CHAPTER 11 FUTURE SOCIO-ECONOMIC FRAMEWORK

11 FUTURE SOCIO-ECONOMIC FRAMEWORK

11.1 Population

The future population of Paraguay was estimated by General Directorate of Statistics, Inquiry and Census (Direccion General de Estadística, Encuestas y Censos) in 1996. According to this result, population of the target year of 2010 and 2020 for this project will be 6,980,320 and 8,570,322 respectively and the growth factors based on 1997 population will be 1.37 (annual growth rate: 2.9%) and 1.69 (annual growth rate: 3.0%) times respectively. Figure11.1.1 shows the trend of population in present and future in Paraguay.

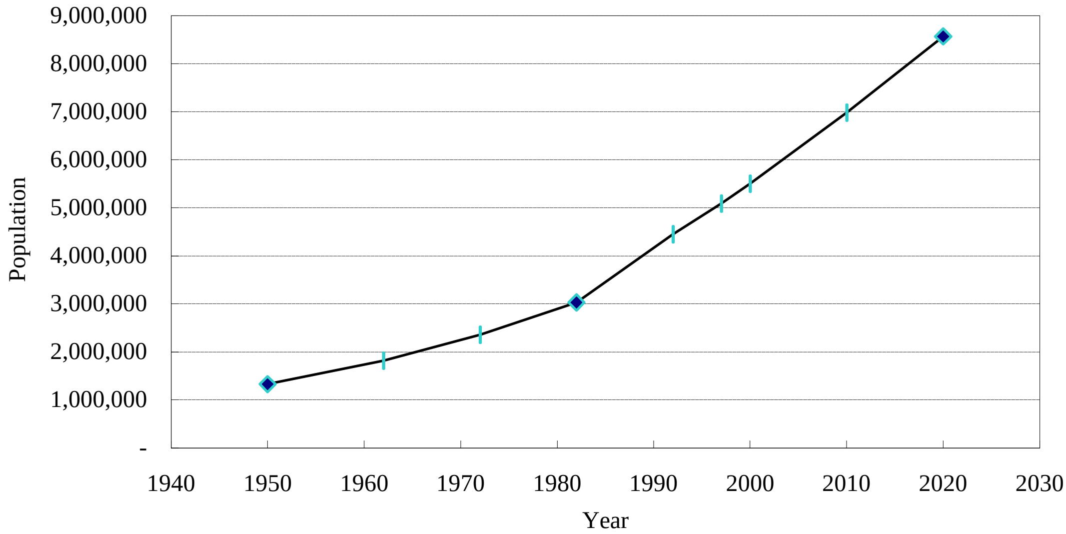


Figure 11.1.1 Present and Future Population Trend in Paraguay

11.2 GDP

Figure 11.2.1 shows the past trend of Gross Domestic Product (GDP) in Paraguay. The GDP in 1997 was 1,130,309 million Gs. in terms of 1982 fixed price.

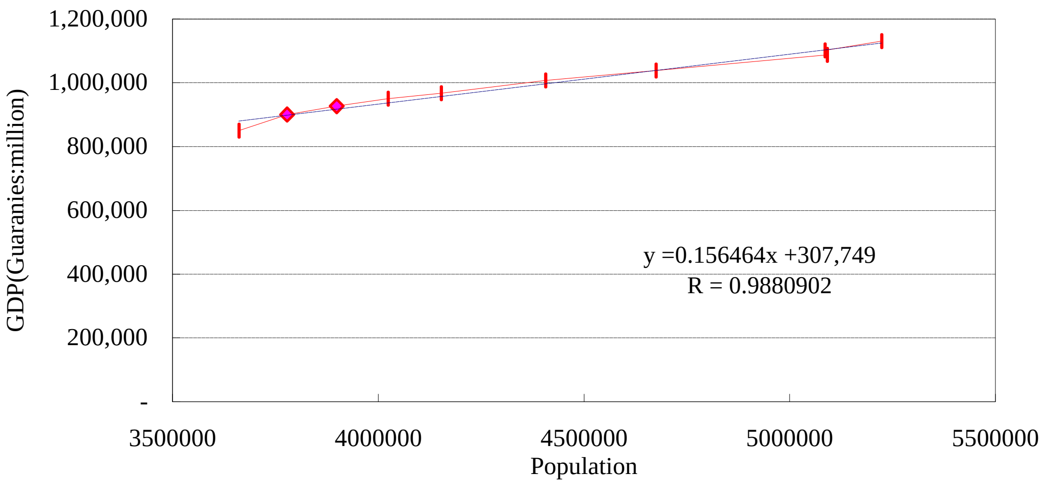


Figure 11.2.1 GDP Past Trend in Paraguay

The following three scenarios have been examined to project the future GDP of Paraguay. As a result, this Study adopts the second scenario that indicates a medium-level figure (annual rate of 3.5%).

Scenario I

There is a close correlation between the past growth trend of GDP and population in Paraguay, and it is expressed in the formula in Figure 11.2.1. With this formula and the population projection for 2010 and 2020, GDP is estimated at about Gs 1.40 trillion (billion in South America's numerical system) and Gs 1.65 trillion for the respective years. From the level of 1997, Gs 1.13 trillion, the annual growth rate up to 2020 is about 1.7%. This rate implies the growth of both GDP and population for the past 15-year period including economic recessions, and also an average value of labor productivity per capita. Considering the projected population growth rate of 2.5% and the rate of an increase in workforce (15 to 65 of age) of 2.9% (an average between 1995 and 2020), this GDP figure seems a bit too pessimistic. If economic growth further pushes GDP upward, the infrastructure development based on this underestimation will not be able to accommodate the demand increase. Therefore, it has been concluded that this scenario is too pessimistic to adopt in this Study.

Scenario II

From 1982 to 1997, the growth of GDP, at the 1982 fixed price, can be depicted by almost a straight line. An average growth rate during this same period is about 3.5%, and GDP can be projected with the following formula.

$$\mathbf{GDP = 689{,}000 * 1.035^{(X-1982)}}$$

where, X: year

With this formula, GDP for 2010 and 2020 are projected at Gs 1.81 trillion and Gs 2.55 trillion, respectively. This is the growth rate of 3.5 to 3.7% annually from 1997. They exceed the population growth rate of 2.5% and that of workforce population of 2.9%, and the growth rate of labor productivity per capita increases by 0.6% every year. Thus, this figure is considered adequate for the Study.

Scenario III

With expectations for impact of MERCOSUR, an expansion of workforce population, and an increase in income, the GDP is projected to grow at an annual rate of 4.5%, adding 1% to the current trend. Then, GDP in 2010 and 2020 will be Gs 2.00 trillion and Gs 3.11 trillion, respectively. They are rather optimistic because they assume productivity growth per worker at 1.6% and productivity growth per capita at 2.0%, both annually. This scenario, therefore, could overestimate needs for additional infrastructure development as well as benefits of such projects.

11.3 Agricultural Products

The main agricultural products in Paraguay are 6 cereals (Sugar cane, Cassava, Soybean, Corn, Wheat, and Cotton). Table 11.3.1 shows the future forecast of products as estimated by ENTA M/P (1992) and ARTERIAL ROAD DEVELOPMENT F/S (1997) JICA study. Figure11.3.1 shows the past trend of corn production in Paraguay and the linear regression formula which was used in this study.

Table 11.3.1 Future Main Agriculture Products

	1997	2010	2020
Soybeans	2,670	3,341	4,239
Cotton	139	3,341	4,239
Sugar cane	2,795	3,439	3,841
Mandioca	23,150	2,944	3,159
Maize	1,056	2,824	4,250
wheat	400	616	973
Total	30,210	16,505	20,701

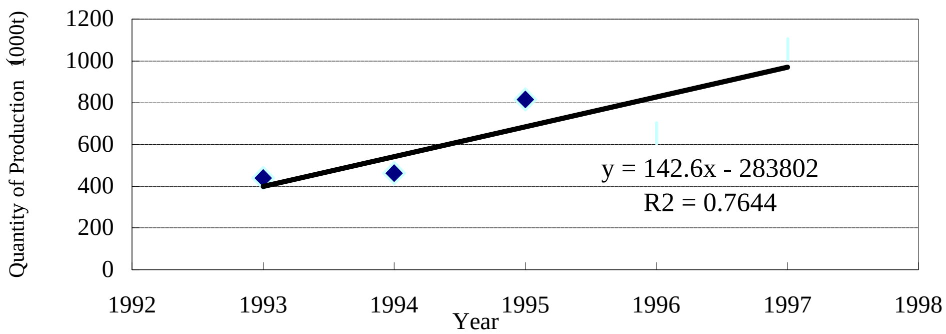


Figure 11.3.1 Corn Production Past Trend in Paraguay

11.4 Vehicle Registration

Figure11.4.1 shows the past trend per type of registered vehicle in Paraguay. The national total of registered vehicles was 395,339 in 1998. The composition of registered vehicles per type is Cars and utility cars 88%, Trucks 9%, Buses 3%. The annual growth rate of car owner-ship for the most recent ten-year period remains high at 8.7%.

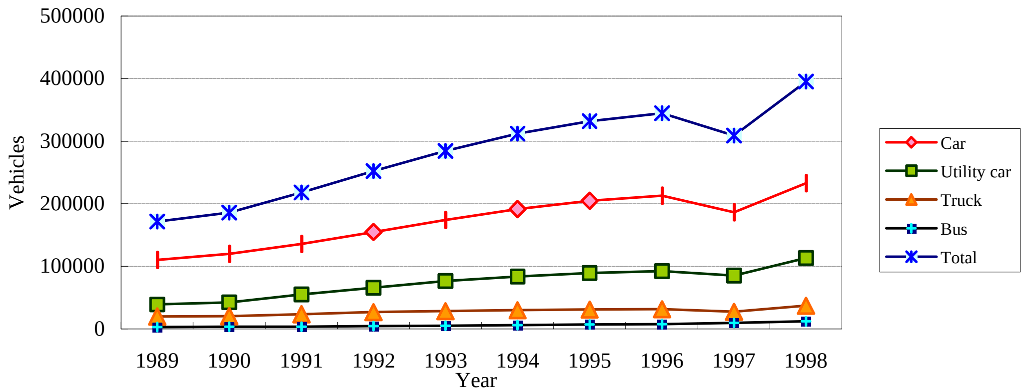


Figure 11.4.1 Vehicle Registration Past Trend per Type in Paraguay

Table 11.4.1 Vehicle Registration in 1999

	All Paraguay	(%)	Central and Asuncion	(%)
Car	243,796	59.1	136,511	65.6
Utility Vehicle	118,206	28.7	55,061	26.5
Truck	37,362	9.1	14,386	6.9
Bus or other	12,906	3.1	2,150	1.0
Total	519,130	100.0	208,108	100.0
Car owner ship				
per/1000 habitant	96		120	

The multiple correlation coefficient in the multiple regression analysis between the number of registered motor vehicles and GNP, population in Paraguay is high at 0.988 for cars and utility vehicles, 0.964 for trucks, 0.920 for bus and 0.972 for all vehicles.

Table shows the estimated vehicles from medium assumptions of GNP and population in Paraguay, which was calculated using the multiple correlation formula.

A multiple regression analysis gives the following relation:

$$V = A * Population + B * GNP + C$$

where, *V*; Vehicle Ownership (Vehicles)
GNP (million Guaranies)
A,B = slope
C = constant
($r^2 = 0.80\text{-}0.98$)

Table 11.4.2 Coefficient for Forecast

Type of Vehicle	A	B	C	Correlation
Car and Utility	0.52039	0.4676	-462234	0.99
Truck	0.00173	0.0541	-34948	0.96
Bus	0.00071	0.0269	-24582	0.92

It is expected that the number of registered motor vehicles will increase by factors of 1.77 and 2.63 from present level in the years 2010 and 2020. Numerical values in parentheses apply to the case of GNP medium assumption. For Paraguay, the figure of 121 for the year 2020 is about the same level as the 1999 Asuncion and Central department car-ownership.

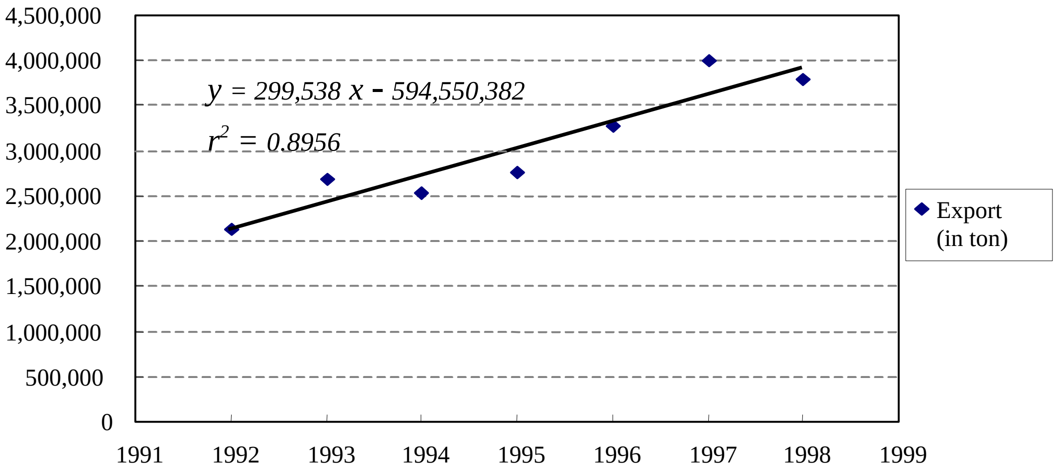
Table 11.4.3 Future Registered Vehicles in Paraguay (Medium Case)

	1998 (Veh.)	2010 (Veh.)	2020 (Veh.)
Car and utility car	346,089	619,317	912,031
Truck	37,132	60,255	87,305
Bus	12,118	21,767	34,993
Total	395,339	701,339	1,034,330
Growth rate to1998		1.77 times	2.62 times
Vehicle ownership (Per 1000 habitants)	78	100	121

11.5 Exports and Imports

(1) Forecasting Future Exports

According to the data on export amount growth provided by the Central Bank (Banco Central) and the Custom Office (ADUANA), future exports in total can be forecasted with the following formulae.



Data Source: Central Bank of Paraguay and the Custom Office (Banco Central del Paraguay and ADUANA)

Figure 11.5.1 Trend of Exports Amount in Recent Years

With the formulae shown above, exports in 2010 and 2020 is estimated as follows.

Table 11.5.1 Estimated Total Exports in 2010 and 2020

(Unit: tons)

Year	Export	Remarks
1998	3,802,705	(actual figure)
1999	4,226,151	
2010	7,521,070	(1.98 times of that in 1998)
2020	10,516,450	(2.77 times of that in 1998)

With the data provided by the Custom Office (ADUANA) and those on Annual Statistics (1989-1996), shares of related ports to the total exports in 2010 and 2020 are estimated as follows:

Table 11.5.2 Estimated Shares in Exports from Related Ports in 2010 and 2020

Year	Capital*	Ciudad del Este
1996	22%	52%
1999	24%	53%
2010	28%	55%
2020	30%	57%

Note *: includes Asunción, Jose Falcon, Villeta and 80% of Private Ports

Therefore, exports from related ports can be estimated as shown in the table below.

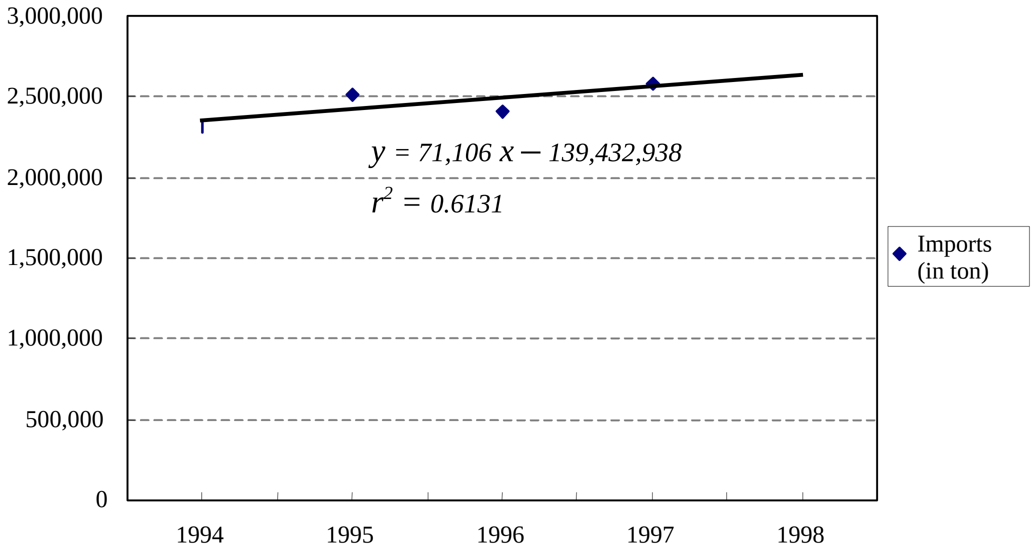
Table 11.5.3 Estimated Amount of Exports from Related Ports in 2010 and 2020

Year	Capital*	Ciudad del Este
1999	1,014,276	2,239,860
2010	2,105,900	4,136,588
2020	3,154,935	5,994,377

Note *: includes Asunción, Jose Falcon, Villeta and 80% of Private Ports

(2) Forecasting Future Imports

According to the data on change in import amount provided by the Central Bank and the Custom Office (Banco Central and ADUANA), future imports in total can be forecasted with the following formulae, as done for exports.



Data Source: Central Bank of Paraguay and the Custom Office (Banco Central del Paraguay and ADUANA)

Figure 11.5.2 Trend of Import Amount in Recent Years

With the formulae shown above, imports in 2010 and 2020 are estimated as follows. Compared with the total exports, the growth in import amount is quite low.

Table 11.5.4 Total Import in 2010 and 2020

(Unit: tons)

Year	Export	Remarks
1997	2,587,794	(actual figure)
1999	2,708,111	
2010	3,490,278	(1.36 times of that in 1997)
2020	4,201,339	(1.64 times of that in 1997)

With the data provided by the Custom Office (ADUANA) and those on Annual Statistics (1989-1996), shares of related ports to the total imports in 2010 and 2020 are estimated as follows:

Table 11.5.5 Estimated Shares in Imports to Related Ports in 2010 and 2020

Year	Capital*	Ciudad del Este
1996	63%	21%
1999 - 2020	63%	21%

Note *: includes Asunción, Jose Falcon, Villeta and 80% of Private Ports

Therefore, imports to related ports can be estimated as shown in the table below.

Table 11.5.6 Estimated Amount of Imports to Related Ports in 2010 and 2020

Year	Capital*	Ciudad del Este
1999	1,706,110	568,703
2010	2,198,875	732,958
2020	2,646,843	882,281

Note *: includes Asunción, Jose Falcon, Villeta and 80% of Private Ports

CHAPTER 12 FUTURE TRAFFIC DEMAND

12 FUTURE TRAFFIC DEMAND

12.1 Methodology

(1) Process

The future demand forecast process is shown in Figure 12.1.1. The process is divided mainly into two parts. One is model building of traffic generation/attraction to introduce from socio-economic data and existing origin destination data. Other one is calculation of traffic assignment at each road using the distribution model to introduce the road net work data and future OD table.

(2) Generation/Attraction Model

The Generation/Attraction Model shall be created by using the present OD table and the present socio-economic data. The socio-economic indicators of generation and attraction model are as follows;

1) Population
2) Car ownership
3) Agriculture products

(3) Distribution Model

The traffic distribution model is made using the Origin/Destination table by Generation/Attraction volume. The traffic distribution model shall be made according to the present OD pattern.

(4) Future Traffic Estimation

As future traffic estimation, future generation/attraction volume and distributed OD volume shall be calculated by future socio-economic indicators and future demand forecast model.

(5) Future Traffic Assignment

The future OD table shall be assigned on future road network by traffic assignment system. Then the future traffic demand of target road shall be calculated.

(6) Project Evaluation of Traffic Demand Side

The project evaluation indicators of traffic demand are calculated as VOC (Vehicle Operating Cost) and TTC (Travel Time Cost). These VOC and TTC are made by Vehicle x km and Vehicle x hr that are estimated from the future traffic assignment results on the whole study area.

The benefit of road project is the difference of VOC and TTC between “Do Nothing Case” result and “Do Project Case” result. If the benefit is greater than the project cost, including construction cost and maintenance cost, this project is considered effective.

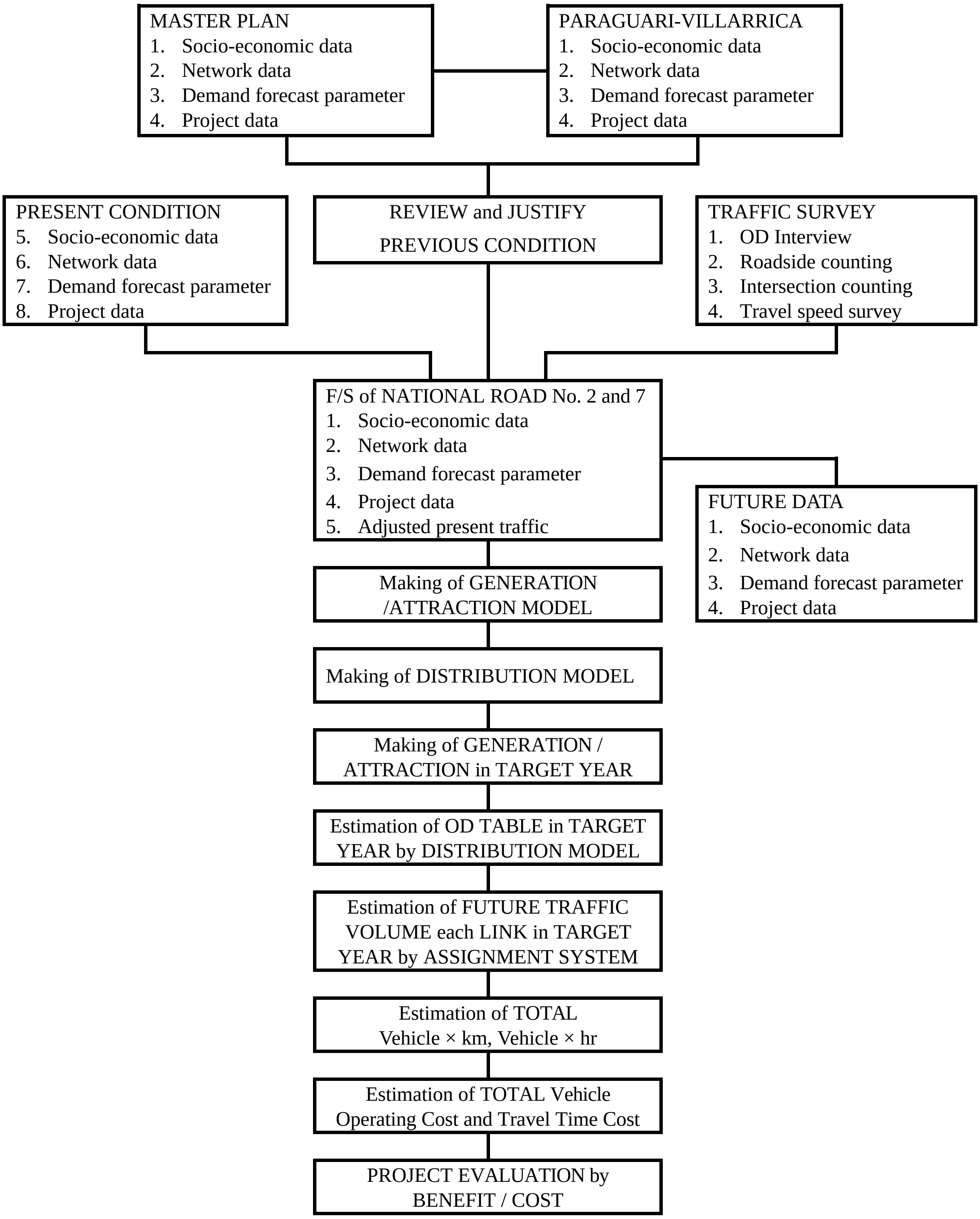


Figure 12.1.1 Future Demand Forecast Process

12.2 Present OD Table

12.2.1 Base of Present OD Table

The present OD table is based on the result of previous study in 1996 which is the PARAGUARI-VILLARRICA study. The result of the PARAGUARI-VILLARRICA study was also based on the ETNA study. So the OD table of the PARAGUARI-VILLARRICA study must be adjusted to the 1999 OD table by increasing the ratio between 1996 and 1999. The annual traffic increase ratio is 1.0834 by average permanent traffic count increase ratio which is shown in Figure 12.2.1. The Present OD Development process is shown in Figure 12.2.2

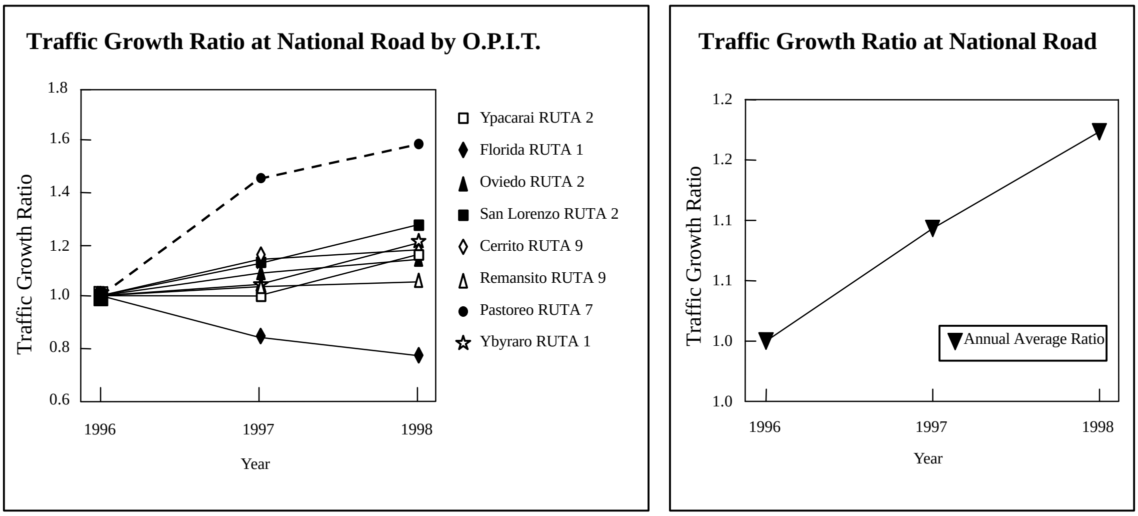


Figure 12.2.1 Annual Traffic Increase Ratio

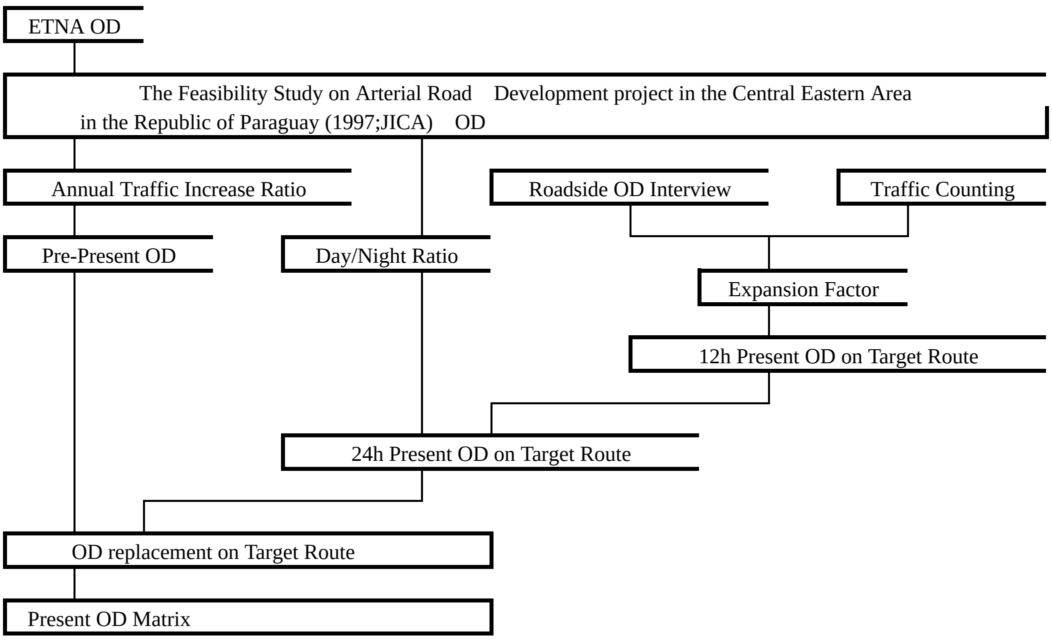


Figure 12.2.2 Present OD Development Process

12.2.2 Present OD Table Arrangement by Traffic Survey

A part of the Present OD table base where national roads 2 and 7 are related was replaced by an OD table which is the result of a traffic survey. The OD table which is the result of a traffic survey is a 24-hour annual average traffic volume.

