)
8) Master Plan of Urban Transport for Lima and Callao Metropolitan Area （M/P） (JICA, August 2005)
9) Study of Urban Transport Corridor Improvements: Carretera Central (Delcanda International Limited, for MML, 1983).
10) Corridor Improvement: N. Ayllon-Carretera Central (Invermet-MML,1993)
11) Feasibility Study of the Corridor Av. Venezuela(IMP-Invermet,1993)
12) By-Pass N. Ayllon-Riva Aguero-28 de Julio (IMP-Invermet,1993)
13) Feasibility Study of the Corridor Av. Venezuela-Callao Section (IMP-Corde Callao,1994)
14) Definitive Engineering Study of the Corridor. Av. Venezuela-Av. Arica (HOB Consultant SA, for MML, 1997)
15) Road Intersection: La Molina-Carretera Central/Av. Los Frutales-Carretera Central (INVERMET, solution at surface, definitive study, EMAPE, two bypasses, preliminary plan)
16) Bypass Av. Venezuela-Av. Universitaria (Feasibility Study, IMP; Definitive Study, EMAPE)

17) Av. Corridor Grau (Feasibility Study, IMP; Definitive study and Work in execution, EMAPE)

18) Bus Rapid Transit Project (COSAC-1) (Protransporte)

19) Complementary Corridor Study (Protransporte)

Especifically, the preliminary design of the trunk busway on Av. Venezuela/Av. Arica and Av. Ayllon/Carretera Central was conducted with reference to the following past studies and projects.

1) Intersection Improvement Plan Between Carretera Central and Av. La Molina (1993).(INVERMET)
2) Intersection Improvement Plan Between Carretera Central and Av. Separadora Industrial (1993). (INVERMET)
3) Intersection Improvement Plan Between Av. Ayllon and 28 de Julio (1996) (INVERMET)
4) Intersection Improvement Plan Between Av. Venezuela and Av. Universitaria(INVERMET)
5) Intersection Improvement Plan Between Av. Venezuela and Av. Faucett
6) Final Design Av. Venezuela and Av. Arica (1997) (INVERMET)
7) Feasibility Study (PTUL) (COSAC Project) (2003)

7.2. TRUNK BUSWAY FACILITIES DEVELOPMENT CRITERIA

7.2.1. FUNCTION AND CHARACTERISTICS OF TRUNK BUSWAY

As mentioned previously, the trunk busway consists of the following three different types of busway or bus lanes, in order to meet the right of way (ROW) width of the existing road. The trunk busway facility is planned at within the ROW of the existing road without additional land acquisition if possible. The definitions of the three busway type are described below,

1) Exclusive Trunk Busway
2) Exclusive Trunk Bus Lane
3) Priority Trunk Bus Lane

(1) Exclusive Trunk Busway

The exclusive trunk busway is operated by the traffic of trunk bus system without obstruction by other private traffic and transport..The major functions and characteristics of the exclusive busway are as follows:

1) The exclusive trunk busway is operated only by the trunk bus during the whole day.
2) Conventional buses, private cars, taxis, and bicycles are prohibited from circulating on the exclusive trunk busway. Conventional buses selected are operated on the frontage road or right side lane of the existing carriageway.
3) The exclusive trunk busway is fully segregated from the other traffic flows by a separator which is made with a cement concrete structure.
4) The exclusive trunk busway is adopted on the existing road which is maintained with about a 52 m to 36m right of way (ROW) width on the existing road segments.

(2) Exclusive Trunk Bus Lane

The function and characteristics of the exclusive trunk bus lane are as follows:

1) Exclusive trunk bus lane is operated exclusively by the trunk bus.
2) Conventional buses, private cars, and taxis, cannot be driven in the exclusive trunk bus lane. The conventional buses selected are operated on the frontage road or right side lane of the existing carriageway.
3) Exclusive trunk bus lane is segregated by low separators such as cats-eyes or traffic delineators.
4) Exclusive trunk bus lane is introduced on the existing road which is maintained at about a 36m to 30 m right of way (ROW) width on the existing road segments.

(3) Priority Trunk Bus Lane

The function and characteristics of the priority trunk bus lane are as follows:

1) Priority trunk bus lane is mainly operated by trunk buses during peak hours. The conventional buses selected are operated on the frontage road or right side lane of the existing carriageway.
2) Private cars and taxis can be used on this lane during peak hours, however, when trunk buses are circulating, private cars or taxis should avoid passing through the trunk bus traffic flows.
3) In the off peak hours, all vehicles can use this lane.

4) Priority trunk bus lane is not segregated by any separator from other traffic flows.

5) Priority trunk bus lane is introduced on the trunk road which is maintained at about 25ms right of way (ROW) width of the existing road.

7.2.2. TYPICAL CROSS SECTION OF TRUNK BUSWAY

(1) Design Criteria

1) Geometric Design

The design criteria of the trunk busway are as follows:

a) Design vehicle is adopted as articulated bus

b) Design speed is adopted at 60 km/h considering the function and characteristics of Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central. These roads are classified as the primary trunk road (Arterial) in Lima and Callao metropolitan area.

c) The roads to be studied which consist of Av. Venezuela, Av. Arica, Av. Ayllon and Carretera Central are located in the urban area.

Based on the above design criteria, the geometric design of the trunk busway is shown in Table 7.2-1.

Table 7.2-1 Geometric Design Standards

Items	Min. Design Standards	Adopted Standards
Road Function	Arterial	Arterial
Design Speed(km/h)	60	60
Stopping Sight Distance(m)	65	----
Passing Sight Distance(m)	420	-----
Min. Curvature (m)	100	300
Max. Grade (%)	4	1.0
Super Elevation (%)	2.0	2.0
Thought Traffic Lane Width (m)	3.5	3.5
Shoulder Width(m)	0	0.5
Frontage Road Lane Width(m)	6	6
Reservation Width(m)	2	2
Horizontal Clearance(m)	4.5	-----

2) Type of Vehicle Adopted

Generally, the trunk busway is operated by the articulated bus fleet (the transport capacity is about 150 passengers to 170 passengers).

3) Horizontal and Vertical Alignment

The trunk busway is constructed on the existing Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central. These roads are developed in almost flat terrain (about 1.0% to 2.1% longitudinal gradient) in the Lima and Callao metropolitan area. Therefore, the horizontal curvature and vertical or longitudinal gradient on these roads are very gentle. The horizontal and vertical alignments of the trunk busway are adopted at the same alignment of the existing roads.

4) Minimum Curvature and Maximum Gradient

The minimum horizontal curvature and the maximum longitudinal gradient of the existing Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central are shown in Table 7.2-2

Table 7.2-2 Minimum Curvature and Maximum Gradient on Project Roads

Items	Av. Venezuela side	Carretera Central side
Min Curve (m)	3,000	500
Max Gradient (%)	1.0 to 2.1	1.0 to 2.0

(2) Width of Cross Section Elements to be Adopted

1) Traffic Lane Width

The existing Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central are formed as the primary trunk road network in the Lima and Callao metropolitan area, and these roads are classified as the arterial road. According to the road design manual in Lima, the following lane width is recommended:

a) Through traffic lane width=3.50 m

b) Frontage traffic lane width=3.00 m

2) Road Shoulder Width

According to the road design manual, the road shoulder width is not mentioned. However, 0.50 ms width of carriageway shoulders on both sides of the carriageway are recommended, considering mainly the following reasons:

a) The shoulder width or space can be protected to prevent traffic accidents on the through traffic lane.

b) The shoulder width or space can be used for parking space for emergencies/ accidents of vehicles (for instance, engine troubles during operation).

c) The shoulder width or space can be maintained in good pavement condition on the carriageway.

d) The shoulder width or space can be used for compatible driving on the trunk roads.

e) The shoulder width or space can be used for working on the improvement of the carriageway without interrupting the existing operation of traffic flows.

3) Central and Outer Reservation Width

The 2.0 m width of central reservation and outer reservation width is recommended, and also, trees and grass should be planted in these reservations, for keeping good natural environmental aspects in the Lima and Callao metropolitan area.

4) Side-walk Width

According to the road design manual in Lima, the side-walk is adopted at the 3.5 m width. However, a side-walk width of 4.0 m which includes walking and plantation spaces is recommended in the Study.

(3) Number of Lanes Required for Trunk Busway

In general, the number of lanes required is decided on the basis of the lane capacity and the number of vehicles projected. However, the number of bus lanes required should consider the capacity of bus stop facilities. The relationship between the lane capacity, bus stop capacity, and number of bus vehicles projected is shown in Table 7.2-3. As a result of the comparison study, one bus lane per direction is adopted.

Table 7.2-3 Capacity of Lane and Trunk Bus Volume Projected

Items	Exclusive Busway	Exclusive Bus Lane	Priority Bus Lane
Capacity/Lane	2,500 pcu/hour/lane	2,250 pcu/hour/lane	2,000 pcu/hour/lane
	710 Bus/hour/lane	640 Bus/hour/lane	570 Bus/hour/lane
Capacity/1-Bus Booth	180 -200 Bus/hour/lane	180-200 Bus/hour/lane	180-200 Bus/hour/lane
Capacity/2-Bus Booth	360-400 Bus/hour/lane	360-400 Bus/hour/lane	360-400 Bus/hour/lane
No. of Bus Volume 2010	80 bus fleets / hour/lane	80 bus fleets / hour/lane	80 bus fleets / hour/lane
No. of Bus Volume 2025	100 bus fleets/hour/lane	100 bus fleets/hour/lane	100 bus fleets/hour/lane
No. of Bus lane required	1-lane/direction	1-lane/direction	1-lane/direction

(4) Route Location of Trunk Busway

The route location of the trunk busway is decided based on the following factors:

1) The results of the recommendation of future trunk bus network of the Urban Transportation Master Plan in Lima and Callao metropolitan area which was conducted by the JICA in 2004.
2) The existing road right of way (ROW) width on the Av. Venezuela, Av. Arica, Av. Ayllon, y Carretera Central.
3) The function of exclusive trunk busway, exclusive trunk bus lane, and priority trunk bus lane.
4) The existing road network configuration.
5) The existing and future bus passengers demand.
6) The existing bus operation network.

The west side route of the trunk busway is located on Av. Venezuela (Callao) and Av. Arica as the west side, and the east side is located on Av. Ayllon and Carretera Central at Santa Anita.

(5) Typical Cross Section of Trunk Busway

As mentioned previously, the trunk busway is classified in three types, namely the exclusive trunk busway, exclusive trunk bus lane, and priority trunk bus lane based on the right of way width of the existing road. The exclusive trunk busway is also divided into three (3) typical cross section such as Type-A, Type-B, and Type-C depending on the right of way width of the existing road. The exclusive trunk bus lane is adopted at the typical cross section Type-D, and the priority trunk bus lane is adopted at the typical cross section Type-E respectively. The conditions of each typical cross section are described below:

1) Exclusive Trunk Busway (Type-A)

The exclusive trunk busway is adopted on the existing road which is ensured a right of way (ROW) width of about 52m. The exclusive trunk busway is divided by concrete separators from the private vehicle traffic flows, to maintain traffic safety, and to ensure the effectiveness of trunk bus operation. The typical cross section of the exclusive trunk busway (Type-A) is shown in Figure 7.2-1.

