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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS & HIGHWAYS

Feasibility Study of the Road Improvement Project on the Pan-Philippine Highway (Philippines-Japan Friendship Highway)

FINAL REPORT

EXECUTIVE SUMMARY

(VOLUME I)

SEPTEMBER, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

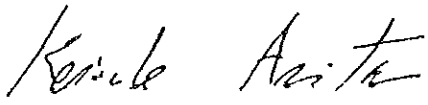
In response to the request of the Government of the Republic of the Philippines, the Government of Japan has decided to conduct a feasibility study on the Road Improvement Project of the Pan-Philippine Highway (Philippines-Japan Friendship Highway) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Tsuneo Bekki, and organized by Nippon Engineering Consultant Co., Ltd. and Katahira & Engineers Inc., from June 2, 1986 to June 23, 1987. The Team had discussions with the officials concerned of the Government of the Philippines and conducted a field survey in the project area. After the Team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

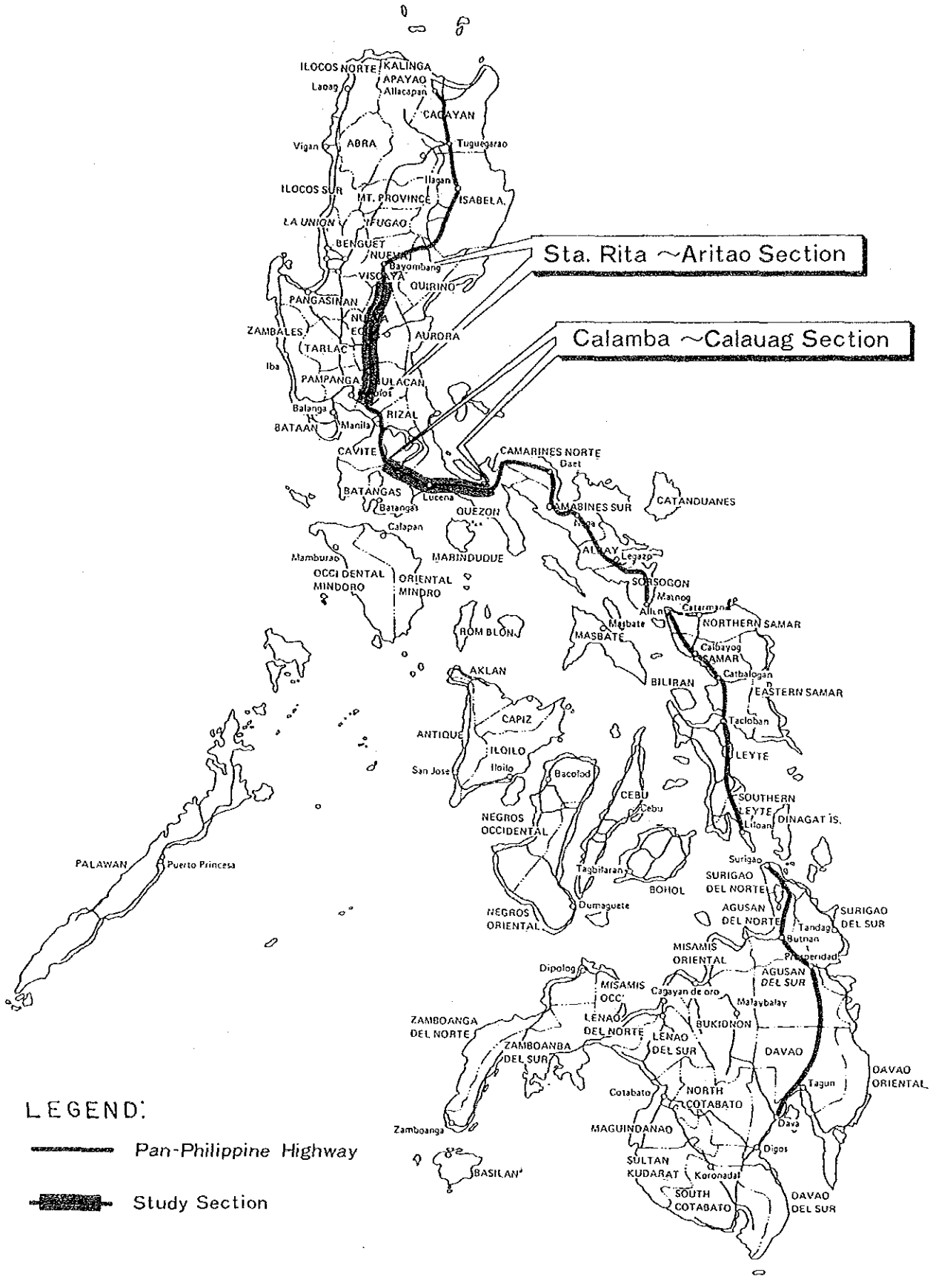
I wish to express my deep appreciation to the officials concerned of the Government of the Philippines for their close cooperation extended to the team.

September, 1987



Keisuke Arita
President
Japan International Cooperation Agency

LOCATION MAP



TYPICAL RURAL SECTION
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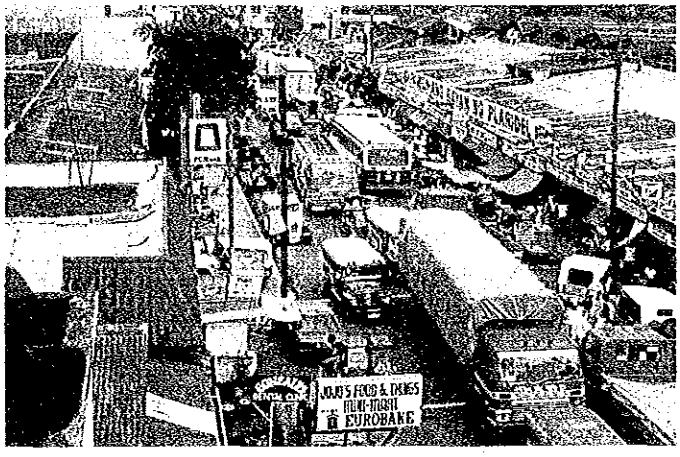
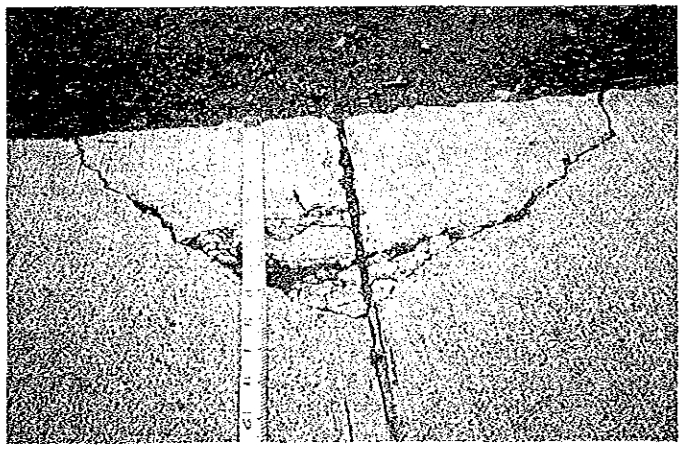


MOST CONGESTED
URBAN SECTION
(Plaridel Urban Section)

UNCONTROLLED INTERSECTION
(Plaridel Intersection)

TRANSVERSE
CRACK

LONGITUDINAL CRACK



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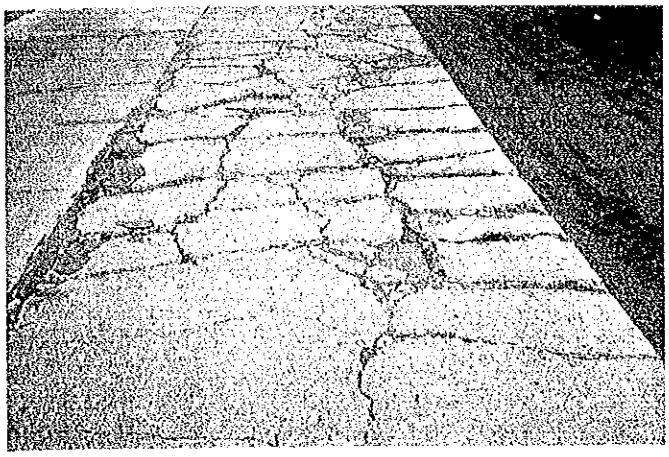
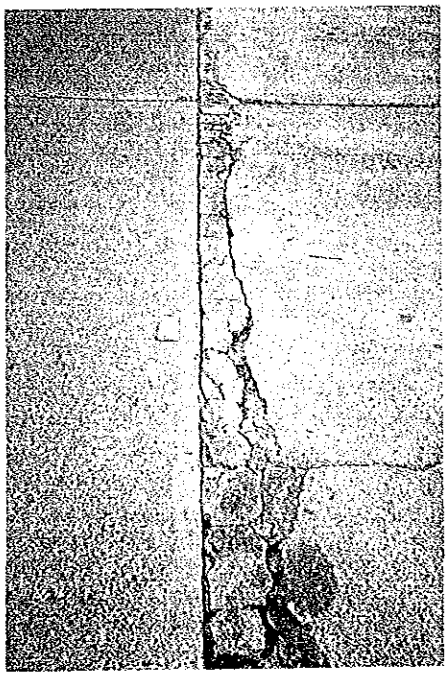
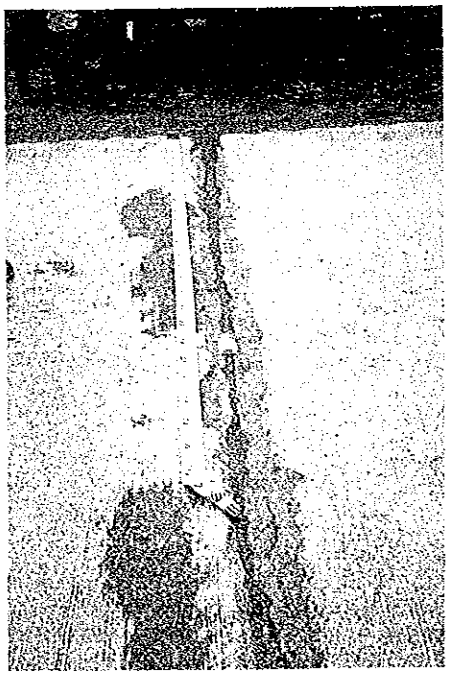


BLOCK CRACKING
(Separation of Slab)



SPALLING



JOINT SEAL DAMAGE OF
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I. INTRODUCTION

I INTRODUCTION

1. BACKGROUND

The Pan-Philippine Highway (Philippines-Japan Friendship Highway) is undoubtedly the most important trunkline in the country's highway network linking the four major islands of Luzon, Samar, Leyte and Mindanao, and extends for about 2100 kms. Initial upgrading of existing sections was started in 1969 with financial assistance from Japan and the entire length of the highway was completed in 1979. The Highway is by standards a two-lane road with 6.7 meters pavement width, 95 percent of which is paved with portland cement concrete and the rest with asphalt concrete.

Since the initial improvements were undertaken, socio-economic development activities along the entire span of the highway have continuously increased at a pace even faster than what was initially envisioned. Consequently, vehicular traffic increased in folds and problems related to transport efficiency in the utilization of the facility has likewise increasingly developed thru the years. Capacity problems are starting to be felt so much so that traffic congestion has become critical in the urban areas traversed. Pavements in many sections have deteriorated resulting in high cost of transportation and maintenance. These, plus other problems, have started to affect the overall efficiency of the network, which if not corrected, will impede the momentum of the socio-economic development currently being pursued for the country.

Cognizant of the related problems and in view of the importance of the Pan-Philippine Highway in the overall network of the country, the Government of the Philippines (hereinafter referred to as "GOP") thru the Department of Public Works and Highways (DPWH) has decided to pursue THE FEASIBILITY STUDY OF THE ROAD IMPROVEMENT PROJECT ON THE PAN-PHILIPPINE HIGHWAY (PHILIPPINES-JAPAN FRIENDSHIP HIGHWAY) (hereinafter referred to as "the Study") thru a technical assistance from the Government of Japan (hereinafter referred to as "GOJ").

In response to the request of GOP, GOJ has decided to conduct the Study. The Japan International Cooperation Agency (hereinafter referred to as "JICA"), which is the official agency responsible for the implementation of GOJ technical cooperation programs, dispatched a team of seven experts to be engaged in the Study. A Study Team composed of members of the JICA consultant team and the Philippine counterpart team commenced the work in June 1986 and completed in September, 1987.

2. OBJECTIVE OF THE STUDY

The objectives of this Study are:

1) To identify and establish the needed improvement works to upgrade the functional efficiency of the Study section.

2) To prioritize the road segments for which improvement works are required.

3. To conduct the feasibility study of typical improvement works proposed within the prioritized segments.

3. SCOPE OF THE STUDY

1) Study Section

Sta. Rita-Aritao Section (approximately 200 kilometers) and Calamba-Calauag Section (approximately 180 kilometers)

2) Improvement Works

The Study Section shall be assessed to identify improvement works as mentioned below.

a. Establishment of new by-passes
b. Widening of narrow roads
c. Intersection improvement and/or installation of traffic signals
d. Geometric realignments
e. Road structures and sections on weak foundations

4. REPORTS

The following reports were prepared during the Study:

INCEPTION REPORT
PROGRESS REPORT
INTERIM REPORT
DRAFT FINAL REPORT

The Final Report was developed based on the GOP's comments on the draft final report, and presented in six (6) volumes as follows:

Volume I: Executive Summary
Volume II: Main Text
Volume III: Appendix
Volume IV: Drawings
Volume V: Guide for Road Function Improvement Planning
Volume VI: Guide for Pavement Rehabilitation Design

The Study was carried out jointly by a team composed of JICA experts and a group of GOP counterparts and support staff. Technical guidance in the conduct of the Study was provided thru periodic review by the Steering Committee of the Philippines and the Advisory Committee of Japan.

II. FINDINGS AND RECOMMENDATIONS

II. FINDINGS AND RECOMMENDATIONS

1. BASIC INFORMATION

LENGTH OF STUDY SECTION

North Study Section	200 Kms	(Sta. Rita – Aritao, Km 39 – Km 239)
South Study Section	181 Kms	(Calamba – Calauag, Km 52 – Km 233)

TYPES AND NUMBER OF ROAD FUNCTION IMPROVEMENT WORKS
(SHORT TERM)

Unit: Number

Improvement Type	North Study Section	South Study Section	Total
Signalization	6	-	6
Improvement of Geometrics	1	2	3
Paving of Shoulders/Sidewalks	6	7	13
Widening to a 4-lane	-	1	1
R.O.W. Acquisition	3	-	3
TOTAL	16	10	26

TYPES AND NUMBER OF PAVEMENT REHABILITATION WORKS
(SHORT TERM)

Unit: Lane-Km

Rehabilitation Type	North Study Section	South Study Section	Total
2-lane PCC Reconstruction	91.92	110.68	202.60
1-lane PCC Reconstruction	113.96	21.12	135.08
2-lane AC Overlay	69.00	5.00	74.00
TOTAL	274.88	136.80	411.68
Treatment of Weak Subgrade	2.00	–	2.00
Side Ditch	109.73	74.52	184.25
Subsurface Drainage	3.25	11.25	14.50
TOTAL	114.98	85.77	200.75

PROPOSED ROAD FUNCTION IMPROVEMENT WORKS

	Segment	Segment Length (Km)	Short Term (1987-1992)				Medium Term (1993-1998)		Long Term (1999-2010)
			Improvement of Intersection	Paving of Shoulder and Sidewalks Within ROW	ROW Acquisition for Widening/Bypass	Widening to 4-Lane Road	Construction of Bypass/ Alternative Route	Widening to 4-Lane Road	
North Study Section	N-1 (Sta. Rita-Gapan)	46	•Plaridel •Baliuag Bypass *	•San Ildefonso (1.0 km)	•Sta Rita-Plaridel (1.5 km) •Plaridel Bypass (4.6km)	—	•Plaridel Bypass (4.6 km)	Sta. Rita Plaridel (1.5 km)	For majority of rural sections; either/combination of •Bypass plus widening of existing road •Bypass plus constructiuon of roads to link bypass •Construction of alternative route
	N-2 (Gapan-Cabanatuan)	35	•Gapan •Sta. Rosa •Cabanatuan II •Cabanatuan IV	•Gapan (1.2 km) •Sta Rosa (1.1 km) •Cabanatuan (4.5 km)	•Cabanatuan Bypass (7.1 km)	—	•Cabanatuan Urban Section (7.1 km) (Alternative) Route)		
	N-3 (Cabanatuan -San Jose)	42	•San Jose	•Talavera (1.0 km) •San Jose (3.5 km)	—	—			
	N-4 (San Jose-Dalton)	38	—	—	—	—			
	N-5 (Dalton-Aritao)	39	—	—	—	—			
South Study Section	S-1 (Calamba-Tiaong)	42	Sto. Tomas I & II (Geometric Improvement)	•Alaminos (1.2 km)	—	•Calamba-Sto. Tomas (10.0 km)	—	—	Same as North Study Section
	S-2 (Tiaong Pagbilao)	42	—	•Tiaong (1.2 km) •Candelaria (1.0 km) •Sariaya (1.0 km) •Pagbilao (1.3 km)	—	—	•Tiaong (3.0 km) •Candelaria (4.0 km) •Sariaya (4.0 km)	—	
	S-3 (Pagbilao-Plaridel)	46	—	—	—	—	—	—	
	S-4 (Plaridel-Callauag)	39	—	•Gumaca (1.5 km) •Lopez (1.0 km)	—	—	—	—	