12.2.3 Present Traffic Volume by Range

The present traffic volume by range is shown in Table 12.2.1 and Figure 12.2.3. Traffic flow are characterized by the high share of short distance trips. 35% trips of all vehicle type are movements of 0-50km distance range, while truck (18.6%) and bus (18.8%) show relatively low rates.

Table 12.2.1 Present Traffic Volume by Range

Unit : Vehicle / day

Distance Range (km)	P.Car	Bus	Truck	Total
0.- 50.	12,816	658	3,308	16,782
50.-100.	5,566	1,115	3,270	9,951
100.-150.	1,357	187	1,539	3,083
150.-200.	1,329	148	1,805	3,282
200.-250.	565	224	798	1,587
250.-300.	1,201	272	1,873	3,346
300.-350.	1,424	486	2,092	4,002
350.-400.	650	266	987	1,903
400.-450.	225	38	344	607
450.-500.	136	5	276	417
500.-	559	97	1,469	2,125
Total	25,828	3,496	17,761	47,085

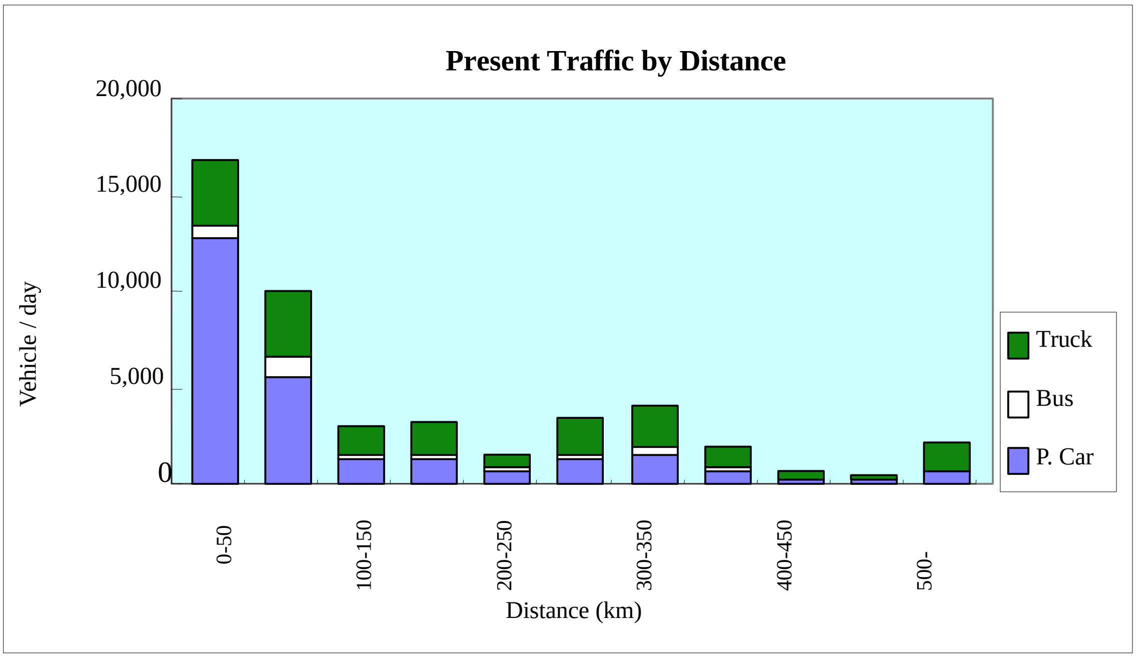


Figure 12.2.3 Present Traffic Volume by Range

12.3 Zoning

12.3.1 Zoning Intention

The target route formed by national roads 2 and 7 is an inter-city route between the Asuncion metropolitan area and Ciudad del Este. In this study, a future demand forecast is required to include inter-city traffic because of the characteristics of the target route. The zoning intention is the zoning size shown in Figure 12.3.1. The "A" zoning size is for international traffic, then the demand forecast does not include inter-city traffic. The "C" zoning size is like a city transportation study size. The size of this zone is too large for this study purpose. The "B" zoning size has been selected in this study for study purposes. And this zoning size gets socio-economic data with ease, because the "B" zoning size is an usual administration border size.

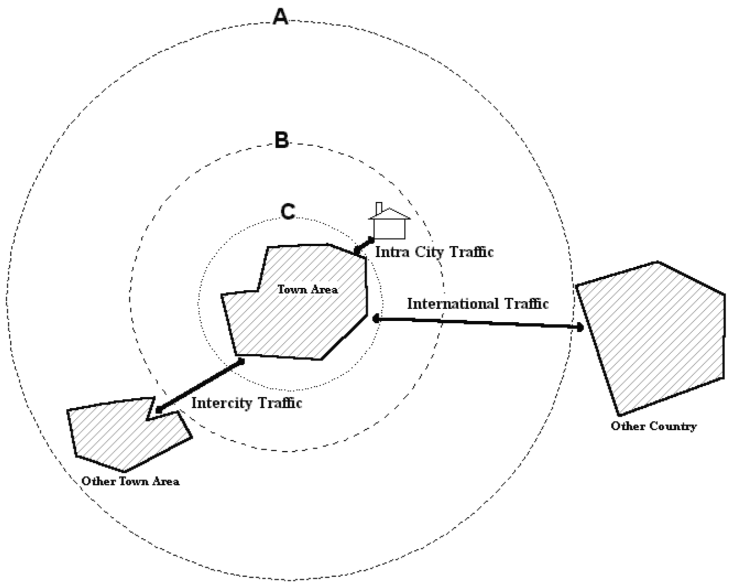


Figure 12.3.1 Zoning Intention

Surrounding of the study area were included as outside of study area. The study area was divided into traffic zones on the basis of boundary of municipality and department. Municipalities along the study road and the proposed bypass routes were divided into smaller traffic zones on the basis of district boundaries. Finally the study area and surrounding area were divided into 50 traffic zones which is shown in Figure 12.3.2.

The zoning and all mode vehicle future generation and attraction are shown in Table 12.3.1.

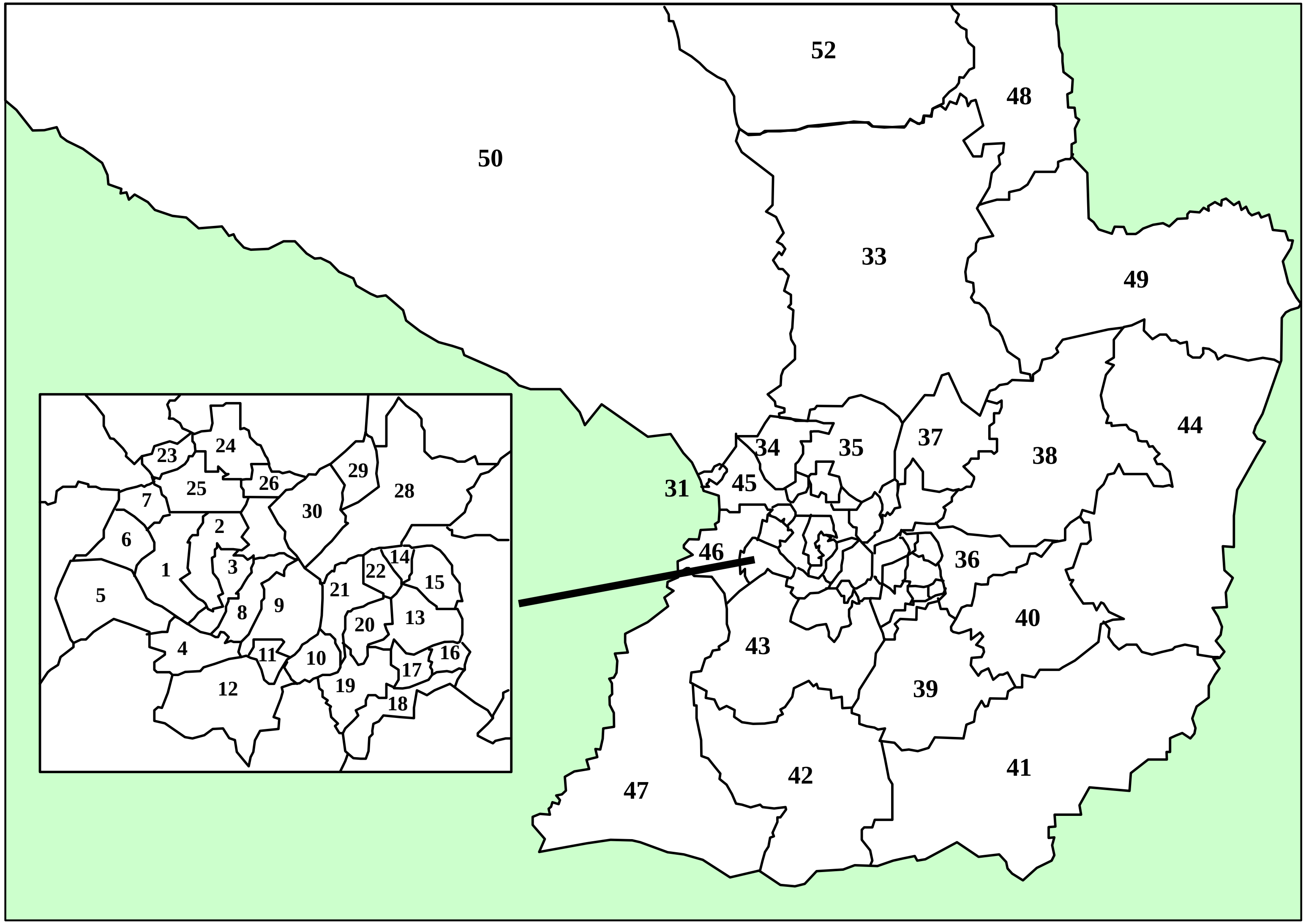


Figure 12.3.2 Zoning Map

Table 12.3.1 Zoning and All Mode Vehicle Generation and Attraction

Unit : Vehicle/day

Zone No.	Zone Name	1999 Generation	1999 Attraction	2010 Generation	2010 Attraction	2020 Generation	2020 Attraction
1	PARAGUARI	641	441	1,326	712	1,314	659
2	ESCOBAR	48	170	444	409	309	397
3	SAPUCAI	59	123	360	360	200	328
4	ACAHAY	96	131	112	340	82	162
5	CARAPEGUA	282	243	554	567	249	333
6	YAGUARON	249	301	718	676	421	543
7	PIRAYU	243	390	175	240	68	117
8	CABALLERO	40	88	263	319	110	247
9	YBYTIMI	27	108	89	244	94	154
10	TEBICUARY MI	67	50	195	219	97	193
11	LA COLMENA	142	70	327	113	233	121
12	YBYCUI	74	86	67	220	78	121
13	VILLARRICA	896	876	1,038	1,316	687	1,225
14	YATAITY	129	73	447	224	400	200
15	MBOCAYATY	231	156	378	302	292	252
16	NUMI	145	94	249	155	174	87
17	SAN SALVADOR	62	80	529	272	483	268
18	ITURBE	130	233	116	366	91	307
19	BORJA	76	137	148	129	167	108
20	ITAPE	69	43	259	99	175	107
21	CORONEL MARTINEZ	45	95	368	291	348	311
22	FELIX PEREZ CARDOZO	87	79	418	231	366	227
23	CAACUPE	2,158	2,408	1,242	1,562	1,012	1,603
24	EUSEBIO AYALA	907	631	476	400	552	468
25	PIRIBEBUY	983	765	649	523	769	614
26	ITACURUBI DE LA CORDILLERA	683	239	175	174	199	198
27	VALENZUELA	116	135	64	84	65	88
28	CORONEL OVIEDO	1,899	1,657	601	958	723	762
29	NUEVA LONDRES	134	109	238	272	190	227
30	SAN JOSE DE LOS ARROYOS	245	239	129	125	146	145
31	ASUNCION	9,661	8,925	16,014	15,547	17,901	17,921
32	CONCEPCION	1,973	1,914	1,100	1,629	1,300	1,204
33	SAN PEDRO	1,906	2,797	3,663	3,605	4,295	4,233
34	CORDILLERA OESTE	776	1,147	69	182	71	88
35	CORDILLERA ESTE	1,006	1,043	120	124	141	146
36	GUAIRA	658	496	74	79	76	81
37	CAAGUAZU OESTE	169	705	83	83	90	90
38	CAAGUAZU ESTE	1,192	1,351	2,127	2,182	2,315	2,371
39	CAAZAPA OESTE	583	532	129	80	159	97
40	CAAZAPA ESTE	438	541	66	93	62	102
41	ITAPUA	3,133	2,901	5,579	5,831	6,381	6,634
42	MISIONES	701	703	1,420	1,425	2,070	2,073
43	PARAGUARI SUR	514	410	19,771	19,627	25,679	25,598
44	ALTO PARANA	1,681	1,590	8,614	8,472	11,869	11,759
45	CENTRAL NORTE	11,335	12,770	16,742	16,928	21,883	21,893
46	CENTRAL SUR	1,468	1,635	2,692	3,354	3,960	4,994
47	NEEMBUCU	343	927	301	1,613	124	1,138
48	AMAMBAY	1,535	1,009	740	647	1,154	1,013
49	CANINDEYU	1,304	1,415	796	931	1,215	1,399
50	CHACO	1,328	922	2,631	2,587	3,588	3,581

12.4 Trip Generation and Attraction Model

12.4.1 Trip Generation and Attraction Model Equation

The correlated parameters for the Generation/Attraction model are shown in Table 12.4.1 and the parameters of the Generation/Attraction model are shown in Table 12.4.2. The correlation between real value and estimated value is shown in Figure 12.4.1. The Trip Generation/Attraction model formula is as follows;

$$\begin{aligned} Gai &= Cpop \times POi + Ccar \times CAi + Cbus \times BUi + Csoy \times SOi + Ccot \times COi \\ &+ Csug \times SUi + Ccas \times CSi + Cmai \times MAi + Cwhe \times WHi \\ &+ C_{fg1} \times FG1 + C_{fg2} \times FG2 + C_{fg3} \times FG3 + C \end{aligned}$$

Legend

GAi :	Generation/Attraction in i zone	C :	Constant
Cpop :	Population Coefficient	POi :	Population in i zone
Ccar :	Car Registration Coefficient	CAi :	Car Registration in i zone
Cbus :	Bus Registration Coefficient	BUi :	Bus Registration in i zone
Csoy :	Soybean Coefficient	SOi :	Soybean in i zone
Ccot :	Cotton Coefficient	COi :	Cotton in i zone
Csug :	Sugarcane Coefficient	SUi :	Sugarcane in i zone
Ccas :	Cassava Coefficient	CSi :	Cassava in i zone
Cmai :	Maize Coefficient	MAi :	Maize in i zone
Cwhe :	Wheat Coefficient	WHi :	Wheat in i zone
C_{fg1} :	Flag 1 Coefficient	FG1 :	Flag in i zone
C_{fg2} :	Flag 2 Coefficient	FG2 :	Flag in i zone
C_{fg3} :	Flag 3 Coefficient	FG3 :	Flag in i zone

Table 12.4.1 Correlated Parameters for the Generation/Attraction Model

	P. Car Generation	P. Car Attraction	Bus Generation	Bus Attraction	Truck Generation	Truck Attraction
Population	O	O	-	-	O	O
Car Registration	O	O	-	-	-	-
Bus Registration	-	-	O	O	-	-
Soybean	-	-	-	-	O	O
Cotton	-	-	-	-	O	O
Sugarcane	-	-	-	-	O	O
Cassava	-	-	-	-	O	O
Maize	-	-	-	-	O	O
Wheat	-	-	-	-	O	O
Flag 1	O	O	O	O	-	-
Flag 2	O	O	O	-	-	-
Flag 3	O	O	O	-	-	-

Table 12.4.2 Parameters of Generation/Attraction Model

	P. Car Generation	P. Car Attraction	Bus Generation	Bus Attraction	Truck Generation	Truck Attraction
Population	0.0032521	0.0032521	-	-	0.0038888	0.0042689
Car Registration	0.0626675	0.0626675	-	-	-	-
Bus Registration	-	-	0.1127828	0.092252	-	-
Soybean	-	-	-	-	0.0051045	0.0040351
Cotton	-	-	-	-	0.0273116	0.0303642
Sugarcane	-	-	-	-	0.000533	0.0001188
Cassava	-	-	-	-	0.0024494	0.00004
Maize	-	-	-	-	0.0394082	0.0213251
Wheat	-	-	-	-	0.0152118	0.0269309
Flag 1	-2926.132	-2926.132	-78.83852	1189.5684	-	-
Flag 2	925.42874	925.42874	-6.710625	-	-	-
Flag 3	3746.8625	3746.8625	1262.1952	-	-	-
Constant	-903.6691	-903.6691	24.314515	25.440646	77.837517	39.280613
Multiple Correlation Coefficient	0.946502	0.946502	0.9461254	0.9509369	0.8789163	0.9509313

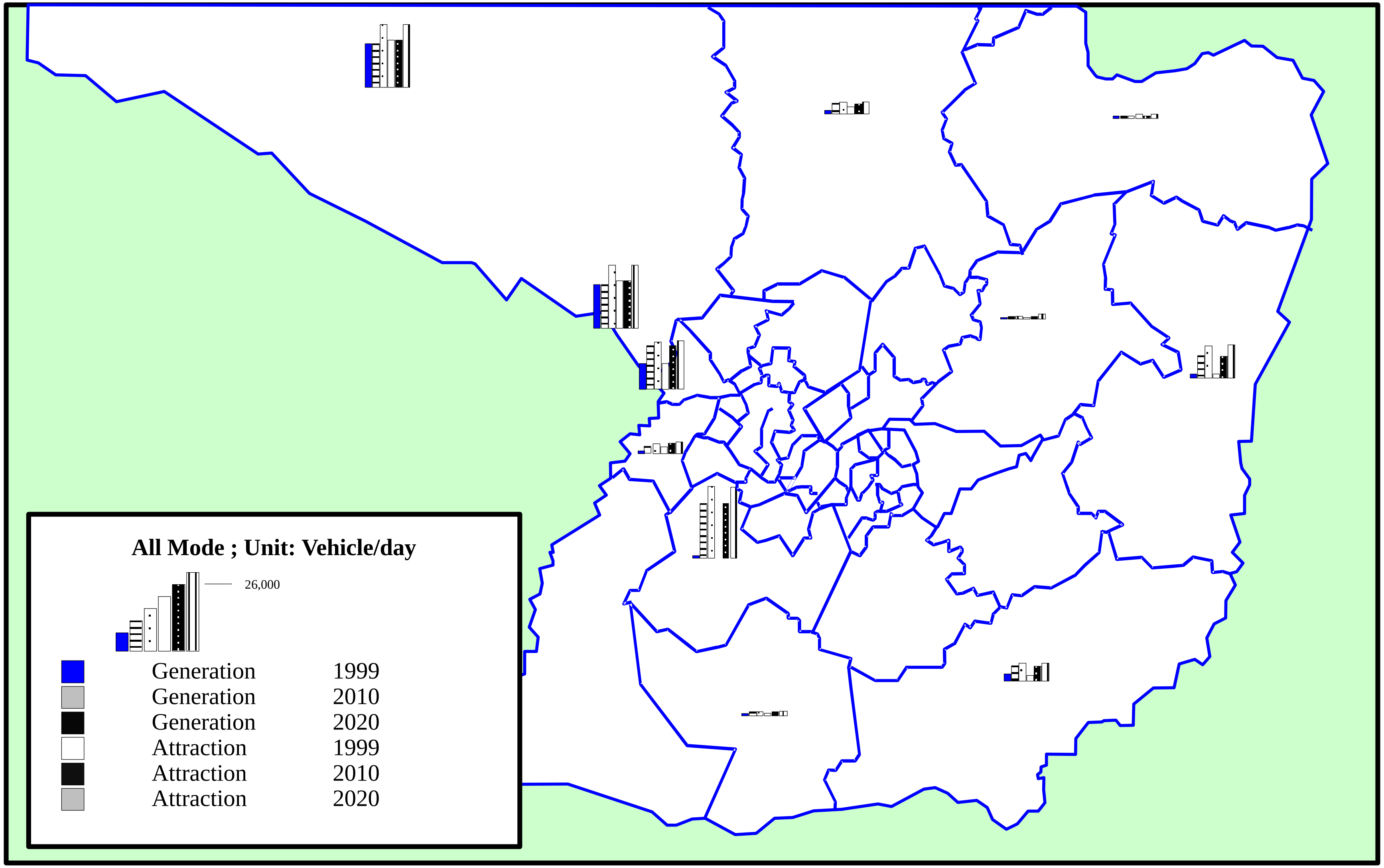


Figure 12.4.1 Trip Generation and Attraction

12.4.2 Future Additional Goods Vehicle Traffic for MERCOSUR

An increase of import and export due to the development of MERCOSUR has been separately added to the future traffic demand on national roads 2 and 7 according to the following reasons;

1) The Generation/Attraction model is made by the relation between generation/attraction volume of each zone is the study area and the social economic index.
2) It is not applicable for the generation/attraction volume outside the study area.
3) The economic index of each zone is the proportional value from the total so that particular zone will be averaged and opt to be smaller than actual.

In concrete terms, the traffic volume due to the increase of exports in each zone of Ciudad del Este and Asuncion has been added to the future OD table estimated by the model. The traffic volume converted from the increase of exports is distributed following the present traffic distribution pattern.

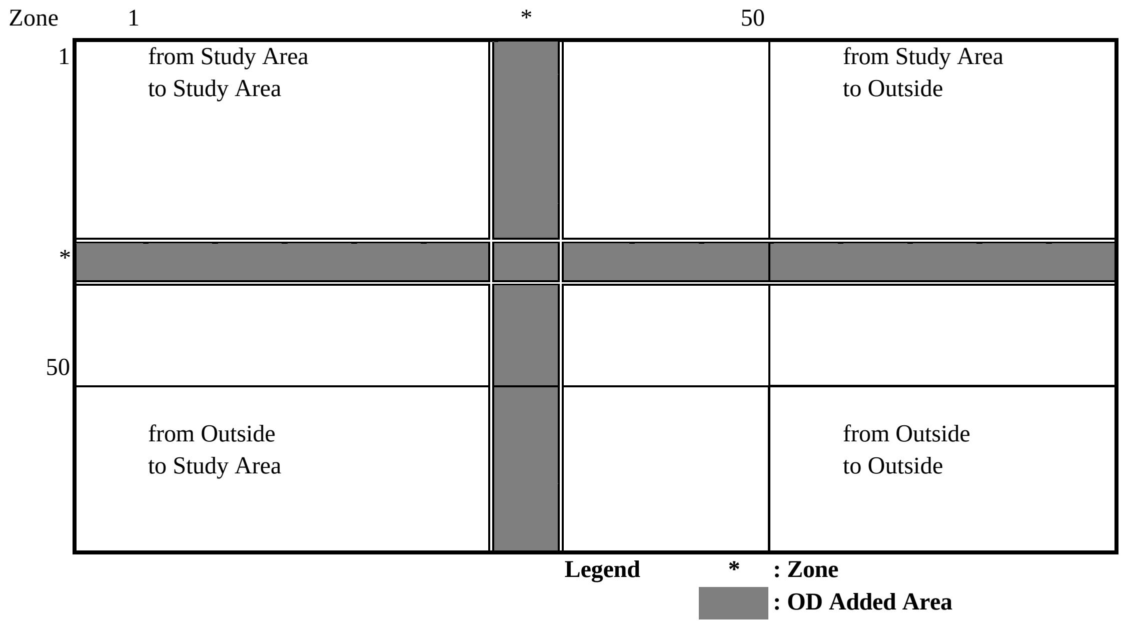


Figure 12.4.2 OD Added Area for MERCOSUR Goods Vehicle

The future OD is necessary including additional goods vehicle volume by MERCOSUR. MERCOSUR-related future export volume is estimated in Table 12.4.3 by this study.

Table 12.4.3 MERCOSUR-related Annual Export Volume

Unit : ton/year

Year	1999	2010	2020
Annual Volume	1,706,110	2,198,875	2,646,843
Ratio by 1999 (%)	100.0 %	128.9 %	155.1 %
Difference by 1999	0	492,765	940,733

A conversion from goods volume to goods vehicle number is the required average loading volume. The average loading volume of goods vehicle by traffic survey in this study is shown in Table 12.4.4.

Table 12.4.4 Average Loading Volume by Traffic Survey

Unit : ton/vehicle

	1999
Average Loading Volume with Empty Vehicle	1.43

The additional MERCOSUR-related future goods volume is shown in Table 12.4.5. In this estimation, the present OD is included for the annual export volume in 1999, then the additional volume is based on the difference with 1999 and the working days used are 300 days. And this volume is assumed to be exported from Ciudad del Este.

Table 12.4.5 Additional MERCOSUR-related Goods Vehicle Volume

Unit : Vehicle/day

Year	2010	2020
Additional Volume	1,149	2,193

12.5 Future OD Table

12.5.1 Future OD Volume

The future OD volume and increase ratio in 2010 and 2020 is shown in Table 12.5.1. It is expected that the number of total OD volumes will increase by factors 1.97 and 2.16 times from present level in the years 2010 and 2020, respectively.

Table 12.5.1 OD Volume and Increase Ratio

Year	Item	P.Car	Bus	Truck	Total
1999	Vehicle/day	26.176	3.494	24.502	54.172
	(%) of 1999	100.0%	100.0%	100.0%	100.0%
2010	Vehicle/day	46.123	6.242	44.965	97.330
	(%) of 1999	176.2%	178.6%	183.5%	179.7%
2020	Vehicle/day	55.376	7.485	54.625	117.486
	(%) of 1999	211.6%	214.2%	222.9%	216.9%

12.6 Future Traffic Demand

12.6.1 Future Traffic Demand on Target Route

The future traffic demand on target route in 2010 and 2020 is shown in Figure 12.6.1 and 12.6.2.