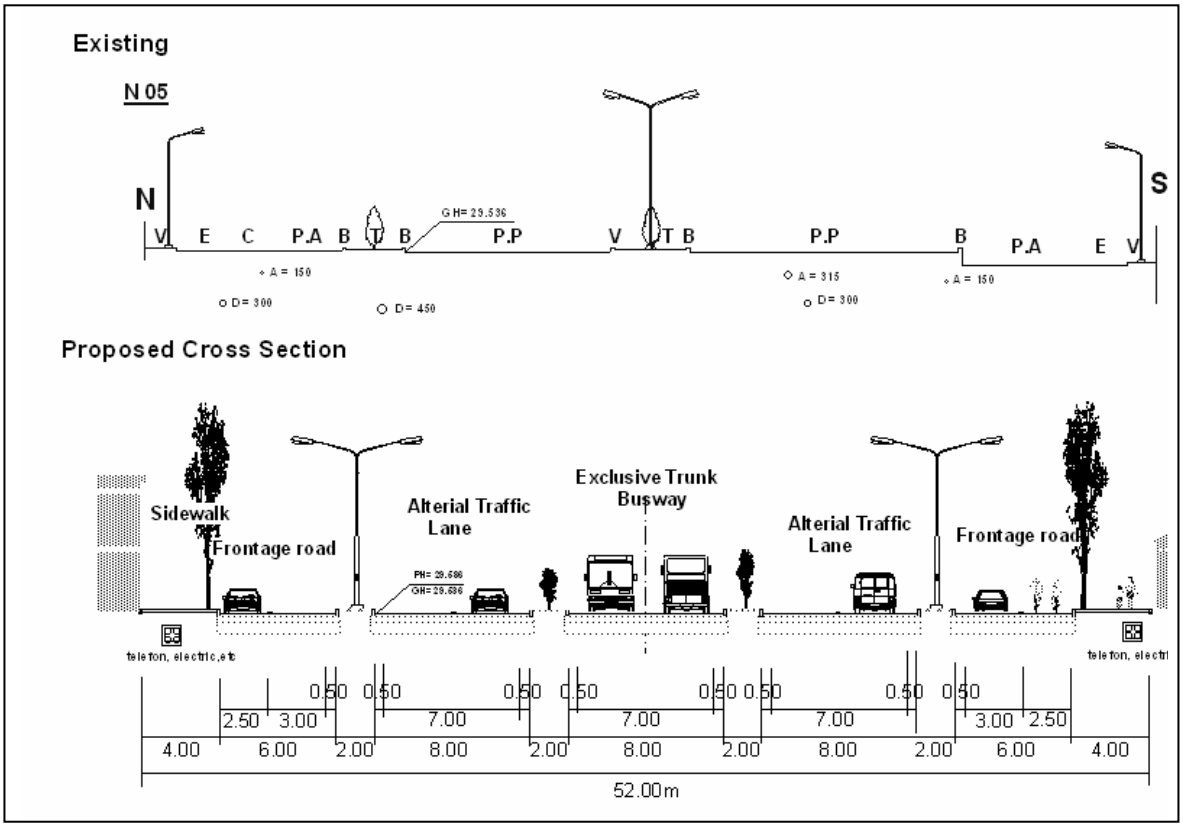


Figure 7.2-1 Typical Cross Section 52m (Type-A)

2) Exclusive Trunk Busway (Type-B)

The typical cross section Type-B is adopted at the about 42.0 m right of way width of the existing road segment. The typical cross section of the exclusive trunk busway (Type-B) is shown in Figure 7.2-2.

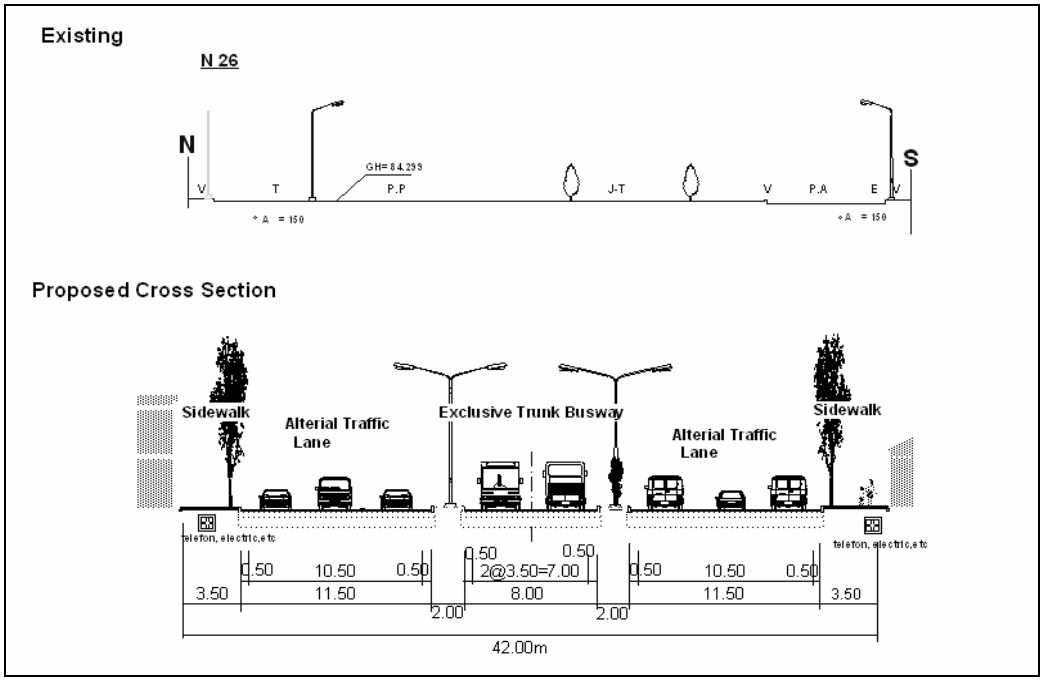


Figure 7.2-2 Typical Cross Section 42m (Type-B)

3) Exclusive Trunk Busway (Type-C)

The typical cross section Type-C is adopted at the about 36.0 m right of way width of the existing road segment. The typical cross section of the exclusive trunk busway (Type-C) is shown in Figure 7.2-3.

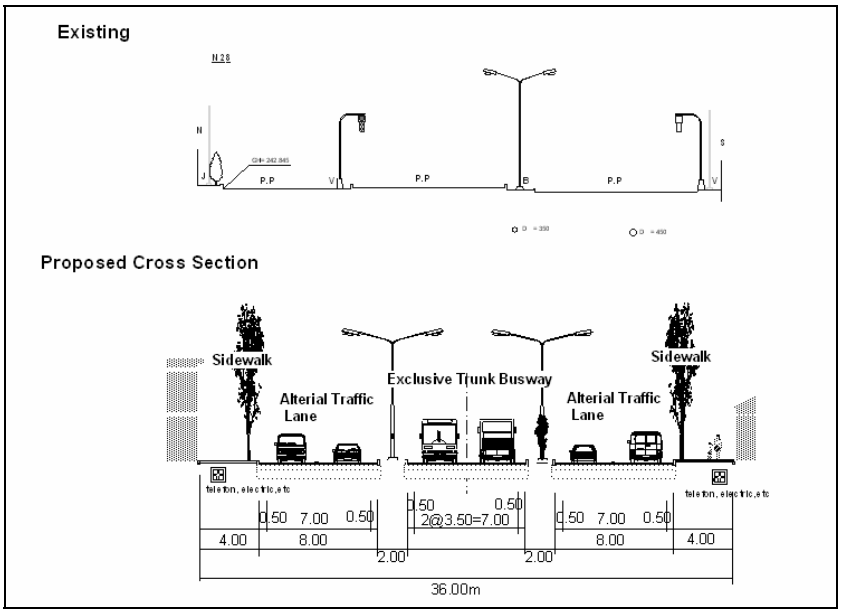


Figure 7.2-3 Typical Cross Section 36m (Type-C)

4) Exclusive Trunk Bus Lane (Type-D)

The exclusive trunk bus lane (Type-D) is adopted on the existing road which is maintained the about 30 m right of way (ROW) width and 6-lane dual carriageway. The exclusive trunk bus lane is divided from private vehicle traffic flows without separator to consider the decreasing the construction costs and easy implementation of the trunk bus system. The typical cross section of the exclusive trunk bus lane (Type-D) is shown in Figure 7.2-4.

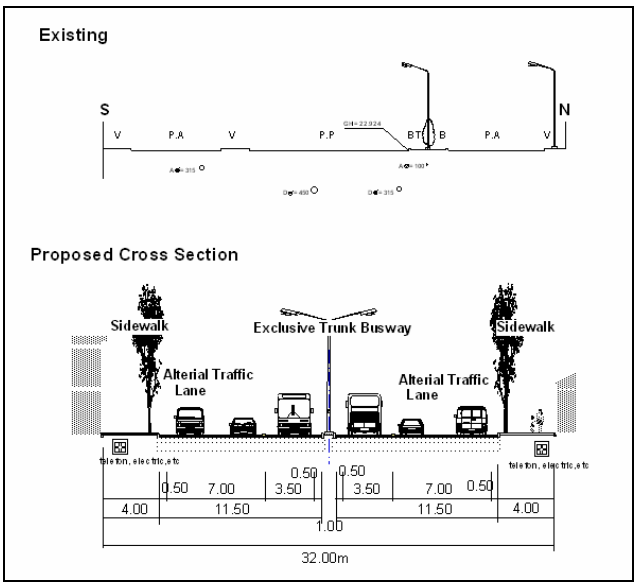


Figure 7.2-4 Typical Cross Section 32m (Type-D)

5) Priority Trunk Bus Lane (Type-E)

The priority trunk bus lane (Type-E) is adopted on the existing road which is marinated at the about 20m to 25m right of way (ROW) width and 4-lane dual carriageway. The priority trunk bus lane is used at the same traffic lane of the existing roads. The typical cross section of priority trunk bus lane (Type-E) is shown in Figure 7.2-5.

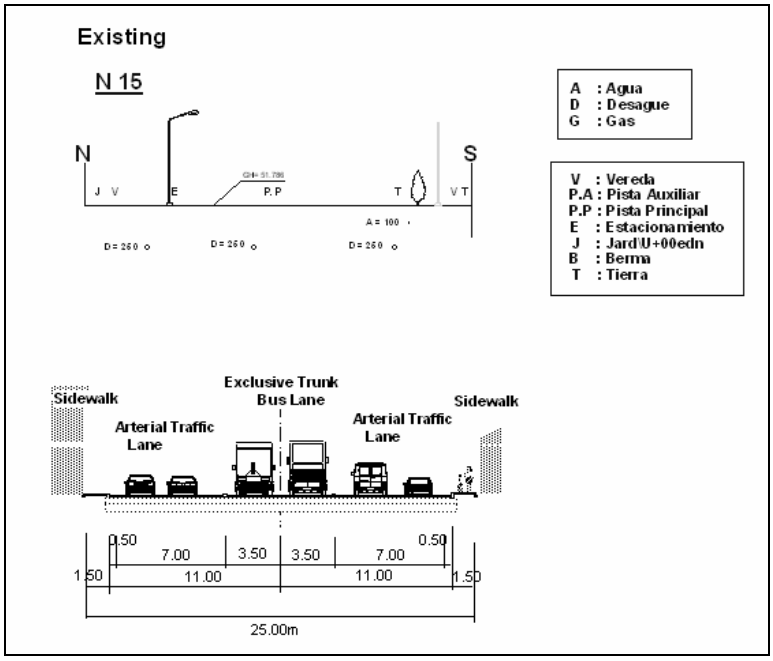


Figure 7.2-5 Typical Cross Section 25m (Type-E)

7.2.3. GUIDELINE OF BUS STOP AND BUS TERMINAL DEVELOPMENT

The preliminary designs of the bus stop and bus terminal facilities are not included in the Study. However, the function of bus stop and bus terminal facilities, and the guidelines or suggestions for preliminary design conducted in the future study are described in this section.

(1) Trunk Bus Stop Facilities

1) Function of Bus Stop Required

The function of bus stop on the trunk busway requires the following characteristics:

a) In future, the trunk bus network will be connected to the entire trunk bus network to introduce the integrated system based on the results of the Urban Transportation Master Plan in Lima and Callao.

b) To generate new job opportunities and to secure a smooth bus operation, a bus ticket sale office should be constructed at the entrance of the bus stop.

c) To ensure traffic safety at the bus stop, the bus stop should be protected by a safety fence and other safety materials.

d) To increase the transportation services, a time table and information boards should be installed at the bus stop.

e) To ensure safety and comfort, lumps, benches, roofs and walls should be installed in the bus stop.

f) To prevent traffic accidents on pedestrian crossings from bus stops to side walks, exclusive pedestrian traffic signals should be installed.

2) Location of Bus Stops

The location of bus stops on the trunk busway is decided based on the following criteria and considerations:

a) To connect directly to the future trunk busway network.

b) To connect to the conventional bus stop where possible.

c) Maximum distance between bus stop on the trunk busway is adopted at a distance of about 800 m to 1,000 m, in order to ensure the traveling comfort of the bus passengers and to ensure the high operation speed of the trunk bus.

d) To connect with the area where a large number of bus passengers are collected.

The location of bus stops on the trunk busway is shown in Figure 7.2-6.