* Geometric Improvement

SUMMARY OF LENGTH FOR PAVEMENT REHABILITATION/DRAINAGE IMPROVEMENT BY TYPE OF WORKS

Unit: Lane-Km

Segment		Segment Length (km)	Short-Term									Medium Term		Total	
			Pavement Rehabilitation (Lane-km)					Drainage improvement (km)							
			2-Lane PCC Recon-struction	1-Lane PCC Recon-struction (Manila Bound)	1-Lane PCC Recon-struction (Opposite Lane)	2-Lane AC Overlay	Sub-Total	Treatment of Weak Subgrade	Side Ditch	Sub-Surface Drainage	Sub-Total	Pavement Rehabili-tation (Lane-Km)	Drainage Improve-ment (Km)	Pavement Rehabili-tation (Lane-Km)	Drainage Improve-ment (Km)
North Study Section	N-1 (Sta. Rita-Gapan)	46	21.50	25.00	15.20	7.00	68.70	2.0	19.30	—	21.30	23.30	26.70	92.00	48.00
	N-2 (Gapan-Cabanatuan)	35	27.90	2.85	2.75	13.00	46.50	—	8.60	—	8.60	23.50	26.40	70.00	35.00
	N-3 (Cabanatuan-San Jose)	42	5.10	15.02	1.95	—	22.07	—	9.75	—	9.75	61.93	32.25	84.00	42.00
	N-4 (San Jose-Dalton)	38	10.90	17.18	14.53	25.00	67.61	—	35.08	—	35.08	8.39	2.92	76.00	38.00
	N-5 (Dalton-Aritao)	39	26.52	11.74	7.74	24.00	70.00	—	37.00	3.25	40.25	8.00	2.00	78.00	42.25
	Sub-Total	200	91.92	71.79	42.17	69.00	274.88	2.0	109.73	3.25	114.98	125.12	90.27	400.00	205.25
South Study Section	S-1 (Calamba-Tiaong)	42	10.22	7.03	1.65	—	18.90	—	12.95	—	12.95	65.10	29.05	84.00	42.00
	S-2 (Tiaong-Pagbilao)	54	12.76	2.13	0.85	3.00	18.74	—	10.85	—	10.85	89.26	43.15	108.00	54.00
	S-3 (Pagbilao-Plaridel)	46	44.10	3.40	1.10	—	48.60	—	25.45	11.25	36.70	43.40	20.55	92.00	57.25
	S-4 (Plaridel-Calauag)	39	43.60	2.48	2.48	2.00	50.56	—	25.27	—	25.27	27.44	13.73	78.00	39.00
	Sub-Total	181	110.68	15.04	6.08	5.00	136.80	—	74.52	11.25	85.77	225.20	106.48	362.00	192.25
TOTAL		381	202.60	86.83	48.25	74.00	411.68	2.0	184.25	14.50	200.75	350.32	196.75	762.00	397.50

PROJECT COST
(SHORT TERM)

Unit: Million Peso

		November 1986 Price			Escalated Cost		
		Road Function	Pavement Improvement	Total	Road Function	Pavement Improvement	Total
Detailed Engineering	Foreign	7.97	22.90	30.87	7.97	22.90	30.87
	Local/Tax	5.34	9.81	15.15	6.71	11.56	18.27
	Total	13.31	32.71	46.02	14.68	34.46	49.14
Right-of-way Acquisition	Foreign	—	—	—	—	—	—
	Local/Tax	25.06	—	25.06	31.46	—	31.46
	Total	25.06	—	25.06	31.46	—	31.46
Construction	Foreign	86.49	490.75	577.24	86.49	490.75	577.24
	Local/Tax	66.86	326.93	393.79	85.45	422.00	507.45
	Total	153.35	817.68	971.03	171.94	912.75	1,084.69
Construction Supervision	Foreign	4.69	34.35	39.04	4.69	34.35	39.04
	Local/Tax	3.14	14.71	17.85	3.94	19.27	23.21
	Total	7.83	49.06	56.89	8.63	53.62	62.25
TOTAL	Foreign	99.15	548.00	647.15	99.15	548.00	647.15
	Local/Tax	100.40	351.45	451.85	127.56	452.83	580.39
	Total	199.55	899.45	1,099.00	226.71	1,000.83	1,227.54

SUMMARY OF PROJECT COST
— ROAD FUNCTION IMPROVEMENT AND PAVEMENT REHABILITATION —
(SHORT TERM AND MEDIUM TERM)

North Study Section

Unit: Million Pesos Nov. 1986 Prices

Segment	Short Term (1987-1992)			Medium Term (1993-1998)			
	Road Function	Pavement	Sub-Total	Road Function	Pavement	Sub-total	Total
N — 1	17.42	153.22	170.64	90.63	68.57	159.20	329.84
N — 2	64.22	95.27	159.49	63.00	71.32	134.32	293.81
N — 3	28.57	51.33	79.90	—	148.90	148.90	228.80
N — 4	—	142.48	142.48	—	32.13	32.13	174.61
N — 5	—	153.56	153.56	—	29.28	29.28	182.84
Sub-Total	110.21	595.86	706.07	153.63	350.20	503.83	1,209.90
South Study Section							
S — 1	72.67	46.44	119.11	—	152.23	152.23	271.34
S — 2	9.94	39.14	49.08	82.50	185.53	268.03	317.11
S — 3	—	111.68	111.68	—	93.59	93.59	205.27
S — 4	6.73	106.33	113.06	—	59.73	59.73	172.79
Sub-Total	89.34	303.59	392.93	82.50	491.08	573.58	966.51
TOTAL	199.55	899.45	1,099.00	236.13	841.28	1,077.41	2,176.41

NOTE: Project cost included construction, right-of-way acquisition and consultancy costs.

ECONOMIC INDICATORS
– ROAD FUNCTION AND PAVEMENT REHABILITATION –
(SHORT TERM)

Segments	Length (Km)	IRR(%)	B/C	NPV (M₱)	Implementation Priority
N – 1 (Sta. Rita – Gapan)	46	105.6	4.39	645.5	1
N – 2 (Gapan – Cabanatuan)	35	76.1	4.78	631.7	1
N – 3 (Cabanatuan – San Jose)	42	41.3	2.77	118.9	3
N – 4 (San Jose – Dalton)	38	39.3	2.38	163.4	3
N – 5 (Dalton – Aritao)	39	38.1	2.31	163.5	2
North Study Section	200	61.7	3.58	1,722.9	
S – 1 (Calamba – Tiaong)	42	56.8	6.17	461.9	2
S – 2 (Tiaong – Pagbilao)	54	78.4	4.09	95.4	3
S – 3 (Pagbilao – Plaridel)	46	41.3	2.44	127.1	1
S – 4 (Plaridel – Calauag)	39	34.9	2.08	86.3	3
South Study Section	181	49.9	3.67	770.7	
Whole Study Section	381	57.2	3.61	2,493.5	

CONSTRUCTION COST PER UNIT
(SHORT TERM)

November 1987 Price

	North Study Section	South Study Section
Road Function Improvement	6.0 M₱/number	8.2 M₱/number
Pavement Rehabilitation	1.8 M₱/lane-km (2.4 M₱/km)	1.7 M₱/lane-km (1.3 M₱/km)
Drainage Improvement	0.5 M₱/lane-km (0.29 M₱/km)	0.5 M₱/lane-km (0.24 M₱/km)

( ) per study section length

IMPLEMENTATION SCHEDULE (SHORT TERM 1987–1992)

			1986	1987	1988	1989	1990	1991	1992	Total
Feasibility Study (This Study)			———	———						
Financial Arrangement for Implementation				———	———					
Detailed Engineering					———	———	———			
Prequalification/Tender					———	———	———			
Construction	High Priority Segments (N-1, N-2, S-3)					———	———	———		
	Second Priority Segments (N-5, S-1)						———	———		
	Third Priority Segments (N-3, N-4, S-2, S-4)							———	———	
Construction Supervision						———	———	———	———	
Project Cost	Road Function	Foreign Component			1.98 (1.98)	28.80(28.80)	31.40(31.40)	36.97(36.97)	–	99.15 (99.15)
		Local Component			6.65 (7.47)	21.83(26.00)	28.49(35.97)	43.43(58.12)	–	100.40 (127.56)
		Total			8.63 (9.45)	50.63(54.80)	57.89(67.37)	80.40(95.09)	–	199.55 (226.71)
Nov. 1986 Price (Escalated Cost)	Pavement Rehabilitation	Foreign Component			10.70 (10.70)	77.50(77.50)	216.45(216.45)	141.10(141.10)	102.25(102.25)	548.00 (548.00)
		Local Component			4.58 (5.15)	48.05(53.34)	142.17(179.49)	91.61(122.59)	65.04(92.26)	351.45 (452.83)
		Total			15.28 (15.85)	125.55(130.84)	358.62(395.94)	232.71(263.69)	167.29(194.51)	899.45 (1,000.83)
Unit: Million ₱	TOTAL	Foreign Component			12.68 (12.68)	106.30(106.30)	247.85(247.85)	178.07(178.07)	102.25(102.25)	647.15 (647.15)
		Local Component			11.23(12.62)	69.88(79.34)	170.66(215.46)	135.04(180.71)	65.04(92.26)	451.85 (580.39)
		Total			23.91 (25.30)	176.18(185.64)	418.51(463.31)	313.11(358.78)	167.29(194.51)	1,099.00 (1,227.54)

Figures in parenthesis show the escalated fund requirement.
Annual escalation rate: Foreign Currency: 0%
Local Currency : 6%

3. FINDINGS AND RECOMMENDATIONS

3.1 Road Function Improvement

Short Term Improvement Measures (1987-1992)

In general, the "rural" sections of the Study Section are still providing relatively good quality of service, except the two sections nearest to Metro Manila, i.e. the Sta. Rita-Plaridel section and the Calamba-Sto. Tomas section. The latter is recommended to be widened to a 4-lane road in the Short-term period, while the former is recommended to be partly widened to a 4-lane road with the construction of a new route to bypass the central business district of Plaridel in the medium term period.

On the other hand, traffic related problems were observed mainly in the urban sections, due mainly to the presence of large volume of tricycles whose operation is not only slow but most of all chaotic and disorderly; uncontrolled loading and unloading of commodities as well as passengers of public utility vehicles, "on-street" parking, heavy roadside friction at the public markets and other business areas, uncontrolled intersections; etc. The situation is aggravated by the fact that most of the urban sections are still of the "rural" type cross section, i.e. gravel shoulders with no sidewalks. In the short term period, improvement measures for urban sections are recommended from the viewpoints of maximum utilization of the existing road right-of-way as follows:

- Paving of shoulders that will be used mainly as tricycle lanes and for loading/unloading zones for public utility vehicles (13 urban sections)
- Construction of sidewalks which will secure pedestrians' safety and minimize friction between pedestrians and vehicular traffic (13 urban sections)
- Signalization of intersection to improve functional efficiency of the urban section as a whole and to attain orderly traffic flow (6 intersections);
- Improvement of intersection geometrics to secure traffic safety and to assign right-of-way to traffic on the Pan-Philippine Highway (3 intersections);
- Strict enforcement of traffic rules and regulations;
- Road right-of-way acquisition for projects to be undertaken in the medium term (3 projects).

Medium Term Improvement Measures (1993-1998)

The "rural" road sections as described in the short term period are expected to provide still an acceptable level of service within the medium term period and therefore no significant improvement measures are recommended.

Some of the major urban sections are expected within the medium-term period to have serious traffic problems in view of two incompatible functions of mobility and access i.e. mobility would be required by long-distance or thru traffic while access would be demanded

by local traffic. In this case, it is recommended, among the options considered, to construct a bypass or an alternative route along the following urban sections in the medium term period:

North Study Section (at the early stage of this period);

- Plaridel Urban Section
- Cabanatuan Urban Section

South Study Section (at the latter stage of this period);

- Tiaong Urban Section
- Candelaria Urban Section
- Sariaya Urban Section

Long Term Improvement Measures (1999-2010)

In the early stage of this period the "rural" section will begin to suffer capacity problems. By the end of the period, about 50 percent of the "rural" section along the North Study Section and 25 percent along the South Study Section would by then be congested and therefore need improvements. The following three schemes and/or combination of these schemes should be studied to find out the optimum solution at the early stage of this period:

- Bypass + widening of existing rural sections
- Bypass + construction of roads to link bypasses
- Construction of an alternative route

3.2 Pavement Rehabilitation

The road pavements along the Study Section are in a state of progressive deterioration which require immediate rehabilitation before these are completely lost.

It appears that premature deterioration is caused mainly of the following factors: i) over-loaded vehicles; ii) inadequate pavement structural capacities; iii) inferior material qualities, and iv) poor/non-drainage systems.

Realizing the fact that pavement deteriorations are progressive and likely to be more and more severe in a fast pace if no immediate intervention is undertaken, the following basic technical propositions are recommended to be adopted and practiced when any road improvement/rehabilitation work is planned to be undertaken.

Design

- Pavement structures should be designed to withstand projected number of traffic loading applications.

- The desired level of reliability (combined standard error of traffic prediction and performance prediction) should be established for each road class in the country.

- The selection of pavement types should be made on initial investment cost required and total discounted cost based on life-cycle cost analyses as well as non-monetary considerations. The relative importance of each factor should be assigned by the project characteristics.

Traffic

- Traffic loading data is a key factor in pavement design. Traffic damaging factors should be well established to unify the reliability of pavement performance in the country.

- The strict implementation of traffic regulations is highly recommended, otherwise, the huge investments are inevitable.

Material Quality

- Properties of material available locally should be examined thoroughly to establish the standard values for pavement design requirements.

- Bearing capacity of roadbed soils (subgrade) should be investigated accurately and extensively.

Drainage

- Pavement life is dependent upon the drainage conditions, and, therefore, must be adequately provided and maintained at all times.

III. SUMMARY

III. SUMMARY

1. STUDY SECTIONS

History of the Pan-Philippine Highway

In 1966, the plan of the Highway was formulated with focuses on establishments of efficient linkages between Metro Manila and potential but depressed regions of Cagayan, Bicol, Eastern Visayas and Mindanao. The total length of the Highway under the original plan was about 3480 kms from Laoag in the northern tip of Luzon to Zamboanga in the southern tip of Mindanao (Phase I and Phase 2). The section from Allacapan to Davao City (Phase 1) extends to about 2100 kms.

In 1969, the construction was started employing mainly local contractors and finally completed in 1979. The Highway has been in service for 7 to 8 years.

Topography and Geology

The Philippine Fault runs north and south through the Philippine islands, the secondary faults and holds resulting from the major fault can be seen in all regions.

The North Study Section of the Highway runs through the Luzon Central Plain from Sta. Rita (km. 39) to San Jose (km. 161), climbs up and down the Dalton Pass of the Caraballo Mountain Range between San Jose and Sta. Fe (km. 216), then traverses the Cagayan Valley from Sta. Fe to Aritao (km. 239). Faults and developed fracture zones are found in the Dalton Pass Section.

The South Study Section runs through the Luzon Upland from Calamba (km. 52) to Lucena (km. 130), crosses the southern tip of the Southern Sierra Madre between Lucena and Atimonan (km. 177) where faults and developed fracture zones are found, then runs along the coastal area from Atimonan to Calauag (km. 227).

Climate

The Philippines is located in a region recognized as having the greatest frequency of tropical cyclone in the world. Average annual frequency of tropical cyclones in 36 years (1948-1983) is 19.9, of which 4.0 are tropical depression, 5.1 tropical storms and 10.8 typhoons.

The average annual rainfall of the country is 2504.4 mm. Luzon has an annual average of 2812.8 mm, Visayas 2304.0 mm and Mindanao 2394.0 mm.

The mean temperature of the country is 27.0°C. The average annual temperature in Luzon is 26.8°C, Visayas 27.3°C and Mindanao 26.9°C.

Road Network

The Pan-Philippine Highway and the Manila North Road are the two axes of trunk road network system in North Luzon. The former serves the entire Cagayan Valley, which is bordered on three sides by the Sierra Madre Range along the eastern coast, the Luzon Central Cordillera located slightly to the west of center and the Caraballo Mountains to the South.

The Manila North Road runs through the narrow flat land along the western coast of North Luzon.

South Luzon, from Quezon Province southward, is a generally long and narrow land with only 20 to 50 kms wide. The only trunk road serving the southern corridor of Luzon is the Pan-Philippine Highway.

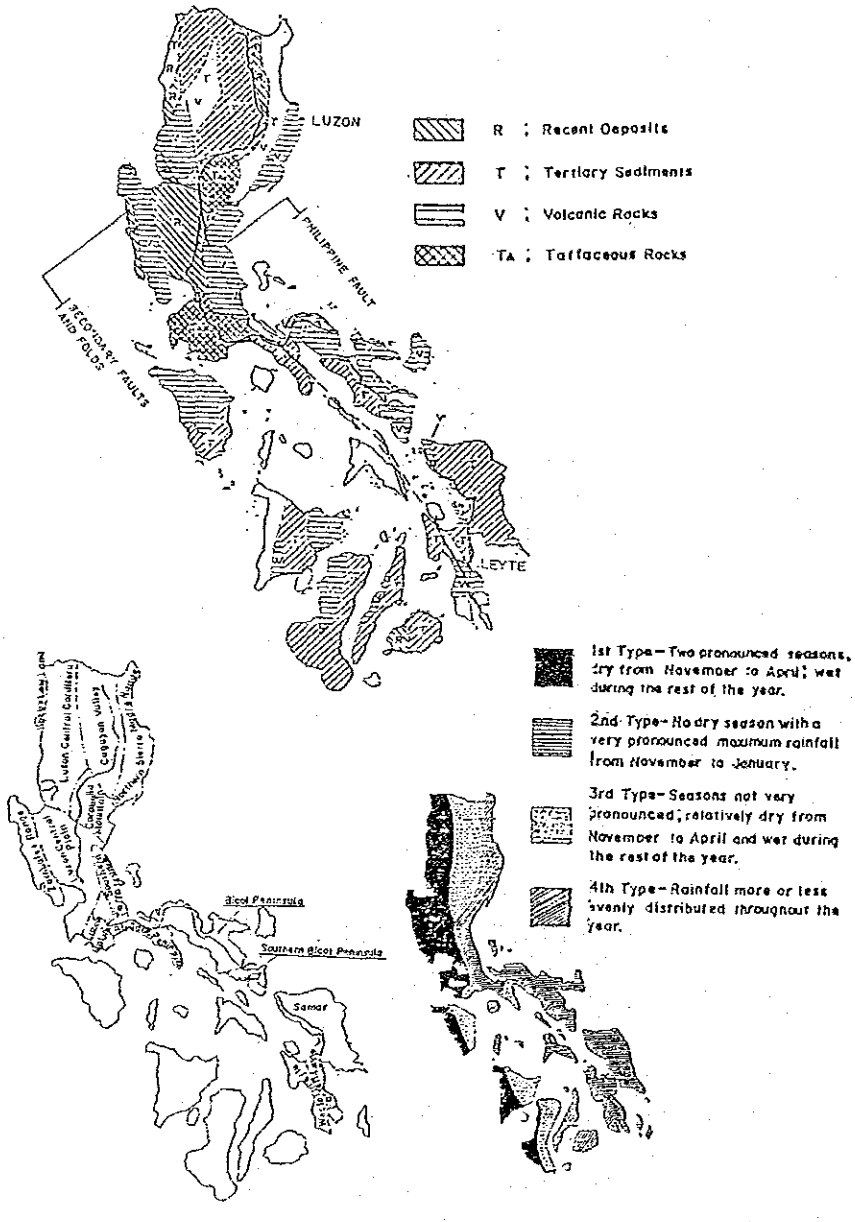


FIGURE 1-1 GEOLOGY, TOPOGRAPHY AND CLIMATE OF THE STUDY AREA

2. TRAFFIC

2.1 Traffic Characteristics (Present)

At present, the traffic characteristics on the highway are summarized by number of passengers, trip purposes, major commodity flow and traffic compositions. See Table 2.1-1, 2.1-2 and 2.1-3.