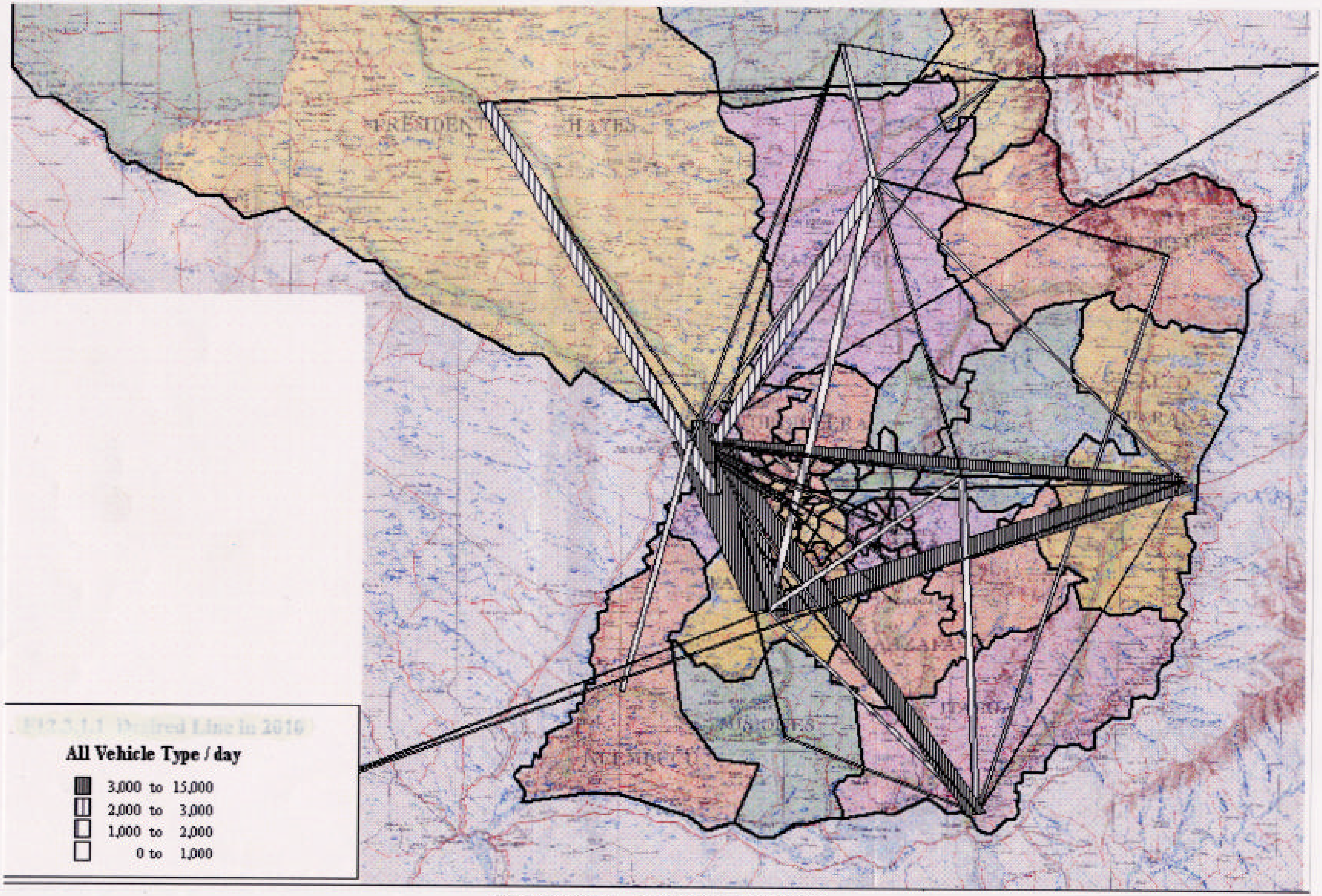


Figure 12.6.1 Desired Line in 2010

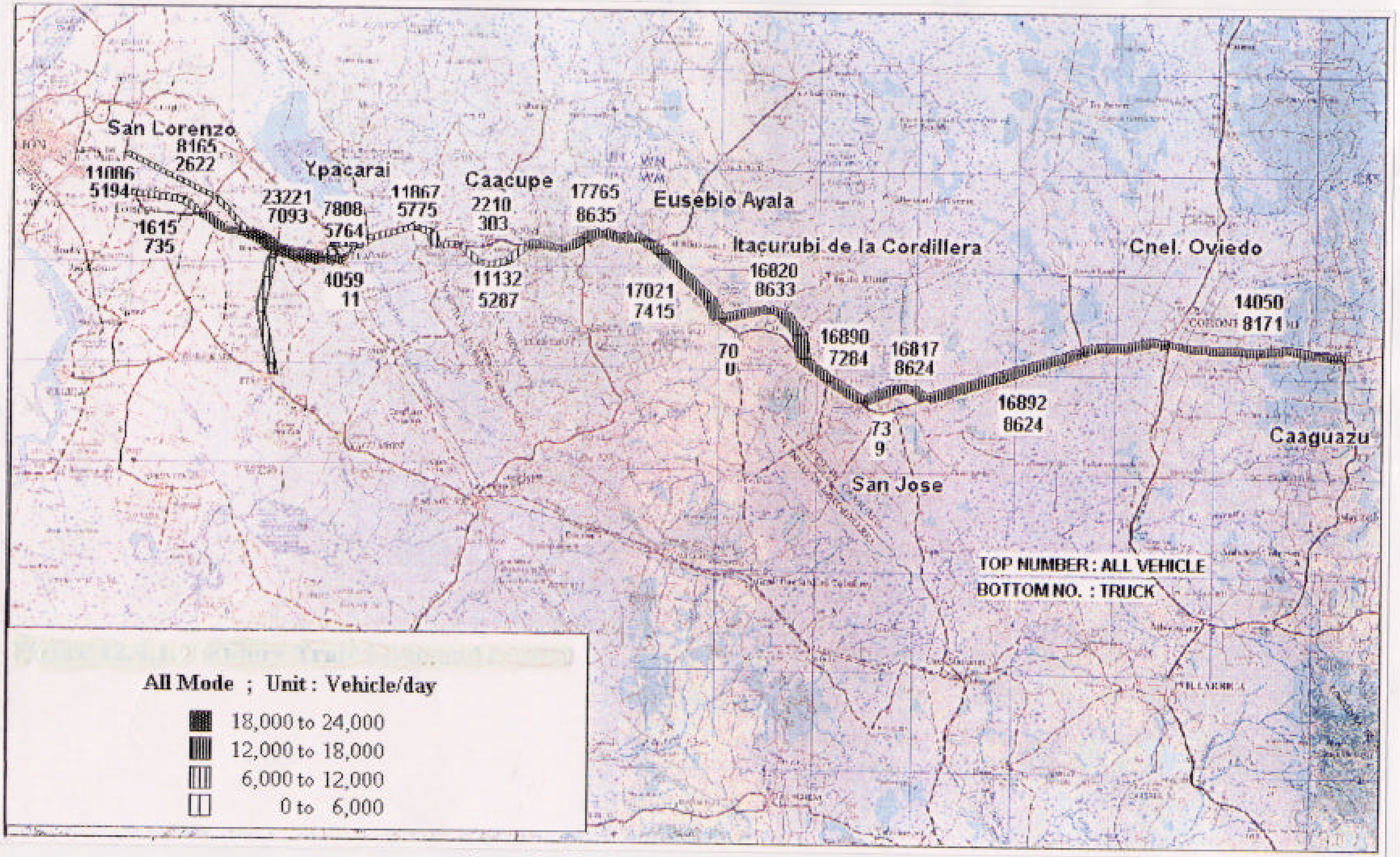


Figure 12.6.2 Future Traffic Demand in 2010

CHAPTER 13
PLANNING CONCEPT

13 PLANNING CONCEPT

13.1 Planning Policy

(1) Objectives of the Plan

Considering the function and the future role of the national road route 2 and route 7, the following objectives are proposed :

1) to strengthen the transportation system corresponding to MERCOSUR strategy.
2) to provide for balanced economic development in the Country.
3) to create a transportation axis from Asuncion Metropolitan Area to Ciudad del Este.
4) to secure traffic safety for users and preserve a good environment for citizens.

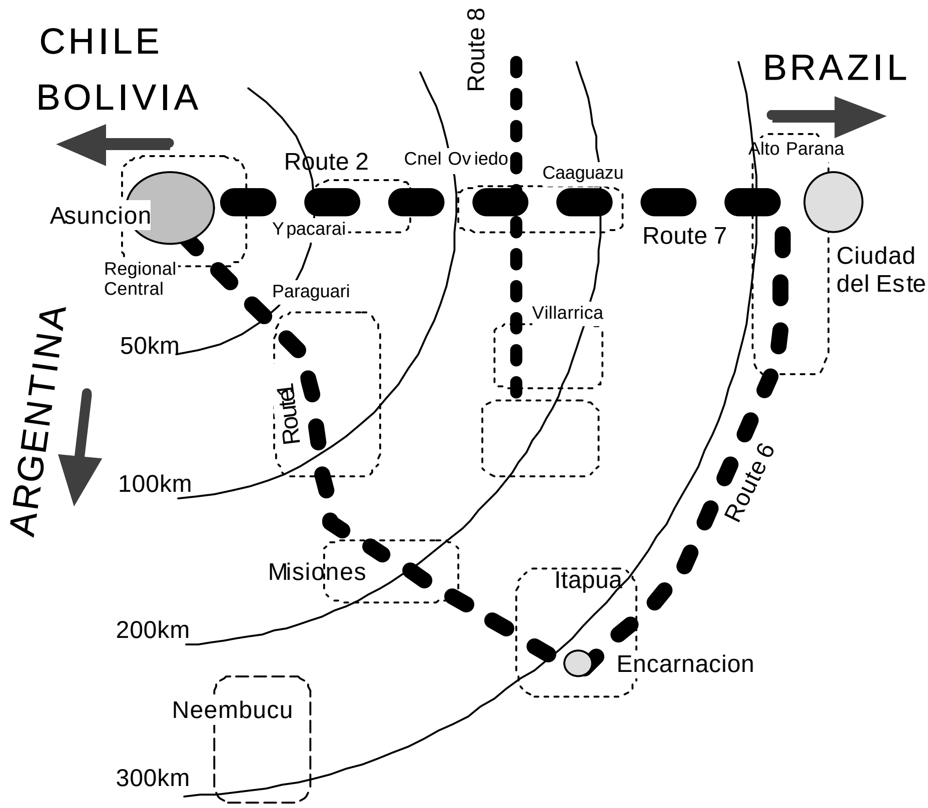


Figure 13.1.1 Location Map of Route from Asuncion to Ciudad Este

(2) Targets of the Plan

1) to achieve mobility with high velocity.
2) to achieve high standards of traffic services.
3) to pursue safety in making the transport plan formulation.
4) to ensure the preservation of environment.
5) to improve public transport.
6) to cope with the traffic demand.
7) to ensure the function of other modes.

(3) Necessary Road Functions

The following road functions are proposed in order to achieve the above targets :

1) to serve as the most important national road, and especially as the Land-Bridge highway between the two Oceans.
2) to serve as a corridor to transport passengers between Asuncion Metropolitan Area and Ciudad del Este.
3) to assist urban infrastructure development in Asuncion Metropolitan Area, Ciudad del Este and their vicinities.
4) to meet with the daily commuter traffic demand.
5) to ensure the strategy for Integration into MERCOSUR.

13.2 Regional Planning Concept

In order to define future road functions, the future development related to roads should be clarified. This involves the trend of the economy and social activities of Asuncion and Ciudad del Este. Since the development plan is greatly influenced by the trend of Integration in MERCOSUR, the influence or "impact" of MERCOSUR on it needs to be investigated.

(1) Relation of Both Cities

The two cities are closely related in the following manner:
Asuncion City continues growing as the center of the administration, economy, and culture in Paraguay.

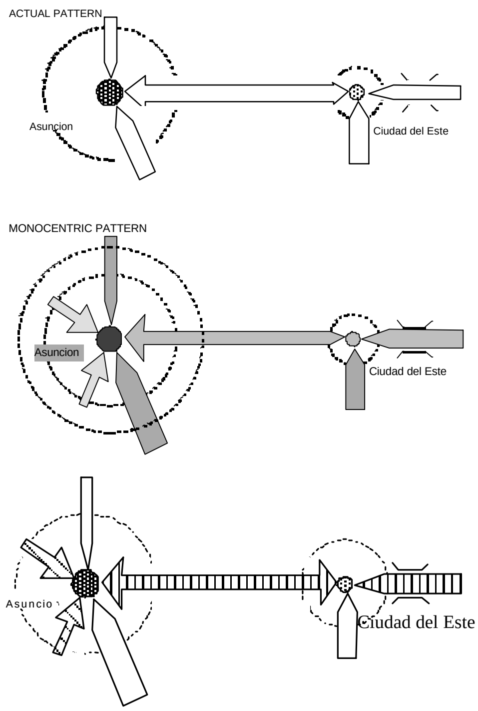
1) All social economic activities have been concentrated in Asuncion Metropolitan Area. Moreover, this phenomenon has accelerated recently.
2) There are large-scale grain warehouses in the outskirts of the city, which draw heavy traffic from the surrounding agricultural area.
3) The community limits of Asuncion City are the town of Caacupe.

Ciudad del Este is the second largest city in the country, and it borders with Brazil. It is the town to which tourists from Brazil come for shopping. Ciudad del Este is a city which has prospered on its duty-free status.

1) Since there was no customs duty affecting Ciudad del Este, the city was absorbing tourists from Brazil. However, this duty-free status will be abolished by the MERCOSUR agreement in 2001. For this reason, the advantages of Ciudad del Este will decrease.
2) Ciudad del Este is searching for measures which make use of the advantages of a border town.

(2) Development Pattern

The improvement plan of national roads route 2 and route 7 must take into consideration the development pattern of the two big cities. The above-mentioned items are taken into consideration. Three development patterns of the Asuncion Metropolitan Area and Ciudad del Este Area are shown in Figure 13.2.1



1) Existing Pattern : This pattern shows the concentration of all socio-economic activities in the Asuncion Metropolitan Area.

2) Mono-Centric Pattern : This pattern shows that only the Asuncion Metropolitan Area is developed and Ciudad del Este is left undeveloped. This pattern would probably occur if Ciudad del Este is left undeveloped.

3) Twin City Pattern : this pattern shows that the growth of Ciudad del Este is significant, while the growth of Asuncion Metropolitan Area is steady. Urban infrastructure development and job supply in Ciudad del Este would be required.

Figure 13.2.1 Development Pattern

(3) Proposed Development Pattern

From a study of the patterns shown above, the Twin City Pattern is proposed for the following reasons :

1) Ciudad del Este is on the transportation route which exports agricultural products to the international market. Primary industry will greatly contribute to the economic growth of Paraguay in the future.
2) The capacity of grain storage facilities bears an important relationship to the shipment of an export item like grain. Alto Parana prefecture accounts for 35% of grain production, Itapua prefecture 25%, and Central prefecture 20%. The transportation of grain for the economic development of Paraguay is concentrated in the Asuncion to Ciudad del Este transport corridor, and will increase in the future.
3) Asuncion is positioned as the main route for export such as crude oil from Paraguay river, container cargo, and cotton. Moreover, Asuncion plays the role of an export base for grain transportation to Brazil and Bolivia, and will become large.
4) In the future traffic demand in 2010, the vehicle count will exceed 8,000 vehicles/day.

13.3 Recommended Improvement Level of Service

13.3.1 Level of Service

The level of service is the level used to plan for more efficient traffic control, and it is defined as a qualitative measure describing operational conditions within a traffic stream, and the perceptions of road users.

The national roads route 2 and 7 will be employed as a two-lane highway for the traffic demand in 2010, except for urban areas.
For a two-lane highway, the level of service for Design Service Volume is classified according to AASHTO into 6 types:

A- best operating condition,
Operating speeds of 100 km/h (60 mph) or higher. 75 percent of passing maneuvers can be made with little or no delay. Under ideal conditions, a service volume of 400 passenger vph, total two-way, can be achieved.

B- good operating conditions,
Operating speeds of 80 km/h (50 mph) or higher. Volumes may reach 45 percent of capacity with continuous passing sight distance. Volumes of 900 passenger cars per hour, total two-way, can be carried under ideal conditions.

C- fair operating conditions,
Flow still stable. Operating speeds of 65 km/h (40 mph) or above with total volume under ideal conditions equal to 70 percent of capacity with continuous passing sight distance, or 1 ,400 passenger vph total two-way.

D- poor operating conditions,
Approaching unstable flow. Operating speeds approximately 57 km/h (35 mph). Volumes, two-direction, at 85 percent of capacity with continuous passing opportunity, or 1,700 passenger cars per hour total two-way under ideal conditions.

E- bad operating conditions, and
Operating speeds in neighborhood of 48 km/h (30 mph) but may vary considerably. Volumes under ideal conditions, total two-way, equal to 2,000 passenger vph. Level E may never be attained. Operation may go directly from Level D to Level F.

F- the worst operating level of services.
Forced, congested flow with unpredictable characteristics. Operating speeds less than 48 km/h (30 mph). Volumes under 2,000 passenger cars per hour, total two-way.

As for the level of service, D is selected because the traffic demand volume in 2010 will be about 1,200 pcph to 1,600 pcph.

13.3.2 Level of Service of the Existing Roads

Road capacity depends, as described above, upon road conditions, land use, the volume of access traffic, and level of service (LOS). Even with the same volume of traffic, it can vary with passenger car equivalent of heavy vehicles on steep gradients.

Table 13.3.1 shows the ratio of the capacity of the existing roads (V/C) in 2010 to the forecast traffic volume at the LOS of D, assuming the value of the passenger car equivalent at 3, in sections where the gradient of vertical alignment of over 3% continues for more than 500m. When the value of V/C exceeds 1.0, the LOS becomes E, and smooth flow of traffic cannot be expected. It is thus necessary, in such cases, to take some measures.

Measures that should be taken before 2010 in order to accommodate an increase in traffic demand are described below.

- Measures to improve those intersections lowering the traffic capacity between San Lorenzo and Ypacaraí
- Measures against lowering capacity in urban areas where the national route passes
- Measures to increase traffic capacity on rolling terrain where the gradient of over 3% continues for more than 500m, and the volume is expected to increase in terms of passenger car equivalent
- Measures against lowering capacity at intersections in urban areas of Cnel. Oviedo and Caaguazú

Table 13.3.1 Level of Service of the Existing Road with Forecast Traffic Volume

Location	Point	Sta.	Existing Capacity (PCU)	V/C Year 2010	Counter Measure
San Lorenzo –Ypacarai	Suburban	Built-up Area	45000	1.04	Improvement of Intersection
Ypacarai	Urban	34.00-39.00	32000	1.35	Mini Bypass
Caacupe	Urban	50.00-56.00	32000	1.32	Mini Bypass
Caacupe	Rolling	67.00-68.00	24000	1.45	Climbing Lane
Mocobli	Rolling	79.50-80.50	24000	1.32	Climbing Lane
Itacurubi	Urban	85.00-91.00	20000	2.47	Mini Bypass
Itacurubi	Rolling	92.00-93.40	24000	1.31	Climbing Lane
San Jose	Urban	101.00-105.00	20000	1.50	Mini Bypass
San Jose	Rolling	120.00-122.00	24000	1.42	Climbing Lane
Cnel. Oviedo Intersection	Urban	132.00	25000	1.25	Improvement of Intersection
Cnel. Oviedo	Rolling	146.00-150.00	24000	1.15	Mini Bypass
Cnel. Oviedo	Rolling	154.00-155.00	24000	1.15	Climbing Lane
Caaguazu	Rolling	162.00-163.50	24000	1.15	Climbing Lane
Caaguazu	Rolling	166.00-168.00	24000	1.15	Climbing Lane
Caaguazu	Urban	179	25000	1.16	Improvement of Intersection

13.3.3 Recommended Improvement Level of Service

From the viewpoint of rural and suburban arterial planning, principal roads should be planned to provide higher quality services as far as possible to provide faster, safer and more comfortable means of transport, taking into consideration the functions of principal roads, if such plans are economically and financially feasible. Furthermore, the minimum acceptable level required by road users would be the lowest allowable level. The level of service D will be recommended as the improved level of traffic demand in 2010.

From the viewpoint of the traffic function, national road routes 2 and 7 are the major principal roads serving for long-distance trips and connecting the Capital Asuncion with Ciudad del Este. There are various functions for a road, the traffic function is the main. The traffic function consists of two parts: mobility and local access. These functions are incompatible. The traffic function of the national road routes 2 and 7 requires high speed mobility and this mobility should be given higher priority.

13.4 Geometric Design Standard

There is no geometric design standard in Paraguay. The geometric design standard is decided for each project and for the principal roads. In this study, the design standard is determined taking consideration of the road function shown below,

1) The main principal road connects Asuncion, the capital city of Paraguay, and Ciudad Este, the second city in order of importance.
2) Many feeder roads connect the national route 2 and 7, and serve as development axis along the route.
3) The national route 2 and 7 are a critical export corridor connecting to Brazil, they constitute an international road corresponding to MERCOSUR.
4) The volume of large-sized traffic is high.
5) For the traffic volume in 2020, the principal roads need to be widened to four lanes.
6) When passing by suburban areas, road protection screens against noise and pollution must be constructed for the roadside houses.

This study is designed according to the principal road standard of AASHTO.
The geometric design standard applied to the rehabilitation works of national route 2 between Asuncion and Ypacaray is also shown to provide a comparison with the improvement standards of the national road route 2 and 7.

Table 13.4.1 Improvement Design Standard of the National Route 2 and 7

Work	Existing Road			This Study		
Terrain	Flat	Rolling	Mountainous	Flat	Rolling	Mountainous
Design Speed (km/h)	60-80	50-60	40-50	60-80	60-80	50-60
Carriageway Width (lane/m)	3.00-3.25	3.00-3.25	3.00-3.25	3.65	3.65	3.65
Shoulder Width (m)	1.80	1.80	1.80	2.5	2.5	2.5
Right-of-way (m)	50.0	50.0	50.0	50.0	50.0	50.0
Radius (m)				200-400	200-400	150-200
Grade (%)				3-4	3-4	4-6
Passing Sight Distance (m)				350-550	350-550	250-550

13.5 Typical Cross Section

(1) The cross section of the road in this study must take into account the following items:

1) The cross section must provide for high design speed and large traffic volume.
2) The cross section must provide for the traffic forecast of the target year.
3) The cross section must provide for the separation of the different traffic modes - high speed vehicles, low speed vehicles, bicycles, and pedestrians.
4) The cross section and the alignment must endeavor to preserve a good living environment according to the location of residences and the land use plan.
5) For an easy road maintenance management, the cross-section must follow a standard type as far as possible.
6) The design of interchanges considered the improvement of safety as the first priority.

(2) The typical Cross Section of this study is shown below,

1) The right-of-way adopted is 50.0m for new bypass roads which is the same width of the principal road width of Paraguay
2) The Carriageway width adopted is 12 feet (3.65m) according to principal road width.
3) The right shoulder adopts the principal road standard value of 8 feet.

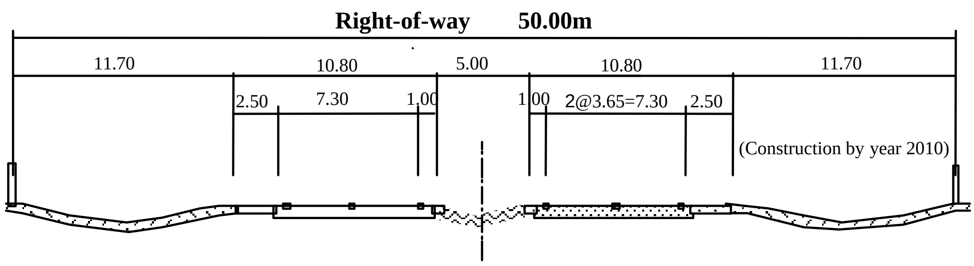
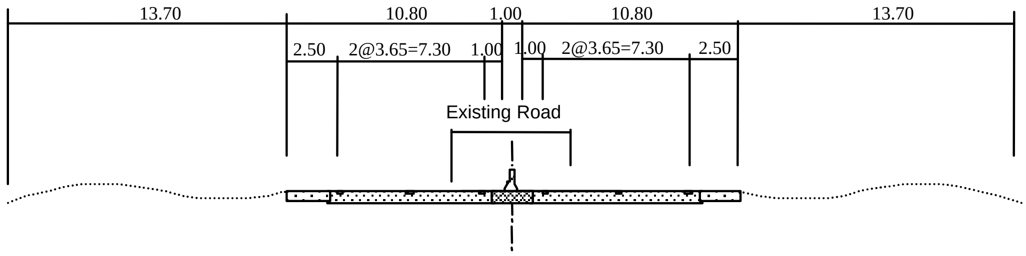


Figure 13.5.1 Typical Cross-section

(3) The existing road extension plan

Alternative A, which shows the extension plan along the existing road in Fig. 13.5.2, and alternative B using the established road are taken into consideration. This study recommends Alternative A because of a low construction cost and ease of construction work. However, Alternative B is adopted in the city area section from the environmental viewpoint.

Alternative A



Alternative B

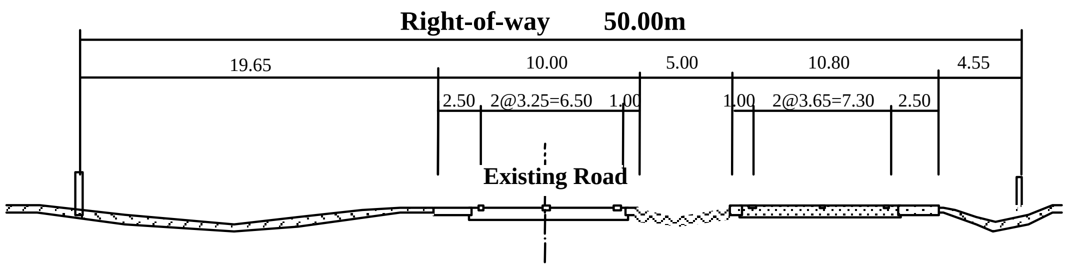


Figure 13.5.2 Existing Road Extension Plan

CHAPTER 14 IMPROVEMENT METHOD

14 IMPROVEMENT METHOD

14.1 Proposed Improvement Measures

National roads 2 and 7 are the most critical principal roads for Paraguay. It is necessary that the section from Asuncion to Ciudad del Este be a road of four or more lanes as principal road of the country by the year 2020. However, the traffic volume estimated for the year 2010 on this road is considerably less than the traffic capacity of the existing two lane roadway.

Therefore, the target year for planning the project road has been set for the year 2010, so the project road should be constructed in order to meet the traffic volume estimated for 2010. The project road aims at the improvement of the 2 lane road except for the Asuncion urban area, and the improvement of the present road structure is proposed.

The following three stages are proposed for the improvement of the national roads 2 and 7.

a. Short Term (2000 – 2005)

Improvement of the problems of the existing road

1) Improvement of at-grade intersection
2) Construction of climbing lane
3) Installation of safety facilities for traffic flow

b. Medium Term (2006 – 2010)

Construction of bypass roads

1) Construction of mini bypass roads

c. Long Term (2011 – 2020)

Road construction corresponding to MERCOSUR standards and to the necessity of construction of bypass roads in highly urbanized areas.

1) Construction of bypass road to alleviate congestion on inter-urban sections
2) Widening in highly urbanized areas
3) Construction of four or more lanes road

14.2 Specific Problems on National Route 2 and 7

14.2.1 Improvement of At-grade Intersections

The sections which need at-grade intersection improvement are shown below.

- The section from Kilometer Post 14 km (San Lorenzo) to 33 km (Ypacaraí) on national route 2
- Road Kilometer Post 132 km (Cnel. Oviedo intersection)
- Road Kilometer Post 179 km (Caaguazú intersection)

1) San Lorenzo, Capiata, Itauguá: National route 2 is a 4-lane dual mode road in the urban areas. Those at-grade intersections do not have a left turning lane. There is no space for a passing lane, so left-turning vehicles become an obstacle for traffic flow. The installation of a left-turn lane is needed in order to improve traffic safety and traffic flow. However, there is no space for the required extension of the right-of-way for improvement of at-grade intersections. The roadside in those areas is used for commercial activities, and is a high-density area. Therefore, the at-grade intersection improvement plan does not consider land acquisition since extension is difficult.

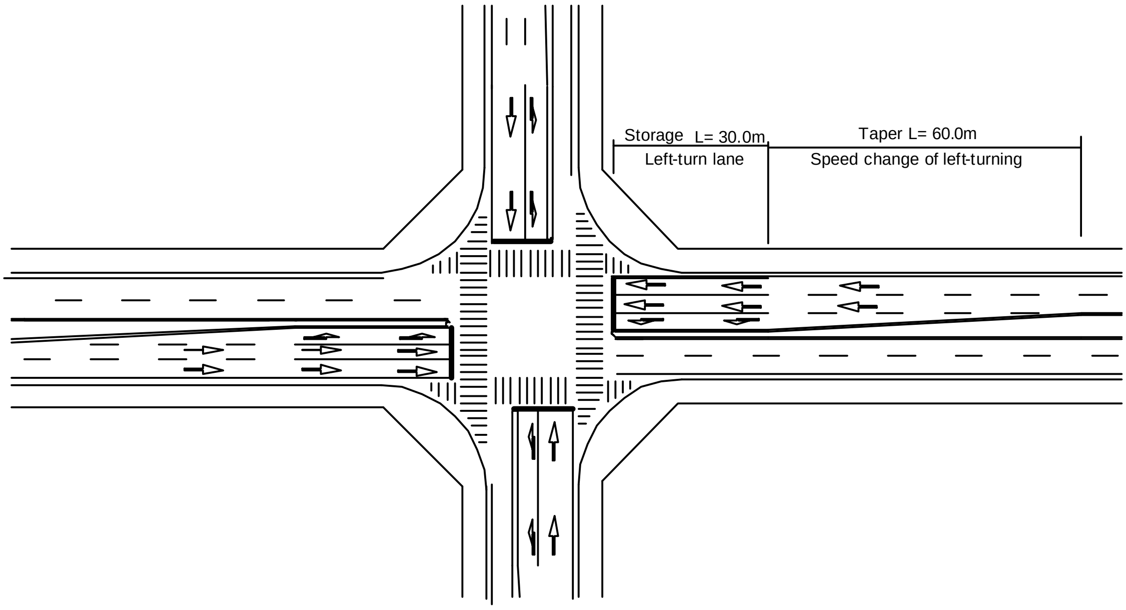


Figure 14.2.1 At-grade Intersection

2) At Cnel. Oviedo intersection: There is a circular intersection with a 50 m diameter. The intersection needs another type of at-grade intersection or a fly-over so that vehicles coming from a long straight road section do not need to slow down. In this project a fly-over type intersection is recommended for the traffic flow of a principal road. Moreover, it will meet the demands of the traffic volume in 2010.