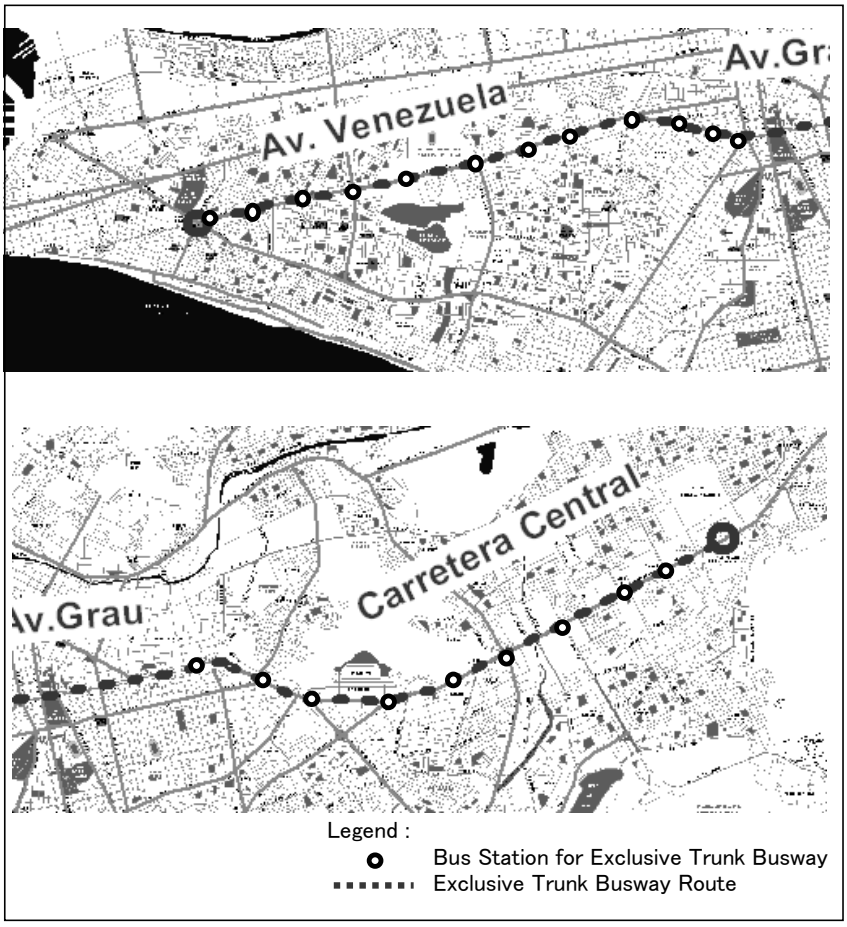


Figure 7.2-6 Location of Bus Stops on Trunk Busway

3) Height of Platform Level of Bus Stop and Door Side of Bus Fleet

As mentioned previously, the exclusive trunk busway was constructed on Av. Grau, and the final design of COSAC project which includes the construction of an exclusive trunk busway on the North-South traffic axis and a central bus terminal under the Paseo De Los Héroes Navales were completed. The heights of the platform of the bus stop and the door side of the bus fleet between Av. Grau project and COSAC project are different, however, these two (2) exclusive trunk busways are directly connected in the Central Bus Station which is located under the Paseo De Los Héroes Navales. And also, the East-West trunk

busway (the Project) is directly connected to COSAC project via trunk busway on Av. Grau.

This section, will clarify the differentiation between COSAC project and Av. Grau project, and make a suggestion for the final design of the East- West trunk busway which will be implemented in the future. The planning situations of the exclusive trunk busway of COSAC project and the Av. Grau project are shown in Figure 7.2-7

a) Planning Conditions and Situation of COSAC Project

The planning conditions and situations of the COSAC project are as follows:

- The Central Bus Station is planned at the underground (B-1 floor) of the Paseo De Los Héroes Navales, and the construction of the Central Bus Terminal will commence in September 2006 and will be completed in the middle of 2008.
- In the Central Bus Station, five (5) bus platforms for articulated buses are planned, and three (3) bus lanes with anti-clockwise traffic flows are planned.
- The 5 bus platforms are planned on the left hand side of the trunk bus lane, so, the bus fleet should have its doors on the left hand side of the vehicles.
- Existing conventional bus fleets have their doors on the right hand side of the vehicles.
- The height of the platform located in the bus terminal is planned at 90 cm from surface of bus lane.
- The bus stops of COSAC project are planned at the left side of both bus lanes, Therefore, the door of the bus fleet should be located on the left hand side of the vehicles.
- The height of the platforms of the bus stops is planned at 90 cm from surface of the bus lane.

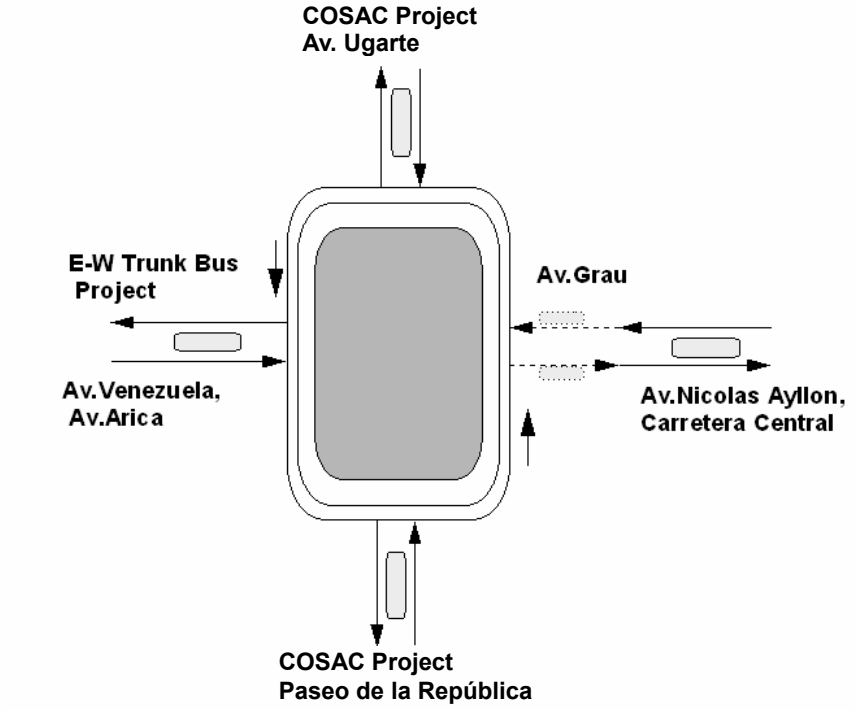


Figure 7.2-7 Bus Stop and Central Bus Station

b) Construction Conditions and Situations of Av. Grau Project

The construction conditions and situation of the Av. Grau project are as follows:

- The construction was completed in August 2006.
- The exclusive trunk busway with 4-lane dual carriageway is constructed as an underpass of the existing lateral roads.
- The bus stops of Av. Grau are located on the right hand side of the bus lanes.
- The height of the bus stop platform is about 20cm.
- The right side of the bus fleet door should be operated.
- Therefore, buses which circulate on the Av. Grau cannot use the Central Bus Terminal without modification of the doors on the bus fleet.

c) Relationship Between Low Level (20 cm) and High Level (90 cm) Platform

The advantages and disadvantages of low and high level platforms are as follows:

- The 90 cm in high level platform of the bus stops cannot be used for the existing conventional buses, due to the fact that the existing platform of conventional buses is constructed at a low level.
- The high level platform can be maintained for smooth and rapid on-boarding and off-boarding from/to the bus fleet.
- The low level platform can be maintained for the future extension of the trunk bus system on the other route.
- The high level platform is required to provide the slope and lift facilities at the bus stop for physically handicapped and elderly persons.
- Therefore, the high level platform is more costly than the low level platform.

d) Differentiation between COSAC project and Av. Grau Project

The differentiation of bus facilities between COSAC project and Av. Grau project is shown in Table 7.2-4.

Table 7.2-4 Differentiation of Bus Stop Conditions

Items	COSAC Project	Av. Grau Project	Correlation
Operated Bus Type	Articulated bus	Articulated bus Conventional bus	No relation
Location of Bus Stop	Left side of bus lane	Right side of bus lane	No relation
Height of Platform at Bus Stop on existing road	H=90 cm	H=15cm to 20 cm	No relation
Height of Platform at Bus Stop on Bus Terminal	H=90 cm	(Connected to Same Bus Terminal)	No relation
Door Side of Bus Fleet	Left side of bus	Right side of bus	No relation

e) Right Side Door and Left Side Door of Bus Fleet.

The advantages and disadvantages of door side of bus fleet are mentioned as follows:

- The door of existing conventional buses is maintained on the right side.
- Therefore, existing buses cannot use the central bus terminal without modification of the bus fleet.

- When the left side door bus fleets become old, they cannot be shifted to the other bus routes.

f) Door Side and Height of Platform Adopted on the East- West Trunk Busway

Considering the above mentioned situations about the COSAC project and Av. Grau improvement project, and also the results of discussion with the Peruvian Counterparts, the type of bus stop facility on the East-West trunk busway is adopted at the same system of COSAC project. The adopted bus stop facilities conditions are as follows.

1) Bus stop will be planned at the left side of trunk busway
2) Platform height of bus stop is 90 cm from surface of the busway pavement
3) Door of trunk bus will be installed at the left side of bus fleet
4) New bus fleets for operation on the East-West trunk busway should be procured.

g) Bus Stop Facility Improvement Plan on Av. Grau Conducted

As mentioned in previous Chapter 7.2.3 (1), 3) d), the location and high of platform conditions at bus stop between COSAC project and the existing Av. Grau is not harmonized. Therefore, the Peruvian counterparts decide to change the following existing bus stop conditions on Av. Grau.

1) The location site of bus stop should be changed from right side of bus lane to left side of bus lane.
2) The platform height of bus stop should be changed from 20 cm high to 90 cm high.

In accordance with the above mentioned changing conditions, the bus stop facility improvement plan on the existing Av. Grau is conducted. The plan and cross section design of improvement plan is shown in Appendix "Drawings", and the rough construction cost for improvement is estimated. The rough cost is shown in later section 7.5 "Project Cost Estimate."

4) Typical Bus Stop Facility

Considering the function of bus stop for the trunk busway, the following facilities should be constructed:

a) At least, 2-bus booths should be constructed.
b) Bus booth should be protected by a fence or guardrail.
c) Information boards and bus operation timetables should be installed.
d) Roof, wall, lighting, and benches etc. should be installed.
e) Bus ticket sales office should be installed in bus booth.
f) Pedestrian crossing should be installed with traffic signals for passengers on both sides of the road.

5) Suggestion for Preliminary and Final Design of Bus Stop

When the preliminary and final designs of bus stop facilities for the trunk busway are implemented in the future, the following matters should be considered:

a) To ensure the bus stop functions mentioned previously.
b) To create the modern type of bus stop such as Curitiba city in Brazil and Bogota city in Colombia, considering perspective and environmental viewpoints of Lima and Callao metropolitan area.

c) To ensure safety and to incorporate comfortable facilities.

d) To review the height of platform and door side conditions of the articulated bus fleet.

e) In the future, the railway extension project and the trunk busway will be connected with the railway station on the existing Av. Grau. The preliminary and final design of the bus stop of the trunk busway should consider the following items:

- Future passenger demand between trunk busway and the railway should be forecasted, and the passenger characteristics should be analyzed.
- The space for the construction of railway station and bus stops is limited. Therefore, the full utilization of the existing road will be required.
- To increase the future passenger demand of the railway and the trunk bus, the re-development project near the railway station and trunk bus stop will be required.
- The construction schedules of the railway project, the trunk busway project, and re-development project should be coordinated to ensure simultaneous completion.

(2) Central Bus Station

1) General Conditions of the Central Bus Station

The general conditions of the Central Bus Station are as follows,

a) The Central Bus Station was planned for bus station of COSAC trunk bus Project, and the final design was also completed by Protransporte already.

b) However, the construction stage is not commenced yet.

c) The Central Bus Station was located at the underground of Paseo de los Hetoes Navales.

d) The size or area of bus platform is 225m length for north-south direction and 36.5 m wide for east-west direction as shown in Figure 7.2-8.

e) The five (5) bus booths for COSAC project are planned.

f) The length of each bus booth is prepared at 34.0m (articulated bus=18.5m and weaving length=15.5m)

g) The 90 cm high of platform is designed.

h) Three bus lanes are prepared around bus platform by counterclockwise.

i) Commercial area is planned at the Center of bus platform

j) The Central Bus Station will be directly connected to Av.Ugarte, Paseo de la Repubulica, and Av. Grau.