TABLE 2.1-1 NUMBER OF PASSENGERS AND TRIP PURPOSES

Unit: Passengers/day

	Section	Bus	Jeepney	Car	Total
North Study Section	Sta. Rita – Plaridel	29,670 • Visit Relatives • To/from Work	13.230 • To/from Work • Visit Relatives	14.660 • Business	57,560
South Study Section	Sto. Tomas	49,470 • To/from Work • Visit Relatives	21,230 • To/from Work • Shopping	28,900 • Business	99,600

TABLE 2.1-2 MAJOR COMMODITY FLOW

Unit: Ton/day

	From Manila to Cagayan		From Cagayan to Manila	
North Study Section	• Gasoline, Diesel	821	• Stone, Gravel, Sand	3,465
	• Groceries, Daily product	433	• Lumber, Log	2,023
	• Fertilizer, etc.	362	• Milled Rice	1,405
	From Manila to Bicol/Batangas		From Bicol to Manila/Batangas	
South Study Section	• Foodstuff for animals	977	• Copra	1,011
	• Groceries, Daily Products	682	• Fruit and Vegetables	425
	• Milled Rice	498	• Vegetable Oil, fats	419

It is noted that the Manila bound from Cagayan along the North Study Section carried considerable tons of materials e.g. stone, gravel, sand, lumber, log and milled which are more than 3 times of tons carried by other bounds.

It is surprising that number of tricycles in Cabanatuan and San Jose are about 60% of total traffic volume.

TABLE 2.1-3 TRAFFIC COMPOSITIONS

	Section	Car	Jeepney	Bus	Truck	Tricycle	Total
North Study Section	Cabanatuan	3,886 (16.2)	3,469 (14.5)	742 (3.1)	1,614 (6.7)	14,220 (59.5)	23,931 (100)
	San Jose	2,175 (14.6)	1,908 (12.8)	233 (1.6)	1,055 (7.1)	9,480 (63.9)	14,851 (100)
South Study Section	Candelaria	2,613 (28.2)	1,128 (12.2)	622 (6.7)	1,229 (13.3)	3,680 (39.6)	9,272 (100)
	Sariaya	2,540 (32.6)	1,600 (20.5)	489 (6.3)	1,004 (12.9)	2,160 (27.7)	7,793 (100)

2.2 Present and Projected Traffic Volumes

Table 2.2-1 shows the future GNP and per capita GNP targets used in calculating for the traffic growth rates shown in Table 2.2-3. Figures 2.2-1 and 2 show the results of the projected traffic volumes. Number of tricycles are separately shown.

TABLE 2.2-1 FUTURE GNP AND PER CAPITA GNP TARGETS (AT CONSTANT 1972 PRICES)

Year	GNP (Million ₱)	Growth Rate	Per Capita GNP (₱)	Growth Rate
1986	88,432	1.0	1,595	4.3
1987	93,738	6.0	1,651	3.5
1988	99,362	6.0	1,709	3.5
1989	105,820	6.5	1,779	4.1
1990	112,699	6.5	1,852	4.1
1991	120,024	6.5	1,928	4.1
1992	128,426	7.0	2,020	4.8
Average Growth Rate (1987-1992)	—	6.4	—	4.0

SOURCE: Medium Term Philippine Development Plan (1987-1992)

TABLE 2.2-2 TRAFFIC GROWTH RATE

Unit : Percent

	1986-1990	1990-2000	2000-2010
North Study Section	5.2 (4.7-5.8)	5.6 (5.1-5.9)	5.6 (5.1-5.9)
South Study Section	4.3 (2.8-5.0)	5.3 (4.0-5.9)	5.4 (4.8-5.9)

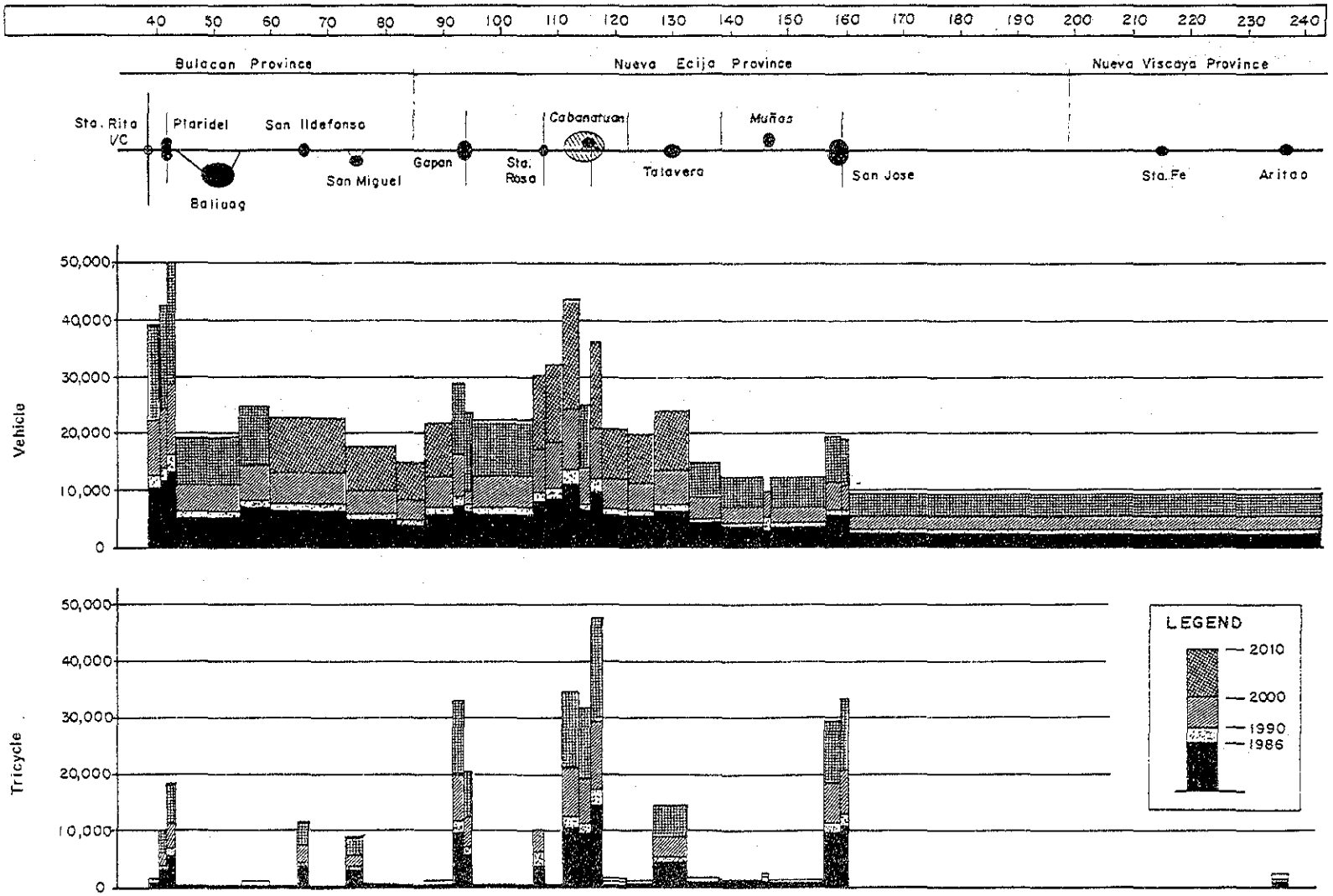


FIGURE 2.2-1 PROJECTED TRAFFIC VOLUME ON NORTH SECTION

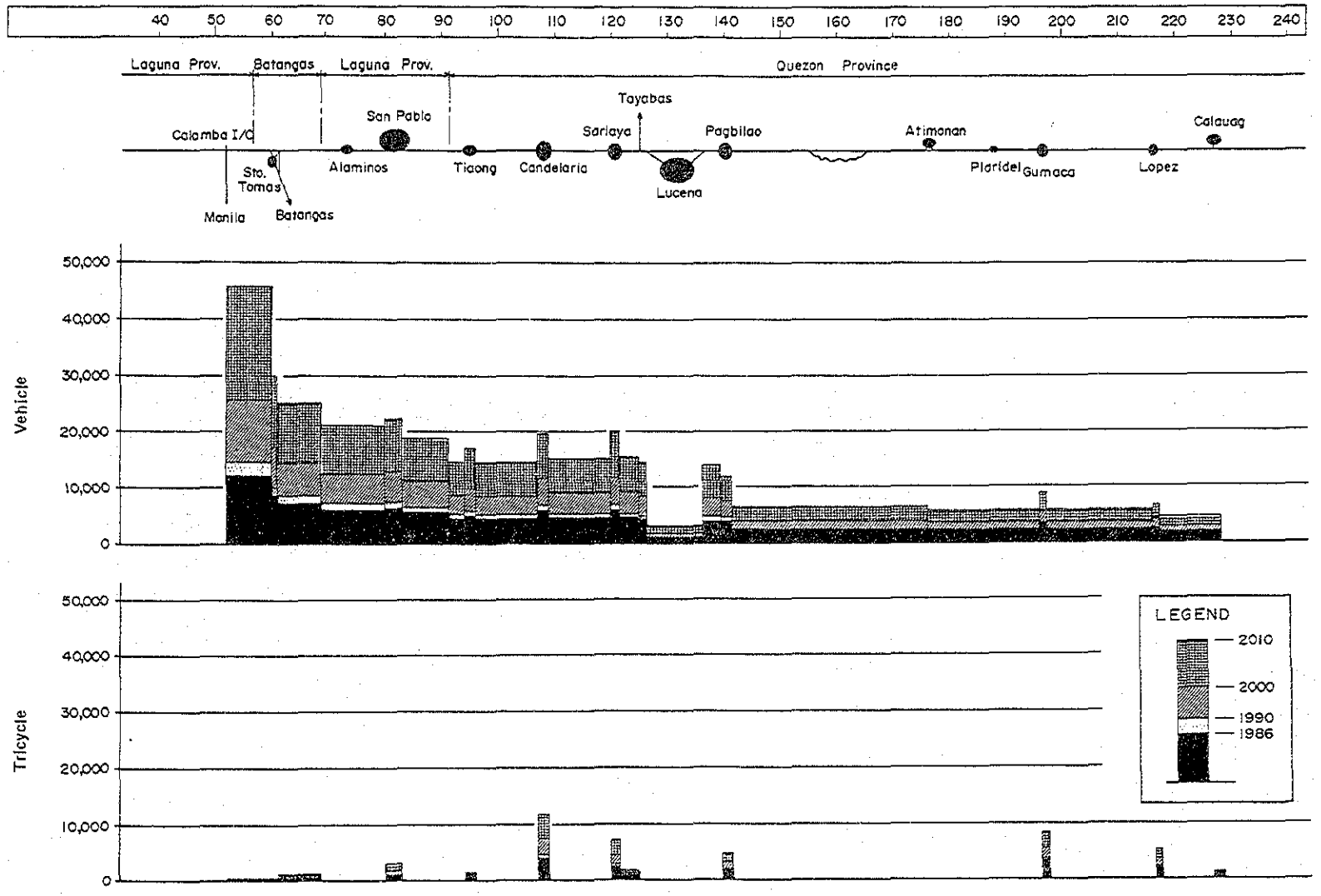


FIGURE 2.2-2 PROJECTED TRAFFIC VOLUME ON SOUTH SECTION

3. ROAD FUNCTION

3.1 Evaluation of Present Road Function

3.1.1 Road Function Surveys

The following surveys were conducted to assess road function:

- Road function survey (roadway conditions, control conditions)
- Road environmental survey (land use, development plan)
- Traffic survey (traffic count, intersection traffic, OD, travel time)
- *Interview survey on road users' opinion*
- Observation survey by traffic/highway engineers
- Headway analysis by video tape recording

3.1.2 Evaluation Methods

The following evaluation methods were adopted to establish road function:

- Level of service (LOS) analysis
- Average travel speed
- Percent time delay (the average percent of time that all vehicles are delayed while travelling in platoons due to the inability to pass)

  Passenger car equivalent factors of jeepney and tricycles were analyzed by video tape recording and LOS as shown in Table 3.1-1.

TABLE 3.1-1 PASSENGER CAR EQUIVALENT FACTORS

Vehicle Type	Two-Lane Highway		Unsignalized Intersection	
	HPM[1]	This Study	HPM[1]	This Study
Jeepney	1.5	1.5		1.0
Tricycle	2.5	1.0	Not	0.6, 1.0[3]
Truck	2.0	2.0 – 2.2[2]	Specified	1.5
Bus	2.0	1.6 – 2.0[2]		1.5

NOTE: [1] Highway Planning Manual

[2] Highway Capacity Manual

[3] For signalized intersection

3.1.3 Major Problems Identified

Major problems identified through the road function survey and evaluation analysis are as follows. See Appendix 1.

North Study Section

- Sta. Rita-Plaridel; Load capacity, LOS approaching E
- Plaridel Urban Section; Heavy roadside friction due to public market
- Cabanatuan Bypass; High share of tricycle, heavy roadside friction
- Six (6) Urban Sections for paving of shoulders
- Six (6) intersections for installation of traffic signal
- One (1) intersection for geometric improvement

South Study Section

- Calamba-Sto. Tomas; Low capacity, LOS approaching E
- Seven (7) urban sections for paving of shoulders
- Two (2) intersections for geometric improvement

3.2 Recommended Improvement Level for Road Function

The improvement level for road function were analyzed from the viewpoint of road users' desire, engineers' observations and the roles of the Highway.

Table 3.2-1 summarizes the daily traffic volumes and travel speeds for levels of service (LOS) observed along the Study Section.

Table 3.2-2 specifies the improvement level recommended for road function by types of improvement measures.

TABLE 3.2-1 LEVEL OF SERVICE, DAILY TRAFFIC VOLUME AND TRAVEL SPEED ON THE PAN-PHILIPPINE HIGHWAY

S : Speed (Km Per Hour)
V: Volume (Vehicle Per day)

Level of Service		Rural Section	Urban Section
A (Free Flow)	S	60 ≦	40 ≦
	V	Less than 3,500	Less than 3,500
B (Stable Flow Speed Free)	S	56 – 60	37 – 40
	V	3,000 – 6,500	2,800 – 6,500
C (Stable Flow Speed Affected)	S	48 – 56	31 – 37
	V	5,500 – 11,000	5,000 – 11,000
D (High-Density but Stable Flow)	S	38 – 48	23 – 31
	V	9,000 – 17,500	8,000 – 16,000
E (Unstable Flow)	S	20 – 38	10 – 23
	V	15,000 – 28,500	12,500 – 25,000
F (Forced or Breakdown Flow)	S	20 >	10 >
	V	–	–

TABLE 3.2-2 SUMMARY OF RECOMMENDATION ON IMPROVEMENT LEVEL

Section	Type of Improvement Measures	Improvement Level
Rural Section	Widening to a 4-lane Road	the latter stage of LOS D
Urban Section	Major Improvement [1/] (Bypass)	the early stage of LOS E
	Minor Improvement	the early stage of LOS E
Inter-Section	Signalization	the early stage of LOS E

NOTE: 1/ *In case that a project requires bigger investment than* usual due to construction of a long bridge or such, improvement level at the middle stage of LOS E is recommended.