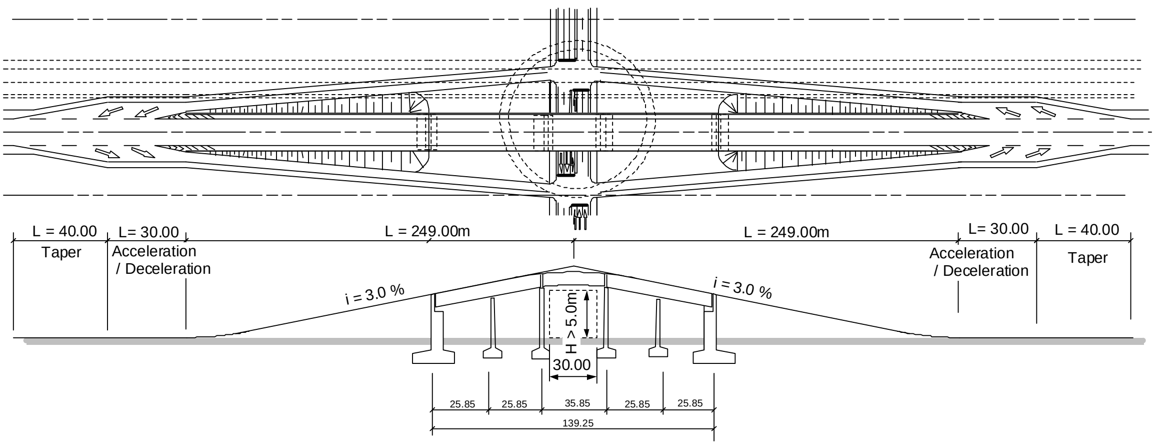


Figure 14.2.2 Fly-over Intersection

14.2.2 Construction of Climbing Lane

a. Necessity of a Climbing Lane

1) In sections with a 3% gradient or more, large-scale trucks running speed becomes less than 20km/h and traffic accidents caused by dangerous passing occur frequently.
2) Traffic flows of passenger cars are interrupted by low speed vehicles, which decreases the traffic capacity on national routes 2 and 7.

The installation of a climbing lane will be taken into account for the reasons stated above.

b. Installation Position

1) Climbing lanes are provided for vertical-section slopes of 3% or more.
2) The minimum length adopted for a climbing lane is 500 m or more.
3) In vertical-sections with a 3% slope or more, traffic flow slows down as shown in Figure 14.2.3. The following figure is speed-distance curves for typical heavy trucks of 300 lb/hp for deceleration. Typical heavy trucks are shown in AASHTO. In Paraguay, a 60% value is adopted because trucks are over loaded and poorly maintained.

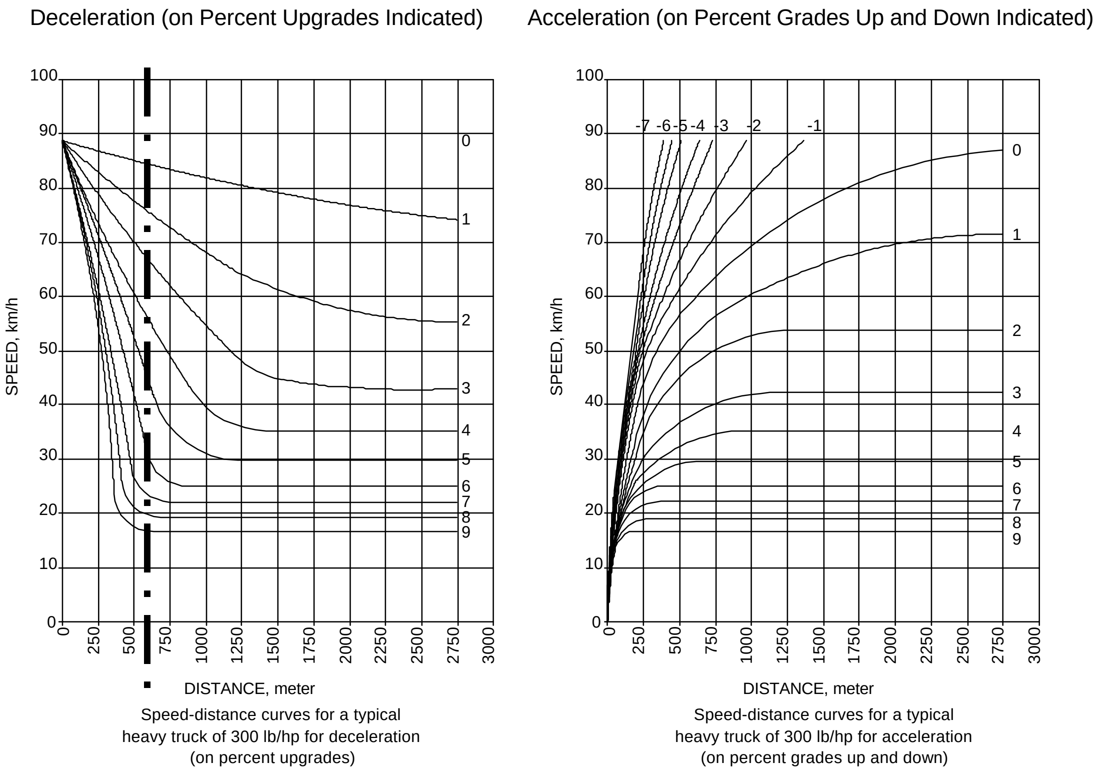


Figure 14.2.3 Speed-distance Curves for Typical Heavy Trucks of 300 lb/hp for Deceleration

14.2.3 Installation of Safety Facilities

The study team looked for frequent traffic accident points on the national routes, 2 and 7, in order to determine the necessary safety facilities. The most dangerous points found are bridges and sharp bends.

1) Bridge Crashing
   Bridge crashing accidents occur mostly because of a reduced road-shoulder width and unclear lane guidance and road signs.

2) Sharp Bend Sections
   Frequent accidents on sharp bends occur in the section from Kilometer Post 146.5km to 149.5km on national route 7. Sudden "s" sharp bends appear after a straight-line section.

14.3 Construction of Mini Bypass Road

Large-scale vehicles pass by the cities of Ypacaray, Caacupe, Itacurbi, and San Jose, so pedestrians and residents along the route are always in danger. The roads should be classified according to their function in Main Road and Frontage (local) Road. A main road functions at high speed and is fundamental for the transportation of freight. A frontage road is to be used by the community of roadside residents

A mini-bypass in the out skirts of these city areas is needed.

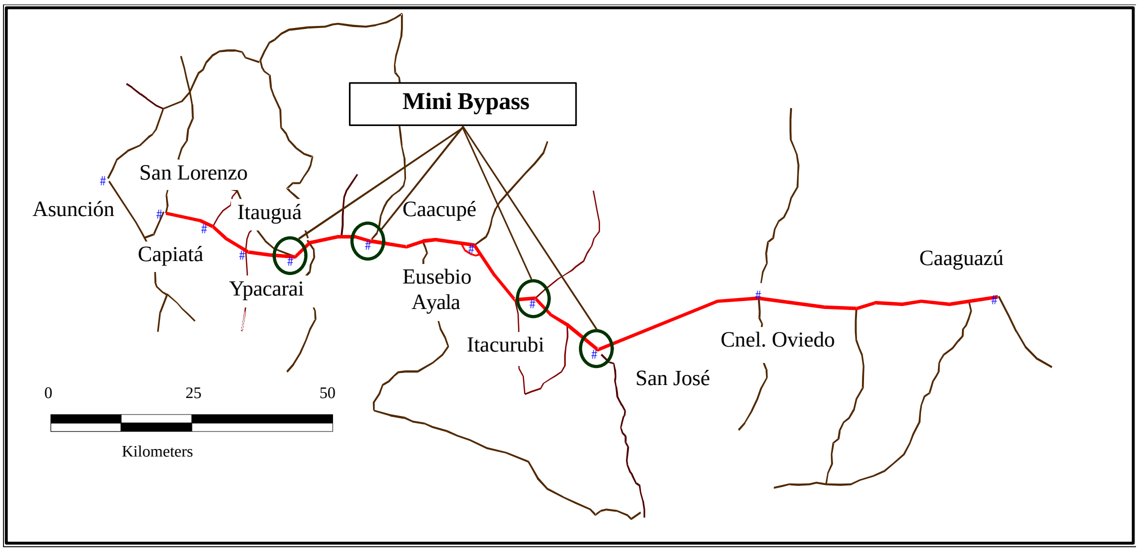


Figure 14.3.1 Location of Bypass Roads

CHAPTER 15 INITIAL ENVIRONMENTAL EXAMINATION

15 INITIAL ENVIRONMENTAL EXAMINATION (IEE)

At an early period in the planning stage of a development project, execution of an Initial Environmental Examination (IEE) is required to evaluate environmental impacts which might arise from implementation of a specific project. The primary objective of IEE is to evaluate whether Environmental Impact Assessment (EIA) is necessary for the project. Accordingly, IEE is conducted using the following procedure.

1) To determine the scope of EIA, if the project is evaluated as requiring an EIA.
2) To examine countermeasures for mitigating effects of the project which require environmental consideration, if the project is evaluated as not requiring an EIA.

15.1 Environmental Items

Generally, environmental fields to be examined in a development project cover a very wide area. Therefore, “environmental items” for IEE shall be selected for use in analyzing and summarizing the environmental aspects and issues of a specific project.

In this study, as mentioned above, the environmental items were selected in accordance with the purpose of IEE, the characteristics of the study area, Law No. 294 regarding EIA of *Paraguay* and so on. The selection of the items was performed after discussions with officials of the Directorate of Environmental Control (*Direccion de Ordenamiento Ambiental*: DOA) of the Ministry of Agriculture and Stock Farming (*Ministerio de Agricultura y Ganaderia*: MAG), and the DMA (*Dirección de Medio Ambiente* which is former *Unidad Ambienta*) of the MOPC as show in Table 15.1.1.

Table 15.1.1 Environmental Items

1. Social Environment					
1.1	Resettlement	1.4	Split of Community	1.7	Public Health Condition
1.2	Economic Activities	1.5	Cultural Heritage & Properties	1.8	Waste
1.3	Traffic and Public Facilities	1.6	Water Rights and Common Rights	1.9	Disaster (Risks)
2. Natural Environment					
2.1	Topography and Geology	2.4	Hydrological Situation	2.7	Meteorology
2.2	Soil Erosion	2.5	Coastal Zone	2.8	Landscape
2.3	Ground Water	2.6	Fauna and Flora		
3. Pollution					
3.1	Air Pollution	3.3	Soil Contamination	3.5	Ground Subsidence
3.2	Water Pollution	3.4	Noise and Vibration	3.6	Offensive Odors

15.2 Examination of the Environmental Situation

Based on the environmental characteristics of the study area which was reviewed in the previous section, the environmental situation can be discussed and examined from the viewpoint of IEE by environmental items as follows:

15.2.1 Social Environment

(1) Resettlement

Settlements have been identified along routes 2 and 7. Specially in the city area of the routes, such as in *San Lorenzo, Ypacarai, Caacupe, Eusebio Ayala, Itacurubi, San Jose, Cnel. Oviedo* and *Caaguazu*, there are many settlements, commercial shops and restaurants.

Therefore, it is considered that there are possibilities that resettlement will be required due to the execution of bypass projects and widening of the routes during both the preparation and construction stages. On the other hand, illegal settlements and specific indigenous communities' areas have not been identified along the routes in the study area.

The extent and number of houses to be resettled because of the above mentioned projects shall be studied to estimate the compensation values to be given, to carry out the official resettlement program, and to find alternative land for resettlement if necessary.

(2) Economic Activities

There will be both positive and negative impacts on economic activities by the implementation of the improvement projects during the construction and operation stages.

Based on a review of the economic activities in the study area in (2) of section 9.2.2 and data of Table 9.2.7, the characteristics of the economic activities can be summarized in the following Figure 15.2.1 and explanation.

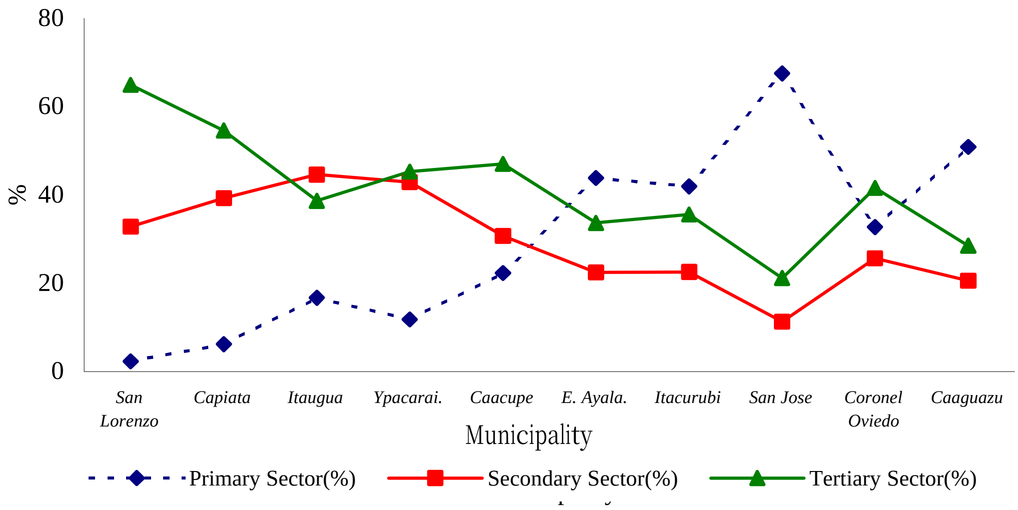


Figure 15.2.1 Ratio of Economic Activities by Sector in the Study Area

- From *San Lorenzo* to *Caacupe*, the secondary sector (industries, construction and etc.) and tertiary sector (services and etc.) are most active.
- From *E. Ayala* to *Caaguazu*, the primary sector (agriculture, silviculture, stock farming, etc.) prevail.

It is considered that construction of a bypass in the secondary and tertiary sector areas would give benefits and conveniences to the commercial and industrial activities in these areas, and that the widening of the routes in the primary sector area would increase the transportation of agricultural and silvicultural products in the specific sector. Therefore, several positive impacts on the economic activities are expected by the bypass and widening construction.

However, possibility of changes to economic structures and land use values including agricultural production, commercial activities and job opportunities will be considered by construction of bypass and widening section, specially in the areas of the primary sector. These changes would have both positive and negative impacts depending on the circumstances and situations in these areas. Therefore, bypass construction and widening sections shall be planned and designed to mitigate possible negative impacts in accordance with future developments and land use plans.

(3) Traffic and Public Facilities

Public facilities such as bus terminal, cemetery, school and hospitals and other public utilities will be affected depending on the alternative bypass route. In general, the structure of a city or town in Paraguay has one center called “*centro*” where at least one Christian church is located .

Accordingly, necessary attention shall be paid to these facilities before deciding the locations of a bypass in the planning stage to avoid negative impacts.

Many monuments for traffic accident victims and other deaths have been seen along both sides of routes 2 and 7. These monuments, called “*Nicho*”, were built by the families or relatives of the victim(s) to mourn their dead by traffic accidents and others. As a matter of course, they are not public facilities. However, from the sense of common humanity, it is considered that special consideration should be paid to these monuments during construction of bypasses and widening of existing routes. If necessary, these monuments shall be moved to suitable locations during the preparation and construction stage in accordance with local religious practice.

(4) Split of Community

Several indigenous communities have been identified in specific departments of the study area. However, these communities are located outside the routes 2 and 7 of the study area. Therefore, it is not anticipated that construction and operation will affect these communities. As a matter of fact, for the widening of sections of existing routes, the communities were not affected.

However, at the planning stage, administrative and cultural boundaries shall be identified in the bypass construction areas to mitigate possible negative impact.

(5) Cultural Heritages and Properties

As reviewed in (4) of the section 9.2.2, each city from *San Lorenzo* to *Caaguazu* was established more than 100 years ago, and there are many old Christian churches and other old buildings in these cities. Some of them will have historical and cultural value. Accordingly, negative impact on these churches and buildings will be considered during the construction stage.

Therefore, construction of bypasses and the widening of sections in the study area shall be carefully designed to avoid negative impact on these churches and buildings during the preparation and construction stages.

(6) Water Rights and Common Rights

Routes 2 and 7 cross several rivers and streams in the study area. Therefore, specific information on water rights and common rights shall be identified in the bypass construction area before its execution.

(7) Public Health Condition

Roadside gutters for rain and domestic water shall be improved and covered for the environmental sanitation and hygiene protection along the road sides.

(8) Public Health Condition

Generation of surplus soil, construction and demolition waste, debris and logs and so on can be anticipated during the construction stage of the improvement project. On the other hand, increase of general solid waste along the improved routes can be expected after construction, i.e. in the operation stage in accordance with increase of the traffic volume and population.

Therefore proper solid waste management will be required during the bypass and widening construction stage and operation stage as well.

(9) Disaster (Risks)

1) Flooding
   In *Ypacarai*, 36 km from *Asuncion*, a wetland extends on both sides of route 2. During heavy rain, the level of the water in this wetland often reaches the road level. Therefore, flooding is anticipated in this area during the rainy season or in days of particularly heavy rain.
2) Landslide
   In *Caaguazu* district between 160 and 180 km from *Asuncion*, there are possibilities of landslide due to the undulating configuration and greater use of the ground by surrounding settlements at the edge of route 7 and execution of the soil cut during construction of the road without any slope protection.

15.2.2 Natural Environment

(1) Topography and Geology

There will be no large scale excavation for the construction of bypasses and widening. Therefore, no impact will be anticipated during and after the improvement.

(2) Soil Erosion

There will be no large excavation during the construction of improvement projects. Therefore, no impacts on soil erosion can be predicted by the projects.

However, if excavation and slope cutting is required during the construction stage of the improvement project between *Ypacarai* and *Caacupe,* due to the relatively high and hilly configurations in that area, precautions to avoid soil erosion would be necessary during the construction stage.

Removal of existing vegetation and shade trees will be anticipated for construction of bypasses and widening of existing routes. Accordingly, necessary measures will be required in such a case to avoid exposure of the surface soil during and after construction.

(3) Ground Water

There will be no large scale excavation for the construction of bypasses and widening. Therefore, no impact on the ground water is expected.

(4) Hydrological Situation

There will be no large scale excavation for the construction of bypasses and widening. Therefore, in principle, no impact on the hydrological situation is expected in the study area.

However, there are many streams and river crossings, and rainwater ditches constructed along routes 2 and 7 in the study area. Due to these circumstances, attention to minimize the damage to such facilities as bridges and rainwater ditches, by the construction of improvement projects will be required at the detailed design stage and during construction .

(5) Coastal Zone

There is no sea coastal zone in the study area. Accordingly there is no impact on it.

(6) Fauna and Flora

Endangered species of fauna and flora have been recognized in the three departments of the study area. However, as a result of the literature review and field reconnaissance survey, specific fauna and flora to be protected have not been identified along routes 2 and 7 in the study area, and it is considered that any such species are located outside the study area. Therefore, in principle, there are no negative impacts on the specific fauna and flora during the preparation, construction and operation stage.

On the other hand, regarding the natural reservoirs and parks in the study area, there are several reservoirs and parks as shown in Table 9.2.3 and Figure 9.2.1. Accordingly, review of habitats of the fauna and flora, territory of national reservoirs and their legal frameworks are necessary in the bypass and several widening construction areas, specially in the surroundings of route 2 in *Ypacarai*.

(7) Meteorology

This project involves the improvement of existing roads including construction of a short bypass and widening of existing routes, etc. Therefore, no large scale excavation, no land reclamation and no large construction such as water reservoirs and high-rise buildings is planned for the implementation of the improvement. Accordingly, no impacts can be predicted on the meteorological situation.

(8) Landscape

It is considered that there are no specific landscapes and views to be protected in the study area. However, the configuration between *Ypacarai* and *Caacupe* is relatively high and hilly. The *Ypacarai Lake* is observed from some positions along the route from *Ypacarai* to *Caacupe*. And several unusually beautiful shade trees along the routes in the study area have been identified. Therefore, attention at the design stage shall be paid to the design, layout and location of the widening and other improvements to harmonize with the surrounding environment. If this is done, a positive impact on the landscape can be expected by the execution of the improvement project.

15.2.3 Pollution

(1) Air Pollution

It can be evaluated that air quality in the study area is not a critical situation at present, according to field survey results and existing data.

In *Paraguay*, leaded fuel is still used legally. As a result of a survey in 1993 and the JICA survey in 1999 regarding air pollution, it is observed that there was a decreasing trend of Pb concentration in the air between 1993 and 1999. It can be considered that the reason for the decreasing trend is the increasing use of unleaded fuel in recent years in *Paraguay*. Actually, little leaded and alcohol fuel are available at present in Paraguay. It can be considered that this movement away from leaded and alcohol fuels is positive for the environment. In order to decrease air pollution and the negative impact on human health from vehicle exhaust, leaded fuel should be controlled by regulation and should be prohibited by stages in accordance with economic development.

As a matter of course, the increase of total numbers of vehicles in the study area, namely, the increase of total quantity of exhaust gas will worsen the surrounding air quality.

(2) Water Pollution

There will be no large scale excavation for construction of the improvement projects. Therefore, no impact on water is expected in the study area. However, there are many streams and rivers in the study area as mentioned already. During the construction stage, the surplus soil, construction debris and so on shall be controlled to avoid contamination of these streams.

(3) Soil Contamination

As mentioned already in (1) Air Pollution, leaded fuel is used by vehicles in *Paraguay*. Of course, in the operation stage of the improvement project, vehicle exhaust gases will contaminate the roadside soil. A stepped control for prohibiting the use of leaded fuel is required in order to decrease soil contamination by lead from vehicle exhaust.

On the other hand, construction materials such as asphalt emulsion may possibly be dispersed in the soil along the routes in the study area during the construction stage. Therefore, suitable construction management will be required to control the dispersion.

(4) Noise and Vibration

Roadside noise levels of more than 70 dB(A) in daytime have been observed in field surveys in the four major cities along Route 2. It is considered that the situation caused by this noise level is one of the environmental issues in the study area. Most of the noise sources at survey locations are summarized as follow.

- Gasoline and diesel engines.
- Faulty exhaust systems in such vehicles as old and reconditioned cars, buses, trucks. (Retail muffler sellers have been seen often along the streets in *Asuncion* and other cities. The quality of these mufflers is questionable if they are not genuine products of the vehicle makers.)
- Vehicle horns.
- Relatively worn out tyres (to get high friction co-efficient) on the road surface.

Therefore, introduction of obligatory systems for equipping muffler devices with adequate quality controlled by a technical standard and a muted horn with a national standard on every vehicle will be principal measures for mitigating road noise.

(5) Ground Subsidence

No large scale excavation which will affect the groundwater and geographical situation will be proposed. Therefore, no ground subsidence can be anticipated by the implementation of the improvement projects.

(6) Offensive Odor

No offensive odors will be caused by the implementation of the improvement projects except exhaust gas from vehicles during the construction and operation stages of the improvements. Especially, as a matter of course, there will be increase of odors from exhaust gas in the bus terminals at *Caacupe* and *Caaguazú* due to the likelihood of increase of bus traffic in the operation stage after the improvement.

It is considered that vehicle engine maintenance is the principal and usual method for controlling odors from the exhaust system. Therefore, introduction of a vehicle engine maintenance system will be expected together with a car inspection system as discussed in the environmental item of Air Pollution and Noise and Vibration already.

15.3 Summary of the IEE

Each environmental item shall be evaluated from the viewpoint of the Initial Environmental Evaluation (IEE). The evaluation can be carried out in accordance with the rating method using four categories as shown in Table 15.3.1. In this method, every environmental item which is evaluated as category “A” and ”B” is considered to require study in the form of an environmental impact assessment (EIA). For items evaluated as category “C” further studies are required to clarify the impact.

Table 15.3.1 Evaluation Categories

Category	Examination and Evaluation	Remarks
A	Serious impact will be expected	EIA is required
B	Some impact will be expected	EIA is required
C	Extent of impact is unknown	Further study will be required
D	No impact will be expected	-

As a result of the discussions and the examinations conducted in section 15.2, the improvement projects could be evaluated and summarized as shown in the following Table 15.3.2.

In addition to the evaluation above mentioned, environmental items which could be predicted to have any positive impact by the implementation of the improvement projects were marked as “P” in the “Remarks” column of the table.

Table 15.3.2 Summary of the IEE

Environmental Items		Evaluation	Reasons	Remarks
Social Environment	Resettlement	B	Resettlement will be predicted by the construction of bypass and winding of the existing route	
	Economic Activities	C	Modification of the economic structures, and fluctuations of real estate price will be predicted by a bypass construction	P
	Traffic and Public Facilities	C	Public facilities such as religious and public utilities will be affected depending on the alternative bypass route.	
	Split of Communities	C	There is no indigenous community. However, administrative and cultural boundaries shall be identified in the bypass construction area.	
	Cultural Property	C	There are old buildings, Christian churches and so on in some cities.	
	Water Rights and Common Rights	C	Specific information shall be identified in the bypass construction area before execution	
	Public Health Condition	D	Road side gutters for rain and domestic water shall be improved and covered.	
	Waste	D	Proper solid waste management shall be required during the bypass and widening construction stage.	
	Hazards (Risk)	C	There is a possibility flooding around *Ypacarai* Lake basin.	
Natural Environment	Topography and Geology	D	There will be no large excavation by the construction of bypass and widening	
	Soil Erosion	C	There will be no large excavation by the construction of bypass and widening	
	Groundwater	D	There will be no large excavation by the construction of bypass and widening	
	Hydrological Situation	D	There will be no large excavation by the construction of bypass and widening	
	Coastal Zone	D	No coastal zone in the study area	
	Fauna and Flora	C	Endangered rare species of fauna and flora have been identified in the departments in the study area. Study on the fauna and flora is necessary in the bypass construction area and widening section	
	Meteorology	D	There is no large scale construction and modification of the land configurations	
	Landscape	D	Bypass, widening and other improvement measures shall be constructed to harmonize with the surrounding landscape.	P
Pollution	Air Pollution	B	More or less, traffic volume will be increased after the improvement.	
	Water Pollution	D	No direct impact on the water will be expected by the execution of improvement.	
	Soil Contamination	D	More or less, traffic volume will be increased after the improvement.	
	Noise and Vibration	B	More or less, traffic volume will be increased after the improvement.	
	Land Subsidence	D	There is no excavation and construction that will affect ground water	
	Offensive Odor	D	More or less, traffic volume will be increased after the improvement.	

Note:
A : Serious impact will be expected
B : Some impact will be expected
C : Extent of impact is unknown (Further study will be required)
D : No impact will be expected
P : A positive impact will be expected

15.4 Conclusion of IEE

15.4.1 Environmental Items requiring EIA

According to the results of the IEE study in the previous sections, the following items which are evaluated as category “B” are considered to be affected by the execution of the improvement projects. Consequently, an environmental impact assessment (EIA) study will be required for the environmental item of “Resettlement”, “Air Pollution” and “Noise and Vibration” as follows.

(1) Resettlement

The prediction of the resettlement should be done by using a detailed map of the distribution of housing and other construction in the target area. Accordingly, a mapping survey for each project will in principle be required in order to identify the number of inhabitants, their economic conditions, related information, etc.

Regarding compensation for resettlement, there is no such system at present in *Paraguay*. MOPC should prepare the compensation system and force regulations in the project area in accordance with the National Constitution and enactment. Therefore, past experience on resettlement and compensation measures taken by the MOPC shall be reviewed and the feasibility of applying them shall be evaluated.

The conditions of the resettlement sites shall be studied as to whether these sites are suitable for alternatives from the viewpoint of living environment.

(2) Air Pollution

Total quantity of pollutants emitted from vehicle exhausts shall be predicted for evaluating air pollution in the target year. Especially, CO_2 and NO_X are the critical pollutants from vehicle traffic. There are several prediction methods. The principal method is to calculate them by use of several parameters such as “traffic volume by each vehicle type”, “vehicle velocity (km/h)” etc. Therefore, these parameters shall be obtained or assumed from existing data or other studies at the EIA stage to make the necessary prediction.

(3) Noise Level

A prediction of the noise level expected at the target year should be made. Of course, there are several prediction models for road noise. Depending on the situation and purpose of the prediction, a suitable model should be chosen. As one of the models, the equivalent sound level can be calculated by use of several parameters such as “average power level(PWL)”, “vehicle average interval(m)”, “vehicle velocity (km/h)”, and “distance between noise source and the monitoring position (m)”. Therefore, these parameters shall be obtained or assumed from existing data or other studies at the EIA stage to make the necessary prediction.

15.4.2 Other Environmental Items requiring Further Study

Other environmental items which were evaluated category “C” require further studies in the target areas of the improvement projects as discussed in the previous section. The following Table 15.4.1 lists environmental items for further study and provides a brief study plan.

Table 15.4.1 Environmental Items requiring Further Study and the Study Plan

Environmental Item		Study Plan
Social Environment	Economic Activities	To study future land use plan and future economic structures in the target area of the improvement projects and so on.
	Traffic and Public Facilities	To survey and identify the distribution of public facilities in the target areas of the projects.
	Split of Communities	To survey and identify the cultural and administrative structures in the target areas of the projects.
	Cultural Property	To survey and identify the distribution of the cultural properties in the target areas of the improvement projects.
	Water Rights and Common Rights	To study and identify these rights in the target areas of the projects
	Hazards (Risk)	To study maximum water level and collect past data on the flooding and land slides at critical points in the areas of the improvement projects.
Natural Environment	Soil Erosion	To study and identify critical areas and collect past data on soil erosion and basic data of the specific areas in the improvement projects.
	Fauna and Flora	To study and identify the habitats of the fauna and flora to be protected in the areas of the improvement projects.