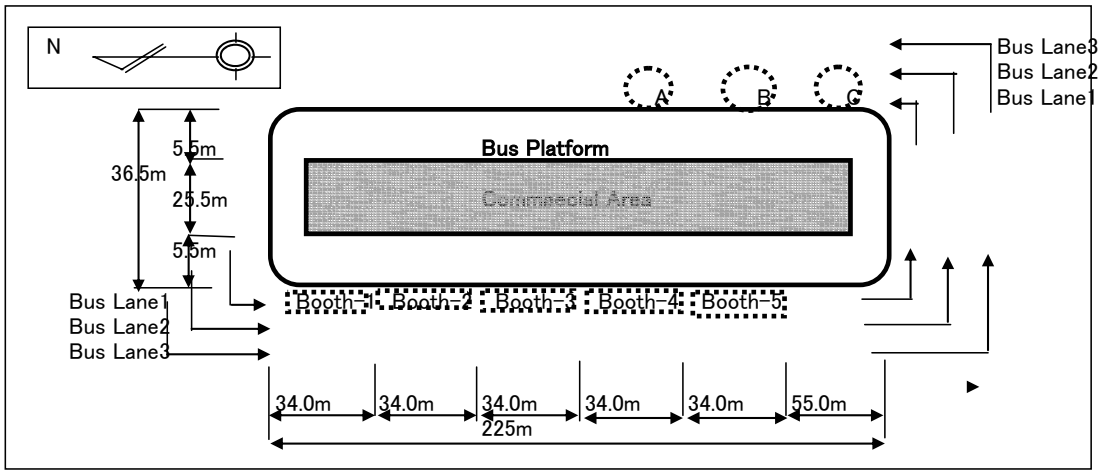


Figure 7.2-8 General Layout of Central Bus Station

2) Function of Central Bus Station

The first, the Central Bus Station was designed for only COSAC trunk bus project. Therefore the layout of commercial area and bus booth are designed only for COSAC trunk bus project. However, the trunk bus routes of the East-West trunk bus are recommended to connect to COSAC trunk bus route in the Central Bus Station as shown in Figure 7.2-9.

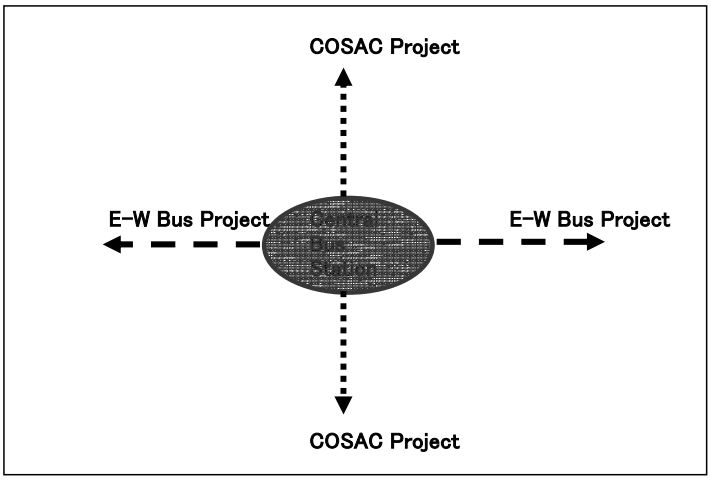


Figure 7.2-9 Connection System between COSAC and East-West Project

Considering connection system between COSAC and East-West projects, the following functions are required in the Central Bus Station.

a) The Central Bus Station is not bus terminal. Therefore, location of bus paring areas will not be required.
b) To ensure smooth transfer between COSAC trunk bus passengers and East-West trunk bus passengers.
c) To ensure the safety and good environmental aspects especially ventilation of air control.

3) Required Facility by East-West Trunk Bus Project in Central Bus Station

In East-West trunk bus project, three operation bus routes such as Line-1(Santa Anita Bus Terminal----Central Bus Station), Line-2(Callao Bus Terminal----Central Bus Station), and Line-3(Santa Anita Bus Terminal----Callao Bus Terminal via Central Bus Station) are recommended.

Considering trunk bus operation bus Lines and demand of each bus operation Lines, the following total three (3) bus booths for the East-West trunk bus project are required in the Central Bus Station.

a) Operation Line-1= 1-bus booth
b) Operation Line-2=1-bus booth
c) Operation Line-3=1-bus booth

The required length of each bus booth is adopted at 34.0m (length of articulated bus fleet=18.5m, length of weaving of bus lane= 15.5m) as same as the COSAC project

4) Frequency and Number of Bus Passengers of Each Bus Operation Lane in Central Bus Station by East-West Trunk Bus Project

The number of passenger, number of bus operated, and bus stopping time at bus booth are presented in Table 7.2-5.

Table 7.2-5 Operation Conditions of East-West Trunk Bus Project in Central Bus Station

Bus Line	Direction	No. of Passenger /hour	Frequency (minute)	No. of Passenger / Bus	No. of passenger / bus door	Bus Stopping Time at bus booth(second)
Line-1	East-West	3,337	1.46	81	20	20
	West-East	2,992	1.46	73	18	18
Line-2	West-East	2,051	2.61	89	23	23
	East-West	2,893	2.61	125	31	31
Line-3	East-West	829	2.07	20	5	5
	West-East	553	2.07	19	5	5

From the Table 7.2-5, the following conditions are pointed out.

a) The frequency of the trunk bus on the bus operation Line-1 is estimated at 1.46 minute interval and bus stopping time at bus booth is estimated at 38 seconds (boarding time = 20 s, alighting time=18 s).

b) The frequency of the trunk bus on bus operation Line-2 is estimated at 2.61 minute interval and bus stopping time at bus booth is estimated at 54 seconds (boarding time = 23 s, alighting time=31 s).

c) The frequency of the trunk bus on bus operation Line-3 is estimated at 2.07 minute interval and bus stopping time at bus booth is estimated at 10 seconds (boarding time = 5 s, alighting time=5 s).

5) Suggestion for Final Design Conducted by COSAC Project

The three bus booths for the East-West trunk bus project will be constructed at A, B, and C sites shown in Figure 7.2-8. Considering conditions of the Final Design of Central Bus Station by COSAC Project and the number of bus booth required by the East-West trunk bus project, the following conditions are suggested regarding the Final Design conducted by COSAC project.

a) Review of location sites of bus booth

b) Review of location site of commercial area
c) Review of bus passenger flow diagram, and entrance and exit facilities
d) Review of bus information boards and system, and it's related facilities
e) Review of environmental aspects such as air control system.

(3) Trunk Bus Terminal Facilities

1) Function of Trunk Bus Terminal

The trunk bus terminal function should ensure the following goals are achieved:

a) To develop the integrated system between the trunk bus system and feeder bus system in the bus terminal.

b) To connect or to transfer from trunk bus system to private car, conventional bus, taxi, bicycle, and pedestrian in bus terminal.

c) To ensure the smooth trunk bus operation system

d) To maintain safety and provide comfortable space

e) To maintain the administration activities of trunk bus operation

f) To preserve open space for passengers.

2) Location of Bus Terminal Candidate

As a result of discussions and reconnaissance surveys with Peruvian counterparts, the two (2) candidate bus terminals (existing vacant area) located near the beginning point of Av. Venezuela in Callao city and two (2) candidate bus terminals (existing vacant area) at Santa Anita in Lima city have been identified as shown in Figure 7.2-10. The Peruvian counterparts are examining four (4) candidate bus terminals with the District Land Registry. The items being examined are as follows:

a) Existing land owner

b) Existing land use and condition of land

c) Size of land and entrance for articulated bus route.

d) Land price and compensation

e) Possibility of land acquisition

It is very difficult to make the decision of land acquisition for the bus terminal between municipalities and the existing land owners, because the project is currently at the Feasibility Study stage. Therefore, Lima and Callao municipalities should continuously be carrying out negotiations with the existing land owners. However, the land acquisition cost and compensation are estimated, and these costs are included in the project cost.

The location of detailed candidate East-West trunk bus terminals are shown in Appendix "Drawings".

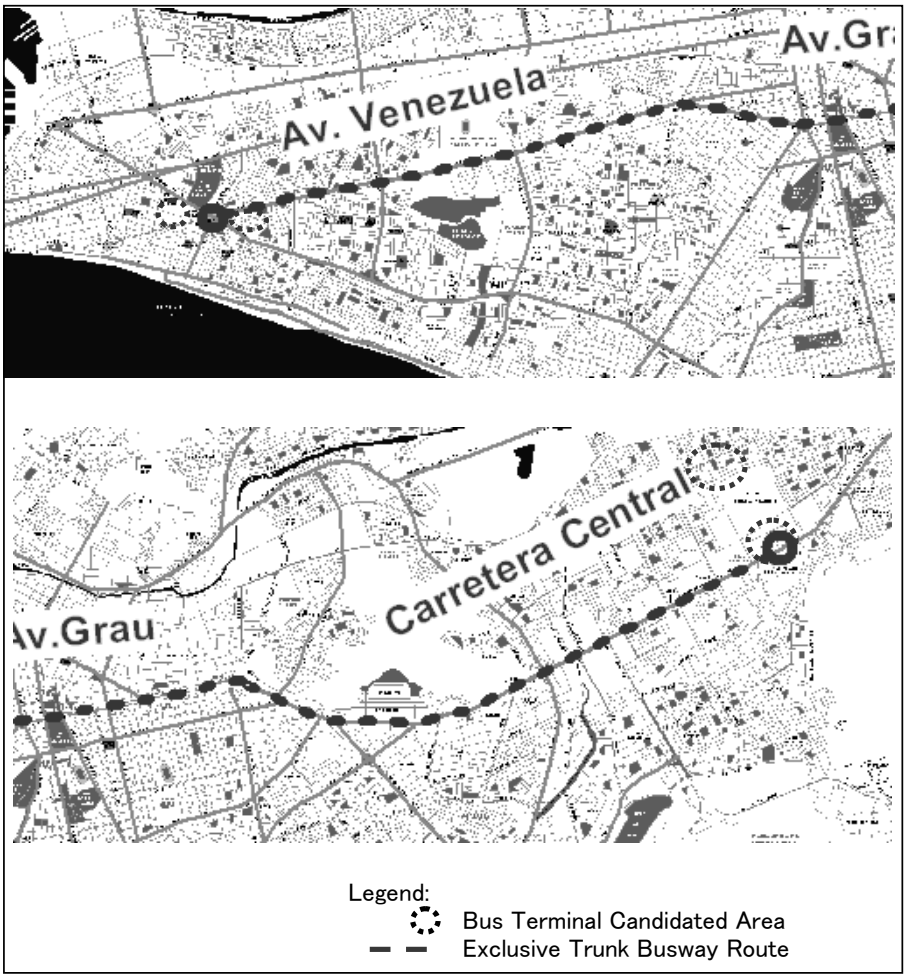


Figure 7.2-10 Location of Candidate Trunk Busway Terminal

3) Bus Terminal Facility Required

Considering the function of trunk bus terminal mentioned previously, the following facilities should be prepared:

a) Terminal should be surrounded by a fence, due to the introduction of the integrated bus system.

b) Trunk bus booth and feeder bus booth with roof

c) Bus waiting room and administrative office

d) Open space for passenger, kiosk, and toilet

e) Car parking space for private cars, taxis, and bicycles.

f) Bus parking space, gas station and bus maintenance office.

g) Bus ticket sales office and bus operator office.

h) Green open space for preserving good environmental aspects.

An initial drawing of the trunk bus terminal is shown in Figure 7.2-11 which will form the basis for the detailed design (final design) to be produced in the future.

4) Suggestion for Preliminary and Detailed Design of Bus Terminal

When the preliminary and detailed design or final design is prepared in the future, the following matters should be considered:

a) Around the trunk bus terminal, space should be prepared for bus stops for the conventional buses and parking for taxis.

b) The safety facilities such as perimeter fence, guardrail, pedestrian crossing, and height of step should be considered.

c) The environmental facilities for physically handicapped and elderly persons should be installed.