3.3 Recommended Road Function Improvement Works

3.3.1 Recommended Works under Short Term (1987-1992)

TABLE 3.3-1 RECOMMENDED WORKS UNDER SHORT TERM

In Million Pesos (November 1986 Price)

Segment No.	Type of Section	Section	Type of Improvement	Construction Cost	Right-of-Way Acquisition Cost	Total
N-1	Urban	San Ildefonso	Paving of Shoulders/Sidewalks	4.16	–	4.16
	Intersection	Plaridel	Signalization	1.57	–	1.57
	Intersection	Baliuag Bypass	Improvement of Geometrics	0.53	–	0.53
	(Rural	Sta. Rita-Plaridel	ROW Acquisition)	–	1.61	1.61
	(Urban	Plaridel	ROW Acquisition)	–	5.60	5.50
			(Sub-Total)	6.26	7.11	13.37
N-2	Urban	Gapan	Paving of Shoulders/Sidewalks	6.01	–	6.01
	Urban	Sta. Rosa	Paving of Shoulders/Sidewalks	6.24	–	6.24
	Urban	Cabanatuan	Paving of Shoulders/Sidewalks	25.52	1.05	26.67
	Intersection	Gapan	Signalization	1.34	–	1.34
	Intersection	Sta. Rosa	Signalization	1.59	–	1.59
	Intersection	Cabanatuan II	Signalization	1.41	–	1.41
	Intersection	Cabanatuan IV	Signalization	1.68	–	1.68
	(Urban	Cabanatuan	ROW Acquisition)	–	12.62	12.62
			(Sub-Total)	43.79	13.67	57.46
N-3	Urban	Talavera	Paving of Shoulders/Sidewalks	5.38	–	5.38
	Urban	San Jose	Paving of Shoulders/Sidewalks	18.90	–	18.90
	Intersection	San Jose	Signalization	1.69	–	1.69
			(Sub-Total)	25.97	–	25.97
North Study Section: TOTAL				76.02	20.78	96.30
S-1	Rural	Calamba-Sto. Tomas	Widening to a 4-lane	57.06	4.28	61.34
	Urban	Alaminos	Paving of Shoulders/Sidewalks	2.36	–	2.36
	Intersection	Sto. Tomas I	Improvement of Geometrics	1.16	–	1.16
	Intersection	Sto. Tomas II	Improvement of Geometrics	1.59	–	1.59
			(Sub-Total)	62.17	4.28	66.45
S-2	Urban	Tiaong	Paving of Shoulders/Sidewalks	2.07	–	2.07
	Urban	Candelaria	Paving of Shoulders/Sidewalks	2.70	–	2.70
	Urban	Sariaya	Paving of Shoulders/Sidewalks	2.20	–	2.20
	Urban	Pagbilao	Paving of Shoulders/Sidewalks	2.07	–	2.07
			(Sub-Total)	9.04		9.04
S-4	Urban	Gumaca	Paving of Shoulders/Sidewalks	3.45	–	3.45
	Urban	Lopez	Paving of Shoulders/Sidewalks	2.67	–	2.67
			(Sub-Total)	6.12		6.12
South Study Section: TOTAL				77.33	4.28	81.61
Study Section : GRAND TOTAL				153.35	25.06	178.41

3.3.2 Recommended Works under Medium Term (1993-1998)

TABLE 3.3-2 RECOMMENDED WORKS UNDER MEDIUM TERM (1993-1998)

In Million Pesos (November, 1986 Prices)

Segment No.	Type of Section	Section	Type of Improvement	Construction Cost	Right-of-Way Acquisition Cost	Total
N-1	Rural	Sta. Rita-Aritao	Widening to a 4-lane	9.20	–	9.20
	Urban	Plaridel	Construction of a bypass	76.30	–	76.30
			(Sub-Total)	85.50	–	85.50
N-2	Urban	Cabanatuan	Construction of an Alternative Route	59.43	–	59.43
			(Sub-Total)	59.43	–	59.43
North Study Section: TOTAL				144.93	–	144.93
S-2	Urban	Tiaong	Construction of a bypass	18.00	2.70	20.70
	Urban	Candelaria	Construction of a bypass	24.00	3.60	27.60
	Urban	Sariaya	Construction of a bypass	24.00	3.60	27.60
			(Sub-Total)	66.00	9.90	75.90
South Study Section: TOTAL				66.00	9.90	75.90
Study Section : GRAND TOTAL				210.93	9.90	220.83

3.3.3 Recommended Works under Long Term (1999-2010)

In this period, traffic volumes on most rural sections will approach to their capacities. Following schemes or combination of these are recommended to be studied in the early stage of this period.

- Bypass + widening of existing sections
- Bypass + construction of roads to link bypass
- *Construction of an alternative route*

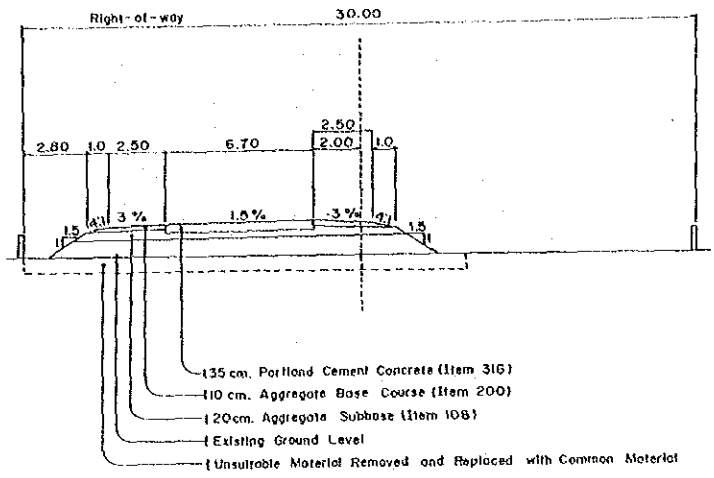


FIGURE 3.3-1 TYPICAL SECTION PLARIDEL BY-PASS/CABANATUAN ALTERNATIVE ROUTE
SCALE 1:200
RIGHT OF WAY ACQUISITION UNDER SHORT TERM

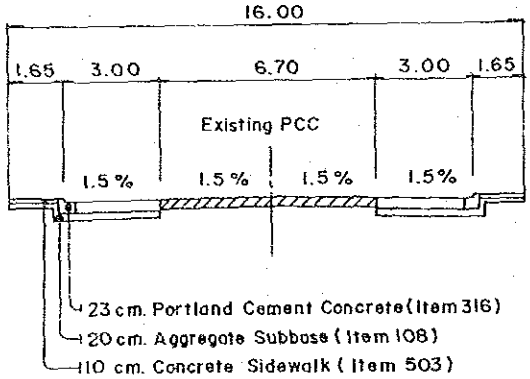


FIGURE 3.3-2 PROPOSED IMPROVEMENT ALONG CABANATUAN CITY URBAN SECTION
SCALE 1:200
PAVING OF SHOULDER AND SIDE WALK (SHORT TERM)

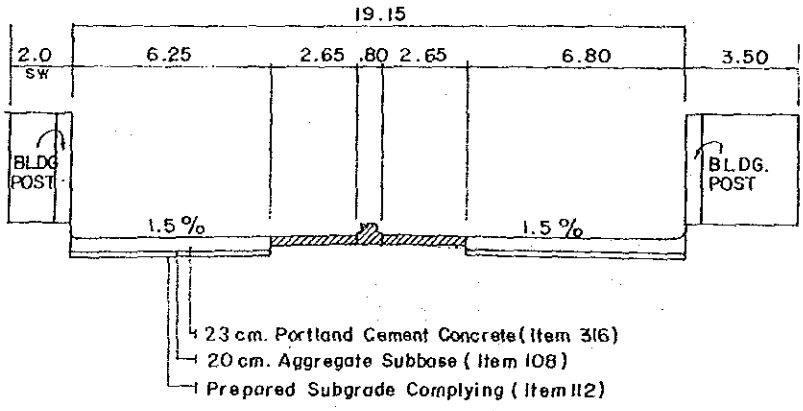


FIGURE 3.3-3 PROPOSED IMPROVEMENT: URBAN SECTION OF SAN JOSE CITY
PAVING OF SHOULDER AND SIDE WALK (SHORT ERM)

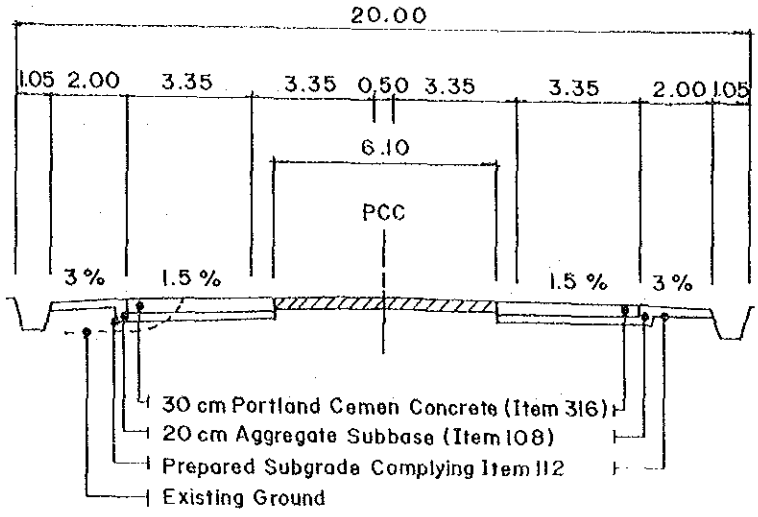


FIGURE 3.3-4 PROPOSED WIDENING TO FOUR LANES CALAMBA – STO. TOMAS SECTION
SCALE 1:200
WIDENING TO A 4–LANE ROAD (SHORT TERM)

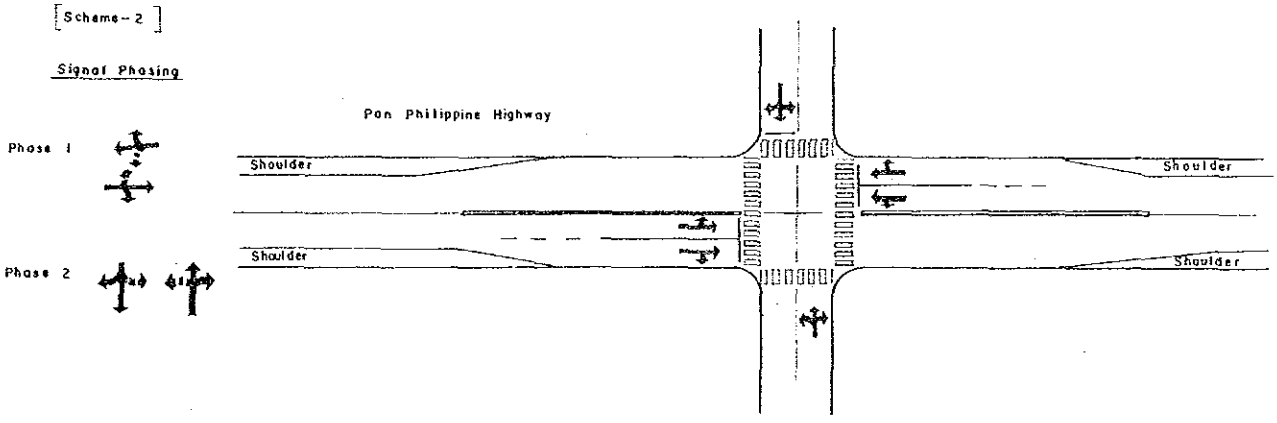


FIGURE 3.3-5 SIGNALIZATION IMPROVEMENT

4. PAVEMENT REHABILITATION

4.1 Evaluation of Pavement Surface Condition

4.1.1 Pavement Surface Condition Survey

The following surveys were performed for evaluation of surface conditions.

- Present Serviceability Survey
- Rehabilitation Requirement Survey
- Roughness Survey
- Pavement Deficiency Survey
- General Information Survey

4.1.2 Evaluation Methods

In evaluating pavement surface conditions, the method basically adopted is the present serviceability concept developed by AASHTO (Present Serviceability Index, PSI). Aside from this method, the concept on rehabilitation requirements was introduced by the Study Team, (Rehabilitation Requirement Index, RRI).

The evaluation criteria for both methods are specified in Table 4.1-1 and the characteristics of both are summarized in Table 4.1.-2.

PSI and RRI Formulas Established

Based on the correlation analysis on present serviceability rating (PSR)/rehabilitation requirement rating (RRR) and measurement variables, i.e. roughness, cracks and patching the formula to express the both indeces were established by least square regression method as follows.

For Rigid Pavement

$$PSI = 7.75 - 2.0 \log (R) - 0.06\sqrt{C + P} \qquad (r = 0.745)$$

$$RRI = 7.53 - 1.5 \log (R) - 0.11\sqrt{C + P} \qquad (r = 0.756)$$

or $$RRI = 3.93 - 0.12\sqrt{C + P}$$

Where: R = Roughness in cm per km
C = Cracking (Total of class 3 and 4 cracks in m per 1000 m^2)
P = Patching in m^2 per 1000 m^2
r = Coefficient of correlation

4.1.3 Evaluation of Pavement Subbase Conditions

Figure 4.1-1 shows the average of cracking and roughness in each PSI/RRI level of the Study Section. Taking into account the initial roughness of PCC pavement in the country and the reasonable compatibility with AASHTO's PSI, RRI was recommended to be used in identifying pavement surface conditions for rehabilitation project.

Figure 4.1-2 summarizes the road lengths by levels of RRI for both bounds of pavements. It is noted that RRI of Manila Bound lane along the North Study Section is quite low, 2.47 and others are about 3.2.

The pavement surface conditions evaluated by RRI and PSI for every 100 m. are presented in Appendix 2.

TABLE 4.1-1 CRITERIA FOR EVALUATION OF PAVEMENT SURFACE CONDITION

Rating Range	Present Serviceability Rating (PSR)	Rehabilitation Requirement Rating (RRR)
5	Very Good	No deficiencies
4	Good	Little Deficiencies
3	Fair	Considerable deficiencies but immediate treatment is not required
2	Poor	Considerable severe deficiencies, immediate treatment is required
1	Very Poor	Reconstruction/Overlay is immediately required
0		

TABLE 4.1-2 CHARACTERISTICS OF PSI AND RRI

Evaluation Indicator	Objectives	Rating Panel	Dominant Factors
Present Serviceability Index (PSI)	Subjective Assessment on comfort/Riding quality	General Public Road Users	Loose and same degree of correlation with roughness and cracking
Rehabilitation Requirement Index (RRI)	Engineering Judgement on physical condition	Highway/Maintenance/ Construction Engineers	Clear correlation with cracking, followed by faulting, pumping and roughness

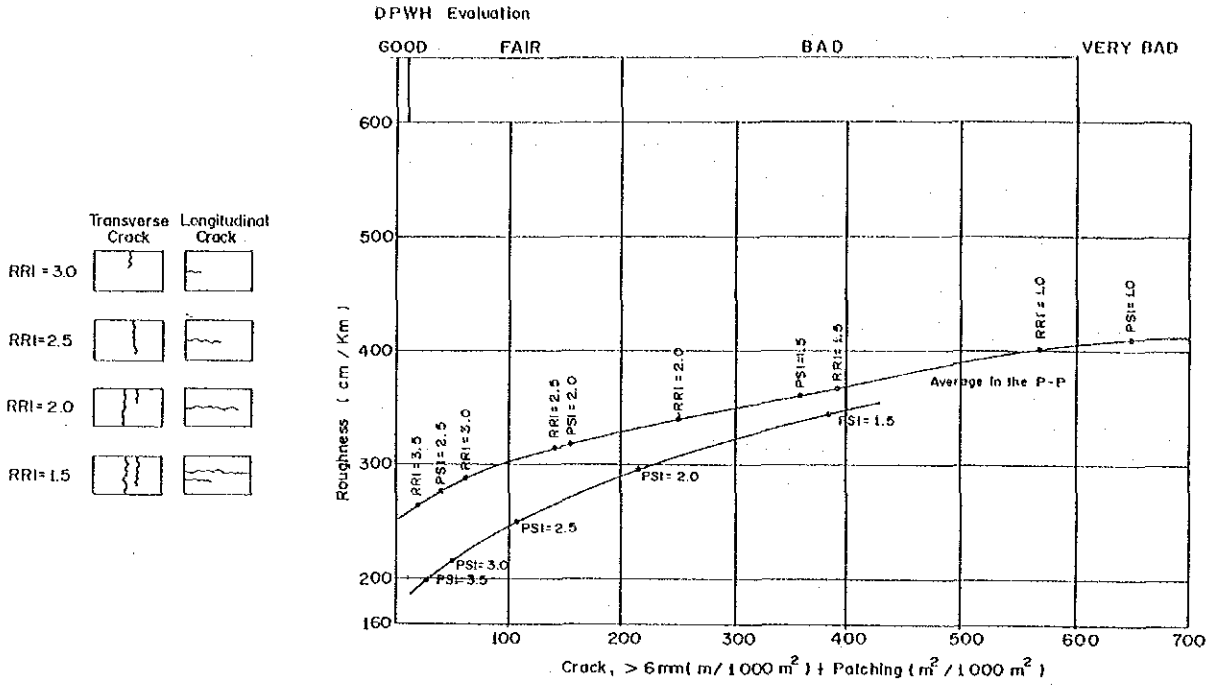


FIGURE 4.1-1 AVERAGE RELATIONSHIP BETWEEN RRI AND ROUGHNESS, CRACKING, PATCHING

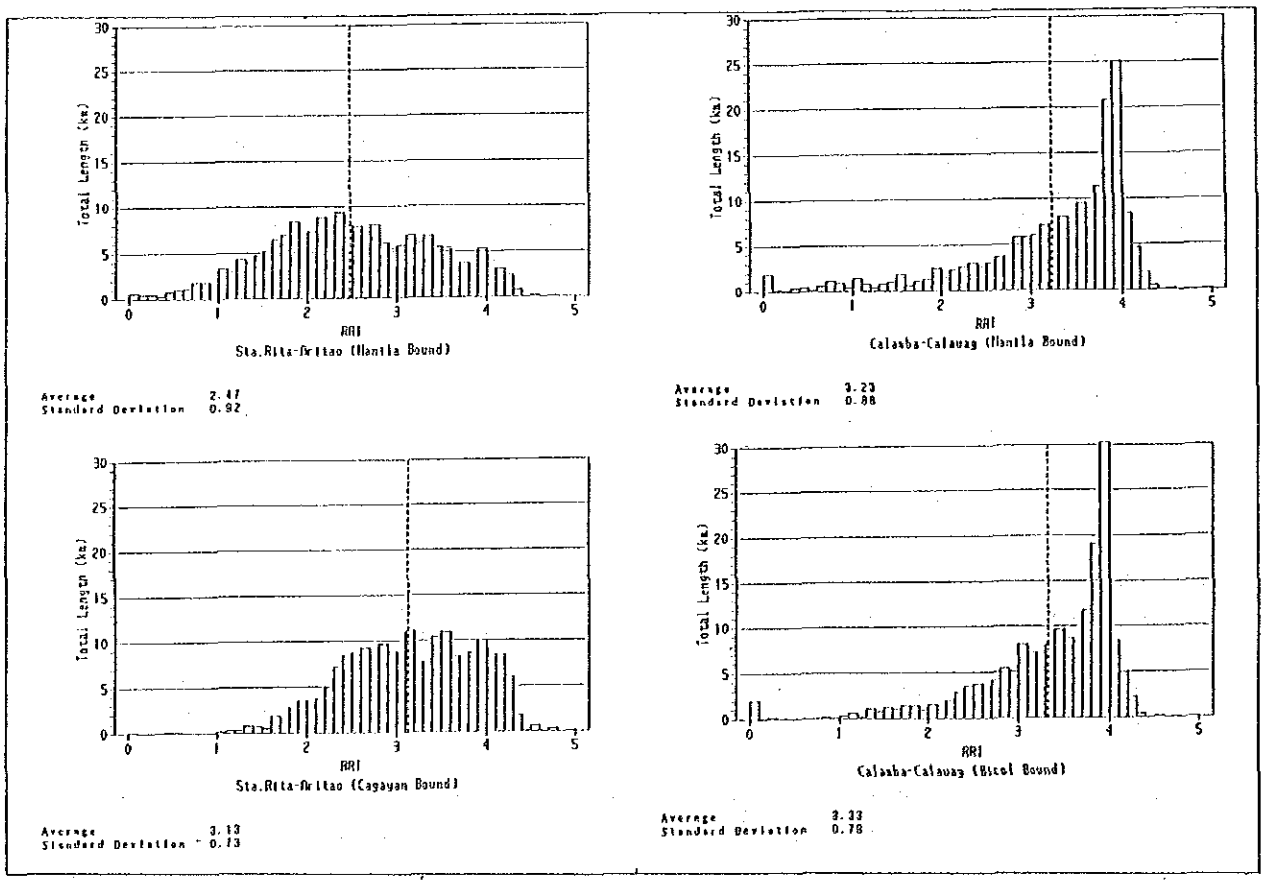


FIGURE 4.1-2 SUMMARY OF PAVEMENT LENGTHS BY LEVEL OF RRI

4.2 Analysis on Causes of Pavement Deterioration

4.2.1 Pavement Deterioration Survey

The number of slabs surveyed are 15 in total for 5 spots.