CHAPTER 16 SELECTION OF THE BEST ALTERNATIVE ROUTE

16 SELECTION OF THE BEST ALTERNATIVE

16.1 Bypass Routes

16.1.1 Ypacarai Bypass

Since the principal road passes by in Ypacarai City, road should be improved as has been mentioned in Chapter 14.3. Alternative routes passing to the north of the existing road have been taken into consideration.

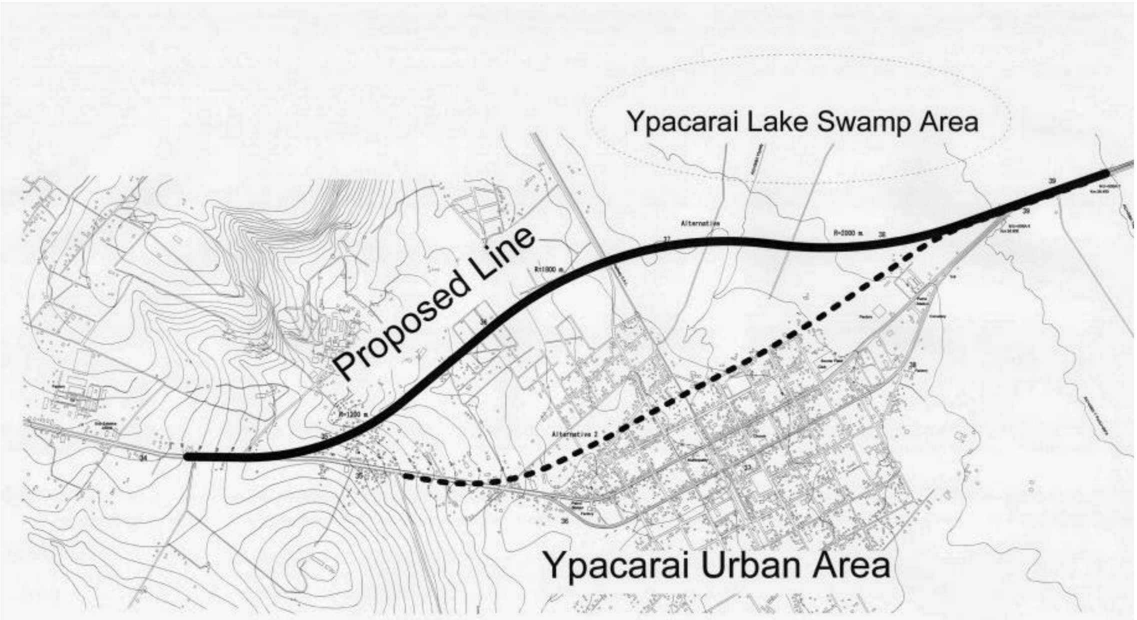


Figure 16.1.1 Mini Bypass Route of Ypacarai

Alternative Route 1: This alternative route avoids the high-density residential area and offers shortest connection to the existing road.

Alternative Route 2: This alternative route avoids the residential area more than route 1.

Factors	Alternatives			Remarks
	Route 1	Route 2 **Selected**	Existing road	
Length of Routes	3.5km	4.6km	——	
1. Technical Evaluation				
Geometry	Good	Good	Bad	
Accessibility to Existing road	Fair	Fair	Bad	
Construction Difficulty	Fair	Fair	Fair	
Construction Cost	Fair	Fair	high	
2. Development Evaluation				
Compatibility with City Development Plan	Fair	Good	Bad	
3. Environmental Evaluation				
Existing Natural Environment	Fair	Fair	Fair	
Socio-Economic Environment	Good	Good	Bad	
No. of Houses	45	33	——	
Land Acquisition	15ha	17ha		
Total Evaluation	○	◎	△	

Selection of the best alternative route:

The Alternative 2 has been selected in order to avoid the residential area.

16.1.2 Caacupe Bypass

Since the principal road passes through Caacupe City, the road should be improved. Alternative routes passing to the north and the south of the existing road have been taken into consideration.

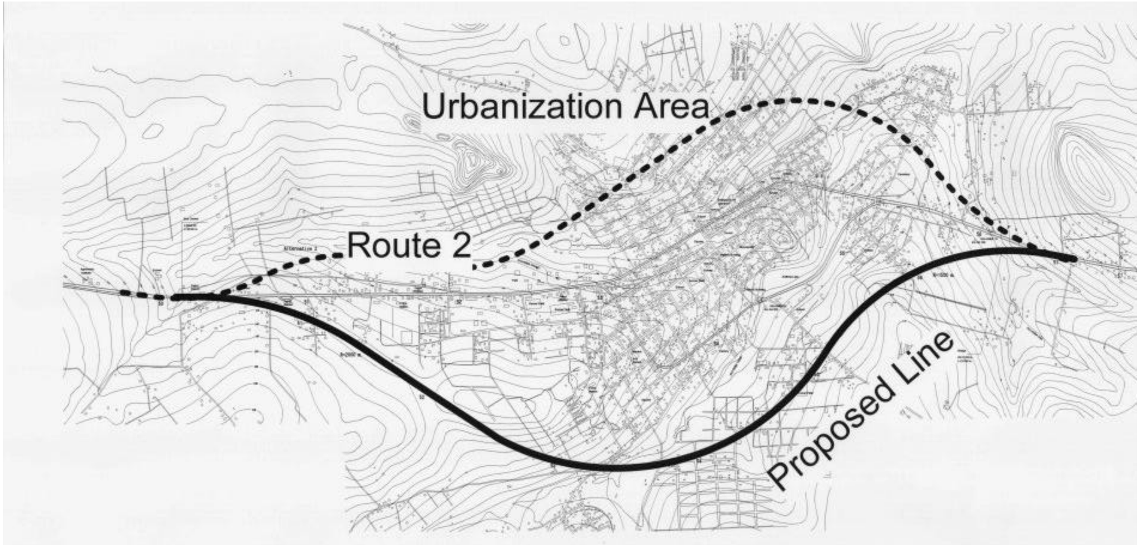


Figure 16.1.2 Mini Bypass Route of Caacupe

Alternative Route 1: This alternative route passes along the south of the city and avoids the residential areas.

Alternative Route 2: This alternative route passes along the north of the city and avoids residential areas.

Factors	Alternatives			Remarks
	Route 1 **Selected**	Route 2	Existing road	
Length of Routes	7.2km	7.0km	——	
1. Technical Evaluation				
Geometry	Fair	Good	Bad	
Accessibility to Existing Road	Fair	Fair	Bad	
Construction Difficulty	Fair	Fair	Fair	
Construction Cost	Fair	Fair	high	
2. Development Evaluation				
Compatibility with City Development Plan	Good	Fair	Bad	
3. Environmental Evaluation				
Existing Natural Environment	Fair	Fair	Fair	
Socio-Economic Environment	Good	Fair	Bad	
No. of Houses	66	80	——	
Land Acquisition	Fair	Difficult	——	
Total Evaluation	◎	△	△	

Selection of the best alternative route:

The Alternative 1 has been selected in order to avoid the residential area. This route is compatible with the city planning, since Caacupe City is spreading towards the north.

16.1.3 Itacurubi Bypass

Since the principal road passes through Itacurubi City, this should be improved. Alternative routes passing to the north and the south of the existing road have been taken into consideration.

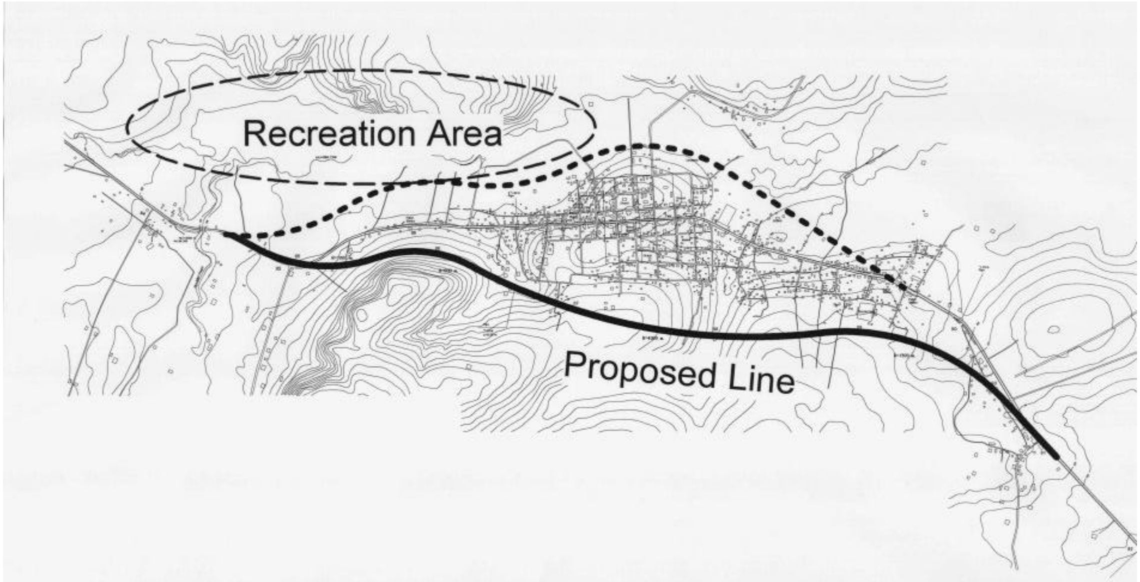


Figure 16.1.3 Mini Bypass Route of Itacurubi

Alternative Route 1: This alternative route passes the north of the city and avoids residential areas. This route passes mainly along the riverside.

Alternative Route 2: This alternative route passes south of the city and avoids residential areas.

Factors	Alternatives			Remarks
	Route 1	Route 2 **Selected**	Existing road	
Length of Routes	5.5km	6.0km	——	
1. Technical Evaluation				
Geometry	Good	Good	Bad	
Accessibility to Existing Road	Fair	Fair	Bad	
Construction Difficulty	Fair	Fair	Fair	
Construction Cost	Fair	Fair	high	
2. Development Evaluation				
Compatibility with City Development Plan	Bad	Good	Bad	
3. Environmental Evaluation				
Existing Natural Environment	Bat	Fair	Fair	
Socio-Economic Environment	Fair	Fair	Bad	
No. of Houses	15	20	——	
Land Acquisition	Difficult	Fair	——	
Total Evaluation	△	◎	△	

Selection of the best alternative route:

The Alternative 2 is selected to avoid the residential area. The route is imfatitile with city planning since Itacurubi City is expanding to the north and there are riverside recreation areas.

16.1.4 San Jose Bypass

Since the principal road passes through San Jose City, this should be improved.
The existing road alignment is U type. Alternative routes passing to the north of the existing road have been taken into consideration.

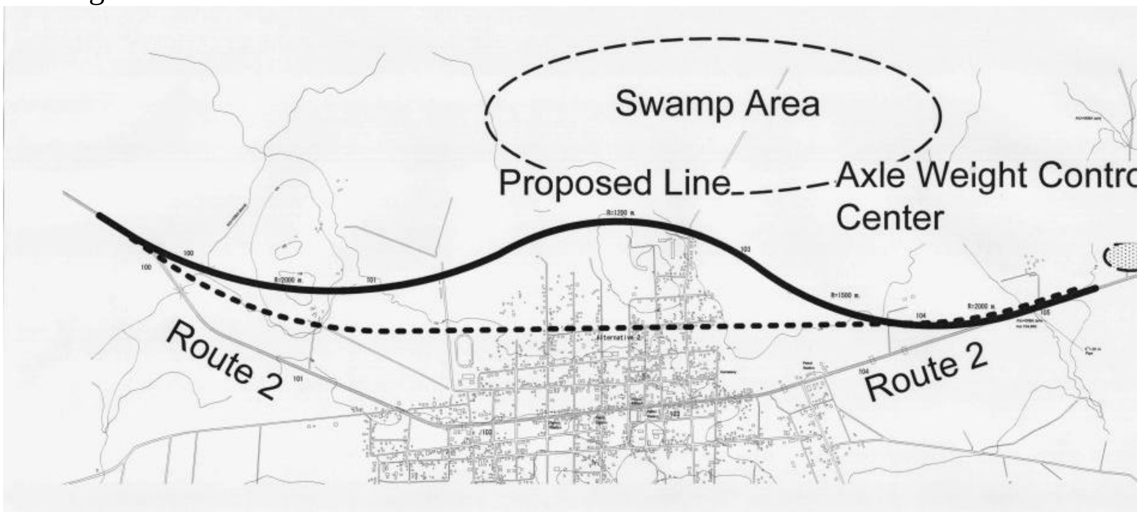


Figure 16.1.4 Mini Bypass Route of San Jose

Alternative Route 1: This alternative route passes along the existing road and avoids residential areas.

Alternative Route 2: This alternative route avoids the housing area and is the shortest connection to the existing road.

Factors	Alternatives			Remarks
	Route 1	Route 2 **Selected**	Existing road	
Length of Routes	4.1km	5.2km	——	
1. Technical Evaluation				
Geometry	Good	Good	Bad	
Accessibility to Existing Road	Fair	Fair	Bad	
Construction Difficulty	Fair	Fair	Fair	
Construction Cost	Fair	Fair	Bad	
2. Development Evaluation				
Compatibility with City Development Plan	Fair	Good	Bad	
3. Environmental Evaluation				
Existing Natural Environment	Fair	Fair	Fair	
Socio-Economic Environment	Fair	Fair	Bad	
No. of Houses	15	2	——	
Land Acquisition	Fair	Fair	——	
Total Evaluation	○	◎	△	

Selection of the best alternative route:
The Alternative 2 has been selected in order to avoid the residential area.

16.2 Position of Climbing Lane

The position of climbing lanes has been decided for sections with a 3% gradient or more.
The minimum length to be adopted for a climbing lane is 500 meters or more.
The Figure 16.2.1 shows the positioning for the above-mentioned item.

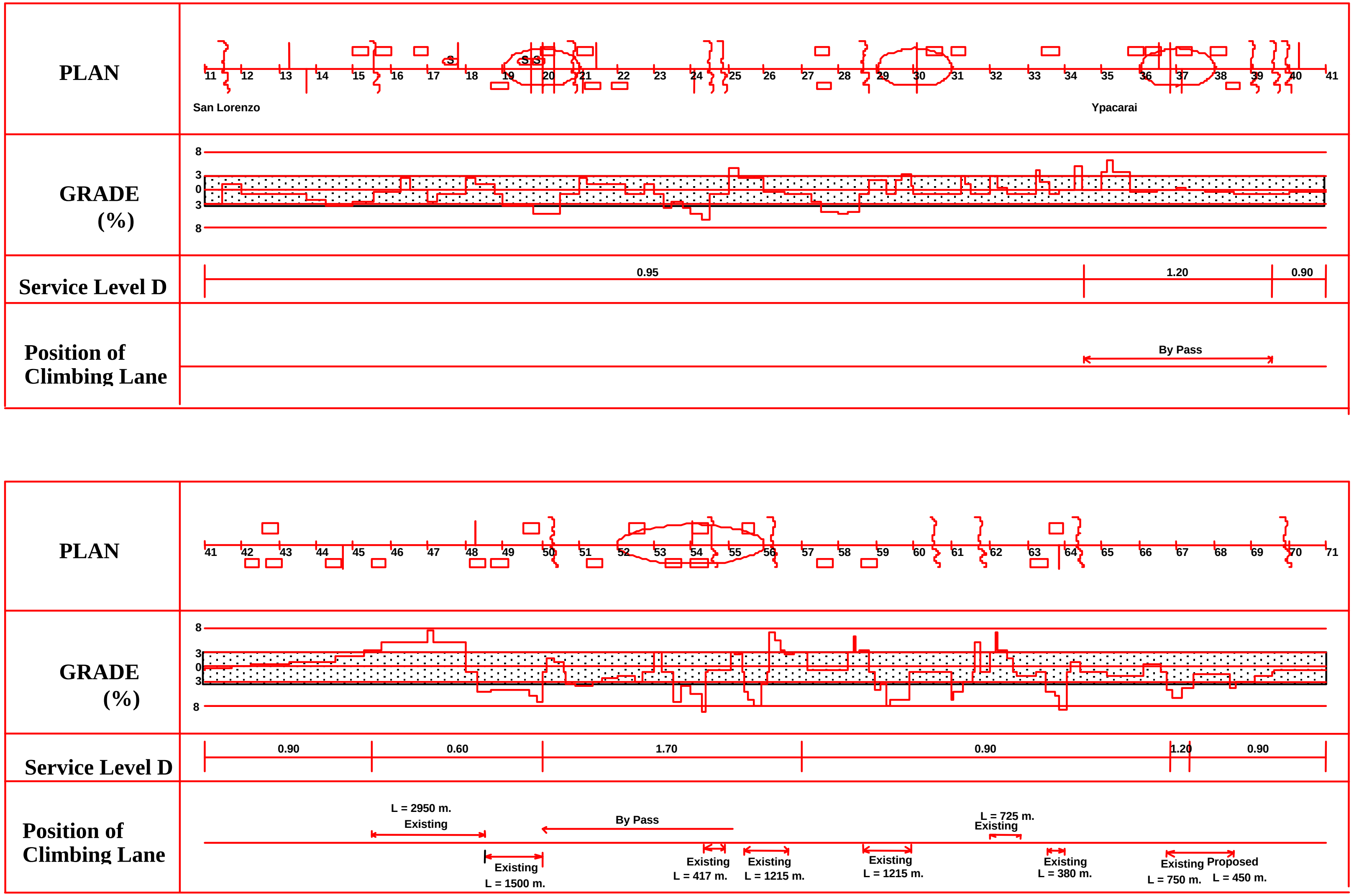


Figure 16.2.1 (1/3) Position of Climbing Lane

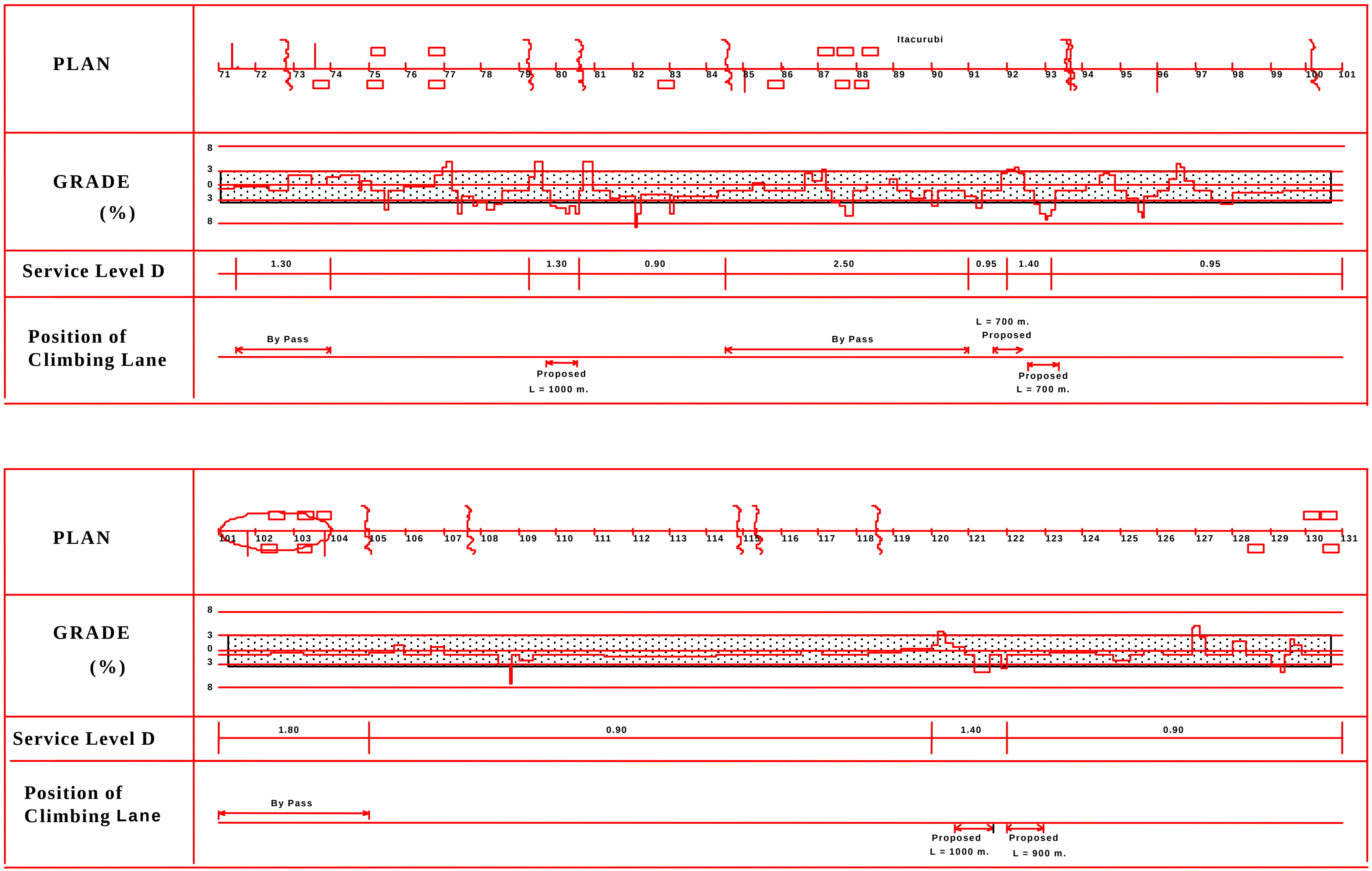


Figure 16.2.1 (2/3) Position of Climbing Lane

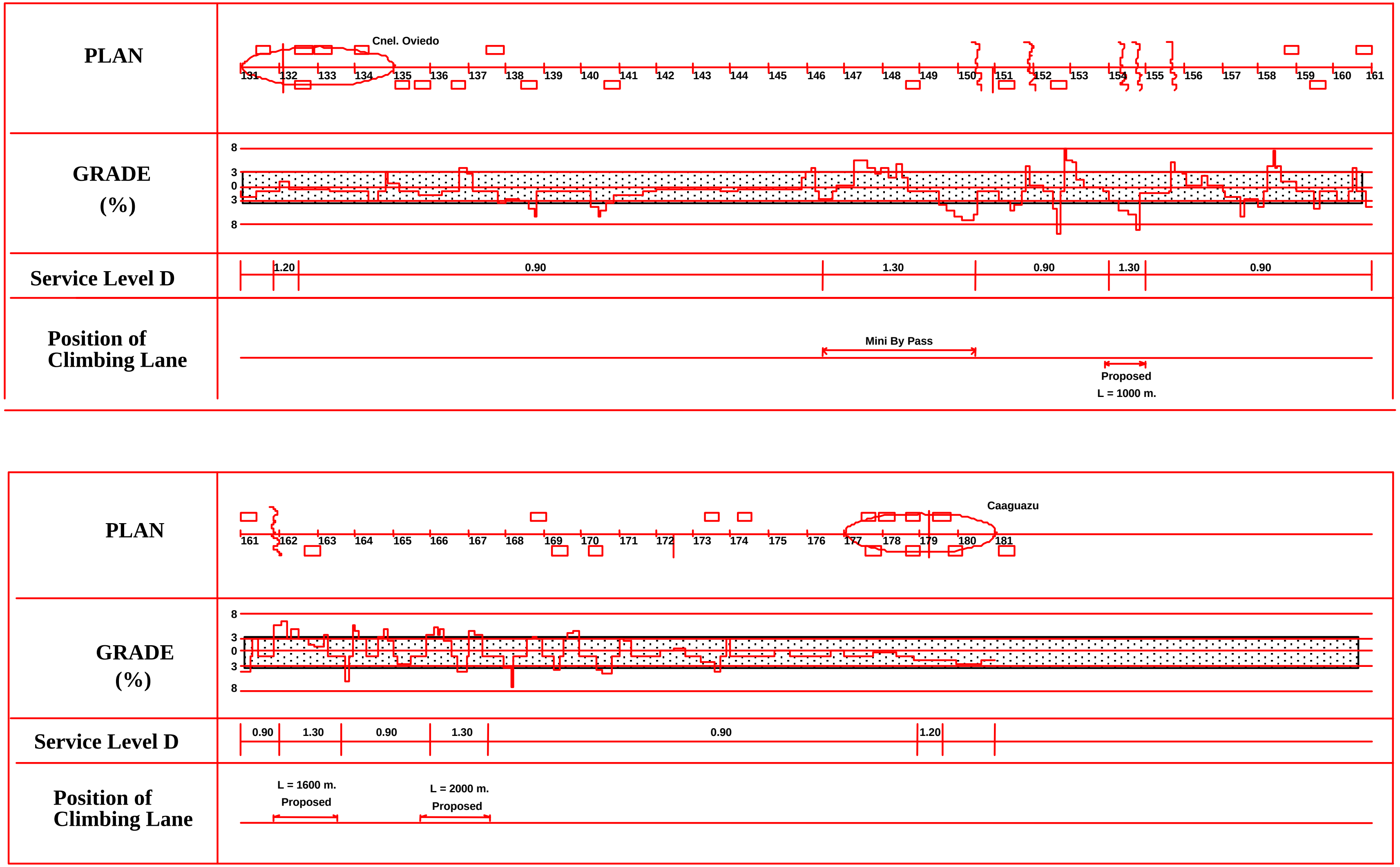


Figure 16.2.1 (3/3) Position of Climbing Lane

CHAPTER 17 PRELIMINARY DESIGN

17 PRELIMINARY DESIGN

17.1 Natural Condition

17.1.1 Topographical Survey

(1) Aerial Photo Map

Existing Topographical Map which is produced by the Military Geographic Service Directorate (DISERGEMIL: Dirección del Servicio Geográfico Militar) with the scale of 1/20,000 and 1/5,000 (Aerial Topographical Photo Map) was applied and scanned within the study area in order to make Mosaic Photo Map with master data. This Master Data was applied in order to decide alternative routes. Finally, Detailed Topographical survey was performed for the optimum routes decided.

(2) Topographical Survey

Topographical Survey with the scale of 1/2,000 had been performed mainly at the sites of newly planned bypasses and climbing lanes in order to obtain precise horizontal and vertical alignment data corresponding to the alternative bypasses to be used for preliminary design.
The work consists of Horizontal and Vertical control Survey, the correction of the scale of 1:2,000 Topographical maps to the scale of 1:500 Topographic maps and Centerline survey including profile and cross section survey.

(3) Topographical Survey Location

The Work Area is located along the Routes 2 and 7, covering the locations shown in Table 17.1.1;

Table 17.1.1 Work Area for Topographical Survey

Locations	Starting Point (km)	End Point (km)	Control Points	
			East	North
Ypacaraí	33,440	39,565	471751.59	7191144.33
Caacupé	49,060	57,065	486932.34	7192564.01
Eusebio Ayala	69,340	74,800	502766.26	7192716.21
Itacurbí de las Cordilleras	83,200	92,000	517321.51	7182489.87
San José de los Arroyos	99,410	105,440	525778.40	7176212.74
Coronel Oviedo	145,160	151,160	573211.28	7182057.43

In order to determine the coordinates of all surveyed points, Base points were applied: One (1) point of the Primary Network Control, established by the Geographic Military Service Directorate(IGM), and four (4) points established by the National Cadaster Service. The points are established with reference to World Geodesic System 1984 (WGS84).

(4) Methodology of Topographical Survey

1) GPS equipment as navigator decimeter type was utilized in order to locate Start Point, End Point and IP of the bypasses.
2) With GPS stations, an accurate positioning the points was obtained which was

materialized by concrete cylindrical pegs, fabricated in the field, of 100 mm diameter and 80 cm deep, protruding from the natural terrain about 5 centimeters.

3) The field data had been adjusted for the design of alternatives for its layout in the field and survey of the horizontal and vertical alignment.
4) For field data processing, the following software were applied; GPSurvey LISCAD, Auto Cad R14 and Auto Cad 2000, installed in (4) four computers.
5) Cartographic projection used for mapping is Universal Transversal Mercator (UTM), with origin in Zone 21, which is standard for Paraguay.
6) Elevation data is referred to a control base on Paraguay River (Port of Asunción).

(5) Drawings

Final Drawings were completed by AutoCad and out putted as follows:

General Plan

Locations	Output Drawing Size	Scale
Ypacaraí	A1	1/7,500
Caacupé	A1	1/10,000
Eusebio Ayala	A1	1/7,500
Itacurbí de las Cordilleras	A1	1/10,000
San José de los Arroyos	A1	1/7,500
Coronel Oviedo	A1	1/7,500

Vertical and Horizontal Alignment

Type	Output Drawing Size	Scale
Horizontal	A1	1/2,000
Vertical	A1	1/200

Cross Sections

Type	Output Drawing Size	Scale
Horizontal	A1	1/200
Vertical	A1	1/200

17.1.2 Geological Survey

Geological Survey was performed after the decision of route alignment. The Survey was performed mainly at the places where structures such as bridges are to be located in order to investigate and decide the bearing capacity, embankment material, subgrade material.