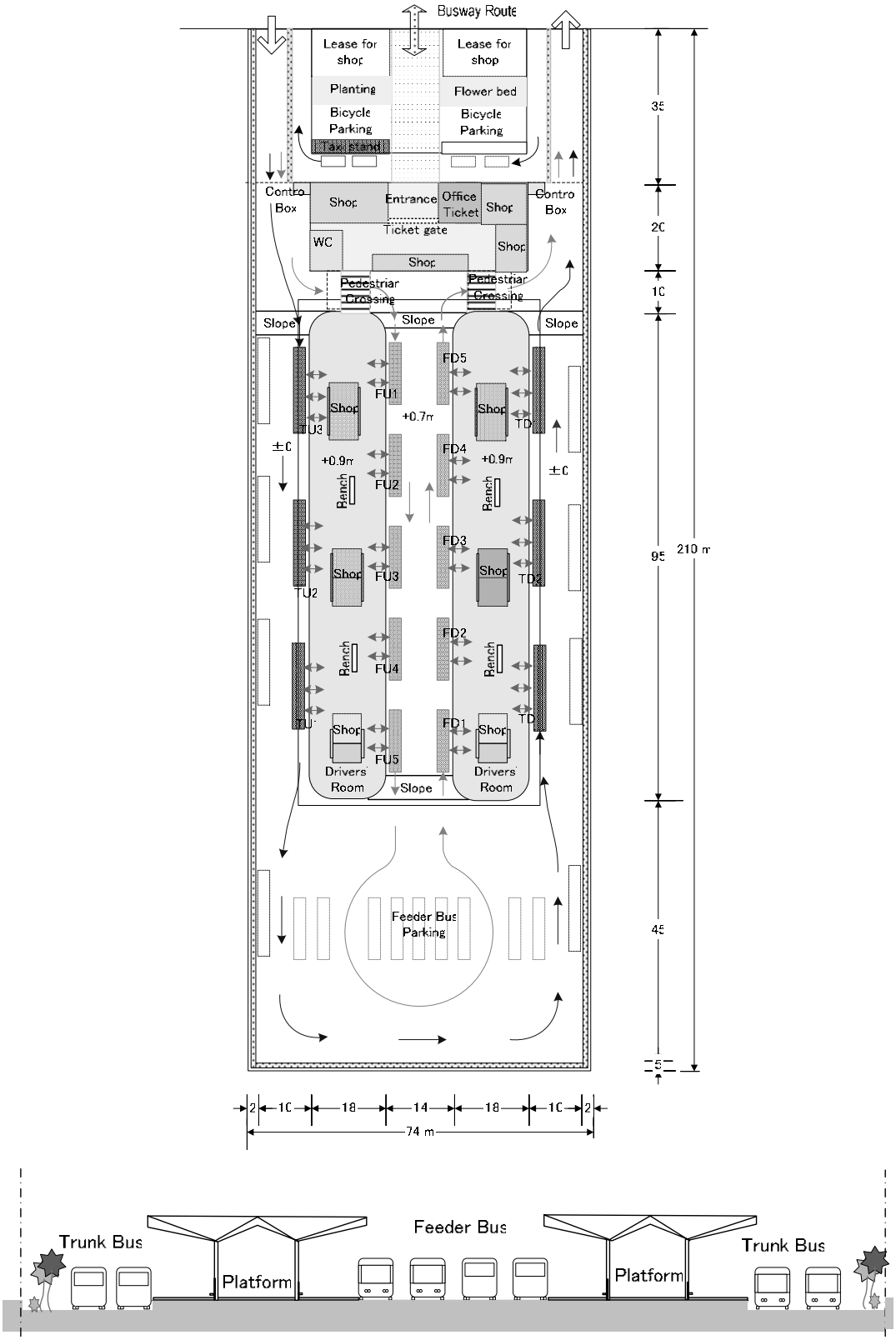


Figure 7.2-11 Initial Drawing of Trunk Bus Terminal

7.3. PRELIMINARY DESIGN FOR TRUNK BUSWAY

7.3.1. CONDITIONS OF PRELIMINARY DESIGN

(1) Designed Road and Facilities

The exclusive trunk busway of the East-West trunk system will be operated from Ovalo Saloon intersection on Av. Venezuela to the intersection of Av. Separadora Industrial on Carretera Central via Av. Arica. Av. Grau. Av. Ayllon. The preliminary design is conducted based on the Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central without Av. Grau, because, the exclusive trunk busway on the Av. Grau was already constructed and operated in August 2006. Therefore, the exclusive trunk busway constructed on Av. Grau is identified as the premises for the preliminary design of East-West trunk busway.

Considering the objectives of the Feasibility Study and working time schedule of the Study, the preliminary design of the bus stop facilities and bus terminal facilities are not included in this preliminary design study. However, the functions and characteristics of these facilities are examined in the Study.

(2) Base Map to be Used

1) Plan and Profile Design

The plan design of the trunk busway is prepared on the basis of the topographic map with a scale of 1: 5,000 (3D) which is published by Instituto Geografico Nacional (IGN).

The profile design of the trunk busway is prepared based on the results of the road inventory survey conducted by JICA Study Team in 2006. The longitudinal profile survey was conducted at about 200 m interval lengths along Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central.

2) Cross Section Design

The cross section design was conducted based on the results of a road inventory survey conducted by JICA Study Team in 2006. The cross section survey was conducted at about 200 m interval lengths and at the change of cross section elements along Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central.

3) Intersection Design

The intersection design was conducted to use the map with a scale of 1:5,000 or the aerial photo scale of 1: 1,000. In addition, the cross section survey was conducted on the intersection related road by JICA Study Team in 2006 in order to increase the accuracy of the design contents.

7.3.2. FIELD SURVEY CONDUCTED

Prior to the commencement of the preliminary design for the trunk busway, the following field surveys were conducted to increase the accuracy of contents of preliminary design and construction cost.

(1) Topographic Survey

1) Longitudinal Survey

The longitudinal profile survey was conducted by JICA Study Team in May and July 2006. This survey used the national bench mark in Peru. The survey was carried out on the right side of the pavement in the carriageway, and survey points were established at 200 m intervals along the existing Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central.

2) Cross Section Survey along the Project Road

The cross section survey was conducted by JICA Study Team in May and July 2006. The survey measured the following cross section elements at the same survey points of the longitudinal profile survey.

a) Right of way width
b) Number of traffic lanes
c) Width of carriageway
d) Width of each lane
e) Central reservation width
f) Pavement width
g) Pavement conditions
h) Related facility conditions
i) Land use condition along the road

In addition to the above, cross section surveys on the related roads at the planning intersection sites were conducted.

(2) Soil Investigation on Project Roads

In the past, many soil investigations of the following projects were conducted on the Av. Venezuela, Av. Ayllon, and Carretera Central as the same road as the Study roads. The results of soil investigation in the following projects are summarized in the Technical Report (Soil Investigation Data) of the Study.

a) Intersection Improvement Plan between Carretera Central and Av. La Molina (1993).(INVERMET)
b) Intersection Improvement Plan between Carretera Central and Av. Separadora Industrial (1993). (INVERMET)
c) Intersection Improvement Plan between Av. Ayllon and 28 de Julio (1996) (INVERMET)
d) Intersection Improvement Plan between Av. Venezuela and Av. Universitaria (INVERMET)
e) Final Design of Av. Venezuela and Av. Arica Improvement (1997) (INVERMET)

In addition to the above, the soil investigations (four sites) including the CBR test were conducted by the JICA Study Team in June 2006 in order to increase the accuracy of the existing ground conditions along the project roads. The results of Soil Investigation Data conducted are presented in Appendix 7-2 of this section.

(3) Underground Facilities Survey

The under ground facilities such as water supply pipe and sewage pipe survey was conducted based on the data collection from Servicio de Agua Potable y Alcantarillado de Lima (SEDAPAL), and field survey. According to the data collected and discussion with the staff of SEDAPAL, the large size of the facility under the existing road has not been examined.

1) On Existing Av. Venezuela

The water supply pipes are located under the side-walks of the existing Av. Venezuela. The size of water supply pipes are located at the about D=100 mm to D=315 mm with

depth about 2.0 m under ground from the road surface, and sewage pipes are located at about D=250 mm to D=450 mm with depth at about 2.5 m to 3.0 m under ground from road surface. There are about 239 manholes for sewage pipes along the existing Av. Venezuela. The typical water supply pipes and sewage pipes are shown in Figure 7.3-1.

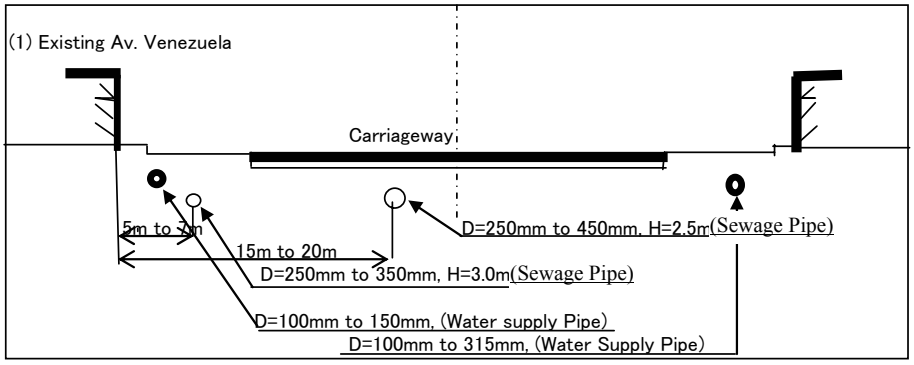


Figure 7.3-1 Typical Location of Water Supply and Sewage Pipe in Av. Venezuela

2) On Existing Av. Arica

The water supply pipes are located under the side-walks of the existing Av. Arica. The size of water supply pipes are located at about D=100 mm to D=150 mm with depth of about 2.0 m under ground from road surface, and the sewage pipes are located at about D=150 mm to D=600 mm with depth at about 2.5 m to 3.0 m under ground from road surface. There are about 71 manholes for the sewage pipe along the existing Av. Arica. The typical water supply pipes and sewage pipes are shown in Figure 7.3-2 .

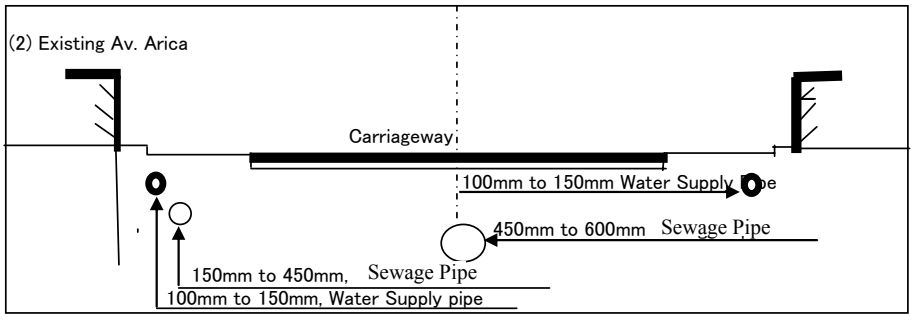


Figure 7.3-2 Typical Location of Water Supply and Sewage Pipe in Av. Arica

3) On Existing Av. Ayllon

The water supply pipes are located under the side-walks of the existing Av. Ayllon. The size of water supply pipes are located at about D=100 mm to D=250 mm with depth of about 2.0 m under ground from road surface, and the sewage pipe is located at about D=150 mm to D=400 mm with depth at about 2.5 m to 3.0 m under ground from road surface. There are about 142 manholes for the sewage pipes along the existing Av. Ayllon. The typical water supply pipes and sewage pipes are shown in Figure 7.3-3. The detailed water supply and sewage system are presented in Technical Paper “Water Supply and Sewage Pipe System.

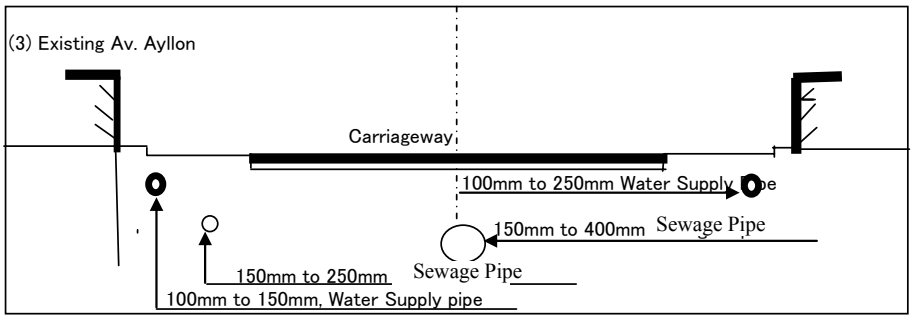


Figure 7.3-3 Typical Location of Water Supply and Sewage Pipe in Av. Ayllon

4) On Existing Carretera Central

The water supply pipes are located under the side-walks of the existing Carretera Central. The size of water supply pipes are located at about D=100 mm to D=200 mm with depth of about 1.5 ms to 2.0 m under ground from road surface, and the sewage pipe is located at about D=150 mm to D=600 mm with a depth of about 2.5 m to 3.0 m under ground from road surface. There are about 83 manholes for sewage pipes along the existing Carretera Central. The typical water supply pipes and sewage pipes are shown in Figure 7.3-4 The detailed water supply and sewage system are presented in Technical Paper "Water Supply and Sewage Pipe System.