- Data collection on traffic loading
- Pavement deterioration survey
- Engineering survey (Boring, CBR, Deflection, Concrete Strength)
- Drainage condition survey

4.2.2 Analysis Methods

The following analysis were made to assess the probable causes of pavement deteriorations.

- Analysis on Traffic Loading
- Analysis on Pavement Material Properties
- Analysis on Slab Thickness by Design Standard
- Analysis on Structural Strength by Emperical/Theoretical Methods
- Analysis on pavement variable affecting pavement strength

4.2.3 Assessment of Probable causes of Pavement Deterioration

The assessment of the probable causes of pavement deterioration are summarized as follows:

1) Traffic

The primary causes might be over-weight traffic. The basis of this inference are:

- Fatigue ratio is considerably high comparing with erosion ratio (PCA and Westergaard)
- Transverse cracks are predominant.
- Relative damaging effects of traffic are high.
  (8.1 for Manila bound along the North Study Section)
  (3.6 for Manila bound along the South Study Section)

2) Concrete Slab

The qualities of concrete vary in wide ranges. The modulus of rupture vary from 430 psi to 630 psi (30 – 44 kg/cm^2). The required value is 525 psi (at 14 days BPH Memo Circular No. 48, 580 psi, (41 kg/cm^2) assumed at 28 days).

The thicknesses of concrete slab are thin (8.60 – 11.25 inches) in general and vary in wide ranges. It did not tally with the number of ESAL estimated.

3) Subbase and Subgrade

In some sections, the CBR values of subbase are lower (the lowest is 3) than those of subgrades. This might be due to saturation/erosion of subbases. Although the resilient modulus of subbase and subgrade has relatively small

effects to the structural strength of pavement in case of concrete pavement, the localized loss of support and void beneath concrete slab may have significantly affected the pavement performance.

4) Drainage System

The drainage system involves the most remarkable effects to the pavement performance among those pavement variables. Moreover, the drainage factor is changeable according to the condition of sections/spots.

In the Study sections, the highest drainage factor was estimated as 1.1 (good, San Jose-Aritao) and the lowest 0.8 (poor, many section).

4.3 Recommended Improvement Level for Pavement Rehabilitation

The improvement level for pavement rehabilitation were analyzed from the viewpoints of serviceability, rehabilitation requirement, failure criteria (TRRL) and maintenance/rehabilitation criteria (JRA) as well as the role of the Highway.

For the Study road, RRI of 2.5 was recommended as the improvement level. However, the pavement sections with RRI less than 3.0 may be included in rehabilitation plan taking into consideration of the progress of cracks and implementation timing.

TABLE 4.3-1 RECOMMENDED IMPROVEMENT LEVEL FOR PAVEMENT REHABILITATION

Highway Class	RRI	Typical Pavement Condition	
		Roughness	Cracking
Major Highway	2.5	320	140
Highway with a low Classification	2.0	340	250
Minor Highway	1.5	370	400

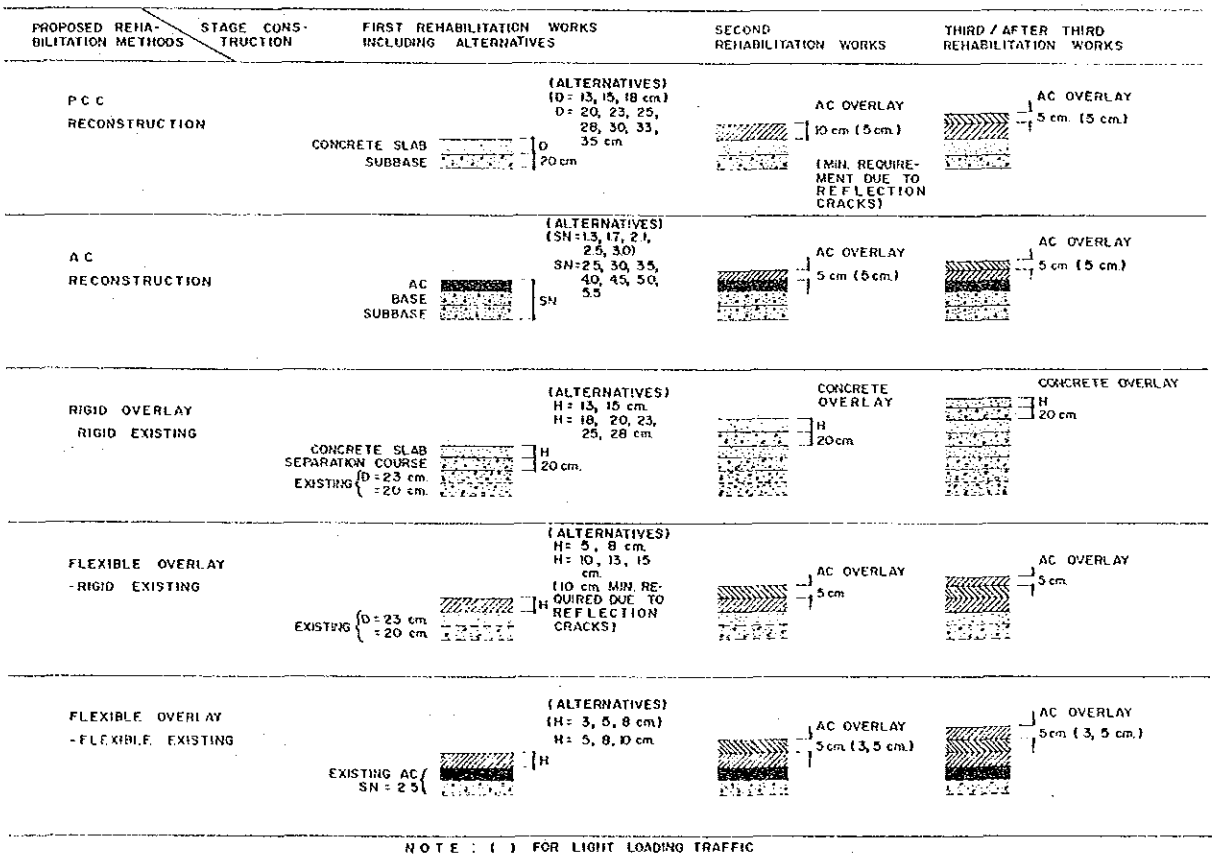
NOTE: Roughness; cm/km
Cracking; m/1000 m^2 cracks under Class 3 and 4

4.4 Pavement Structural Design

4.4.1 Proposed Rehabilitation Methods

The five (5) rehabilitation methods were proposed for comparative analysis, as shown in Figure 4.4-1. Among the five, only PCC reconstruction and flexible overlay-rigid existing (AC overlay) were recommended. PCC reconstruction has two alternatives i.e. 2-lane PCC reconstruction and 1-lane PCC reconstruction. For 2-lane PCC reconstruction, AC overlay was adopted to be applied as the second and the succeeding rehabilitation. See Figure 4.4-1. While in case of 1-lane PCC reconstruction, the second and succeeding rehabilitation method were always 1-lane PCC reconstruction.

FIGURE 4.4-1 PROPOSED REHABILITATION METHODS



NOTE: ( ) FOR LIGHT LOADING TRAFFIC

4.4.2 Design Requirements

Design methods adopted in the Study is AASHTO Guide for Design of Pavement Structures, 1986. The Guide specifies the design requirements as shown in Table 4.4.-1.

Major Design Requirements

TABLE 4.4-1 MAJOR DESIGN REQUIREMENTS

	PCC Pavement	AC Pavement
Reliability Performance Period	not considered See Table 4.4-3	not considered See Table 4.4-3
Traffic Loading Class	See Table 4.4-4	See Table 4.4-4
Serviceability	Initial; 4.5 Terminal; 2.5	Initial; 4.2 Terminal; 2.5
Effective Roadbed Soil Resilient Modulus	———	MR assumed by CBR See Table 4.4-2
Effective Modulus of Subgrade Reaction	K value assumed by CBR See Table 4.4-2	———
Pavement Layer Material Characteristics	Subbase ESB = 8000 psi Base EBS = 22000 psi AC EAC = 350000 psi PCC EC = 3.20×10^6 psi	Subbase ESB = 8000 psi
PCC Modulus of Rupture	625 psi (36.8 kg/cm^2); 14 days 580 psi (40.0 kg/cm^2); 28 days	—
Structural Layer Coefficient	AC = 0.39 Bitumen Stabilized Base = 0.2 Mechanically Stabilize = 0.125 Crushed Run Base = 0.105 Subbase = 0.095	—
Drainage	CD = 0.9	m = 0.8
Load Transfer Coefficient	4	—
Loss of Support	1	—
Visual Construction Factor of PCC Slab (RRI = 2.5)	0.4	—

TABLE 4.4-2 STRENGTH OF SUBGRADE

CBR of Subgrade	k (pci) of Subgrade	MR (pci) of Subgrade	k (pci)
2	50	2,500	80
3	100	4,000	130
4	120	5,000	170
6	160	6,000	210
8	180	7,000	230
10	200	8,000	250
15	230	12,000	280
20	250	15,000	300

Performance Period

The most economical performance periods were analyzed based on life-cycle cost analysis, as shown in Table 4.4-3.

TABLE 4.4-3 PERFORMANCE PERIOD OF INITIAL PAVEMENT STRUCTURE

Traffic Loading Class	P C C Reconstruction	A C Reconstruction	AC Overlay -PCC Existing
L-1, L-2, L-3 ESAL's $\leqq 0.03 \times 10^6$	20 years [1] or Min. Thickness 13 cm	15 years	25 years[1] or Min. Thickness 5 cm
A, B, C, ESAL's = $0.031 \sim 0.4 \times 10^6$	15 years	12 years	12 years[1] or Min. Thickness 10 cm
D, E ESAL's = $0.41 \sim 1.0 \times 10^6$	15 years	8 years	8 years[3]
F, G ESAL's = $1.1 \sim 2.0 \times 10^6$	15 years	8 years	8 years[3]
H, I, J ESAL's = $2.1 \sim 3.5 \times 10^6$	12 years[2] or Max. Thickness 35 cm	5 years[2] or Max. SN 5.5	5 years[2] [3] or Max. Thickness 15 cm

NOTE: 1) Performance period is governed by the minimum structural requirement as the case may be.
2) Performance period is governed by the maximum pavement structure as the case may be.
3) Not applicable where performance period is too short (less than 5 years) even if the maximum pavement structure is applied (see "Basic Design")

Standard Traffic Loading Classes

Traffic loadings along the Study Section were classified as shown in Table 4.4-4.

TABLE 4.4-4 STANDARD TRAFFIC LOADING CLASSES

	Traffic Loading Class	Number of ESAL At Initial Year
Light Loading Traffic	L – 1	0.005×10^6
	L – 2	0.01
	L – 3	0.03
Heavy Loading Traffic	A	$0.03 - 0.1 \times 10^6$
	B	0.11 – 0.2
	C	0.21 – 0.4
	D	0.41 – 0.7
	E	0.71 – 1.0
Extra Heavy Loading Traffic	F	$1.1 - 1.5 \times 10^6$
	G	1.6 – 2.0
	H	2.1 – 2.5
	I	2.6 – 3.0
	J	3.1 – 3.5

4.4.3 Recommended Structural Capacities

Based on the outputs of structural design and engineering judgement as well as traffic regulation policy, the structural capacities for PCC new/reconstruction, AC new/reconstruction and AC overlay-PCC existing were proposed as shown in Table 4.4-5. Figure 4.4-2 and 4.4-3 show examples of cross sections and planned rehabilitation strategy.

PCC New / Reconstruction

TRAFFIC LOADING CLASS (X10⁶) \ CBR		2	3	4	6	8	10	15	20	PCC THICKNESS PERFORMANCE PERIOD
LIGHT TRAFFIC LOADING	L-1 (0.005)	APPLY MIN. THICKNESS 20cm.								MORE THAN 25 YEARS
	L-2 (0.01)									
	L-3 (0.03)									
HEAVY TRAFFIC LOADING	A (0.1)				23					15 YEARS
	B (0.2)	25								
	C (0.4)	28			25					
	D (0.7)				28					
	E (1.0)				30					
EXTRA HEAVY TRAFFIC LOADING	F-J (1.5 ~ 3.5)	30 OR 33 OR 35 1/								5~12 YEARS

AC NEW / RECONSTRUCTION

TRAFFIC LOADING CLASS (X10⁶) \ CBR		2	3	4	6	8	10	15	20	STRUCTURAL NUMBER PERFORMANCE PERIOD
LIGHT TRAFFIC LOADING	L-1 (0.005)	2.1		1.7				1.7		10~16 YEARS
	L-2 (0.01)	2.5		2.1						
	L-3 (0.03)	3.0		2.5				2.1		
HEAVY TRAFFIC LOADING	A (0.1	4.0		3.5		3.0		2.5		8~14 YEARS
	B (0.2	4.5		4.0		3.5		3.0		
	C (0.4)	5.0		4.5		4.0				
	D (0.7)							3.5		
	E (1.0)			5.0		4.5				
EXTRA-HEAVY TRAFFIC LOADING	F-J (1.5 ~ 3.5)	4.0 OR 5.0 OR 5.5 1/								5 - 8 YEARS

AC OVERLAY-PCC EXISTING

TRAFFIC LOADING CLASS (X10⁶) \ CBR		2	3	4	6	8	10	15	20	OVERLAY THICKNESS (cm) PERFORMANCE PERIOD
LIGHT TRAFFIC LOADING	L-1-L-3 (0.005 ~ 0.03)				APPLY MINIMUM THICKNESS 5cm. 2/					MORE THAN 30 YEARS
HEAVY TRAFFIC LOADING	A (0.1)									12~30 YEARS
	B (0.2)	NOT								
	C (0.4)	RECOMMENDED			APPLY MIN. THICKNESS					
	D (0.7)				10cm.					
	E (1.0)									
EXTRA-HEAVY TRAFFIC LOADING	F-J (1.5) (3.5)				15	13		10		5~12 YEARS