(1) Boring Survey

a. Purpose of Boring Survey

Boring Survey was carried out in the Study area. The total number of bore holes drilled was twenty (20).

The purpose of the boring survey is to obtain information regarding Geological Conditions at proposed bridges.

b. Location of Boring Survey

Location of Boring Survey is shown in Figure 17.1.1 and outline of the Survey is shown in Table 17.1.2.

Table 17.1.2 Outline of Boring

No	Depth (m)	Purpose	No	Depth (m)	Purpose	No	Depth (m)	Purpose
S1	6.72	Bridge Foundation	S8	1.40	Bridge Foundation	S15	14.00	Bridge Foundation
S2	8.69	Bridge Foundation	S9	15.00	Bridge Foundation	S16	13.55	Bridge Foundation
S3	10.40	Bridge Foundation	S10	12.00	Bridge Foundation	S17	10.00	Bridge Foundation
S4	6.70	Bridge Foundation	S11	8.70	Bridge Foundation	S18	10.00	Bridge Foundation
S5	6.40	Bridge Foundation	S12	4.81	Bridge Foundation	S19	8.00	Bridge Foundation
S6	1.60	Bridge Foundation	S13	10.40	Bridge Foundation	S20	6.00	Bridge Foundation
S7	1.50	Bridge Foundation	S14	4.67	Bridge Foundation			

Source Study Team

c. Result of Boring Survey for proposed Bridges

The Purpose of Boring Survey is to confirm the depth and strength of bearing stratum for proposed bridge foundation. Boring Survey at the site finished after confirming the stratum with N value of 30 and thickness of 5 meters. Based on the boring survey, geological conditions as a result of investigation at the site are as follows:

i Ypacarai Site

The boring locations of S1, S2, S3 and S4 clarified that the subsoil consists of clayey sand (SC) with an average thickness of 4.00 meter. It overlies a layer of silty sand (SM) very poorly graded silt (SP - SM) ($10 < N < 30$) with a thickness of 3.25 meters. Under this type of sand, there is a sandstone soil that contains friable thin grain mainly silt. In terms of Geological characteristics, it could be considered as a part of the Paraguarí Formation from the Caacupe Group (ORUE 1996). This “Structure” has fairly good capacity for the support of foundations for the bridges.

ii Caacupe Site

At the boring locations of S5, S6, S7 and S8, rocky outcrops were found in the beds of the creeks. This soil has small veiled of 0.40 meters found in the location of S5, which becomes up to 1.60 meter thick in the locations of S6 and S7. The soil contains silt and clayey sand (SM - SC). The layer is underlay by a quartziferrous sand with a very fine grain. It is very friable and breakable and has in the color of pink and white. As a result of the investigation, it is clarified that the soil belongs to the Tobati formation from the Caacupe Group. Although it appears to be friable in structure, it has a very good bearing capacity for direct foundation of bridges.

iii Eusebio Ayala Site

The locations of S9 and S10 reveals that soil consists of two layers very well defined:

– It is a clean sand, poorly graded and silty (SM) and (SP - SM) that varies from "loose" (4 < N < 10) in the first meter of depth to "compact" (10 < N < 30) near the second formation. It has a thickness of 7.50 meters and it overlays the following formation:

– It is clayey of low compressibility (CL) with the color of gray and green stained yellow. Its consistency is from "very rigid" (15 < N < 30) to hard (N > 30) near to the end of the boring. This stratum consists of strongly pre consolidated clayey soil with very good bearing capacity. The foundation could be supported on this formation through an indirect foundation. Underground water was detected at 3.00-meter depth from the Ground Level, very close to the water level of the creek.

iv Itacurubi de la Cordillera Site

– The Location of S11 and S12
The subsoil contains silty sand (SM) with a 4.50 meters of thickness. It varies from the property of "very loose" to "loose" (4 < N < 10) in the upper side with an insertion of a silty layer of low comprehensibility (ML) containing clay of "very rigid" consistency (10 < N < 30) which was clarified in the location of S12 in a 3,00 meter thickness. Due to these characteristics, it is considered as "rough" soil. In the location of S11, the same material was found however of lesser thickness down to the Silty Sand without Natural Plasticity "very dense (N > 50)".
Due to the characteristics of the material previously described, the high density of the soil in the location of S11, drilling was continued from 2.70 meters with a rotary machine. However with this procedure, no sample was able to be obtained. Therefore, S.P.T was performed every 1.5 meters. The result obtained was (N > 50) which indicates the continuity of the bearing layer. Direct foundation is recommended in this stratum.

– The Location of S13 and S14
The subsoil consists of silt (SM) of 4.50 meters thickness. The soil is very variable that going from a "loose" (4 < N < 10) in the location of S13 to a "dense" (10 < N < 10) in the location of S14. The formation is located above the rough soil of 1.5-meter thickness. It is very dense at first (N > 50) and becomes a soil of sand with fine grains at deeper depth. It is micaceous soil that belongs to the Formation of Eusebio Ayala of the Itacurubi Group. This material was investigated down to 10.40 meter of depth at the location of S13. A lotary drilling machine with special element and diamond crown was used for the investigation.

– S15 and S16
These are located in a flooding area. No rocky material was detected in the locations. The subsoil contains very low compressible clay (CL). It varies from rigid consistency (8 < N < 15) to very rigid pre consolidated consistency. Below 4 meters depth it is clarified that there is clay with low compressibility (ML). It is similar to the clay of upper level. After this, it was found that there is clay with high compressibility (MH). Drilling 12 meters below a "hard" consistency (N > 30) was found. This indicates that the soil has a strong degree of consolidation. This characteristics remains until 14 meters below the formation with a very good load bearing capacity. Triaxials tests were made on the samples.
At the location of S16 , in order to obtain more information on the materials (CL) and (MH), PVC capsules were utilized. The samples were taken from 3.55 meters to 4.00 meters and from 10.55 to 11.00 meters. The samples were

applied to the triaxials test.
From the results of the test, it was clarified that C = 0.36 kg/cm^2 and ϕ = 4.5 ° .

v San Jose de los Arroyos Site

The area of S17 and S18 consist of two formations;

- Down to 5 meters of depth, it is clay with low compressibility (CL) of rigid consistency (8 < N < 15) with gray color, with natural moisture, which gives it stability under the influence of water due to climatic changes.
- There is a clayey soil (SC) in this formation. It is not so dense (10 < N < 30) to a depth of 4.50 meters. Afterwards, it becomes very dense (N > 50) until 10 meters of depth. Indirect foundation is recommended for this area. The formation has very good bearing capacity.

At the site of S17, samples were obtained in order to find out friction coefficient of the upper level (CL). The samples obtained were at 3.55 to 4.00 meters below the GL. Applied tests are just the same as the one performed for S15. The parameters obtained are shown as follows;

C = 1.05 kg/cm^2 and ϕ = 8.0 ° .

vi Coronel Oviedo Site

The area of S19 and S20.
This is only a formation all down to the depth investigated. It is clayey soil of low compressibility (CL). Its consistency goes from "medium" (4 < N < 8) becoming "hard" (N > 30) at 6.00 meters below the GL.

The observed clay is strongly pre consolidatial having good bearing capacity at 3.00 meters of depth, which is suitable for the foundations. These may be observed in the results of the S.P.T tests and in the triaxial test performed with samples obtained from the mentioned level (2.55 to 3.00 meter) at S20.

(2) Borrow Pits (Borrow Materials)

As it was already explained in Section II 1b, the method to be used in the investigation of these loans (local materials) will basically consist in the summary of the results. The information regarding Borrow Pits may provide the following:

- volume availability from Borrow Pit
- owner
- available area
- volume
- location coordinates as indicated in the road plans as well as in the distribution of the rock drill holes and trial pits.

Table 17.1.3 shows the Summary of the Borrow Pits investigation.

Table 17.1.3 Summary of the Borrow Pits Investigation

Locations	Properties	Coordinates	Approx. Area (ha)	Rock drill depth (m)	Available Volume (m^3)	Design CBR (%)
Ypacarai	Sra. Librada Britez de Vera	487734 7180310	2.00	0.80	10,000	-
Ypacarai	Sr.Delfio Bento	465514 7195668	4.00	2.00	68,000	16.2 4.8
Caacupé	Sr.Tolentino Aquino	483450 7189746	4.50	1.35	47,250	26.5
E. Ayala	Sr.Leoncio Gonzáles	503812 7190432	10.00	2.00	170,000	11.9
E. Ayala	Sr.Marcos Aguilera	503812 7190432	5.00	2.00	85,000	15.6
Itacurbi	Sr.Pedro León	514981 7183161	2.00	1.08	15,600	11.8
San José	I.B.R	526626 7172314	9.00	2.00	153,000	3.6
Cnl.Oviedo	Sr.Sixto Mendoza	569534 7183471	3.00	2.00	51,000	5.0
Cnl.Oviedo	Sra. Reinolda Mendoza	571625 7184671	5.00	2.00	85,000	5.7

The surface layer of soil to be removed was found to be 0.30 meters drill holes. The soil information shown in the Table 17.1.3 was obtained from the trial pits.
The C.B.R. corresponds to 95% of the maximum density normally adopted for Design. In the area located in the land of Mrs. Librada Britez de Vera, no sample for C.B.R. was available, because most part of the land contains sandstone at very shallow depth around 30 to 40 centimeters.

Nearby to the land of Mr. Pedro León, materials for the construction may be obtained. They are located at Mr. Villanti's land, which is an area of 2.00 acres. Trial pits were made in the place (C6)

17.1.3 Hydrology

There are 21 divided drainage areas in Paraguay. The study area belongs to 4 drainage areas. The direction of the flow of the underground water is from west to east or southeast however it appears to be more complicated in the eastern area. It is already reported that it was submerged to the toe of the road slope in the study area of routes 2 and 7. However, the road pavement itself has not been flooded.

In accordance with Hydrological Data from Asunción and Villarrica observation stations, the size of the drainage structure was estimated by considering the probable rainfall intensity in the consideration of catchment area.

(1) The Study of Catchment Areas

The catchment areas were identified in the study area. The catchment area for drainage facility is shown as the Table 17.1.6.

The areas are being drained by the rivers. These rivers are perennial rivers. During the rainy season these streams flow in full swing.

These rivers are braided rivers. The river banks height is variable from 2 to 3m throughout its course therefore the width of the channel depending upon the morphology, slope and nature of formation. The streams represent typical anatomizing pattern. The river channel meanders making numerous cut offs and bends. Most of catchment are farmland.

(2) Collection of Climatological & Hydrological Data

a. Rainfall

The annual rainfall in Paraguay increases from west to east, averaging about 1,400 mm to 1,600 mm annually. The months of October to June are rainy while other months are dry. In the dry season, the average monthly rainfall is approximately 100 mm.

The average rainfall in the project area is 1,400mm to 1,600mm.

The monthly rainfall data was collected from two stations in the project area for the period 1940 to 1999.

b. Rainfall Depth

During the time of the November 1994 flood, the pluviometric surplus in Villarrica was 368.5mm. The rainfall depth causing the flooding in Villarrica is as shown in the Table17.1.4.

Table 17.1.4 Rainfall Depth during the Flood of November 1994 at Villarrica

Day	Villarrica Station
1	0.0
2	0.0
3	0.0
4	0.0
5	180.0
6	71.0
7	70.0
8	45.0
9	0.0
10	0.0
Total	366.0

Source: Dirección de Meteorología y Hidrología

c. Hydraulic Analysis

i Runoff Calculation

– Method

There are several methods to calculate runoff discharge. These include rational formula, the unit hydrology method, the triangular method, and storage function method. The rational formula can provide only peak discharge. However, the others provide flood hydrographs. It is the recommendation from MOPC to use the rational formula for small catchments less than 10 km^2, and the triangular method for catchment of more than 10 km^2.

– Rational Method

$$Q = \frac{CiA}{6}$$

Where,
Q = discharge (m^3/sec)
C = runoff coefficient
i = rainfall intensity in concentration time (mm/min)
A = catchment area (ha)

– The Triangular Hydrograph Method(THM)

This method was developed and recommended by the US Soil Conservation Service.
MOPC recommends using this for the runoff calculation.

Formulas

$$qp = \frac{2.08 \times A}{tp}$$

Where,
qp = maximum peak of flow (for THM)
A = basin area in km^2
tp = peak time

$$tp = \frac{\Delta t}{2} + 0.6tc$$

tc = concentration time, in hours(*)

$$\Delta t = \frac{tc}{5} UnitaryTime(hour)$$

tr = 1.67 tp = recess time (hour)
tb = 2.67tp = base tome (hour)
* The concentration time was calculated by the same formula used for the rational formula.

$$tc = \frac{10 \times A^{0.3} \times L^{0.2}}{K \times i^{0.4}}$$

Effective Rainfall

In order to establish the effective rainfall (Pe), the total rainfall (P) is used in accordance with the US Soil Conservation Service.

$$CN = \frac{1000}{10 + S}$$

where,
CN = curve number for the basin
S = retention and infiltration for the studied basin

$$Pe = \frac{(P' - 0.2S)^2}{P' + 0.8S}$$

Where,
Pe = effective rainfall in inches
P'= total rainfall in inches

* The total rainfall(P) was obtained using the formula h = a ln t + b and P'

$$P' = \frac{P \times (1 - 0.1 \times \log A)}{25}$$

P' is used only for areas larger than 25 km^2
If A<25km^2 P=P'

The hydrograph

Outside the effective rainfall for each ΔT, the discharge is calculated for intervals by multiplying the order of the THM by the Δpe(cm). These values for the projected hydrograph are:

Qi = Pei.q1 + Pei-1.q2 + Pei-2.q3 + …..Pe1.q1

– Rainfall intensity values

The rainfall intensity values at Villarrica based on a long period (1960-1994) are available. Table 17.1.5 indicates the values at various frequencies.

Table 17.1.5 Rainfall Intensity Values at Various Frequencies

Years	t = 6 min	t = 60 min	24 hours
5	1.60	5.99	14.25
10	1.82	6.75	16.22
23	2.09	7.69	18.70
50	2.30	8.36	20.55

Source : MOPC

The intensity of the concentration time is calculated based on the following formula.

$$Q = \frac{a}{T^n}$$

Where,
Rd : Rainfall intensity
a :Constant
n :Constant
T :concentration time

– Calculation Result
The catchment area are measured based on the topographic map. Then probable discharge obtained by the rational method and the triangular hydrograph method are listed in Table 17.1.6.

Table 17.1.6 Probable Discharge at the Site

Basin No.	Name of Bypass	Station	Catchment Area (ha)	Peak Discharge(m^3/s)		
				10	25	50
1	Ypacarai	37+200	1,200	38	44	48
2	Caacupe	50+100	600	35	41	43
3		56+600	1,500	48	55	60
4	Itacurubi	86+600	250	15	17	18
5		88+100	400	23	27	29
6		89+600	150	9	10	11
7		90+400	150	9	10	11
8	San José	100+900	900	53	62	64
9		102+800	400	23	27	29
10		103+300	300	18	21	21
11		103+700	200	12	14	14
12		103+900	100	6	7	7
13		104+600	1,200	38	44	48
14	Coronel Oviedo	146+700	50	3	3	4
15		147+100	400	23	27	29
16		147+200	50	3	3	4
17		147+500	50	3	3	4
18		148+000	50	3	3	4
19		148+300	50	3	3	4

Source: Study Team

Table 17.1.7 Drainage Facilities

Name of Bypass	Station	Catchment Area (km^2)	Box culvert Size (m)	Pipe culvert Size (m)
Ypacarai	37+200	12.0	2.00x2.00	
Caacupe	50+100	6.0	2.00x2.00	
	56+600	15.0	3.00x3.00x3	
Itacurubi	86+600	2.5		D=1.60
	88+100	4.0	2.0x2.0	
	89+600	1.5		D=1.20
	90+400	1.5		D=1.20
San José	100+900	9.0	2.0x2.0	
	102+800	4.0		D=1.20
	103+300	3.0		D=1.20
	103+700	2.0		D=1.20
	103+900	1.0		D=1.20
	104+600	12.0		D=1.20x3
Coronel Oviedo	146+700	0.5		D=1.00
	147+100	4.0	2.0x2.0	
	147+200	0.5		D=1.00
	147+500	0.5		D=1.00
	148+000	0.5		D=1.00
	148+300	0.5		D=1.00

Source: Study Team

17.2 Mini Bypass Road Design

The AASHTO Design Standard has been adopted for new construction of Mini bypass road. New roads shall be designed according to the standards for principal roads.

17.2.1 Ypacarai Mini Bypass

(1) Typical Cross Section

Four (4) lanes are adopted in order to meet the existing number of lanes. For typical cross section design please refer to Chapter 13.

(2) Horizontal Alignment Design

The alignment design avoided the control points shown below.

1) The alignment design avoided the church of Km post 34 on the north side of national road 2.
2) The new bypass road was separated from Ypacarai City urbanization plan.
3) The road passes along the Ypacarai Lake swamp area.
4) The city area has no access to the road structure in order to prevent the extension of the city towards the swamp area.
5) The minimum curvilinear radius has been adapted according to the standard value for 80km/h design speed (minimum R=280m < R).

(3) Vertical Alignment Design

1) The road was designed along the present topography.
2) A swamp area was designed to be raised about 2m above the present ground level.

(4) Other

1) A part of the intersection with a railway was designed as an at-grade intersection because the railway operation is minimal.
2) New road can not be accessed by roads of Ypacarai City.
3) A part of the swamp area functions as a sewer on both sides of the new road structure.
4) Box culvert drainage has been prepared in order not to intercept the natural flow.
5) The existing tollgate will be moved on to the new bypass road.

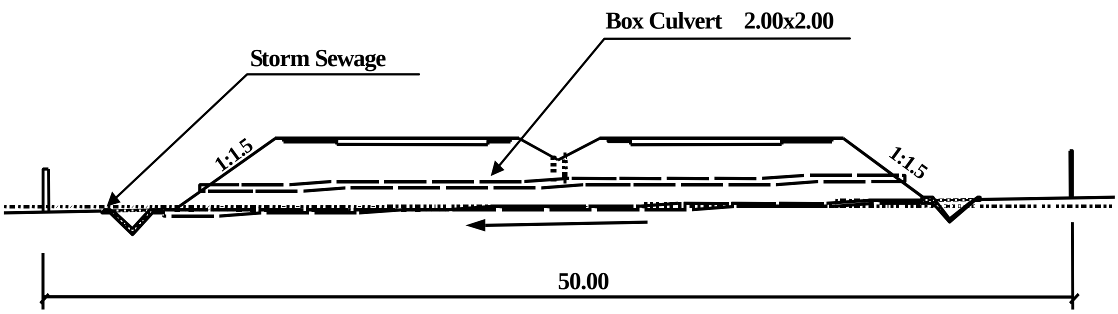


Figure 17.2.1 Ypacarai Bypass Typical Cross Section

17.2.2 Caacupe Bypass

Typical Cross Section: Four (4) lanes have been adopted in order to meet the expansion of urbanization from Asuncion City, since Caacupe is part of the commuting corridor towards Asuncion. For the design of the typical cross section, please refer to Chapter 13.

(1) Horizontal Alignment Design

The alignment design avoided some control points shown below.

1) The alignment design avoided the Caacupé City urbanization plan .
2) Alignment design passes south of Caacupé city and along the river.
3) The road structure has been designed mainly in cut to provide embankment material to Ypacarai mini bypass.
4) The minimum curvilinear radius agrees with the standard value of 80km/h design speed.(minimum R=280m < R)

(2) Vertical Alignment Design

1) The road was designed along the present topography. Since the bypass road passes along mountainous area, the maximum vertical gradient (3%) continues.

(3) Other

1) At km55, 10m widening is required as right-of-way for the shortcut.
2) drainage by box culvert has been prepared along the mountainous area.

17.2.3 Itacurubi Mini Bypass

(1) Typical Cross Section

Two (2) lanes have been adopted in order to meet the existing number of lanes. For typical cross section design please refer to Chapter 13.
Horizontal Alignment Design: the alignment design avoided the control points shown below.

1) the alignment design avoided the north side of the city where there are recreation areas along the riverside.
2) the bypass road was separated from Itacurubi City urbanization plan.
3) The road passes along a mountainous area.

(2) Vertical Alignment Design

1) the road was designed according to the present topography. Since the bypass road passes along a mountainous area, the maximum vertical gradient (3%) continues.

(3) Other

1) Itacurubí’s urban roads do not have access to the new road.
2) drainage by box culvert has been prepared along the mountainous area.

17.2.4 San Jose Mini Bypass

(1) Typical Cross Section

Two (2) lanes have been adopted to meet the existing number of lanes. For typical cross section design please refer to Chapter 13.
Horizontal Alignment Design: the alignment design avoided the control points shown below.

1) the alignment design avoided the residential areas.
2) Mini bypass was designed to avoid the weight control facility of MOPC.

(2) Vertical Alignment Design

1) the road was designed along the present topography.
2) a swamp area was designed to be raised about 2m above the present ground level.

(3) Other

1) a part of the swamp area functions as a sewer on both sides of the new road structure.
2) The existing weight control station will not be moved.

17.3 Climbing Lane Design

Climbing lanes are provided for 3% or more vertical-section slopes mentioned in Chapter 14.

1) Minimum Length
   The minimum length adopted for a climbing lane is 500 meters or more as shown in Figure 14.2.3.
2) Lane Width
   The standard lane width adopted is 3.0m.
3) Pavement Thickness
   The pavement thickness adopted corresponds to the future traffic volume estimated for the year 2020.
4) Acceleration length
   The acceleration length was set up in Table 17.3.1 based on Figure 14.2.3

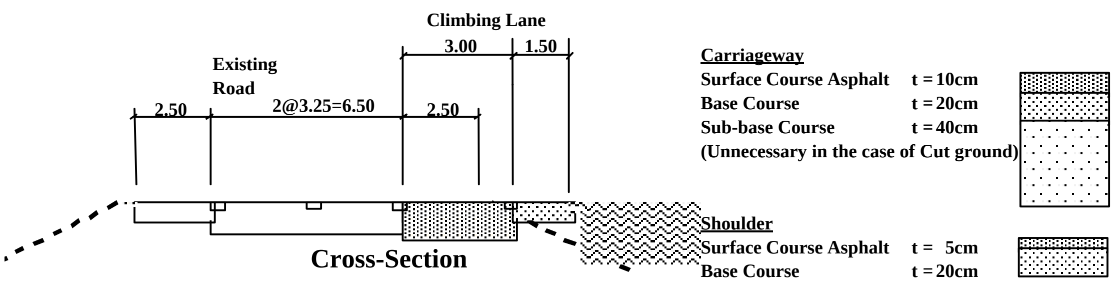


Figure 17.3.1 Typical Cross Section of Climbing Lane

Acceleration Lane Length is based on Table 17.3.1.

Table 17.3.1 Acceleration Lane Length

Profile (%)	-0.5	0	0.5	1.0	1.5	2.0
Acceleration Length (m)	150	200	250	300	350	400

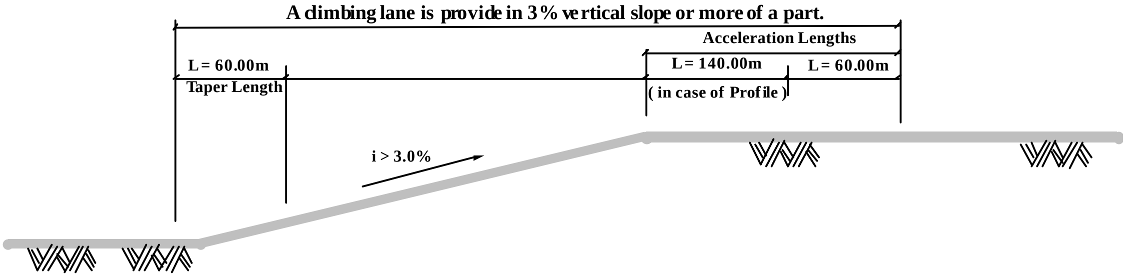


Figure 17.3.2 Profile of Climbing Lane

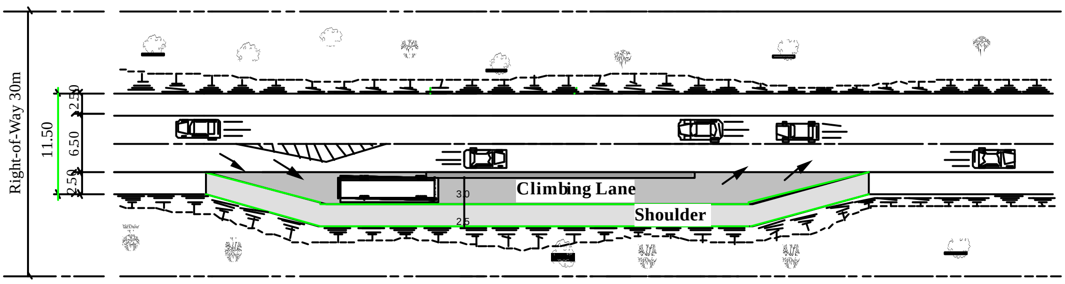


Figure 17.3.3 Plan of Climbing Lane

17.4 Safety Facility Design

Based on the results of the road investigation on national routes 2 and 7, safety facilities are provided at frequent traffic-accident occurrence points.

1) Bridge Crashing
   Bridge crashing accidents occur mostly because of reduced road-shoulder width and unclear lane guidance and road signs. The method for reducing traffic accident is by making an extension to the bridge's road-shoulders. However, construction is difficult and the costs are high. Therefore, in this Study, the method proposed is to show the drivers that they are approaching a bridge.
2) Sharp Bend Sections
   Frequent accidents on sharp bends occur in the section from Kilometer Post 146.5km to 149.5km on national route 7.

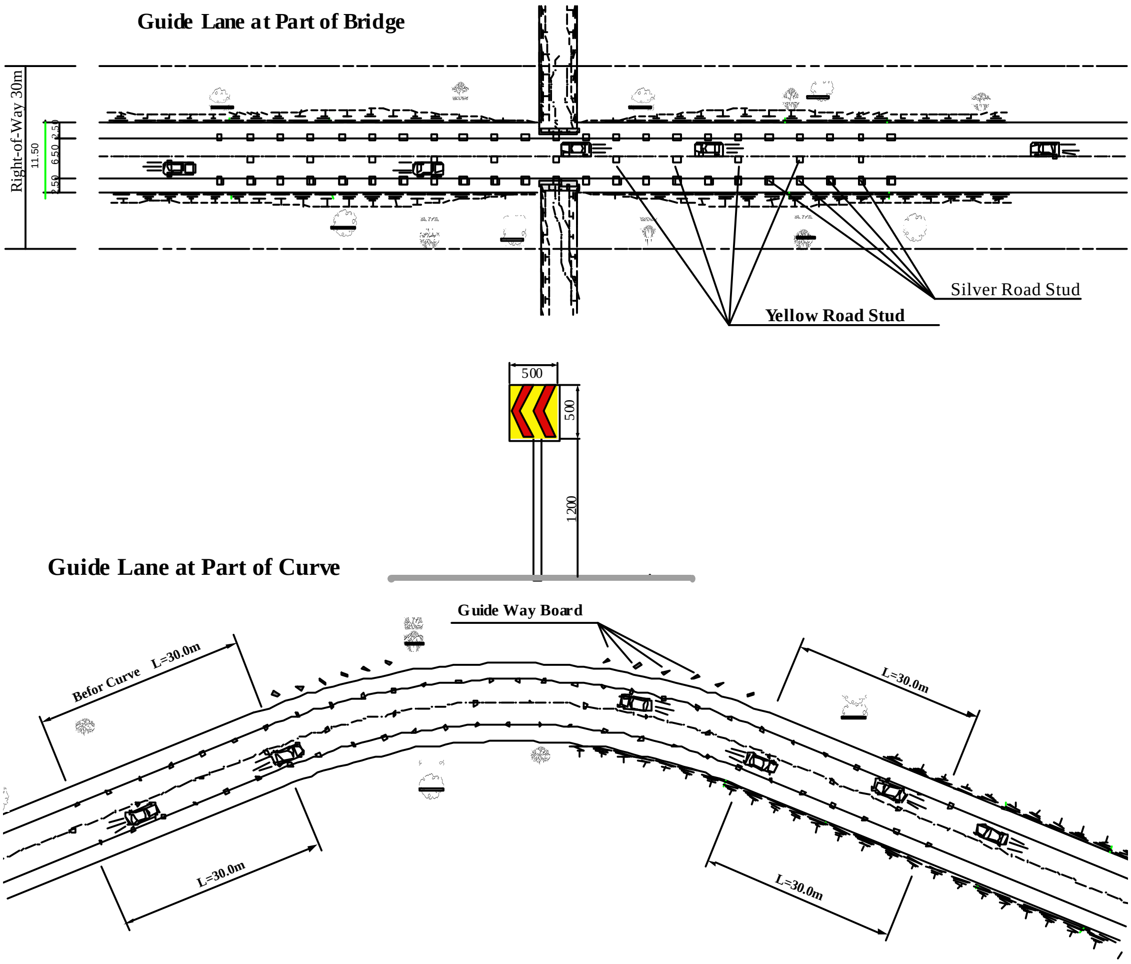


Figure 17.4.1 Safety Facility

17.5 Pavement Design

The pavement structure was designed according to the "AASHTO-Guide for the Design of a Pavement Structure (1986)".