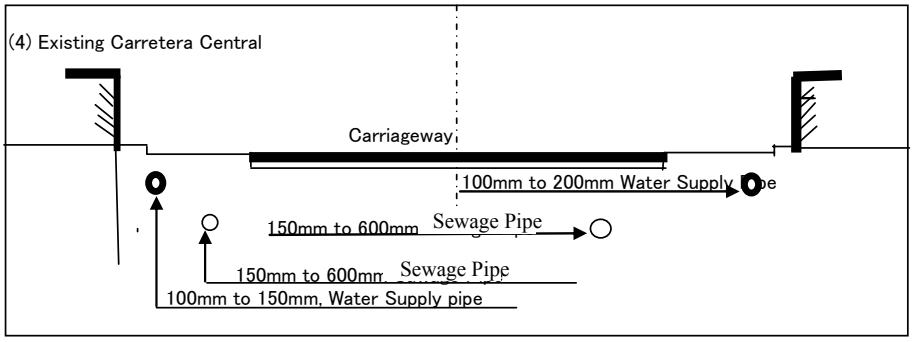


Figure 7.3-4 Typical Location of Water Supply and Sewage Pipe in Carretera Central

5) Telephone Line

The telephone lines in Lima and Callao metropolitan area are controlled by Telefónica Del Perú S.A.A. In general, the telephone lines are covered by PVC pipe with D= 3.0 inches to D= 4.0 inches and are located on both sides of the existing road. According to the drawings of the Project of the Existing Civil Infrastructure of Telefónica in the Trebol of Javier Prado prepared by Telefónica Del Perú S.A.A in 2006, the large size of the facility under the existing road is not observed.

6) Electrical Power Line Distribution

There are two (2) types of electrical power lines distribution. One is underground distribution cable installation at under the side walks with in depth between 0.5m to 2.0 m from surface of side walks. The power lines are covered by small concrete box or PVC or asbestos-cement or fiberglass. The other is over ground distribution cable installation at over the side walks with in high about 5.0 m from side walks by electrical pole.

7) Gas Pipe Line Distribution

In some road segment, the installation of gas distribution pipe lines has not completed yet, and installation works have been carried out by Calidda company in accordance with the

National Construction Regulation for Natural Gas Commercialization by ducts. The size of the main gas pipe is adopted at 8 inches made by polyethylene.

Av. Venezuela section: the main line is installed at section No.3 going out call las Oropendolas towards Av. Venezuela, through the whole road up to the intersection of section No. 5 with Av. Souza Pelaez.

Carre. Central section: the main line are installed at the from section No.2 on block 16 of Av. Ayllon to block 27 of intersection between Av. Ayllon and Av. Nugget. Other road section is installed at from the section No. 5 on block 25 to intersection between Caeeretera Central and Av. Separadora Industrial.

The above mentioned gas pipe are installed at in depth 1.2 m underground of side walks.

8) Suggestion for Detailed Design Stage and Construction Stage

When a detailed design and construction stage is conducted, the following matters should be considered.

a) The connection pipes between the main water supply pipe and each house or building are located at a comparatively shallow depth from the road surface. Therefore, the detailed design stage should be carefully conducted.

b) In addition, the excavation works and compaction works during construction should be carried out carefully so as to avoid damaging the connection pipes.

c) When detailed design and construction is carried out, the detailed water supply and sewage systems should be closely discussed with Servicio de Agua Potable y Alcantarillado de Lima (SEDAPAL).

7.3.3. ALIGNMENT DESIGN OF EXCLUSIVE TRUNK BUSWAY

(1) Horizontal Alignment Design

As mentioned previously, the exclusive trunk busway is constructed to use the space which is located in the central reservation area or central traffic lanes of the existing Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central. Therefore, the horizontal alignment (center line curvature) of the trunk busway is adopted as the same horizontal alignment of the existing roads. The horizontal alignment (center line curvature) of the existing roads is maintained as the almost straight line. The result of horizontal alignment of the exclusive trunk busway is presented in Appendix “Drawings”.

(2) Vertical Alignment Design

The exclusive trunk busway is constructed to use the existing pavement structure of the existing Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central. Therefore, the vertical alignment (longitudinal gradient) of the exclusive trunk busway is adopted as the same vertical alignment of the existing roads. The longitudinal gradient of the existing road is maintained as the almost 1.0 % to 2.1 % down slope from East direction to West direction. The result of vertical alignment of the exclusive trunk busway is presented in Appendix “Drawings”.

7.3.4. CROSS SECTION DESIGN

(1) Designed Section

The cross section design is conducted to use the results of the cross section survey conducted (about 200 m interval) by JICA Study Team. The cross section is conducted at the station No. 1 (Callao side) to station No. 43 (Lima side) along Av. Venezuela and Av. Arica and also conducted at the station No. 1 (Av. Grau) to No. 43 (Santa Anita) along Av.

Ayllon and Carretera Central. The location of No. of cross section design conducted are shown in Figure 7.3-5.

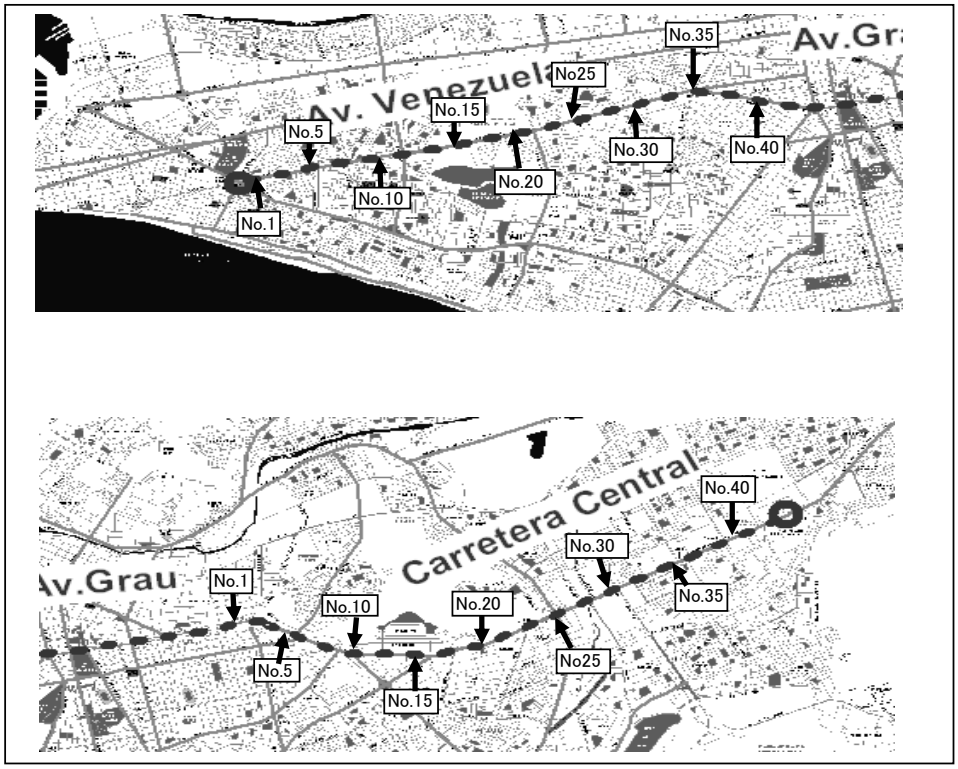


Figure 7.3-5 Location of No. of Cross Section Design Conducted

(2) Conditions of Cross Section Design

1) The cross section design is conducted based on the results of horizontal and vertical alignment design.

2) Design points are at about 200m intervals along the Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera central.

3) Basically, the cross section design is conducted to avoid additional land acquisition required where possible. This is namely, the cross sections of exclusive trunk busway which are designed within the existing right of way space on the existing road. According to the future right of way width (52.0 m right of way was decided by the Municipal Ordinance No.-0018-05 of October 1995), a total of 19 spaces on the Av. Venezuela (existing right of way is about 33m) will require additional land acquisition.

4) The cross section of the exclusive trunk busway should utilize the pavement of the existing road as much as possible, in order to reduce the construction cost.

5) The existing underground facilities such as water supply pipes and sewage pipes are located at 2.0 m to 3.0 m under the existing road. These facilities are used without excavation or demolished. However, the height of manholes should be improved at about 3.0 cm to 5.0 cm (this is overlay depth on the existing road).

6) As mentioned previously, the typical cross section is divided into five (5) types, type-A to type-E. The type of typical cross section is adopted depending on the right of way width of the existing road.

7) The cross section design is conducted to refer to the Detailed Design Reports and Drawings of Av. Venezuela and Av. Arica which was prepared by INVERMET in 1997.

8) The right of way width for the cross section design of the East-West trunk busway is adopted at the above mentioned Detailed Design which was prepared by INVERMET in 1997 based on Municipal Ordinance No.-0018-05 of October 1995.

(3) Results of Cross Section Design

The results of cross section design are summarized in Table 7.3-1. The detailed cross section design will be presented in Appendix "Drawings".

Table 7.3-1 Results of Cross Section Design

Road Name	Station No.	Road Segment Length(m)	Existing Right of Way Width (m)	Typical Cross Section Adopted	Remarks
Av. Venezuela	No. 1 To 4	L=600 to L=650	W=32.50	Type-A (W=52.0m)	1. About 20m width and 600m length of land acquisition is needed on right side of road 2. This land belongs to Callao City. (At present, private company is used) 3. Callao city should negotiate with private company.
	No.4 To 7	L=600 To 650	W=52.20 To 55.30	Type-A (W=52.0m)	———
	No.7 To 8	L=250	W=32.50	Type-A (W=52.0m)	1.About 20m width and 250m length of land acquisition is needed on right side of road 2. This land belongs to Lima City. (At present, private company is used) 3.Lima city should negotiates with private company.
	No.8 To 12	L=800	W=50.90 To 51.70	Type-A (W=52.0m)	1. About 0.5 m width decreased of side-walks
	No.12 To 14	L=300	W=33.40 To 33.80	Type-A (W=52.0m)	1.About 33.5m width and 300m length of land acquisition is needed on right side of road
	No.14 To 17	L=600	W=24.75 To 24.90	Type-A (W=52.0m)	1.About 24.50m width and 600m length of land acquisition is needed on right side of road 2. This land belongs to Lima City. (At present, navy school is used as play ground) 3.Lima city should negotiates with navy school..
	No.18 To 19	L=100	W=24.35	Type-E (W=25.0m)	1. There are ruins on both road sides. 2. About 2.5m width decreased on both sides of side-walks.
	No.19 To 31	L=2,300m	W=40.50 To 42.50	Type-A (W=52.0)	———
	No.31 To 34	L=650m	W=39.00 To 40.70	Type-B (W=42.0m)	1. About 1.0 width deceased on both sides of side-walks.
Av. Arica	No.34 To 43	L=1,600	W=30.0 To 31.0	Type-D (W=32.0)	1. About 1.0 width deceased on both sides of side-walks.
Av. Ayllon	No.1 To 4	L=650	W=23.0	Type-E (W=25.0m)	1. About 1.0 width deceased on both sides of side-walks.
	No.4 To 10	L=1,000	W=26.0	Type-E (W=25.0m)	1. About 2.5 width deceased on both sides of side-walks.