NOTE: 1/ DECIDED FROM THE TRAFFIC REGULATION IMPLEMENTATION AND ENGINEERING AND ECONOMIC CONSIDERATIONS

2/ NO WARRANT ON PERFORMANCE DUE TO LIMITED EXPERIMENTS

TABLE 4.4-5 RECOMMENDED STRUCTURAL CAPACITY

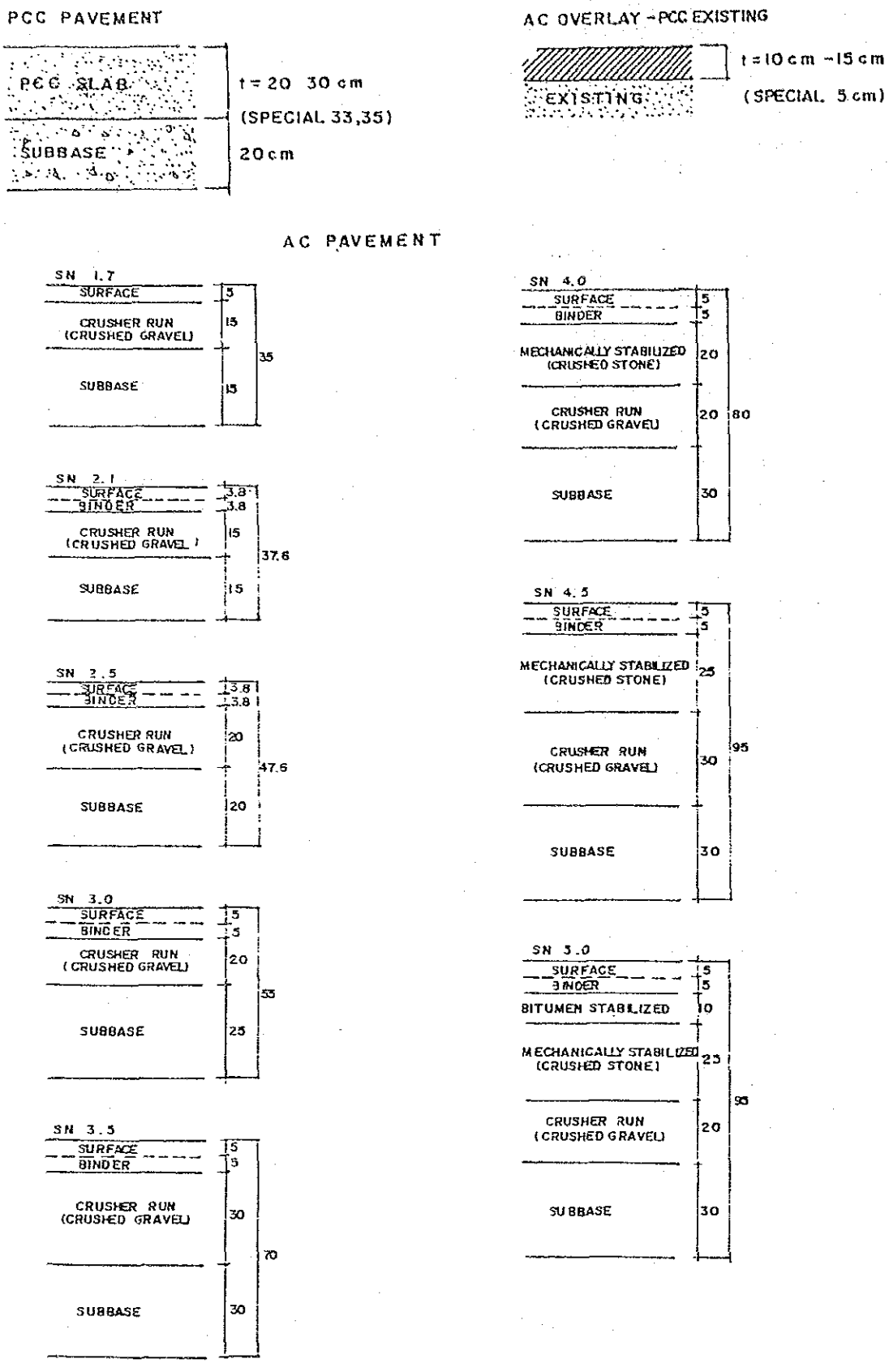


FIGURE 4.4-2 EXAMPLE OF CROSS SECTION DESIGN

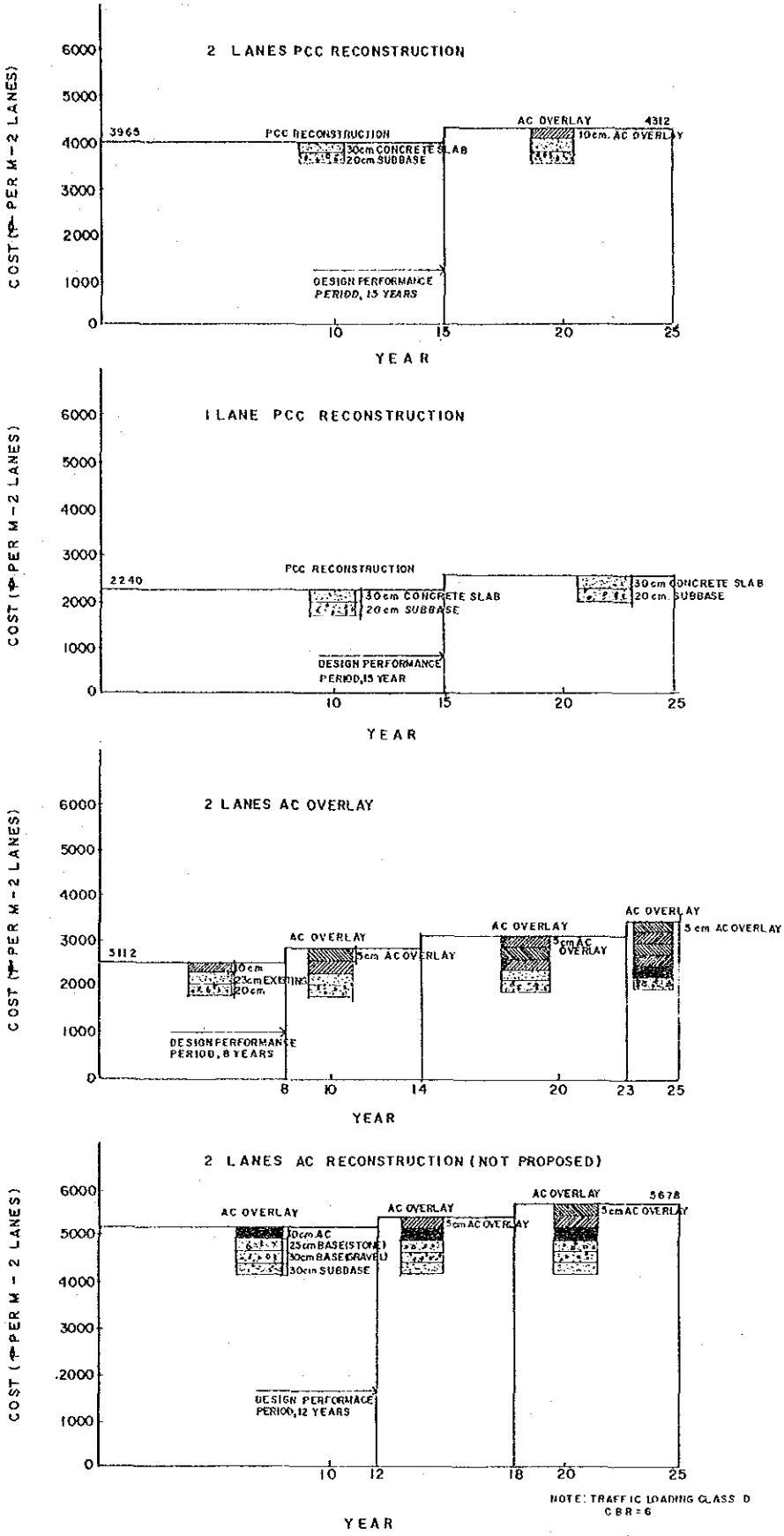


FIGURE 4.4-3 PLANNED REHABILITATION STRATEGY
TRAFFIC LOADING CLASS D
CBR = 6

4.4.4 Selection of Rehabilitation Methods

Rehabilitation Methods

Through the economic evaluation, the economic pavement type were recommended as shown in Table 4.4-6. It is, however, noted that the engineering judgement, especially on AC overlay applicability should be exercised and given precedence over economic considerations in selecting rehabilitation methods.

TABLE 4.4-6 ECONOMIC PAVEMENT TYPES

CBR Value	Traffic Loading Class	Remaining Life XP	Economic Pavement Type
Less Than 4	All Cases	All Cases	PCC Reconstruction (One-Lane)
	More than F	More than 4 years	PCC Reconstruction (One-Lane)
		Less than 3 years	AC Overlay (Two-Lanes)
6	Less than E	All Cases	AC Overlay (Two-Lanes)
More than 8	All Cases	All Cases	AC Overlay (Two-Lanes)

Comparative Study on New PCC and AC Pavements

Figure 4.4-4 shows the cost comparison between new PCC and AC pavements under subgrade CBR of 8.

Standard Pavement Structures in the Philippines

Table 4.4-7 summarizes the comparative analysis on the standard pavement structures in the Philippines under subgrade CBR of 8.

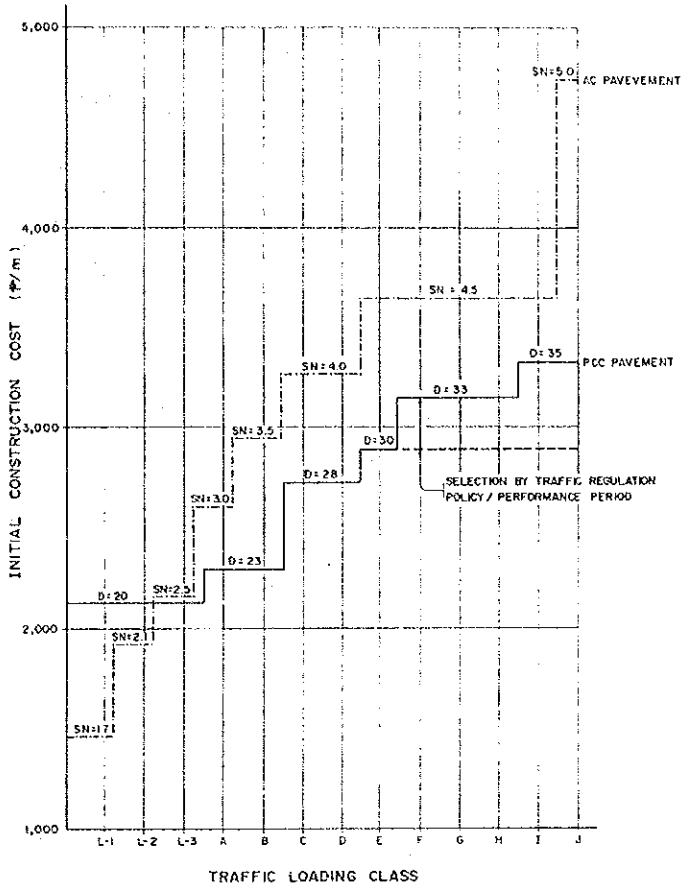


FIGURE 4.4-4 INITIAL CONSTRUCTION/(NEW CONSTRUCTION) *COST OF PCC AND AC PAVEMENT* (CBR 8)

NOTE: D = Thickness of Slab (cm.)
SN = Structural Number
Cost in ₱ per meter with 6.7m in road width excluding shoulder.

TABLE 4.4-7 STANDARD PAVEMENT STRUCTURES IN THE PHILIPPINES

		CBR Value of 8		
		Traffic Loading Class C	Traffic Loading Class D	Construction Cost
PCC	Thickness 23 cm	8.6 years	5.3 years	₱2,400/m
AC	SN = 2.1 1/	less than 1 year	less than 1 year	₱1,500/m
AC	SN = 2.8 1/	2.2 years	1.3 years	₱2,060/m
AC	SN = 3.5 2/	7.3 years	4.4 years	₱2,600/m

NOTE: 1/ Structural Number of Standard AC Pavement in the Philippines
2/ Structural Number of AC Pavement comparable with PCC Thickness 23 cm slab

4.5 Recommended Pavement Rehabilitation Works

4.5.1 Recommended Works under Short Term (1987-1992)

See Table 4.5-1.

Pavement Rehabilitation Sections

- Section with RRI less than 2.5
- Section with RRI of 2.5 to 3.0
  (considering the progress of cracks and project implementation timing).

Pavement Rehabilitation Methods

- 2-lane PCC Reconstruction
- 1-lane PCC Reconstruction
- 2-lane AC Overlay

Drainage Improvement Works

- Surface drainage (side ditch) at the mountain side
- Surface drainage (side ditch) at the embankment anticipated to be scoured by water
- Subsurface drainage at high level of ground water

4.5.2 Recommended Works under Medium Term (1993-1998)

See Table 4.5-1.

Pavement

- All sections other than mentioned above.
- Second rehabilitation of initial rehabilitation under short term

Drainage

- Subsurface Drainages with very bad/bad conditions

4.5.3 Recommended Works under Long Term (1999-2010)

- Observation and study on pavement conditions
- Study on possible installation of drainage system for the entire road length.

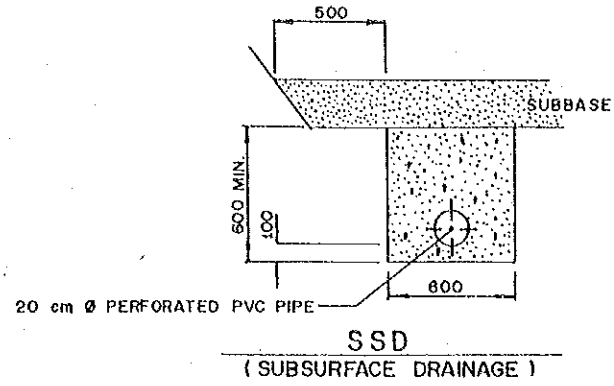


FIGURE 4.5-1 TYPICAL CROSS-SECTION OF SUBSURFACE DRAINAGE

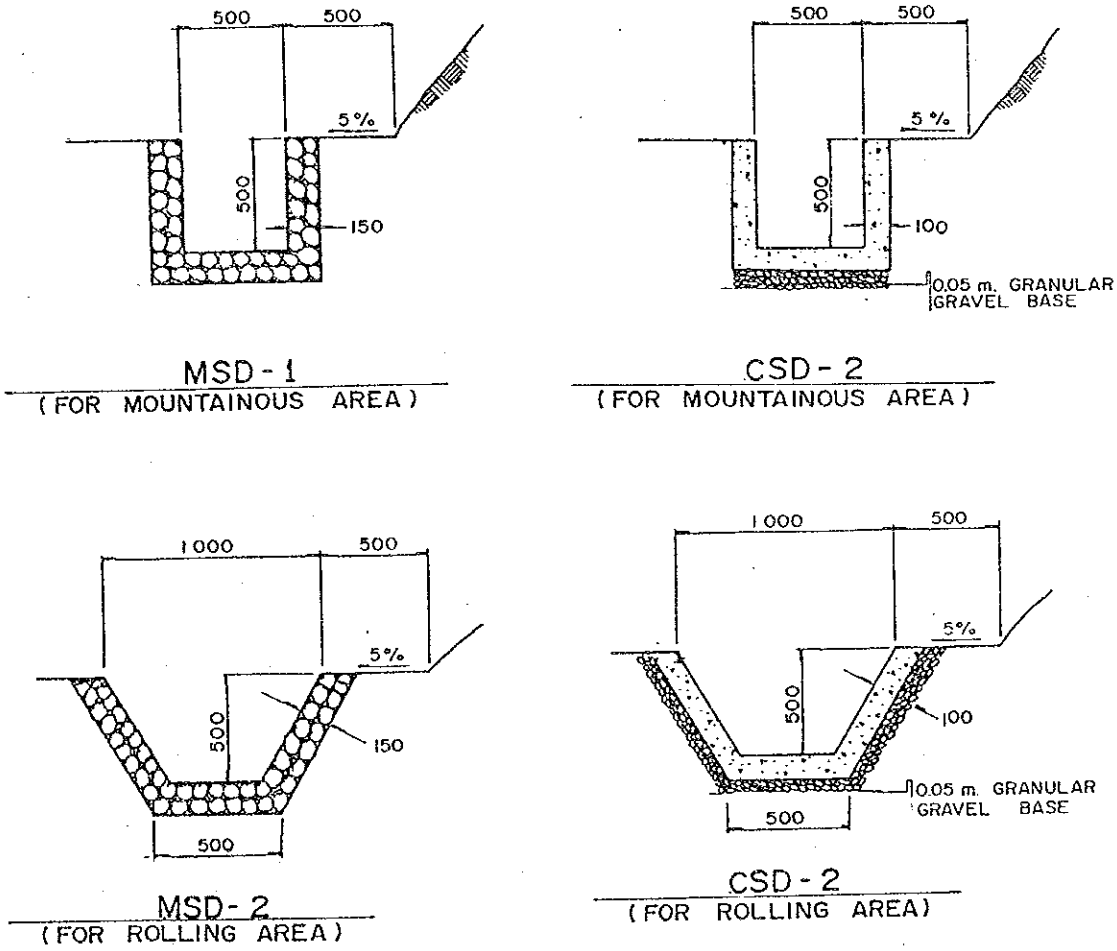


FIGURE 4.5-2 TYPICAL CROSS SECTION OF SIDE DITCH

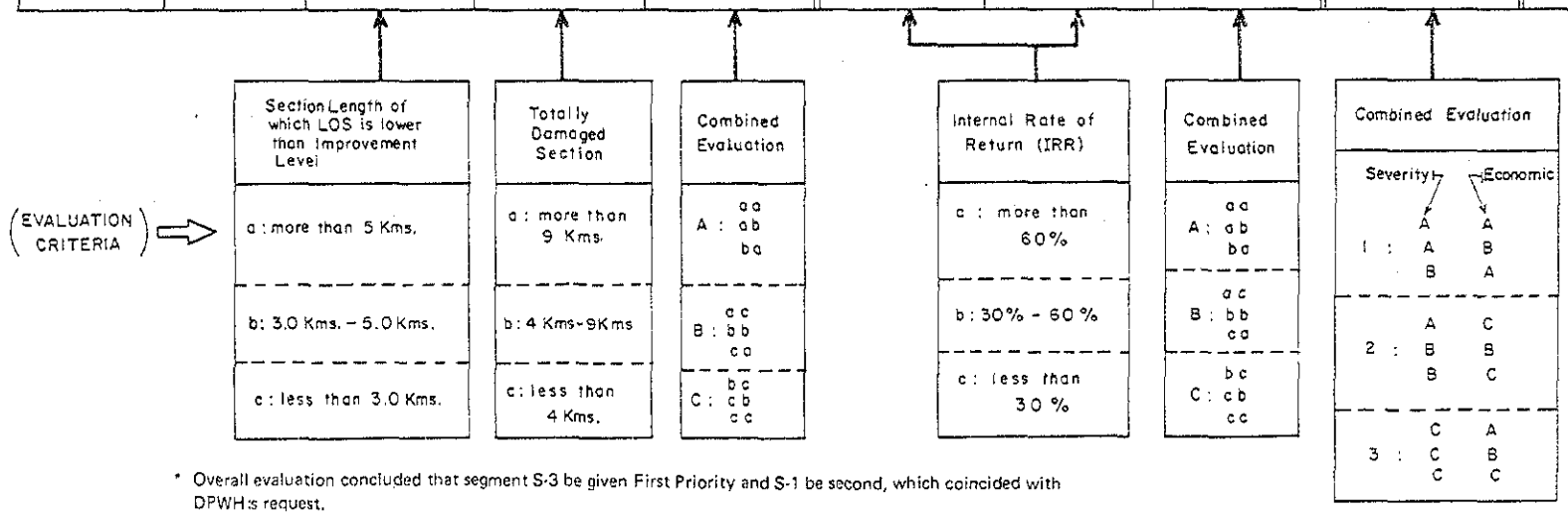
TABLE 4.5-1 SUMMARY OF LENGTH FOR PAVEMENT REHABILITATION/DRAINAGE IMPROVEMENT BY TYPE OF WORKS