17.5.1 15-years ESAL

(1) Analysis Period

The analysis period in the design of the pavement structure was considered to be fifteen years from the year of opening to traffic.

(2) Design Traffic

The design traffic is the cumulative traffic volume during the analysis period. It is expressed by type of vehicle.
The calculated design traffic based on the estimated traffic volume for the years 2010 and 2020 summarized in Table 12.6.1 is shown in Table 17.5.1.

Table 17.5.1 Design Traffic

Section	year	Traffic Volume (vehicle/day)	
		Passenger Car	Truck
Ypacarai	2010	2044	5764
	2020	2240	6153
ESAL2005-2020 factor		19.6	17.6
Caacupe	2010	5845	5287
	2020	7010	5960
ESAL2005-2020 factor		29.8	22.1
E. Ayala	2010	9112	8653
	2020	10682	10225
ESAL2005-2020 factor		26.6	27.7
Itacurubi	2010	8187	8633
	2020	9583	10221
ESAL2005-2020 factor		26.4	27.9
San Jose	2010	8193	8624
	2020	9591	10206
ESAL2005-2020 factor		26.4	27.9
Cnel. Oviedo	2010	8268	8624
	2020	9682	10206
ESAL2005-2020 factor		26.5	27.9

(3) Cumulative 18-kip Equivalent Single Axle Load (ESAL)

The ESAL factor for each type of vehicle was calculated as shown in Table 8.5.2.
The ESAL factors of axle in the fifth column come from the tables d.1 to d.3 in the "AASHTO Guide for design of pavement structure (1986)", assuming that the serviceability and structural numbers are 2.0. In most cases, the number 2.0, this assumption provides sufficiently information for design purposes. kips = kg-pounds

Using the total ESAL factor calculated above, the design ESAL and cumulative 18-kip ESAL for each road section were obtained as follows.
For considerations of safety, the maximum cumulative ESAL is adopted in this design.

Table 17.5.2 Design ESAL and Cumulative 18-kip ESAL

Section	Vehicle type	Design Traffic (A)	ESAL Factor (B)	Design ESAL (A*B)	Cumulative 18-kipESAL
Ypacarai	Passenger car	40,062	0.0004	16	7
	Truck	101,446	1.443	146,387	65,874
15years 18-kip ESAL					65,881
Caacupe	Passenger car	174,181	0.0004	70	31
	Truck	116,202	1.443	167,679	75,456
15years 18-kip ESAL					75,487
E. Ayala	Passenger car	242,379	0.0004	97	44
	Truck	239,688	1.443	345,870	155,641
15years 18-kip ESAL					155,685
Itacurubi	Passenger car	216,137	0.0004	86	39
	Truck	240,861	2.34	563,614	253,626
15years 18-kip ESAL					253,665
San Jose	Passenger car	216,295	0.0004	87	39
	Truck	240,610	2.34	563,026	253,362
15years 18-kip ESAL					253,401
Cnel. Oviedo	Passenger car	219,102	0.0004	88	39
	Truck	240,610	2.34	563,026	253,362
15years 18-kip ESAL					253,401

Note : Cumulative 18-kip ESAL = Design ESAL * DD * DL
Where, DD = Directional Distribution Factor = 0.5, DL = Lane Distribution Factor = 0.9

17.5.2 Predicted Number of 18-kip Equivalent Single Axle Load Applications

(1) CBR of Sub-grade

CBR 6 is adopted in this design, since this value is usually adopted for principal roads.

(2) Resilient Modulus (psi) : M_R

The AASHTO Guide recommends calculating the Elastic Resilient Modulus of the sub-grade (M_R) according to the following formula and tables:

M_R =1,500*CBR (psi)

where , CBR = CBR value of roadbed soil (%)

In this design

M_R =1,500*6 = 9,000 (psi)

(3) Reliability (R)

The AASHTO Guide recommends that the value of reliability for a principal road in a rural area such as the study road should be from 75% to 95%. In this case, a value of 90% was applied.

Table 17.5.3 Suggested Levels of Reliability for Various Functional Classifications

Functional Classification	Recommended Level of Reliability	
	Urban	Rural
Interstate and other freeways	85-99.9	80-99.9
Principal Arterioles	80-99	75-95
Collectors	80-95	75-95
Local	50-80	50-80

(4) Combined Standard Error : (So)

In flexible pavement design, the combined standard error for traffic prediction and performance prediction can be considered to be 0.44.

(5) Design Serviceability Loss : (△ PSI)

The design Serviceability Loss can be obtained from the following formula:

$$\triangle PSI = Po\text{-}Pt$$

Where Po = Initial Serviceability
(AASHTO Guide recommends 4.2 for flexible pavement.)
Pt = Terminal Serviceability
(AASHTO Guide recommends 2.5 for a principal arterial road.)

So, △ PSI = 4.2-2.5 = 1.7

(6) Structural Number (SNi)

Based on the values of cumulative 18-kip ESAL, Elastic Resilient Modulus, Reliability, Standard Deviation, and Design Serviceability Loss, the Structural Number can be obtained using a nomogram prepared in the Guide. The obtained Structural Numbers by road section and by layer are summarized in Table 17.5.4.

Table 17.5.4 Structural Number (SNi)

Segment	Ypacarai	Cnel. Oviedo
SNi	4.7	4.9

(7) i^{th} layer Coefficient (ai)

The Layer Coefficient of a layer is determined by the characteristics of the layer material. According to the description of the Guide, the following values have been assumed for this case :

Table 17.5.5 Layer Coefficients

Pavement component	Method, Material	Description	SN
Surface course	Hot-mixed asphalt mixture		0.44
Base course	Crushed stone for mechanical stabilization	Modified CBR (more 80)	0.14
	Bituminous treated cement treated	Hot-mixing, stability (more 350kg/cm^2)	0.31
	Cement treated	Compressive strength at 7days (30kg/cm^2)	0.22
	Lime treated	Compressive strength at 10 days (10kg/cm^2)	0.18
Sub-base course	Crushed Stone	Modified CBR (more 30)	0.10
		Modified CBR (more 20)	0.08
	Cement Treated	Compressive Strength at 7days (10kg/cm^2)	0.10

(8) Thickness of Each Layer

Based on the values of the Structural Number (SNi) and Layer Coefficient (ai) obtained up to this point, the thickness of each layer can be obtained from the following formula :

$$SN = a_1D_1 + a_2D_2 + a_3D_3 + \ldots$$

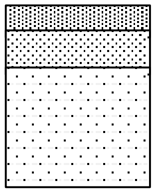
Where

$a_1, a_2, a_3 \ldots$ = layer coefficients representative of surface, base, and sub-base courses, respectively

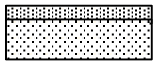
$D_1, D_2, D_3, \ldots$ = actual thickness (in inches) of surface, base, and sub-base courses, respectively

Carriageway
Surface Course Asphalt t = 10cm
Base Course t = 20cm

Sub-base Course t = 40cm
(Unnecessary in the case of Cut Ground)



Shoulder
Surface Cource Asphalt t = 5cm
Base Course t = 20xm



17.6 Bridge Design

17.6.1 Design Codes and Standards

(1) General

The bridge structure design standards in Paraguay have been carried out in accordance with each project standard following the standards of Brazil or the USA, etc. The engineering design in this study is not to determine structural details. Although the principal design work will be accomplished in accordance with Brazil standards, the USA and Japan standards will be applied as well if necessary. It is not necessary to take into consideration seismic coefficients for bridge design in Paraguay.

(2) Material Strength

Concrete strengths have been decided according to Paraguay's current conditions, and steel strength is based on the ASTM standards. The strengths of principal materials are shown in Table 17.6.1.

Table 17.6.1 Material Strength

Material	Item	Strength
Concrete	RC Superstructure	fc = 280kg/m^2
	Pier	fc = 240kg/m^2
	Foundation	fc = 210kg/m^2
	Prestressed Concrete	fc = 350kg/m^2
Reinforcing Bar	Grade 40	fy = 2,800 kg/cm^2
Prestressing Cable	Grade 270	fy = 161 kg/mm^2

Note: fc; Specified compressive strength of concrete at 28 days
fy; Specified yield strength of steel material

17.6.2 Type of Bridge

(1) Superstructure

1) General of Proposed Bridge

In general the type of bridge is determined based on the surrounding conditions such as road alignment, crossing of river, environmental requirements and economic priorities. In particular, planning of highway and river condition should be taken into consideration to determine the bridge span length. The general relation between span length and concrete bridge type is shown in Table 17.6.2. The type of superstructure in this study is determined based on the above description and also taking into consideration the past record of bridge construction and site conditions in Paraguay. In this study, the proposed bridges have been classified into three categories based on their span length for cost estimation purposes. The general dimensions of these classified bridges are shown in drawings in a separate volume. The superstructure types have been assumed to depend on span length as follows.

Bridge (Span =10m)	Reinforced Concrete T-Girder
Bridge (Span =20-30m)	Prestressed Concrete T- Girder
Flyover (Span =25,35m)	Prestressed Concrete T- Girder

There are five bridges in new bypass roads and two bridges in reconstruction of bridge on the existing road. The length of bridges span will be from 10m to 35m including Coronel Oviedo Flyover. The adopted superstructure types of the proposed bridges are shown in Table 17.6.3.

Table 17.6.2 Concrete Bridge Types and Standard Span Length

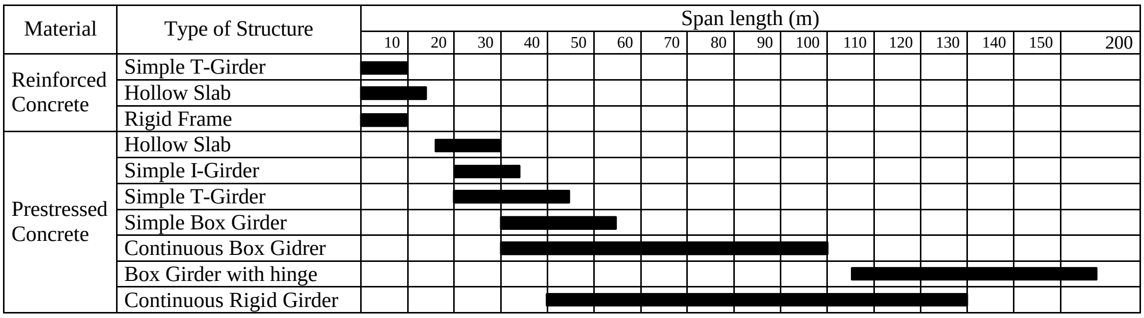
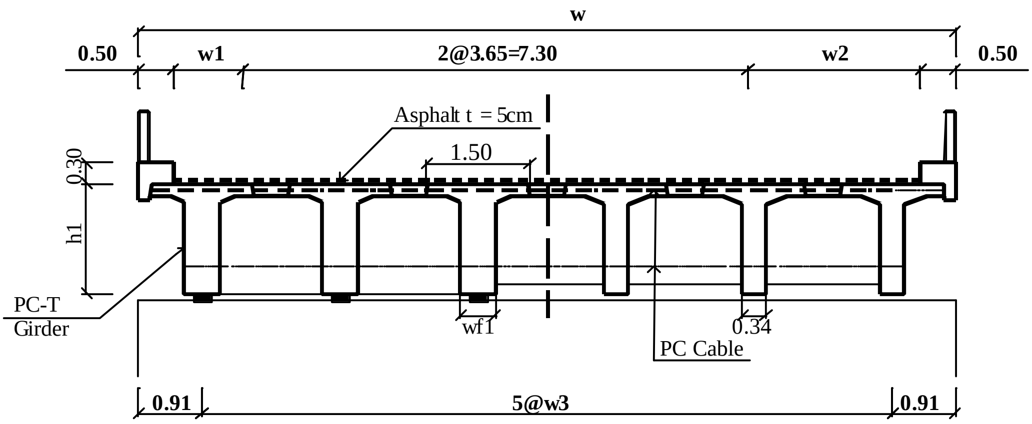


Table 17.6.3 Type of Superstructure for Proposed Bridges

Bridge No.	Station	Width of Bridge (m)	Type of Superstructure	Length of Bridge	Name of Bypass	Remarks
NB-1	38+600	11.80	PC-T Girder	25.80	Ypacaraí	
NB-2	38+600	11.80	PC-T Girder	25.80	Ypacaraí	
NB-3	53+400	11.80	PC-T Girder	30.80	Caacupé	
NB-4	53+400	11.80	PC-T Girder	30.80	Caacupé	
NB-5	100+200	11.30	PC-T Girder	30.80	San Jose	
NB-6	154+400	11.30	RC-T Girder	10.80	-	Reconstruction of existing Nº 21 bridge
NB-7	154+700	11.30	RC-T Girder	10.80	-	Reconstruction of existing Nº 22 bridge
Flyover	132+040	11.30	PC-T Girder	139.25	Coronel Oviedo Flyover	Span = 25.0x4+35.0

2) Girder Height and Number

The cross section of a bridge is shown in Figure 17.6.1. The simple composite prestressed girder with a 1/17 to 1/20 height to span length ratio is the most economic. In this study, 1.50m, 1.80m and 2.00m girder heights will be adopted, corresponding to the 25.0m 30.0m and 35.0m span lengths respectively. The number of girders used is 6 main girders for the 2-lane roadway (width 11.3m and 11.8m), with a 1.9m and 2.0m space between girders.



Span	W (m)	w1 (m)	w2 (m)	w3 (m)	h1 (m)	wf1 (m)
25	11.80	1.00	2.50	2.00	1.60	0.50
25	11.30	1.50	1.50	1.90	1.60	0.50
30	11.80	1.00	2.50	2.00	1.80	0.55
30	11.30	1.50	1.50	1.90	1.80	0.55
35	11.30	1.50	1.50	1.90	2.00	0.55

Figure 17.6.1 Cross Section of Bridge

(2) Substructure

1) Subsoil Characteristics

The subsoil at the planned bridge site consists of silty to clay type sand layer. The bearing layer for foundations is planned based on the soil layer at a depth of 1.0 m to 9.0m from the ground surface with an “N” value of over 30 according to the standard penetration test.

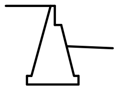
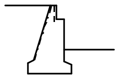
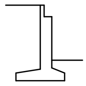
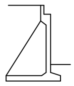
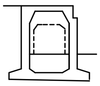
2) Foundation Type

Concerning the determination of the foundation type, the conditions of superstructure, subsoil, construction method, etc., should be previously analyzed with accuracy, in order to select the most economical and reliable foundation. At present, a soil stratum with "N" value of over 30 has been taken as the bearing stratum, taking into consideration the economical aspects, ease of construction, water table level, width of work, etc. A spread foundation will be used when the solid stratum reaches around 4.0m of depth, and in case it gets deeper, a pile foundation will be used. Considering the previous experience in Paraguay, 800 mm cast-in-place reinforced concrete piles will be adopted.

3) Abutments

The type of abutment will be subject to their applicable heights as shown in Table 17.6.4. The type of abutment chosen for a given bridge varies depending on the bearing subsoil condition of the site, height of abutment and economic priorities. Since the planned heights of abutments are 7.0 to 8.0m, a cantilever type abutment will be adopted.

Table 17.6.4 Abutment Types and Standard Height

Abutment Type	Height (m)			Remarks
	10	20	30	
Gravity Type	■			
Semi-gravity Type	■			
Cantilever Type	■	■		
Counterfort Type		■		
Rigid Frame Type		■		

(3) Pier Type

The use of a pier will be provided only for a flyover in this study. Since Paraguay has no seismic effects, it allows the adoption of smaller piers. Concerning the type of pier it should also be aesthetically pleasing and economize the use of materials as much as possible. Also, piers should be located so that they provide minimal interference with the traffic passing underneath the structure. The structural type of piers should be determined to satisfy the surrounding conditions as well as the structural requirements. The type of pier in this study is determined based on the above description. Taking into consideration the past record of constructions and site conditions, a rigid frame type pier will be adopted as shown in Figure 17.6.2.

END SECTION / CENTER SECTION

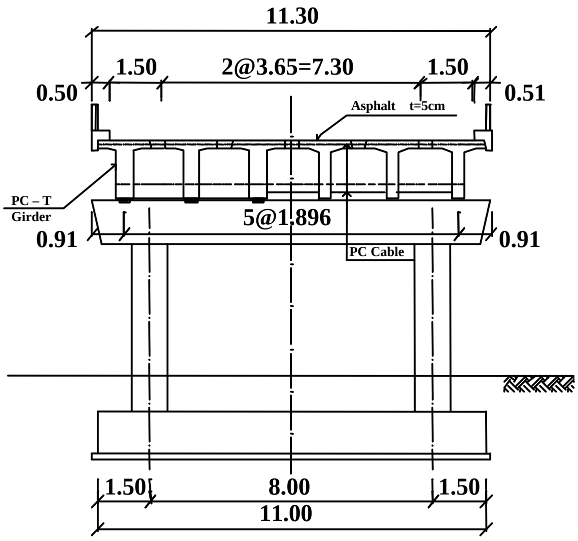


Figure 17.6.2 Cross Section of Pier Flyover

CHAPTER 18 PROJECT COST ESTIMATE

18 PROJECT COST ESTIMATES

18.1 Condition of Cost Estimates

18.1.1 Tax and Exchange Rates

The estimation and analysis of equipment, materials, and labor costs is a pre-requisite for estimating unit costs of major civil works. The construction costs of similar projects in Paraguay and South America have been investigated. The basic conditions for construction cost estimation are the following:

1) Exchange Rate of currencies US$1.0 = Gs 3300 = ¥105
2) Sales tax 10%
3) Import tax of material procurement is 5% and 10% for South American countries and other countries such as the United States of America, respectively.

18.1.2 Direct Costs

The direct construction costs basically consist of the following:

- Labor costs
- Material costs
- Equipment costs

The data collected in the preliminary investigation are as follows.

(1) Labor Cost

The minimum wages prescribed by the "MINISTERIO DE JUSTICIA Y TRABAJO" (Ministry of Justice and Labor) are Gs. 591,445 and Gs. 19,714 for monthly and daily wages, respectively. Labor costs as shown below are based on the hourly cost, which includes social factors. The contents of social factors are as follows.

Social Factors and Work Schedule

- Legal holidays 12 days
- Paid Leave 12 days
- Non workable days 30 days per year
- Working hours per week 40 hours
- Overtime per month 30 hours
- Thirteen months pay, one month
- Social security 16.5% of salary (IPS, health insurance, retirement)

Table 18.1.1 Wage

Labor	Wage hourly (Gs)
Foreman	11,377
Assistant Foreman	7,500
Skilled Labor	6,820
Unskilled Labor	5,560
Driver	7,964
Heavy Equipment Operator	9,100

(2) Material Cost

The current market prices for construction materials have been collected from CONSTRUCTION, market price surveys, and similar projects in MOPC. The materials applied to the project are divided into commercial materials and materials processed by the contractor. The results of the investigation for materials are listed below.

Table 18.1.2 Material Cost

Major materials	unit	Price (Gs) Currency Portion		
Portland Cement Type-1(50 kg)	bag	14,330	60	40
Asphalt Cement penetration 60/80	ton	1,017,000	80	20
Asphalt Cement penetration 85/100	ton	1,017,000	80	20
Coarse Aggregate for base course	m^3	25,630	1)	
Coarse Aggregate for sub base course	m^3	26,975	1)	
Aggregate for Cement Concrete	m^3	28,600	1)	
Plywood ½" x 4' x 8'	pcs	56,000	60	40
Plywood ¾" x 4' x 8'	pcs	75,900	60	40
Gasoline	litters	1,540	80	20
Diesel oil	litters	680	80	20
Motor oil(lubricant)	litters	540	0	100
Reinforcing Steel Grade 60	kg	1,500	60	40
Reinforcing Steel Grade 40	kg	2,500	80	20
Pre-stressing Steel Grade 270	kg	3,500	80	20
Structural Steel	kg	1,580	60	40
Fine Aggregate	m3	23,000	40	60

Sources: " Construction " Revisit de la Camara Paraguay de la Industria de la Construccion Oct 99'
" COSTOS " Revista Especializada en Analisis de Costos de la Construccion Oct 99'
"Similar road projects in MOPC"
Note: 1) indicates price of origin

(3) Equipment Cost

The hourly operation costs of the construction equipment are normally calculated based on fixed costs and running costs. Fixed costs consist of depreciation costs and other costs such as annual spare parts, management costs, and wages. Running costs consist of fuel and lubricant. The following figures have been applied to the project.

Residual Value	:	10% of basic price
Operation Life of Equipment	:	3-8 years depend on the equipment
Annual Management cost	:	2.0%
Maintenance cost	:	20-110%

18.1.3 Project Cost Composition

The project cost comprises direct construction costs, general expenses, land acquisition cost, relocation cost, compensation cost, physical contingency, value-added tax, import tax, and engineering fee. Table 18.1.3 shows the composition of Project cost.

Table 18.1.3 Project Cost Composition

A. Direct Construction Cost [1)]	Estimates
B. General Expenses (Mobilization and Administration)	30% of A
C. Contractor Profit	15% of A
D. Total	A + B + C
E. Indirect cost	
1) Engineering Fee	7% of D
2) Physical Contingency	10% of D+E1
3) Land acquisition	Estimates
4) Relocation /Compensation cost	Estimates
5) Total of E	
F Project Cost	D + E5

Note: 1) includes sale tax and duty

18.1.4 Cost Component of Foreign and Local Currency

The foreign currency and local currency unit cost will be divided by adequate ratios.

18.1.5 Unit Cost Price Method

The unit price method has been authorized internationally for estimating construction costs and has been adopted for this project. The unit price analysis for combining labor rates, material costs, and equipment described above will be carried out for major items.

18.1.6 Summary of Bill of Quantity

The project is divided into two periods in this study that Pakage-1 and Package-2 as below:

Pakage-1: For urgent project are constructed to renovate overage facilities and provided traffic safety devices mainly at a place of traffic accident to be implemented by 2005 year. (Climbing lane, guard rail, improvement of interchange etc.)

Pakage-2: The mini-bypasses project are constructed for increasing traffic capacity as well as traffic safety to be implemented by 2010 year.

The quantities of major materials for packages 1 and 2 are summarized in Table 18.1.4 and Table 18.1.5 respectively.

1) Package 1 Bill of Quantities

The project is divided into two periods that one is urgent maintenance and the other is bypass construction. The construction starts in 2002, and the first period finishes in 2005, and the second in 2009.

– Package-1: Road improvement (climbing lanes) and urgent maintenance
– Package-2: Bypasses in Ypacarai, Caacupe, Itacurubi, and San Jose.

Table 18.1.4 Summary of Bill of Quantities for Package 1

Description	Unit	Coronel Oviedo Climbing Lane	Other Climbing Lanes	Coronel Oviedo flyover	Total
1. Preparatory Works					
1.01 Clearing and Grubbing	0	136,000.00	30,000.00	10,000.00	176000
1.02 House Demolish Works	each	100.00	0.00	100.00	200
2. Earth Work					
2.01 Road Excavation	cum	266,000.00	0.00	1,400.00	267400
2.02 Embankment	cum	124,800.00	173,000.00	12,300.00	310100
2.03 Slope Protection for Embankment	sqm	18,000.00	30,000.00	2,700.00	50700
2.04 Disposal	cum	127,080.00	0.00	0.00	127080
3. Pavement					
3.01 Asphalt Pavement-1 (t = 65cm)	sqm	8,881.00	36,500.00	4,938.00	50319
3.02 Asphalt Pavement-2 (t = 5cm)	sqm	19,090.00	0.00	0.00	19090
3.03 Asphalt Pavement-3 (t = 35cm)	sqm	20,500.00	15,000.00	2,380.00	37880
3.04 Asphalt Pavement-4 (t = 5cm)	sqm	9,466.16	1,402,700.00	1,120.00	1,413,286.16
3.05 Asphalt Pavement-5 (t = 27cm, W = 4m)	sqm	0.00	0.00	4,570.00	4570.00
4. Structure					
4.01 Structure Excavation	cum	546.92	467.20	645.00	1,659.12
4.02 Structure Concrete-A (210kg/cm^2)	cum	197.40	216.00	428.00	841.40
4.03 Structure Concrete-B (240kg/cm^2)	cum	421.55	601.95	510.00	1,533.50
4.04 Structure Concrete-C (350kg/cm^2)	cum	0.00	0.00	0.00	0
4.05 Reinforcement	ton	49.54	55.40	74.00	0.00
4.06 Prestressing Cable	ton	7.91	0.00	11.00	178.94
4.07 PC T-Girder 1 = 20m	pcs	0.00	0.00	0.00	0.00
4.08 PC T-Girder 1 = 25m	pcs	24.00			
4.09 PC T-Girder 1 = 30m	pcs	0.00	0.00	24.00	24.00
4.10 PC T-Girder 1 = 35m	pcs	0.00	0.00	6.00	6.00
4.11 Elastmeric Bearing Pad 40 × 40	pcs	24.00	36.00	60.00	120.00
4.12 Expansion Joint	m	24.00	41.20	62.00	127.00
4.13 ccp Pile d = 80cm	m	0.0	0.00	201,106.00	201,106.00
5. Drainage					
5.01 RC-Pipe d = 100cm	m	76.00	0.00	76.00	152.00
5.02 RC-Pipe d = 120cm	m	0.00	0.00	0.00	0.00
5.03 RC-Pipe d = 200cm	m	0.00	0.00	0.00	0.00
5.04 RC-Pipe d = 60cm	m	0.00	0.00	0.00	0.00
5.05 RC-Box Culvert 2.0m × 2.0m	m	0.00	0.00	0.00	0.00
5.06 RC-Box Culvert 3.0m × 3.0m	m	0.00	0.00	0.00	0.00
5.07 Gutter for Cutting Section	m	4,600.00	0.00	4,600.00	9,200.00
6. Facilities					
6.01 Median Plantation	m	0.00	0.00	0.00	0.00
6.02 Vehicle Guard Rail	m	1,000.00	0.00	1,000.00	2,000.00
6.03 Street Lighting	set	0.00	0.00	0.00	0.00
6.04 Lane Marking	m	7,000.00	172,600.00	7,000.00	186,600.00
6.05 Traffic Sign 1.2m × 2.4m	set	0.00	0.00	0.00	0.00
6.06 Traffic Sign 0.75m × 1.0m	set	10.00	18.00	10.00	38.00
6.07 Yellow Road Stud	set	0.00	264.00	0.00	264.00
6.08 Silver Road Stud	set	0.00	1,200.00	0.00	1,200.00
6.09 Traffic Signal (Vehicle)	set	0.00	0.00	0.00	0.00
6.10 Signalization at Intersection	lot	0.00	0.00	2.00	2.00

2) Package 2 Bill of Quantities

Table 18.1.5 Summary of Bill of Quantity for Package 2

Description	Unit	Ypacarai Bypass	Caacupe Bypass	Itacurubi Bypass	San Jose Bypass	Total
1. Preparatory Works						
1.01 Clearing and Grubbing	0	170000	180000	110000	83000	543,000.00
1.02 House Demolition Works	each	33	66	42	25	166.00
2. Earth Work						
2.01 Road Excavation	cum	14300	692200	71130	27700	805,330.00
2.02 Embankment	cum	160000	407340	284000	153000	1,004,340.00
2.03 Slope Protection for Embankment	sqm	13388	31200	34500	31500	110,588.00
2.04 Disposal	cum	0	256374	0	0	256,374.00
3. Pavement						
3.01 Asphalt Pavement-1 (t = 65cm)	sqm	49800	48970	16600	35690	151,060.00
3.02 Asphalt Pavement-2 (t = 5cm)	sqm	18260	62250	29631	2905	113,046.00
3.03 Asphalt Pavement-3 (t = 35cm)	sqm	20500	33500	22280	18600	94,880.00
3.04 Asphalt Pavement-4 (t = 5cm)	sqm	9466	6640	4150	4150	24,406.00
3.05 Asphalt Pavement-5 (t = 27cm, W = 4m)	sqm	0	0	0	0	0.00
4. Structure						
4.01 Structure Excavation	cum	546.9	547	0	273	1,366.90
4.02 Structure Concrete-A (210kg/cm^2)	cum	197.4	197	0	99	493.40
4.03 Structure Concrete-B (240kg/cm^2)	cum	421.5	501	0	212	1,134.50
4.04 Structure Concrete-C (350kg/cm^2)	cum	0.0	0	0	0	0.00
4.05 Reinforcement	ton	49.5	54	0	24	127.50
4.06 Prestressing Cable	ton	7.9	9	0	2	18.90
4.07 PC T-Girder 1 = 20m	pcs	0.0	0	0	0	0.00
4.08 PC T-Girder 1 = 25m	pcs	24.0	0	0	0	24.00
4.09 PC T-Girder 1 = 30m	pcs	0.0	24	0	6	30.00
4.10 PC T-Girder 1 = 35m	pcs	0.0	0	0	0	0.00
4.11 Elastmeric Bearing Pad 40 × 40	pcs	24.0	48	0	12	84.00
4.12 Expansion Joint	m	33.2	41	0	21	95.20
4.13 ccp Pile d = 80cm	m	140.0	0	0	0	140.00
5. Drainage						
5.01 RC-Pipe d = 100cm	m	820.0	1340	0	0	2,160.00
5.02 RC-Pipe d = 120cm	m	0.0	0	62	95	157.00
5.03 RC-Pipe d = 200cm	m	0.0	0	30	0	30.00
5.04 RC-Pipe d = 60cm	m	68.0	68	0	0	136.00
5.05 RC-Box Culvert 2.0m × 2.0m	m	0.0	36	40	0	76.00
5.06 RC-Box Culvert 3.0m × 3.0m	m	38.0	270	0	0	308.00
5.07 Gutter for Cutting Section	m	4400.0	11800	5500	800	22,500.00
6. Facilities						
6.01 Median Plantation	m	4400	6800	0	0	11,200.00
6.02 Vehicle Guard Rail	m	1000	600	400	0	2,000.00
6.03 Street Lighting	set	400	450	30	0	880.00
6.04 Lane Marking	m	10400	27000	300	10000	47,700.00
6.05 Traffic Sign 1.2m × 2.4m	set	2	2	2	2	8.00
6.06 Traffic Sign 0.75m × 1.0m	set	0	10	8	4	22.00
6.07 Yellow Road Stud	set	600	900	0	0	1,500.00
6.08 Silver Road Stud	set	0	0	0	0	0.00
6.09 Traffic Signal (Vehicle)	set					0.00
6.10 Signalization at Intersection	lot					0.00

18.2 Construction Cost

The construction cost estimates have been carried out in accordance with the condition of cost estimation mentioned above for each package and construction works, described as follows.