	No.10 To 16	L=1,400	W=36.0	Type-C (W=36.0m)	———
Carretera Central	No.16 To 42	L=5,200	W=38.0 To 45.0	Type-B (W=42.0m)	———
	No.42 To .43	L=200	W=52.0	Type-A (W=52.0m)	———

7.3.5. INTERSECTION DESIGN

(1) Existing Intersection Improvement Project

The six (6) intersection improvement projects were designed on the Av. Venezuela, Av. Arica, Av. Ayllon, and Carretera Central prepared by Lima municipality and Callao municipality during the period from 1993 to 1996. The conditions or situation of the above mentioned intersection improvement plans are presented in Table 7.3-2

Table 7.3-2 Conditions and situation of Intersection Improvement Projects

Project Location	Outline of Project	Const. Schedule	Budget Procurement
(1) Between Av. Venezuela and Av. Faucett	1. Road inventory survey was conducted in 2003. 2.Detailed design was conducted in 2005 by private consultant in Lima 3.Through traffic lane with 6-lane dual carriageway of Av. Faucett is passed under Av. Venezuela without connection to the Av. Venezuela. 4.Frontage roads with 2-lane located on both Av. Faucett are connected to Av. Venezuela.	At present, not yet decided. .	At present, not yet decided. .
(2) Between Av. Venezuela and Av. Universitaria	1. In 1993, the detailed improvement design was completed by INVERMET. 2. Av. Universitaria with 6-lane dual carriageway is passed over the existing Av. Venezuela. 3. Type of interchange is adopted at half clover leaf type. 4. Additional land acquisition for construction of project will be needed. However, at present the land required has not yet been acquired. 5. Interchange is adopted at diamond type.	At present, not yet decided.	At present, not yet decided.
(3) Between Av. Ayllon and Av. 28 de Julio, Av. Aguero	1. In 1997, the detailed improvement design was completed by INVERMET. 2. This intersection is formed at 3 different level interchange. 1st level on existing ground is planned at Av. Ayllon, 2nd level is at-grade intersection between Av. Ayllon and Av. 28 de Julio, and Av. 28 de Julio with 3rd level is passed over the at-grad intersection located at 2nd level.	At present, not yet decided.	At present, not yet decided.
(4) Between Carretera Central and Av. La Molina	1. In 1993, the detailed improvement design was completed by INVERMET. 2. This interchange is formed at diamond type. 3. Av. La Molina with 4-lane dual carriage way is passed over Carretera Central.	At present, not yet decided.	At present, not yet decided.
(5) Between Carretera Central and Av. Hermilio Valdiza	1. In 1993, the detailed improvement design was completed by INVERMET. 2. This interchange is formed at diamond type. 3. Av. Hermilio Valdiza with 6-lane dual carriage way is passed over Carretera Central.	At present, not yet decided.	At present, not yet decided.

(6) Between Carretera Central and Av. Separadora Industrial	1. In 1993, the detailed improvement design was completed by INVERMET. 2. This interchange is formed at diamond type. 3. Av. Separadora Industrial with 6-lane dual carriage way is passed over Carretera Central.	At present, not yet decided.	At present, not yet decided.

(2) Conditions of Intersection Design

The preliminary intersection design in this study is conducted based on the following conditions:

1) The intersection design is conducted within area which is covered by right of way width of the existing road to avoid additional land acquisition where possible.
2) The type of intersection designs adopted is at-grade intersection, because, this project should be constructed by 2010.
3) In order to increase the accuracy of construction cost estimates, the cross section surveys on the related roads of the intersection to be planned were conducted in June 2006 by the JICA Study Team. The results of each cross section survey are presented in Technical Report "Road Inventory Survey (Intersection).
4) The preliminary intersection design is conducted at the following nine (9) intersections with scale at 1 to 1,000:
    a) Intersection between Av. Venezuela and Av. Insurgentes (Callao)
    b) Intersection between Av. Venezuela and Av. Faucett (Callao)
    c) Intersection between Av. Venezuela and Av. Universitaria (Lima)
    d) Intersection between Av. Venezuela and Av. Thordike (Lima)
    e) Intersection between Av. Venezuela and Av. Tingo Maria (Lima)
    f) Intersection between Av. Ayllon and Av. Circunvalación (Lima)
    g) Intersection between Av. Ayllon and Av. Arriola (Lima)
    h) Intersection between Av. Ayllon and Av. La Molina (Lima)
    i) Intersection between Carretera Central and Av. Asturias
5) The results of preliminary design of nine (9) intersections will be presented in Appendix "Drawings".

(3) Suggestion for Detailed Intersection Design will be Conducted

The exclusive trunk busway with 2-lane road about 12 m width including bus lanes and central reservation width on both sides of the bus lane is planned to use the center space of the existing road. However, the above mentioned six (6) intersection designs were not considered in the exclusive trunk busway, due to the fact that the detailed design was conducted in the period from 1993 to 1996. When the six (6) intersections are implemented, the following two (2) items should be reviewed.

1) The span arrangement of the bridge which passes over Av. Venezuela, Av. Ayllon, and Carretera Central should be reviewed.
2) The horizontal and vertical alignment of ON, OFF ramps should be reviewed.

7.3.6. PAVEMENT DESIGN

(1) Conditions of Existing Pavement Structure

1) Av. Venezuela and Av. Arica

As mentioned in section 7.1.2 (2) of this report, the existing pavement structure on the Av. Venezuela and Av. Arica is generally formed by a 20 cm. Cement concrete pavement with 20 cm. base course, however, some road segments of poor pavement condition are reinforced by 5.0 cm. hot mixed asphalt overlay.

The 5.0 cm. in depth hot mixed asphalt concrete for surface, 20 cm. in depth for base course, and 25 cm. in depth for sub-base course is recommended in the final design for the improvement of Av. Venezuela and Av. Arica conducted in 1996

2) Carretera Central

The existing pavement conditions on Av. Ayllon and Carretera Central are formed by a 5.0 cm. hot mixed asphalt concrete for surface course, 20 cm. in depth for base course, and 45 cm. for sub-base course.

(2) Pavements Design for East-West Trunk Busway

In order to provide a pavement structure according to the demands stipulated in the East-West corridor, it is proposed to put a new flexible pavement in replacement of those existing pavements in bad conditions, in sub sections with flexible and mixed pavements (rigid pavement with hot mixed asphalt recapping). The design period established is 10 years.

1) General Criteria Applied

In order to define the required thickness of pavement for a new structure, the method AASHTO included in the Guideline of 1993 for designing flexible pavements is used.

The General formula governing the structural number of design is expressed as follows.

$$Log_{10}(W_{18}) = Zr * So + 9.36 * Log_{10}(SN+1) - 0.20 + \frac{Log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.4 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * Log_{10}(MR) - 8.07$$

The method AASHTO-93 includes, among others, the following parameters:

a) Effective Resilience Module of Foundation Land (MR)

This is a different parameter from CBR, referred to as a Punching test, which tries to simulate the dynamic effect of vehicles' loads. The equivalence between the two of them is specified in the Guideline AASHTO for values of CBR < 7.2, MR (psi)= 1500 x CBR, for values of CBR included between 7.20 and 20, different relationships exist. The so called Sudafrican formula is mostly used: MR (psi)= 3000 $CBR^{0.65.}$ In this project for CBRs of granular lands, the correlation suggested by the Civil Aeronautics Institute of Brasil will be used, which is as follows:

CBRsr = 0.0624*(MRsr) 1.176 (Mpa), which, once transformed to pounds per square inch gives the following results:

$$MR_{sr} = \frac{\left\lfloor \frac{CBR}{0.0624} \right\rfloor^{\frac{1}{1.176}}}{0.007} (psi)$$

To select CBRs of design, the CBRs obtained in the Laboratory have been taken into account, as well as the existing strategic profile. So, a division by sectors was made as follows:

Av. Venezuela, the CBR of design equal to 20.0%. (MR=19307 psi) is applied.

Av. Nicolás Ayllón, the CBR of design equal to 10.0%. (MR=13401psi) is applied.

b) Simple Corridors Application of Equivalent Load Esal (w18)

This is the number of vehicles traveling on a simple corridor with dual wheels, of 8.2 tons (18 kips) in weight, which produce a similar effect on the pavement to that of mixed traffic during the design period. The results of the calculations of the equivalent corridors for the arterial roads are shown in Table 7.3-3

Table 7.3-3 Equivalent Corridors (ESAL) for arterial roads

Design Period (years)	Av. Venezuela – Av. Arica (Ovalo Saloon – Plaza Bolognesi)	Carretera Central Av. Graú Crossing- Av. Separadora Industrial Crossing
10	31.9243×10^6	103.950×10^6

c) Confidence Level (So)

Basically, this is a way to include some level of certainty in the process of design in order to guarantee that the projected pavement will survive the period established. The AASHTO guideline for Main Arterial Urban Roads recommends a value between 80 and 99, by adopting for this project an approximate Confidence (R) of 95 % with a Normal Standard Deviation (Z_R) of 1.645, Total Standard Deviation for Flexible Pavements.

AASHTO guidelines recommend a value of 0.45.

d) Total Variation of Durability Rate **($\Delta PSI = pt - po$)**

The initial Durability Rate has been taken as being equal to 4.2 according to AASHTO suggestions for flexible pavements. The final Durability Rate is considered equal to 2.0. These values suggest a need to rehabilitate the pavement for which periodical evaluations will be necessary to do both superficial and structural repairs (Rough Evaluation and Deflectometry respectively), in order to obtain a database to define durable corrective measures.

e) Drainage Coefficient m_i

This represents the percentage of time required for drainage during the Design Period. The granular layers of pavement (Gravel and Sand) will be exposed to levels of humidity close to saturation, which depends on local rainfall, the topography of land, the granular composition of natural land and risks of water and drainage system. In this case a value of 1.00 is adopted, corresponding to a quality of acceptable drainage during an estimated risk time between 5 and 25%.

f) Design Period n

The design period used for obtaining pavement structures is 10 years, which includes both daily and periodical preservation and maintenance works.

(3) Design Calculation

Four (4) types of pavement designs were made (two (2) types for arterial roads of Av. Venezuela and Av. Ayllon/Carretera Central and two types for the frontage roads on other arterial roads).

1) For Arterial Roads

To obtain the structural number (SN) the following data were used:

MR	=	**13401** psi
w_{18}	=	1.0395 * 10 ^ 8 repetitions (for 10 years)
R	=	95% (Safety level for Arterial Roads)
ZR	=	-1.645
So	=	0.45 (Standard Deviation for Flexible Pavements)
ΔPsi	=	4.2 – 2.0 = 2.2.
SN	=	**5.600** (for 10 years)

To obtain the structural number of pavement, the following equation was used:

$$\mathbf{SN = a_1D_1 + a_2 D_2 m_2 + a_3 D_3 m_3 + a_4 D_4 m_4}$$

Where:

a_1, a_2 and a_3 are the structural coefficients of the hot asphalt mix layers, crushed granular Gravel and Sand with values of 0.17/cm., 0.06/cm. and 0.040/cm., respectively;

D_1, D_2 and D_3 are thickness of the corresponding layers of the pavement to be defined and,

m_2 and m_3 are the drainage coefficients of the Gravel and Sand equal to 1.10 and 1.00 respectively.

With the previous equation, the Structural Number SN is obtained for different thickness groups of pavement layers. When combined, they provide the required load capacity capable to carry the foreseen transit during the Design Period. The results of the calculations of surface thickness obtained with Hot Asphalt Mix D_1, Crushed Granular Gravel D_2 and Sand D_3, respectively, are shown in Table 7.3-4.

Table 7.3-4 Pavement Structure Thickness for Arterial Roads (cm.)