Unit: Lane-Km

Segment		Segment Length (km)	Short-Term									Medium Term		Total	
			Pavement Rehabilitation (Lane-km)					Drainage Improvement (km)							
			2-Lane PCC Recon-struction	1-Lane PCC Recon-struction (Manila Bound)	1-Lane PCC Recon-struction (Opposite Lane)	2-Lane AC Overlay	Sub-Total	Treatment of Weak Subgrade	Side Ditch	Sub-Surface Drainage	Sub-Total	Pavement Rehabili-tation (Lane-Km)	Drainage Improve-ment (Km)	Pavement Rehabili-tation (Lane-Km)	Drainage Improve-ment (Km)
North Study Section	N-1 (Sta. Rita-Gapan)	46	21.50	25.00	15.20	7.00	68.70	2.0	19.30	–	21.30	23.30	26.70	92.00	48.00
	N-2 (Gapan-Cabanatuan)	35	27.90	2.85	2.75	13.00	46.50	–	8.60	–	8.60	23.50	26.40	70.00	35.00
	N-3 (Cabenatuan-San Jose)	42	5.10	15.02	1.95	–	22.07	–	9.75	–	9.75	61.93	32.25	84.00	42.00
	N-4 (San Jose-Dalton)	38	10.90	17.18	14.53	25.00	67.61	–	35.08	–	35.08	8.39	2.92	76.00	38.00
	N-5 (Dalton-Aritao)	39	26.52	11.74	7.74	24.00	70.00	–	37.00	3.25	40.25	8.00	2.00	78.00	42.25
	Sub-Total	200	91.92	71.79	42.17	69.00	274.88	2.0	109.73	3.25	114.98	125.12	90.27	400.00	205.25
South Study Section	S-1 (Calamba-Tiaong)	42	10.22	7.03	1.65	–	18.90	–	12.95	–	12.95	65.10	29.05	84.00	42.00
	S-2 (Tiaong-Pagbilao)	54	12.76	2.13	0.85	3.00	18.74	–	10.85	–	10.85	89.26	43.15	108.00	54.00
	S-3 (Pagbilao-Plaridel)	46	44.10	3.40	1.10	–	48.60	–	25.45	11.25	36.70	43.40	20.55	92.00	57.25
	S-4 (Plaridel-Calauag)	39	43.60	2.48	2.48	2.00	50.56	–	25.27	–	25.27	27.44	13.73	78.00	39.00
	Sub-Total	181	110.68	15.04	6.08	5.00	136.80	–	74.52	11.25	85.77	225.20	106.48	362.00	192.25
TOTAL		381	202.60	86.83	48.25	74.00	411.68	2.0	184.25	14.50	200.75	350.32	196.75	762.00	397.50

TABLE 5-1 OVERALL RELATIVE PRIORITY OF SEGMENTS

STUDY SECTION	SEGMENT NO.	PRIORITY BASED ON SEVERITY OF CONDITION			PRIORITY BASED ON ECONOMIC RATE OF RETURN			OVERALL RELATIVE PRIORITY	REMARKS
		Road Function	Pavement	Relative Priority - I	Road Function	Pavement	Relative Priority - II		
NORTH SECTION	N-1	b (3.5)	a (11.3)	A	c (25.6)	a (155.6)	B	1	F/S Segment
	N-2	a (8.5)	b (6.0)	A	a (60.2)	a (134.2)	A	1	F/S Segment
	N-3	c (1.5)	c (1.3)	C	c (19.8)	a (88.0)	B	3	—
	N-4	c (-)	b (5.9)	C	c (-)	b (49.1)	C	3	—
	-5	c (-)	a (9.1)	B	c (-)	b	C	2	F/S Segment
SOUTH SECTION	S-1	a (10.0)	c (0.1)	B	b (42.2)	a (216.2)	A	(1) 2*	F/S Segment
	S-2	c (-)	c (2.0)	C	c (-)	a (112.1)	B	3	—
	S-3	c (-)	a (11.0)	B	c (-)	b (56.4)	C	(2) 1*	F/S Segment
	S-4	c (-)	b (4.0)	C	c (-)	b (44.4)	C	3	—



* Overall evaluation concluded that segment S-3 be given First Priority and S-1 be second, which coincided with DPWH's request.

6. PROJECT COST

6.1 Project Costs for Short and Medium Terms

The project costs composed of civil works, right-of-way acquisition and engineering and management costs were estimated based on the unit cost analysis in November 1986 prices. The total project cost for the short term was estimated at ₱1099.00 M and for the medium term ₱1077.41 M, totalling ₱2176.41 M.

Under the short term, ₱199.55 M is required for the road function improvement and ₱899.45 M for pavement rehabilitation including drainage improvements.

While for the medium term, ₱236.13 M is required for the road function and ₱841.28 M for pavement rehabilitation. See Table 6.1-1.

TABLE 6.1-1 SUMMARY OF PROJECT COST
– ROAD FUNCTION IMPROVEMENT AND PAVEMENT REHABILITATION
(SHORT TERM AND MEDIUM TERM)

North Study Section — Unit: Million Pesos Nov. 1986 Prices

Segment	Short Term (1987-1992)			Medium Term (1993-1998)			
	Road Function	Pavement	Sub-Total	Road Function	Pavement	Sub-total	Total
N – 1	17.42	153.22	170.64	90.63	68.57	159.20	329.84
N – 2	64.22	95.27	159.49	63.00	71.32	134.32	293.81
N – 3	28.57	51.33	79.90	–	148.90	148.90	228.80
N – 4	–	142.48	142.48	–	32.13	32.13	174.61
N – 5	–	153.56	153.56	–	29.28	29.28	182.84
Sub-Total	110.21	595.86	706.07	153.63	350.20	503.83	1,209.90
South Study Section							
S – 1	72.67	46.44	119.11	–	152.23	152.23	271.34
S – 2	9.94	39.14	49.08	82.50	185.53	268.03	317.11
S – 3	–	111.68	111.68	–	93.59	93.59	205.27
S – 4	6.73	106.33	113.06	–	59.73	59.73	172.79
Sub-Total	89.34	303.59	392.93	82.50	491.08	573.58	966.51
T O T A L	199.55	899.45	1,099.00	236.13	841.28	1,077.41	2,176.41

NOTE: Project cost included construction, right-of-way acquisition and consultancy costs.

6.2 Detailed Project Cost for Short Term

The construction cost was estimated at ₱971.03 M, of which the foreign currency component was ₱577.24 M or 59.4% and the local currency component ₱393.79 M or 40.6%.

The right-of-way acquisition cost for both short term and some medium term works was estimated at ₱25.06 M, all of which involves the local currency.

The detailed design services require ₱46.02 M, of which the foreign currency component is ₱30.87 M or 67.1% and the local currency component is ₱15.15 M or 32.9%. The construction supervision fee was estimated at ₱56.89 M, of which the foreign is ₱39.04 M or 68.6% and the local is ₱17.85 M or 31.4%. The detailed design and supervision fee are 4.7% and 5.9% of the construction cost, respectively. See Table 6.2-1.

TABLE 6.2-1 PROJECT COST
(SHORT TERM)

Unit: Million Peso

		November 1986 Price			Escalated Cost		
		Road Function	Pavement Improvement	Total	Road Function	Pavement Improvement	Total
Detailed Engineering	Foreign	7.97	22.90	30.87	7.97	22.90	30.87
	Local/Tax	5.34	9.81	15.15	6.71	11.56	18.27
	Total	13.31	32.71	46.02	14.68	34.46	49.14
Right-of-way Acquisition	Foreign	–	–	–	–	–	–
	Local/Tax	25.06	–	25.06	31.46	–	31.46
	Total	25.06	–	25.06	31.46	–	31.46
Construction	Foreign	86.49	490.75	577.24	86.49	490.75	577.24
	Local/Tax	66.86	326.93	393.79	85.45	422.00	507.45
	Total	153.35	817.68	971.03	171.94	912.75	1,084.69
Construction Supervision	Foreign	4.69	34.35	39.04	4.69	34.35	39.04
	Local/Tax	3.14	14.71	17.85	3.94	19.27	23.21
	Total	7.83	49.06	56.89	8.63	53.62	62.25
TOTAL	Foreign	99.15	548.00	647.15	99.15	548.00	647.15
	Local/Tax	100.40	351.45	451.85	127.56	452.83	580.39
	Total	199.55	899.45	1,099.00	226.71	1,000.83	1,227.54

7. PROJECT EVALUATION

7.1 Technical Evaluation

Road function improvement and pavement rehabilitation do not require any new technology and materials which are not locally available.

However, special attention should be exercised to the following items:

- Adequate pavement design
- Accurate traffic projection and estimation of axle loadings
- Quality control on concrete, subbase and subgrade

7.2 Economic Evaluation

The economic viability of the proposed improvement/rehabilitation works were evaluated taking into consideration the investment opportunity for each proposed work.

Then, the economic evaluation by segments and by road function/pavement rehabilitation was made combining all works under the optimum investment opportunity assigned for each work.

Quantified benefits are:

- Saving in running cost (Road Function/Pavement)
- Saving in fixed cost (Road Function/Pavement)
- Saving in passenger time cost (Road Function/Pavement)
- Reduction in traffic accidents (Road Function)
- Reduction in stopped delay time at intersection (Road Function)
- Saving in Maintenance Cost (Pavement)

The economic evaluation are summarized in Table 7.2-1. N-1 shows the highest IRR of 105.6% while S-4 has the lowest IRR of 34.9%.

7.3 Financial Consideration

The total project cost involves ₱1099.00 M in November 1986 price, of which the foreign currency component was estimated at ₱647.15 M 58.9% and the local currency ₱451.85 M or 41.1%.

Taking into account the local currency component involved, the 4 years construction plan by stages was proposed so that the annual local cash requirement will be about ₱120 M in average.

The foreign currency component was assumed to be financed with external assistance from a foreign country or an international financial institution.

TABLE 7.2-1 SUMMARY OF ECONOMIC EVALUATION

Segments	Length (Km)	Road Function Improvement IRR (%)	B/C	NPV (MP)	Pavement Rehabilitation IRR (%)	B/C	NPV (MP)	Road Function/ Pavement Rehabilitation IRR (%)	B/C	NPV (MP)	Implementation Priority
N-1 (Sta. Rita-Gapan)	46	23.2	1.8	171.5	120.3	5.43	603.1	105.6	4.39	645.5	1
N-2 (Gapan-Cabanatuan)	35	53.1	4.6	295.8	111.8	5.02	335.8	76.1	4.78	631.7	1
N-3 (Cabanatuan-San Jose)	42	18.5	1.3	7.9	68.2	3.61	110.0	41.3	2.77	118.9	3
N-4 (San Jose-Dalton)	38	–	–	–	39.3	2.38	163.4	39.3	2.38	163.4	3
N-5 (Dalton-Aritao)	39	–	–	–	38.1	2.31	163.5	38.1	2.31	163.5	2
North Study Section	200	38.6	3.1	346.1	70.8	3.72	1,376.8	61.7	3.58	1,722.9	
S-1 (Calamba-Tiaong)	42	39.8	5.6	253.1	134.3	7.19	208.8	56.8	6.17	461.9	1
S-2 (Tiaong-Pagbilao)	54	– x	–	–	78.5	4.09	95.4	78.4	4.09	95.4	3
S-3 (Pagbilao-Plaridel)	46	–	–	–	41.3	2.44	127.1	41.3	2.44	127.1	2
S-4 (Plaridel-Calauag)	39	– x	–	–	34.9	2.08	86.3	34.9	2.08	86.3	3
South Study Section	181	39.8	5.6	253.1	54.4	3.23	517.6	49.9	3.67	770.7	
Whole Study Section	381	39.1	3.8	599.2	65.3	3.57	1,894.4	57.2	3.61	2,493.5	

X NOTE: Benefits from improvement of intersections in rural area and paving of shoulders and sidewalks within ROW were not considered because of no negligible amounts.

no/negligible amounts.

7.4 Environmental Assessment

In accordance with the Supplement to Official Gazette, Volume 78, No. 25 issued by the National Environmental Protection Council (NEPC), the environmental assessment on the project was conducted.

The favorable environmental impacts from the project were assessed as a whole, but with the following adverse impacts.

Road Function Improvement

- 52 houses affected by Sta. Rita – Plaridel Widening
- 63 houses affected by Calamba – Sto. Tomas Widening
- 25 houses affected by Plaridel Bypass
- 64 houses affected by Cabanatuan Alternative Route

Pavement Rehabilitation

Traffic disturbance during construction

8. PROJECT IMPLEMENTATION

8.1 Overall Implementation Schedule

Short Term (1987-1992)

- Financial Arrangement; Earliest Possible Time, preferably July 1987 to March 1988 (9 months)
- Detailed Engineering; April 1988 to March 1989 (12 months) October 1989 to June 1990 (9 months)
- Construction; High Priority Segments (N-1, N-2, S-3)
  April 1989 to March 1991 (24 months)
  Second Priority Segments (N-5, S-1)
  January1990 to June 1991 (18 months)
  Third Priority Segments (N-3, N-4, S-2, S-4)
  January 1991 to December 1992 (24 months)

Medium Term (1993-1998)

- Financial Arrangement ; 1992
- Detailed Design ; 1993 to 1994 (18 months)
- Construction ; 1994 to 1998 (4 years)

Long Term (1999-2010)

- Feasibility Study ; 1997 to 1998 (16 months)
- Financial Arrangement ; 1999
- Detailed Engineering ; 2000 to 2001
- Construction ; 2002 to 2010

8.2 Detailed Implementation Schedule for Short Term

Recommended implementation schedule and annual financial requirement broken down into foreign and local currency components for the short term works are presented in Table 8.2-1.

TABLE 8.2-1 IMPLEMENTATION SCHEDULE (SHORT TERM 1987-1992)

			1986	1987	1988	1989	1990	1991	1992	Total
Feasibility Study (This Study)										
Financial Arrangement for Implementation										
Detailed Engineering										
Prequalification/Tender										
Construction	High Priority Segments (N-1, N-2, S-1)									
	Second Priority Segments (N-5, S-3)									
	Third Priority Segments (N-3, N-4, S-2, S-4)									
Construction Supervision										
Project Cost	Road Function	Foreign Component			1.98 (1.98)	28.80(28.80)	31.40(31.40)	36.97(36.97)	–	99.15 (99.15)
		Local Component			6.65 (7.47)	21.83(26.00)	28.49(35.97)	43.43(58.12)	–	100.40 (127.56)
		Total			8.63 (9.45)	50.63(54.80)	57.89(67.37)	80.40(95.09)	–	199.55 (226.71)
Nov. 1986 Price (Escalated Cost)	Pavement Rehabilitation	Foreign Component			10.70 (10.70)	77.50(77.50)	216.45(216.45)	141.10(141.10)	102.25(102.25)	548.00 (548.00)
		Local Component			4.58 (5.15)	48.05(53.34)	142.17(179.49)	91.61(122.59)	65.04(92.26)	351.45 (452.83)
		Total			15.28 (15.85)	125.55(130.84)	358.62(395.94)	232.71(263.69)	167.29(194.51)	899.45 (1,000.83)
Unit: Million ₱	TOTAL	Foreign Component			12.68 (12.68)	106.30(106.30)	247.85(247.85)	178.07(178.07)	102.25(102.25)	647.15 (647.15)
		Local Component			11.23(12.62)	69.88(79.34)	170.66(215.46)	135.04(180.71)	65.04(92.26)	451.85 (580.39)
		Total			23.91 (25.30)	176.18(185.64)	418.51(463.31)	313.11(358.78)	167.29(194.51)	1,099.00 (1,227.54)

Figures in parenthesis show the escalated fund requirement.
Annual escalation rate: Foreign Currency: 0%
Local Currency : 6%

9. GUIDES FOR ROAD FUNCTION IMPROVEMENT AND PAVEMENT REHABILITATION

Two (2) "GUIDEs" were drawn up after compiling the survey and investigation results and study outputs obtained through the undertaking of the Study, namely:

- Guide For Road Function Improvement Planning
- Guide For Pavement Rehabilitation Design

Although there are some limitations in application to other sections, "GUIDEs" are desired to be utilized, whenever applicable, for development of the road planning and engineering.

The former is composed of six (6) chapters as follows:

CHAPTER 1 INTRODUCTION
2 TRAFFIC CHARACTERISTICS ON THE PAN-PHILIPPINE HIGHWAY
3 LEVEL OF SERVICE ANALYSIS
4 IMPROVEMENT LEVEL FOR ROAD FUNCTION
5 PROBLEMS AND POSSIBLE SOLUTIONS
6 EVALUATION OF IMPROVEMENT MEASURES

The latter consists of the following 13 chapters:

CHAPTER 1 INTRODUCTION
2 PAVEMENT DESIGN PRINCIPLES
3 PAVEMENT MATERIAL PROPERTIES
4 TRAFFIC LOADING
5 PAVEMENT DETERIORATION
6 IDENTIFICATION OF PAVEMENT REHABILITATION SECTION
7 SURVEYS FOR PAVEMENT REHABILITATION DESIGN
8 DESIGN REQUIREMENTS OF PAVEMENT REHABILITATION
9 BASIC STRUCTURAL DESIGN OF PAVEMENT REHABILITATION METHOD
10 SELECTION OF PAVEMENT REHABILITATION METHOD
11 WEAK SUBGRADE IMPROVEMENT DESIGN
12 PAVEMENT SUBSURFACE DRAINAGE DESIGN
13 ECONOMIC EVALUATION ON PAVEMENT REHABILITATION

APPENDIX

APPENDIX-1

SUMMARY OF ROAD FUNCTION ASSESSMENT NORTH SECTION

PROVINCE / KILOMETRAGE

BULACAN PROVINCE — NUEVA ECIJA PROVINCE

40 50 60 70 80 90 100 110 120 130

GEOMETRICS

TO MALOLOS; TO ANGA; PLARIDEL; TO BALIUAG; BALIUAG BYPASS; TO BALIUAG; SAN ILDEFONSO; TO SAN MIGUEL; TO TOWN PROPER; SAN MIGUEL; TO SAN FERNANDO; TO GAPAN; GAPAN; TO TARLAC; TO STA ROSA; STA ROSA; TO CABANATUAN CITY; TO GENTINIO; CABANATUAN; TO ALIAGA; TALAVERA

MAJOR CITY / TOWN

ENVIRONMENT — RURAL, SUB-URBAN, URBAN

TOPOGRAPHY — FLAT, ROLLING, MOUNTAINOUS

ALIGNMENT / SIGHT DISTANCE
SC : SHARP CURVE
SG : STEEP GRADIENT
SD : INSUFFICIENT SIGHT DISTANCE

TRAFFIC VOLUME (ADT) — TRICYCLE, JEEPNEY, BUS, TRUCK, CAR

20,000 / 15,000 / 10,000 / 5,000

AVERAGE TRAVEL SPEED (Km/Hr)

70 60 50 40 30

LEVEL OF SERVICE

A B C D E F

PLARIDEL I.S. GAPAN I.S. STA. ROSA I.S. CABANATUAN I.S. CABANATUAN IV I.S.