Table 18.2.1 Construction Cost

	Financial (mill. Gs)	Economic (mill. Gs)
1. Phase 1		
1) Coronel Oviedo Climbing Lane: Construction of climbing lane 4.0 km	17,096	15,368
2) Other Climbing lane & Urgent Maintenance Nine (9) climbing lanes construction and Overlay of existing National road Route 2/7 169 km Two (2) existing bridge re-construction Improvement of traffic safety facilities	60,874	52,783
3) Coronel Oviedo Flyover Construction of one (1) flyover 570m	7,051	6,203
Total Package 1	**85,027**	**74,355**
2. Phase 2		
1) Ypacaraí Bypass Construction of bypass 4.6m Construction of two (2) Bridges	25,681	22,742
2) Caacupé Bypass Construction of bypass 7.2 km in length Construction of one(1) bridge	58,330	52,144
3) Itacurubí Bypass Construction of bypass 6.07 km in length	20,217	18,098
4) San Jose Bypass Construction of bypass 5.15 km in length Construction of one (1) bridge	17,052	15,158
Total Package 2	**121,280**	**108,143**
3. Total package 1+2	206,307	182,488
4. Engineering fee	14,442	12,775
5. Contingency	22,075	1,952
6. Total Construction Cost	**242,824**	**214,800**

18.3 Land Acquisition and Compensation cost

Land acquisition is required for bypass construction, and the bypasses are located almost outside the residential area of the cities such as Ypacaraí, Caacupé, Itacurubí and San Jose. Therefore, land unit price Gs 25,000 /m^2 has been used as an average price for residential areas and others. The compensation price for house relocation has been estimated as Gs 20,000,000 per house.

	Quantity (ha)	Unit Price (mill Gs)	Cost (mill Gs)
Land acquisition cost	98.28	250	24,570
Compensation cost	154.0	20	3,080

18.4 Project Cost

Project cost consists of construction costs, land acquisition costs, and compensation costs.

Table 18.4.1 Summary of Project Cost

Items	Length (km)	Foreign	Local		Total		Remarks
			Financial	Economic	Financial	Economic	
		(US$×1000)	(mill Gs)	(mill Gs)	(mill Gs)	(mill Gs)	
A. Construction Cost							
(1) Road Improvement							
1.0 Coronel Oviedo Climbing Lane	4.00	2,807	7,833	6,105	17,096	15,368	W=5.15m
1.1 Other Climbing Lane & Urgent Maintenance							W=5.15m
1.2 Coronel Oviedo Flyover	0.57	1,198	3,104	2,250	7,057	6,203	W=12.3m enbank W=10.4m flyover
Sub Total (1)		15,116	35,145	25,041	85,027	74,355	W=5.15m
(2) Bypass							
2.1 Ypacarai Bypass	4.60	4,395	8,865	8,239	25,681	22,742	W=2×10.8m
2.2 Caacupe Bypass	7.20	9,761	26,121	19,935	58,330	52,144	W=2×10.8m
2.3 Itacurubi Bypass	6.02	3,378	9,069	6,950	20,217	18,098	W=12.3m
2.4 San Jose Bypass	5.15	2,898	7,490	5,596	17,052	15,158	W=12.3m
Sub Total (2)		20,431	51,544	40,719	121,280	108,143	
Total of A = (1) + (2)		35,547	86,690	65,760	206,307	182,498	
B. Engineering Cost 7% of Total A.	**lump**	**2,488**	**6,068**	**4,603**	**14,442**	**12,775**	
C. Total Construction Cost (A) + (B)		**38,035**	**92,758**	**70,363**	**220,749**	**195,271**	
D. Contingency 10% of C.					**22,075**	**19,527**	
E. Total Construction Cost (C)+(D)					**242,824**	**214,800**	
F. Land Acquisition Cost	**lump**				**24,570**	**11,940**	
G. Compensation Cost	**lump**				**3,080**	**3,080**	
H. Project Cost	**lump**	**38,035**			**270,474**	**229,820**	
Equivalent million US$					82.0		Ius$=Gs3300

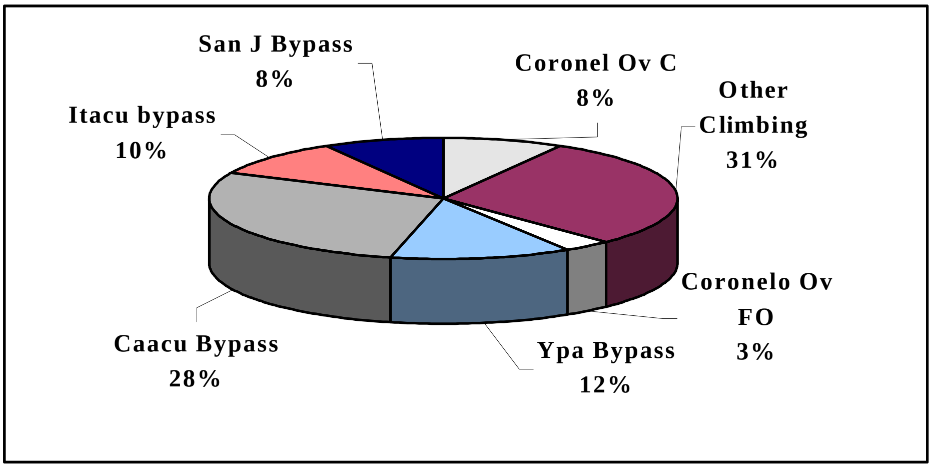


Figure 18.4.1 Cost Component Ratio by the Construction Works

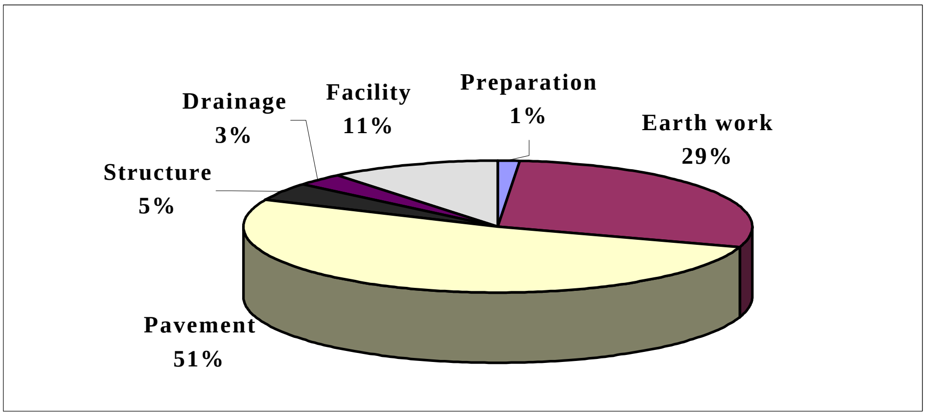


Figure 18.4.2 Cost Component Ratio by Project

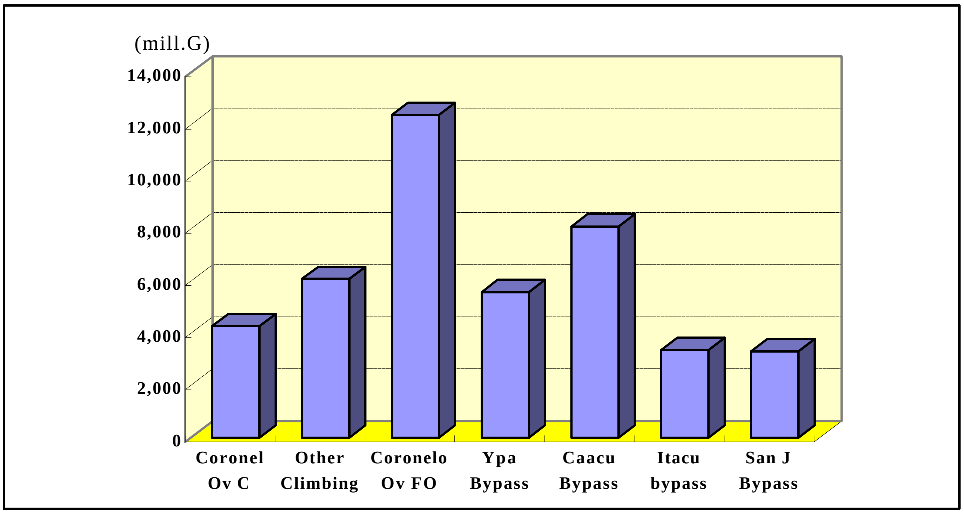


Figure 18.4.3 Comparison of Construction per Kilometer

18.5 Project Implementation

The project is divided into road improvement project (Package-1) and Bypass Road project (package-2). Package-1 consists of Coronel Oviedo Climbing lane, other climbing lanes & urgent maintenance, and Coronel Oviedo Flyover. Package –2 consists of four (4) bypasses such as Ypacaraí bypass, Caacupé bypass, Itacurubí bypass and San Jose bypass. In this study, various road improvements have been proposed target year of 2010. For urgent project of Pakage-1 are constructed to renovate overage facilities and provided traffic safety devices to be implemented by 2005 year. The mini-bypasses project of pakage-2 are constructed for increasing traffic capacity as well as traffic safety to be implemented by 2010 year. The construction starts of each mini-bypasses are determined depending on traffic volume and order of construction from Ypacari to San Jose. The annual disbursements are shown in Table 18.5.1 in accordance with the construction schedule.

Table 18.5.1 Project Implementation Schedule

Works	Unit	Quan-tity	2002	2003	2004	2005	2006	2007	2008	2009	2010	Construction Cost Financial (Gs. million)	Construction Cost Economic (Gs. million)
1 Preparation of Project		lump											
2 Survey and Design		lump										15,886	14,052
3 Construction													
A Package-1 Road Improvement, Urgent Maintenance													
1 Coronel Oviedo Climbing Lane	km	3.87										18,805	16,905
2 Others Climbing Lane & Urgent Maintenance	km	10.0										66,961	58,062
3 Coronel Oviedo Flyover	km	0.57										7,763	6,824
B Package-2 Bypass Construction													
1 Ypacarai	km	4.60										28,249	25,016
2 Caacupe	km	7.20										64,163	57,359
3 Itacurubi	km	6.07										22,239	19,908
4 San Jose	km	5.15										18,758	16,674
C Financial Cost			0	7,943	50,826	64,771	46,206		43,201	20,498	9,379	242,824	
D Economic Cost			0	7,026	44,510	56,815	41,187		38,633	18,291	8,337		214,800

18.6 Operation and Maintenance Cost

18.6.1 Operation Plan

(1) Basic Concept

The organization of maintenance and traffic management System (OMM) consists of the main maintenance center (MMC), maintenance office (MC) and toll collection office as shown in Figure 18.6.1. The buildings consist of the toll collection office and operation and maintenance center, which has MMC and MC function.

The functional roles OMM of toll road are indicated in the following seven items:

- Planning and programming
- Traffic engineering and safety
- Traffic management and operation
- Maintenance and operation
- Toll collection
- Coordination and public relations
- Administration

The definition and function of the toll road OMM system is shown in Figure 18.6.2.

(2) Traffic Management and Operation

1) Function of Traffic Management and Operation

- Maintaining safe and smooth traffic flow on the toll road
- Preventing adverse conditions such as traffic accidents and traffic congestion, which impact traffic flow
- Restoring normal traffic flow as quickly as possible after traffic accidents and traffic congestion

2) Task Items

The traffic management and operation function has four components as follows.

- Toll collection
- Traffic surveillance
- Traffic control
- Traffic regulation

3) Contents of Task Item

a) Toll Collection

Toll revenue is most important for the operation and management of a toll road. Therefore a toll collection system is needed and requires strict management and operation.

The toll collection component is the collection of tolls at tollgate or at the toll barrier from vehicles using the motorway.

- Function of Tollgate
  This is not only to collect the toll fee but also to gather traffic volume data and to prevent entry of oversize or over weight vehicles to preserve the toll road structure.

Data collection and measurement method is as follows;

- Manual counts by vehicle type and automatic record, and display signal
- Weighing of large size vehicles by axle weight scale and display
- Vehicle height check for all vehicles at the entrance before the tollgates
- Automatic vehicle count and automatic record to compare with manual vehicle count

– Toll Collection System

Toll collection method applies the open system for uniform toll tariffs in consideration of the toll road length and management of toll collection. Locations of tollgates are entrance to toll road in consideration of traffic operation management and traffic flow at barrier.

– Tollgate

Toll collection is carried out in the following two locations:

- The first tollgate (Ypacarai)
- The second tollgate (Coronel Oviedo)

b) Traffic Surveillance

Traffic surveillance is the process of obtaining information regarding traffic performance on the toll road and determining existing traffic conditions by using special equipment and other means such as patrol cars, cooperative motorists, etc. Traffic information is analyzed by traffic engineer and conveyed to the traffic patrol or traffic police for traffic control purposes.

– Facilities of Traffic Surveillance

- Traffic surveillance room
- Traffic surveillance equipment
- Traffic detector system
- Remote control video system
- Communication systems (Emergency telephone system, radio system)
- Information systems

c) Traffic Control

Traffic control includes not only general traffic control on toll road under normal conditions (as carried out by the traffic patrol), but also emergency measures taken for the purpose of a daily basis traffic control under unusual conditions. Traffic conditions or weather information gathered at traffic control rooms in the main maintenance center are conveyed to other office patrol units via radio, dedicated or public telephone, variable message signs, etc. and to other broadcasting services.

– Facilities of Traffic Control

- Traffic control room
- Traffic patrol units room
- Traffic control
- Communication systems
- Information systems
- Traffic control vehicles and articles

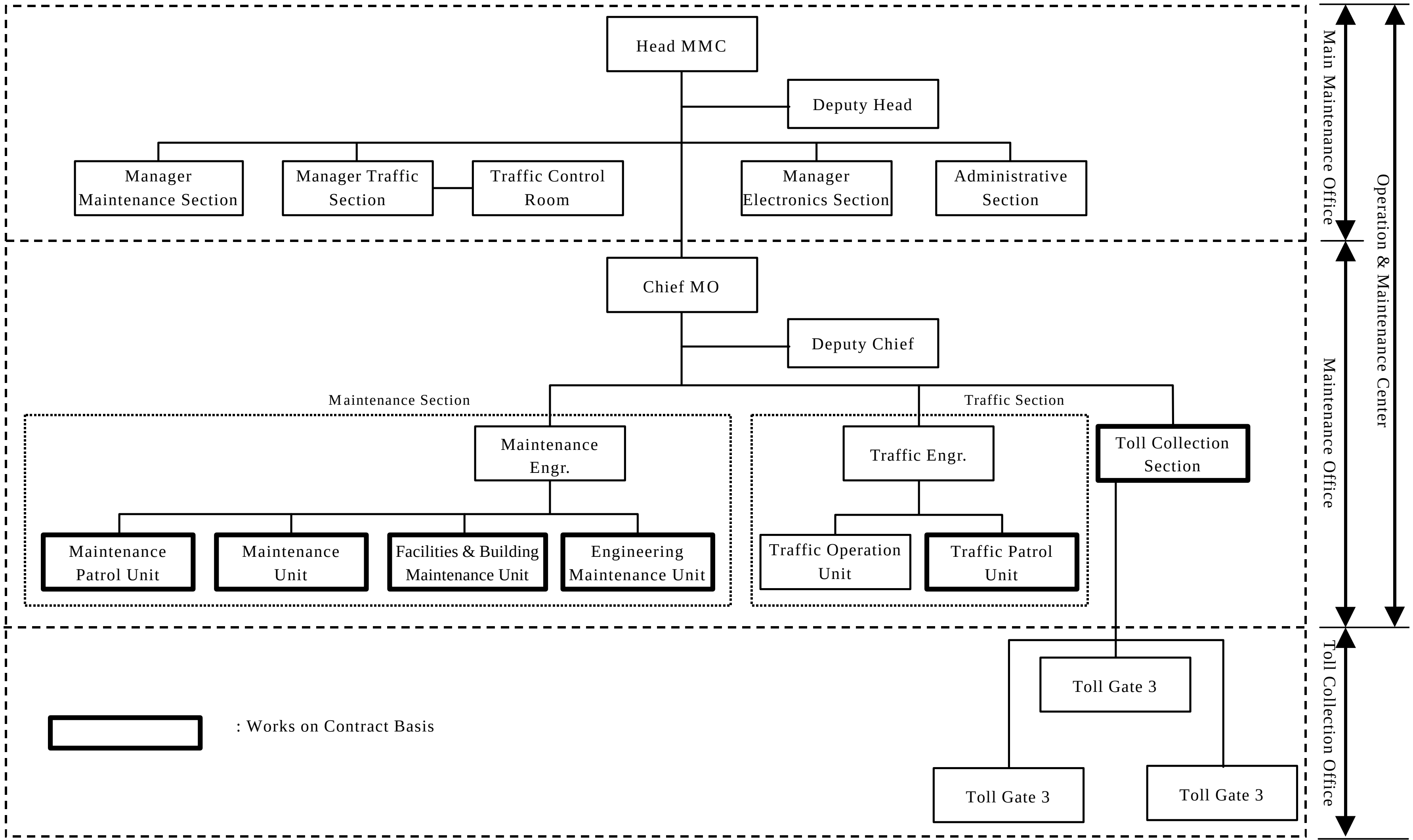


Figure 18.6.1 Main Maintenance Center, Maintenance Office and Toll Collection Office

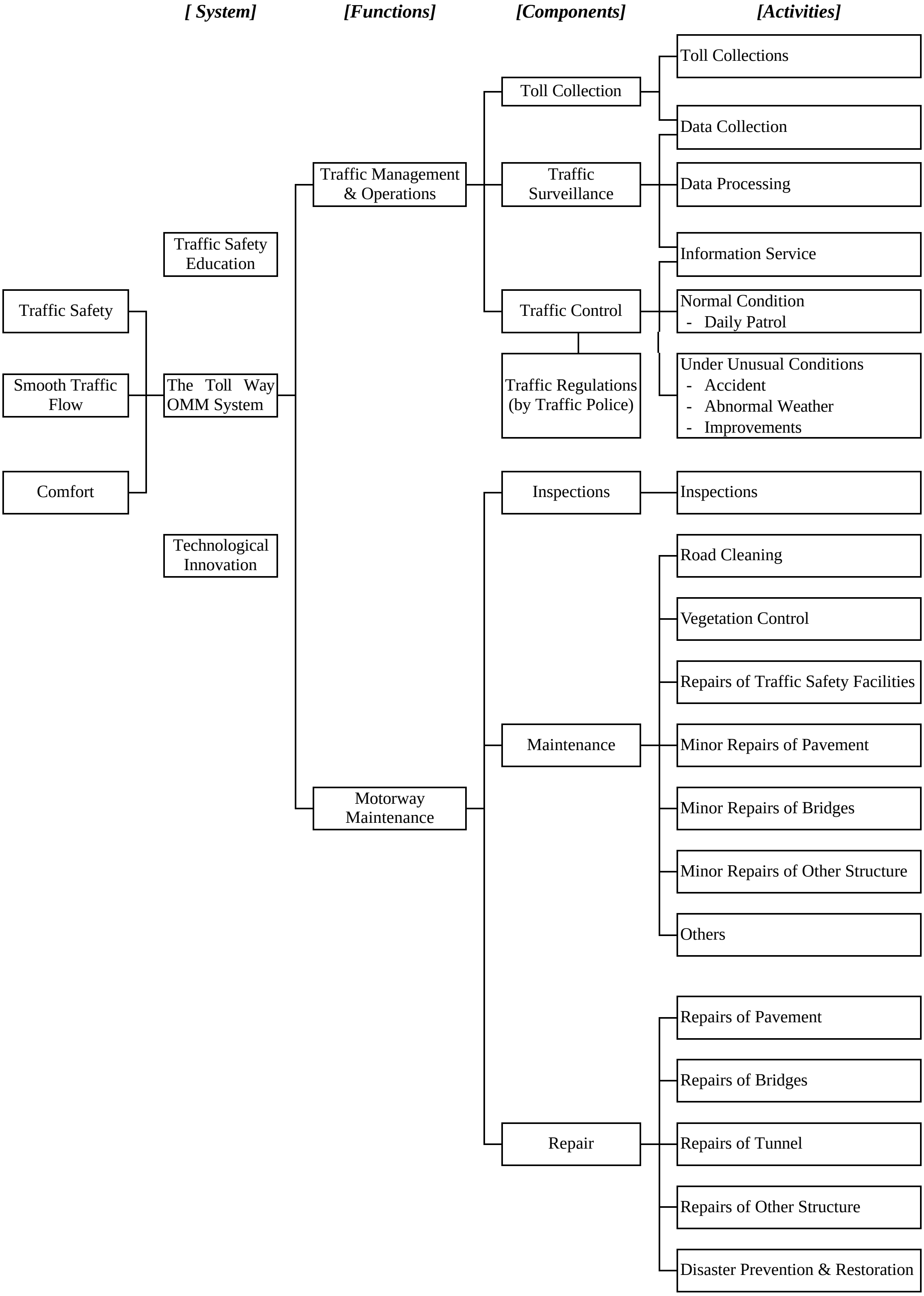


Figure 18.6.2 Definition and Function of the Toll Road OMM System

18.6.2 Maintenance Plan

(1) Road Maintenance and Operation

The purpose of toll road maintenance and operation is as follows;

- To attain traffic safety, smooth traffic flow and riding comfort on toll roads.
- To maintain the road structure and facilities as originally constructed or improved.
- To restore ordinary toll road operation after the damaging effect of weather, vegetation growth, deterioration, traffic wear, traffic accident, and disaster.

(2) Components of Works

Toll road maintenance has the following three components;

- Inspection
- Maintenance
- Repairs

(3) Contents of Works

1) Inspection

All of the works except urgent inspections are basically performed are contract basis.

- Inspection of existing road condition is performed to identify the needs, scale, and time schedule of repairs.
- Inspection works are divided into three kinds: routine, periodic and special.
- Routine inspection is mainly to determine the appropriate action to take for necessary maintenance repair to check the pavement surface, road side and traffic safety condition.
- Periodic inspection is mainly to propose effective countermeasures after investigation of damage to major structures.
- Special inspection is to propose effective countermeasures in consideration of damage to facilities due to accidents or disaster.
- Facilities plan is patrol vehicles and urgent traffic control devices at patrol room.

2) Maintenance

The types of maintenance work are as follows;

- Road cleaning
- Vegetation control
- Repairs of traffic safety and management facilities.
- Minor repair of pavement
- Minor repair of bridges
- Others

3) Repairs

The type of maintenance work is as follows;

- Repair of pavement
  Asphalt overlay or replacement is required due to cracking and rutting caused by heavy traffic and asphalt deterioration overlay and replacement may include areas of existing patching and pothole repairs. An evaluation method shall be established to determine the thickness of overlay required, based on a survey and

analysis of the pavement roughness, cracking ratio, and depth of rutting. In this plan, overlay cost is estimated to replace the surface pavement to a depth of 5cm every 7 years.

- Repair of Bridges
  Repair of superstructures and substructures is needed due to the damage caused by heavy traffic, accidents, weathering, scouring, etc.
  Replacement and strengthening of bridge slabs, expansion joints and bearings based on the identification and evaluation of causes and defects are also required due to the damage caused by heavy traffic, accidents, etc.
- Repair of other structures
  Repair of drainage structures, drainage facilities and office buildings is needed to maintain the toll road.
- Disaster prevention and restoration of damage caused by unforeseen natural disasters.
  Pavement and structural damages can be caused by heavy rainfall. The work includes both prevention and restoration works.

18.6.3 Operation and Maintenance Cost

(1) Operation Cost

- The initial investment of traffic management and operation is structures, which include all construction and installment expenses of equipment to establish a management and operation system for the toll road. The structures consist of tollgates , toll collection offices, maintenance operation office and incidental facilities.
- Operation and maintenance cost are calculated on an annual basis by the maintenance and operation cost of traffic management facilities and personnel expenses.
- The cost of toll collection and maintenance operation cost is estimated on a contract basis in accordance with annual traffic volumes.
- The costs of monitoring of the traffic flow on the road and traffic patrols are estimated on a contract bases.
- Total staff of OMC is 40 persons. Personnel expenses include all social insurance and holiday payments in accordance with Paraguay law. However, increase of annual salary is not considered.
- Works on a contract basis include consumption tax of 10%

(2) Maintenance Cost

- All of the maintenance works is carried out on a contract basis.
- The expenditure of management staff for maintenance is included in the operation cost.
- Overlay of pavement is carried out every 7 years.
- The works on a contract basis include consumption tax of 10%.
- Price escalation is not considered.
- Restoration cost of road damage due to natural calamities or beyond normal expectation is considered an insurance cost

Table 18.6.1 Maintenance and Operation Cost

(Cost per year)

Description	Unit	Quantity	Unit Cost	Cost	Remarks
(1) Initial Cost					
Traffic Management & Operation Cost					
Administration Office Construction & related Facilities	m^2	200	2,000,000	400,000,000	
Toll Gate Office 2×100m^2	m^2	200	2,000,000	400,000,000	
Toll Gate-1 Ypacarai	m^2	50	1,500,000	75,000,000	
Toll Gate-2 San Jose	m^2	50	1,500,000	75,000,000	
Sub Total (1)				**950,000,000**	
(2) Maintenance & Operation Cost					
1) Traffic Management					
Measurement of Heavy Loaded Vehicle	lump	1	40,000,000	40,000,000	
Traffic Patrol	lump	1	200,000,000	200,000,000	
Sub Total 1)				240,000,000	
2) Administration Office Expenses					
Salary					
- Representative	person	24	2,000,000	48,000,000	
- Deputy Representative	person	48	1,500,000	72,000,000	
- Fare Collector	person	230	1,300,000	299,000,000	
Vehicle and Fuel	lump			150,896,000	see back
Office Consumable	lump	24	5,000,000	120,000,000	data
Electric, Gas, Water	lump	24	5,000,000	120,000,000	
Sub Total 2)				**809,896,000**	
3) Road Maintenance & Operation					
Road Inspection					
- Annual Inspection		1	20,000,000	20,000,000	
- Monthly Inspection		12	2,000,000	24,000,000	
Road Cleaning	m^2	3,788	471,328	1,785,390,464	patching
Plantation	lump	1	36,726	36,726	
Repair of Safety Facilities	m	175,476	200	35,095,200	guard rail
Maintenance of Pavement					
- Making	m	32,517	260	8,454,420	
- Overlay	m^2	18,940	1,874,028	35,494,090,320	every 7 year
Bridge Maintenance	m	479,030	17	8,143,510	joint
Earth Work Maintenance	m^2	1,000	471,328	471,328,000	
Lighting Facility Maintenance	lump	1	10,000,000	10,000,000	
Sub Total 3)				**37,856,538,640**	
4) Annual Maintenance Cost					
Sub Total 3) Except Overlay				3,312,448,320	