Avenue	ESAL (x 10^6)	Design Period (years)	MACS (D_1)	Granular Gravel (D_2)	Sand (D_3)	Structural Number (SN)
Nicolás Ayllón	**103.950**	10	15	25	35	5.600
Venezuela-Arica	**31.9243**	10	10	20	30	4.220

Table N° 1

PROJECT:

Feasibility Study for Lima and Callao Metropolitan Transportation

Vía / Avenue: **Exclusive Corridor** / **Nicolás Ayllón**

PAVEMENT DESIGN AASHTO METHOD 1,993

(PAVIMENTOS FLEXIBLES)

ESAL $N_{8,2}$	R (%)	ZR	So	MR	Po	Pt	Δ PSI	SN
1.0400E+08	95	-1.645	0.450	13401	4.2	2.0	2.2	**5.557**

1.0395 E+08

LAYER	THICKNESS Di (cm.)	STRUCTURAL COEFFICIENT ai	DRAINAGE COEFFICIENT mi	STRUCTURAL NUMBER
MACS	15.0	0.170	-	2.550
BGT	25.0	0.060	1.100	1.650
SB	35.0	0.040	1.000	1.400
MSR	0.000	0.030	1.000	0.000
Total	75			**5.600**

LEGEND :

n	Design Period	**= 10 years**
R	Safety Level for Arterial Roads and/or Highways	
ZR	Normal Standard Deviation	
So	Standard Deviation for Flexible Pavements	
MR	Effective Resilience Module of Foundation Material	
Po	Initial Durability	
Pt	Final Durability	
Δ PSI	Total Variation of Durability Rate	
SN	Structural Number	
$N_{8,2}$	Simple Corridors Application of Equivalent Load	

Minimum Thickness

$N_{8,2}$	Asphaltic Concrete cm	Asphaltic Concrete inch	Granular Gravel cm	Granular Gravel inch
Less than 5,0 * 10 ^ 4	2,54 ó TSA	1,0 ó TSA	10.16	4.0
5,0 * 10 ^ 4 - 1,5 * 10 ^ 5	5.08	2.0	10.16	4.0
1,5 * 10 ^ 5 - 5,0 * 10 ^ 5	6.35	2.5	10.16	4.0
5,0 * 10 ^ 5 - 2,0 * 10 ^ 6	7.62	3.0	15.24	6.0
2,0 * 10 ^ 6 - 7,0 * 10 ^ 6	8.89	3.5	15.24	6.0
more than 7,0 * 10 ^ 6	10.16	4.0	15.24	6.0

		Quality Requirement	
MACS	Hot Asphaltic Mix of Surface	Stability	≥ 815 Kg
BGT	Crashed Granular Gravel	CBR	≥ 80 %
SB	Sand	CBR	≥ 25 %

(4) Proposed Pavement Structure

The following pavement structure thickness is recommended for the East-West trunk busway, considering the existing pavement structure conditions, construction execution conditions, and the results of calculation of pavement structure thickness.

1) On Av. Venezuela and Av. Arica

The following pavement structures are proposed.

a) 5.0 cm. in depth of hot mixed asphalt concrete for overlay on the existing pavement is proposed for the existing pavement structure used on arterial road.

b) 5.0 cm. in depth of hot mixed asphalt for overlay of surface course, 20.0 cm. in depth of cement concrete for base course, and 30.0 cm. in depth of granular for sub-base course is

proposed for new construction of arterial section.

c) 5.0 cm. in depth of hot mixed asphalt concrete for overlay on the existing pavement is proposed for the existing pavement structure used on frontage road.

d) 5.0 cm. in depth of hot mixed asphalt for surface course, 20.0 cm. of granular for base course, and 30.0 cm. in depth of sand for sub-base course is proposed for new construction of frontage road section.

2) On Av. Ayllon and Carretera Central

The following pavement structures are proposed.

a) 10.0 cm. in depth of hot mixed asphalt concrete for overlay on the existing pavement is proposed for the existing pavement structure used on arterial road.

b) 15.0 cm. in depth of hot mixed asphalt for overlay of surface course, 25.0 cm. in depth of for base course, and 35.0 cm. in depth of granular for sub-base course is proposed for new construction of arterial section.

c) 5.0 cm. in depth of hot mixed asphalt concrete for overlay on the existing pavement is proposed for the existing pavement structure used on frontage road.

d) 5.0 cm. in depth of hot mixed asphalt for surface course, 20.0 cm. of granular for base course, and 30.0 cm. in depth of sand for sub-base course is proposed for new construction of frontage road section.

The above mentioned detailed pavement structure diagrams are presented in Appendix "Drawings".

7.4. CONSTRUCTION QUANTITY ESTIMATE

7.4.1. CONDITIONS OF CONSTRUCTION QUANTITY ESTIMATE

Based on the results of the preliminary design of the exclusive trunk busway, the construction quantities are estimated. The construction quantities include the following working items:

a) The exclusive trunk busway and lane with improvement of the existing road on Av. Venezuela and Av. Arica. (L = 8,550 m)

b) The exclusive trunk busway and lane with improvement of the existing road on Av. Nicolás Ayllon and Carretera Central. (L = 9,080 m)

c) The improvement of the existing road includes carriageway and sidewalks on both road sides. (L = 8,550 m + 9,080 m = 17,630 m)

d) Bus stops on the exclusive trunk busway and lane on Av. Venezuela, Av. Arica (11 locations). However, as previously mentioned, the preliminary design of the bus stop facility is not included in the Study.

e) Bus stops on the exclusive trunk busway and lane on Av. Ayllon, and Carretera Central (9 locations). However, as previously mentioned, the preliminary design of the bus stop facility is not included in the Study.

f) Bus terminal for the exclusive trunk busway (1 for Lima city, 1 for Callao city). However, as previously mentioned, the preliminary design of the bus terminal facility is not included in the Study.

g) Feeder bus roads are not included, because, the feeder bus will be operated on the existing road without any improvement.

h) Articulated bus and feeder bus fleets are not included. However, the cost of bus fleets is included in the analysis study of economic and financial evaluation.

7.4.2. CONSTRUCTION QUANTITY ESTIMATE

(1) Major Construction Quantity Items

Based on the results of exclusive trunk busway preliminary design, the following construction quantities for the trunk busway are estimated.

1) Preparation works and administration

2) Mobilization works

3) Demolition of the existing facilities

4) New pavement works of trunk busway and widening of carriageway of the existing road

5) Improvement works of the existing road and side walks (overlay of the existing road)

6) Related road and traffic facilities

(2) Construction Quantities Estimate

The conditions of the major construction quantities estimated are shown in Table 7.4-1.

Table 7.4-1 Conditions of Construction Quantities Estimate

Working Items	Sub-Items	Unit	Conditions
1. Administration	Working Site	Vol.	Two sites are adopted. One is Av. Venezuela site, and the other is Carr. Central site.
2. Mobilization	Working site	Vol.	Two sites are adopted. One is Av. Venezuela side, and the other is Carr. Central site.
3. Demolition		Vol	Based on the reconnaissance survey, the materials to be demolished are observed in the site.
4. Excavation			Based on the cross section design, the excavation quantities of pavement, soil material are calculated.
5. Pavement	Overlay	m 2	The area of existing pavement can be used. Based on the cross section design, the area is calculated. 5.0 cm. in depth is adopted on the Av. Venezuela site, and 10.0 cm. in depth is adopted on Carr. Central site.
	Asphalt pavement t = 5 cm..	m 2	The area of new construction of busway and arterial roads for Av. Venezuela site. The area is calculated based on the cross section design.
	Concrete Pavement t = 20 cm.	m 2	Same as the above mentioned
	Sub-base course t = 30 cm.	m 2	Same as the above mentioned
	Asphalt Pavement t = 15 cm.	m 2	The area of new construction of busway and arterial roads for Carr. Central site. The area is calculated based on the cross section design.
	Base course t = 25 cm.	m 2	Same as the above mentioned
	Sub-base course t = 35 cm.	m 2	Same as the above mentioned
	Asphalt pavement t = 5.0 cm.	m 2	The area of new construction of frontage road for Av. Venezuela and Carr. Central sites. The area is calculated based on the cross section design.
	Base course t = 20 cm.	m 2	Same as the above mentioned
	Sub-base course t = 30 cm.	m 2	Same as the above mentioned
6. Facilities	Guardrail	m	The guardrail is installed as barrier between carriageway and side-walks on both sides.
	Lighting	Vol.	The lightings are installed at about 30 m interval along project roads.
7. Bus Stop		Vol.	Based on the plan design, bus stops are estimated as only trunk bus stops. See Appendix “Drawings”
8. Bus Terminal		Vol.	Bus terminals for the trunk bus terminal are planned at Callao and Santa Anita. See Appendix “Drawings”.

The results of calculation of major construction materials area shown in Table 7.4-2.

Table 7.4-2 List of Construction Quantities for Trunk Busway Construction

Items	Unit	Construction Materials		
		Venezuela Side	Central Side	Total
		Quantity	Quantity	Quantity
A Administration				
Working Office and Warehouse in Site	m^2	500.0	500.0	1,000
Administration Office in Site	m^2	500.0	500.0	1,000
Wall and Fence of Site	Unit	1.0	1.0	2
Water & Electrical Supply of Site	Unit	1.0	1.0	2
Safety Control in Site	Unit	1.0	1.0	2
B Preparation and Mobilization				0
Mobilization of Machines and Materials to Site	Unit	1.0	1.0	2
Site Clearing	Unit	1.0	1.0	2
Traffic Control Management	Unit	1.0	1.0	2
C. Direct Cost				
1.Site Clearing and Demolition				
Sidewalk	m^3	2,625.0	2,269.5	4,895
Median Plantation 2.5	m^3	3,396.0	5,640.0	9,036
Light Pole	Vol.	367.0	391.5	759
Electric Pole	Vol.	160.3	538.5	699
Traffic Signal	Vol.	32.0	28.0	60
Traffic Sign	Vol.	18.0	6.0	24
Bus stop facilities	Vol.	8.0	8.0	16
Pedestrian Bridge	Vol.	0.0	3.0	3
Small Tree 10 cm. < t < 20 cm. (Moving)	Vol.	1,256.0	0.0	1,256
Big Tree 30 cm. < t (Moving)	Vol.	38.0	0.0	38
Concrete Structure	m^3	13.0	0.0	13
Other Structure (Wall)	m	5,950.0	0.0	5,950
2.Excavation				
Asphalt (t = 5 cm., t = 10 cm.)	m^2	47,555.0	21,120.0	68,675
Concrete (20 cm.)	m^2	0.0	0.0	0
Soil (Waste)	m^3	10,246.5	9,179.0	19,426
Exc./ Fill	m^3	0.0	0.0	0
Soil Transport	m^3/km	12,310.2	11,014.8	23,325
3.Pavement				
Overlay				
Asphalt (t = 5 cm., 10 cm.)	m^2	115,275.0	184,520.0	299,795
Trunk / Arterial busway				
Asphalt t = 10 cm.	m^2	0.0	0.0	0
Base course t = 20 cm.	m^2	0.0	0.0	0
Sub-base course t = 30 cm.	m^2	0.0	0.0	0
Trunk / Arterial busway				
a. Asphalt t = 15 cm. (Carretera Central)	m^2	0.0	82,080.0	82,080
b. Base course t = 25 cm. (Carretera Central)	m^2	0.0	86,040.0	86,040
c. Sub-base course t = 35 cm. (Carretera Centra	m^2	0.0	86,040.0	86,040
d. Asphalt t = 5 cm. (Av. Venezuela)	m^2	92,430.0	0.0	92,430
e. Cement Conc. t = 20 cm. (Av. Venezuela)	m^2	96,730.0	0.0	96,730
f. Base course t = 30 cm. (Av. Venezuela)	m^2	96,730.0	0.0	96,730
Frontage Lane				
Asphalt t = 5 cm.	m^2	41,600.0	4,550.0	46,150
Base course t = 20	m^2	43,540.0	4,690.0	48,230
Sub-base course t = 30	m^2	43,540.0	4,690.0	48,230
Sidewalk				
Cement Concrete t = 10 cm.	m^2	55,315.0	50,290.0	105,605
Base course t = 10 cm.	m^2	58,015.0	53,330.0	111,345
Plantation	Vol.	1,114.0	350.0	1,464
4.Drainage				
Manhole (5 cm. levee raising)	Vol.	309.0	225.0	534
5.Additional				
Chapter Bar	m	5,100.0	5,100.0	10,200
6.Facilities				
Median 1.0 m, 2.0 m	m	32,400.0	0.0	32,400
Median Plantation 2.0 m	m	14,340.0	13,000.0	27,340
Guard Rail	m	17,100.0	18,160.0	35,260
Lighting	Vol.	519.3	538.6	1,058
Lane Marking	m	31,850.0	32,800.0	64,650
Traffic Signs	Vol.	16.0	10.0	26
Traffic Signal (including bus stop section)	Vol.	11.0	9.0	20
Box Culvert	m	14,700.0	13,000.0	27,700
7 Bus Stop	Vol.	22.0	18.0	40
8.Intersection				
At-grade signalized	Vol.	10.0	12.0	22
At-grade non signalized	Vol.	0.0	0.0	0
9.Bridge				
Pedestrian Bridge	Vol.	0.0	0.0	0
10.Bus Terminal	Unit	1.0	1.0	2
11.Social Environmental - Under	Unit	1.0	1.0	2
Social Environmental - After	Unit	1.0	1.0	2