COMMENT BASED ON OBSERVATION

STA. RITA - PLARIDEL SEC. (L = 2 Km.)
- Widening be studied

PLARIDEL URBAN SEC. (L=5Km.)
- Public market is major cause of heavy roadside friction
- To be studied are
  - Widening on/or a bypass
  - Signalization of a intersection
  - Traffic Management
  - Redevelopment of Public Market

BALIUAG INTERSECTION
- Improvement of Geometrics

SAN ILDEFONSO URBAN SEC. (L = 1Km)
- To be studied are
  - Paving of Shoulder and Sidewalks.
  - Tricycle Terminal

GAPAN URBAN SEC. (L = 3Km.)
- To be studied are
  - Signalization and Geometric Improvement of Intersection
  - Bypass
  - Traffic Management
  - Location of PUV terminal and bus stop

STA. ROSA URBAN SEC. (L=1.1 Km.)
- To be studied are
  - Paving of Shoulder and Sidewalk
  - Tricycle Terminal

CABANATUAN URBAN SEC. (L = 7 Km.)
- To be studied are
  - Paving of Shoulder and Sidewalk
  - Bypass
  - Signalization of Intersection
  - Traffic Management
  - PUV re-routing

PROVINCE / KILOMETRAGE

NUEVA ECIJA PROVINCE — NUEVA VIZCAYA PROVINCE

140 150 160 170 180 190 200 210 220 230

GEOMETRICS

TO GUIMBA; TO MUNOZ TOWN PROPER; TO PANGASINAN; TO RIZAL; TO SAN JOSE

MAJOR CITY / TOWN

MUNOZ; SAN JOSE; STA FE; ARITAO

ENVIRONMENT — RURAL, SUB-URBAN, URBAN

TOPOGRAPHY — FLAT, ROLLING, MOUNTAINOUS

ALIGNMENT / SIGHT DISTANCE
SC : SHARP CURVE
SG : STEEP GRADIENT
SD : INSUFFICIENT SIGHT DISTANCE

TRAFFIC VOLUME (ADT) — TRICYCLE, JEEPNEY, BUS, TRUCK, CAR

20,000 / 15,000 / 10,000 / 5,000

AVERAGE TRAVEL SPEED (Km/Hr)

70 60 50 40 30

LEVEL OF SERVICE

A B C D E F

SAN JOSE I.S.

COMMENT BASED ON OBSERVATION

SAN JOSE URBAN SEC. (L = 4 Km.)
To be studied are
- Paving of shoulder and sidewalks
- Removal of center median island
- Signalization of the intersection
- Traffic Management

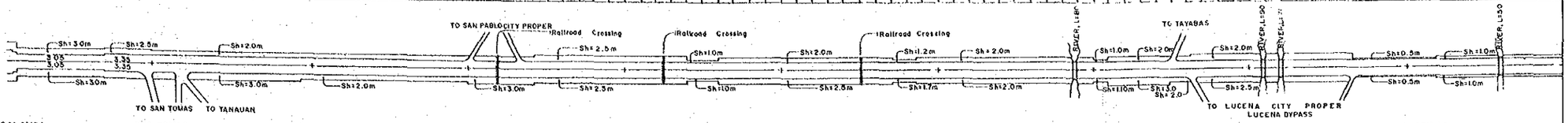
DALTON PASS SEC. (L = 15 Km.)
- Travel speed is low due to lots of Sharp curves and steep gradients.
- Improvement of alignment be studied

SUMMARY OF ROAD FUNCTION ASSESSMENT (SOUTH SECTION)

PROVINCE: LAGUNA | BATANGAS | LAGUNA | QUEZON-I

KILOMETRAGE: 60 70 80 90 100 110 120 130 140 150

GEOMETRICS



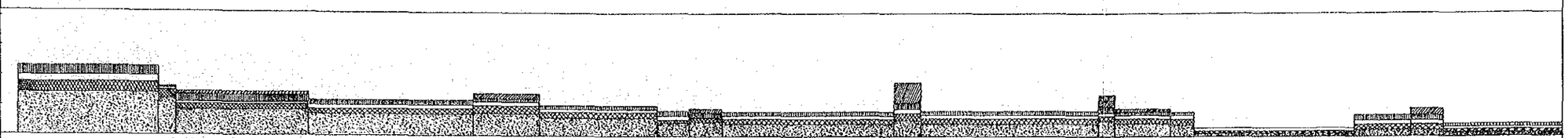
MAJOR CITY / TOWN: CALAMBA | STO. TOMAS | ALAMINOS | SAN PABLO | TIAONG | CANDELARIA | SARIAYA | LUCENA CITY | PAGBILAO

ENVIRONMENT: RURAL | SUB-URBAN | URBAN

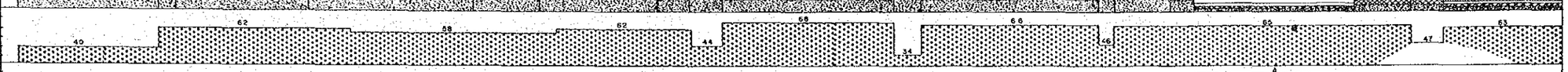
TOPOGRAPHY: FLAT | ROLLING | MOUNTAINOUS

ALIGNMENT / SIGHT DISTANCE
SC : SHARP CURVE
SG : STEEP GRADIENT
SD : INSUFFICIENT SIGHT DISTANCE

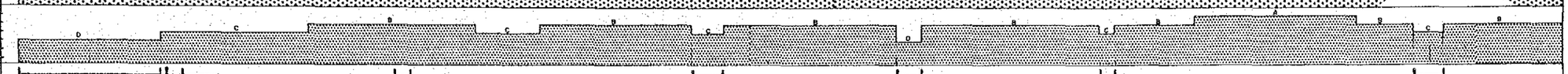
TRAFFIC VOLUME (ADT): TRICYCLE | JEEPNEY | BUS | TRUCK | CAR



AVERAGE TRAVEL SPEED (Km/Hr)



LEVEL OF SERVICE



COMMENT BASED ON OBSERVATION

CALAMBA – STO. TOMAS SEC. (L=10kms)
- Widening be Studied.

STO TOMAS INTERSECTIONS I, II (Km.60 & Km.61)
- Improvement of Geometrics

ALAMINOS URBAN SEC. (L=1.5 Km.
- To Improve Amenity, Paving of Shoulders and Sidewalks be Studied.

TIAONG URBAN SEC. (L=1.2kms)
- To Improve Amenity, Paving of Shoulders and Sidewalks be Studied.

CANDELARIA URBAN SEC. (L=1.0kms)
- To Improve Amenity, Paving of Shoulders and Sidewalks be Studied.

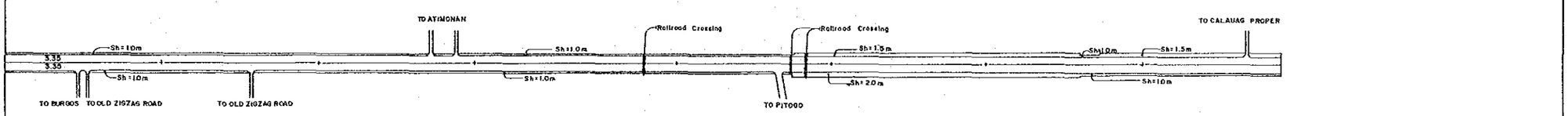
SARIAYA URBAN SEC. (L=1 km)
- To Improve Amenity, Paving of Shoulders and Sidewalks be Studied.

PAGBILAO URBAN SEC. (L=1.5 kms)
- Widening to Remove One-Way Operation be Studied.
- To Improve Amenity, Paving of Shoulders and Sidewalks be Studied.

PROVINCE: QUEZON-I | QUEZON-II

KILOMETRAGE: 150 160 170 180 190 200 210 220 230

GEOMETRICS



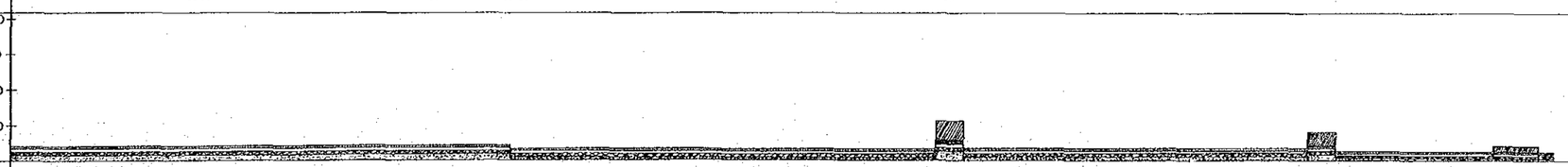
MAJOR CITY / TOWN: ATIMONAN | PLARIDEL | GUMACA | LOPEZ | CALAUAG

ENVIRONMENT: RURAL | SUB-URBAN | URBAN

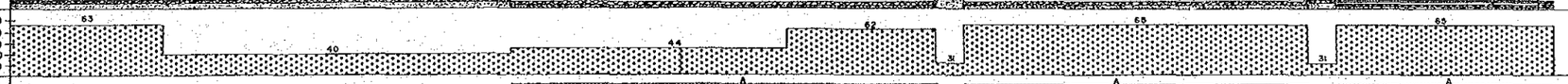
TOPOGRAPHY: FLAT | ROLLING | MOUNTAINOUS

ALIGNMENT / SIGHT DISTANCE
SC : SHARP CURVE
SG : STEEP GRADIENT
SD : INSUFFICIENT SIGHT DISTANCE

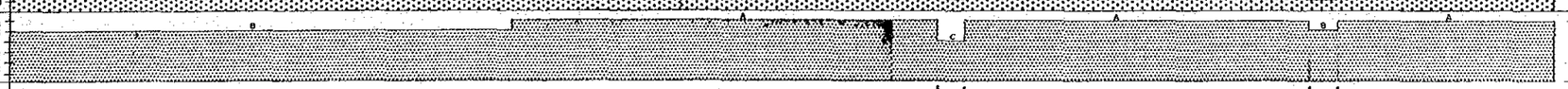
TRAFFIC VOLUME (ADT): TRICYCLE | JEEPNEY | BUS | TRUCK | CAR



AVERAGE TRAVEL SPEED (Km/Hr)



LEVEL OF SERVICE



COMMENT BASED ON OBSERVATION

Travel Speed is Low due to Bad Condition of Pavement

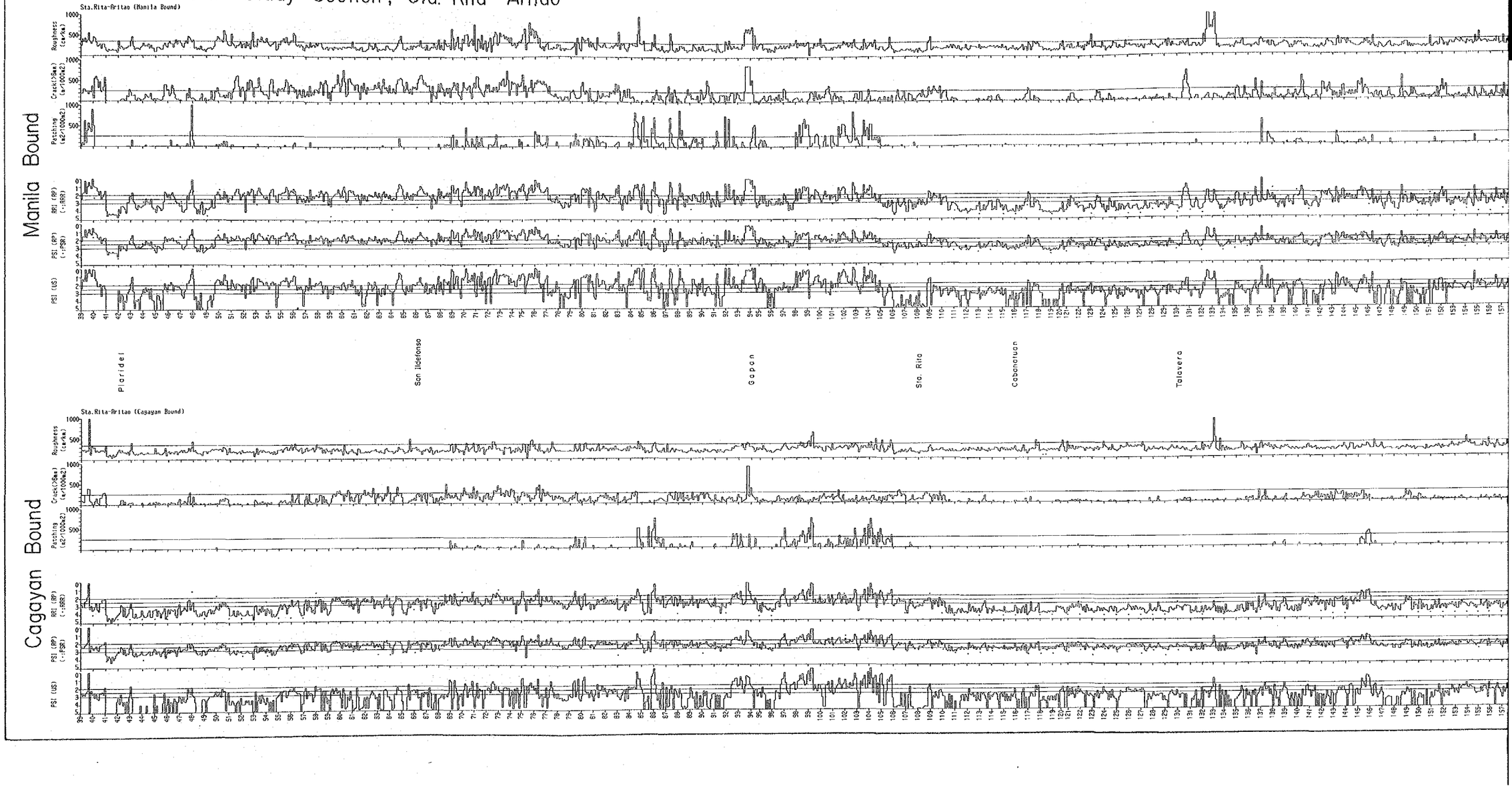
GUMACA URBAN SEC. (L=1.5kms)
- To Improve Amenity, Paving of Shoulders and Sidewalks be Studied.

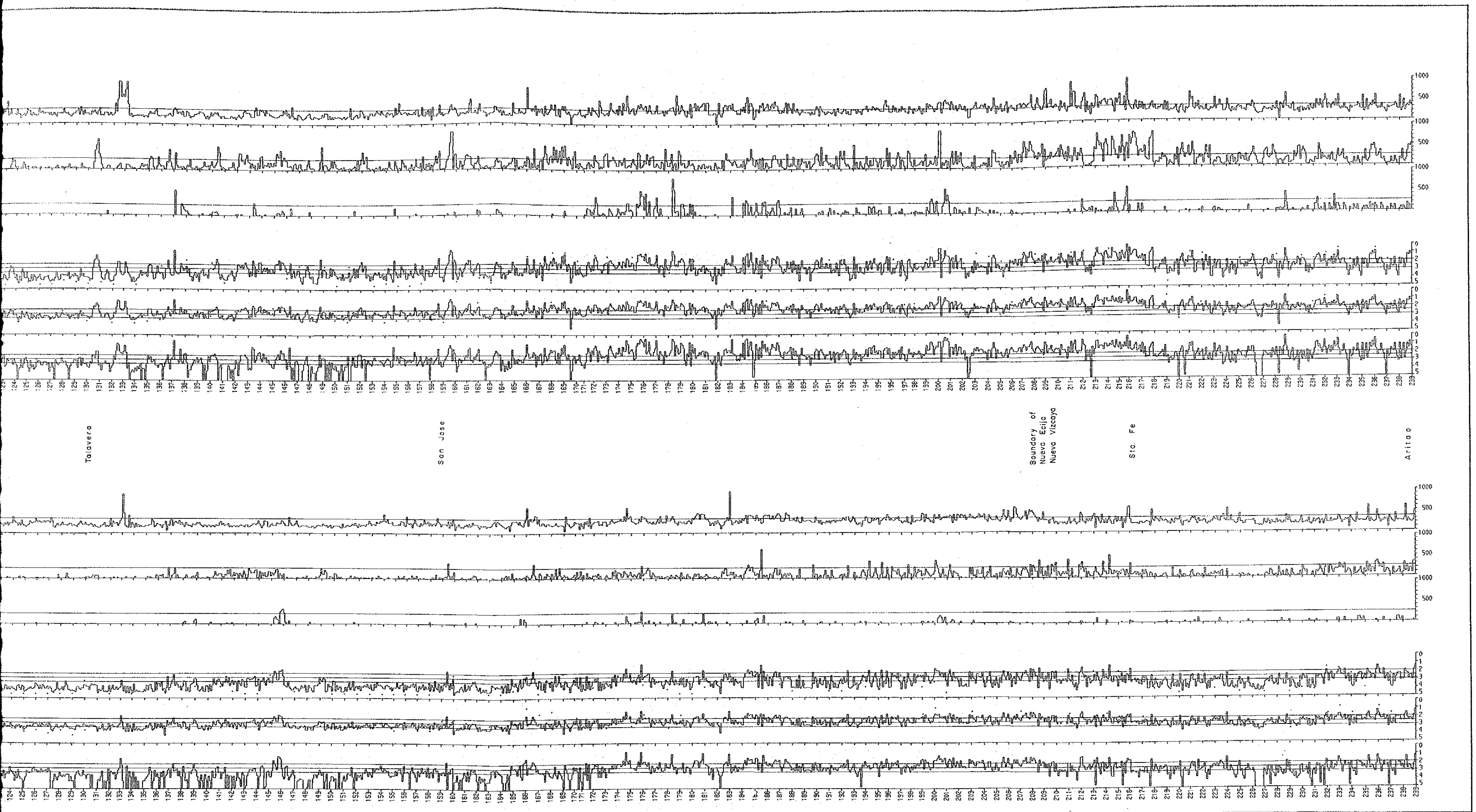
LOPEZ URBAN SEC. (L=1 km)
- To Improve Amenity, Paving of Shoulders and Sidewalks be Studied.

APPENDIX-2

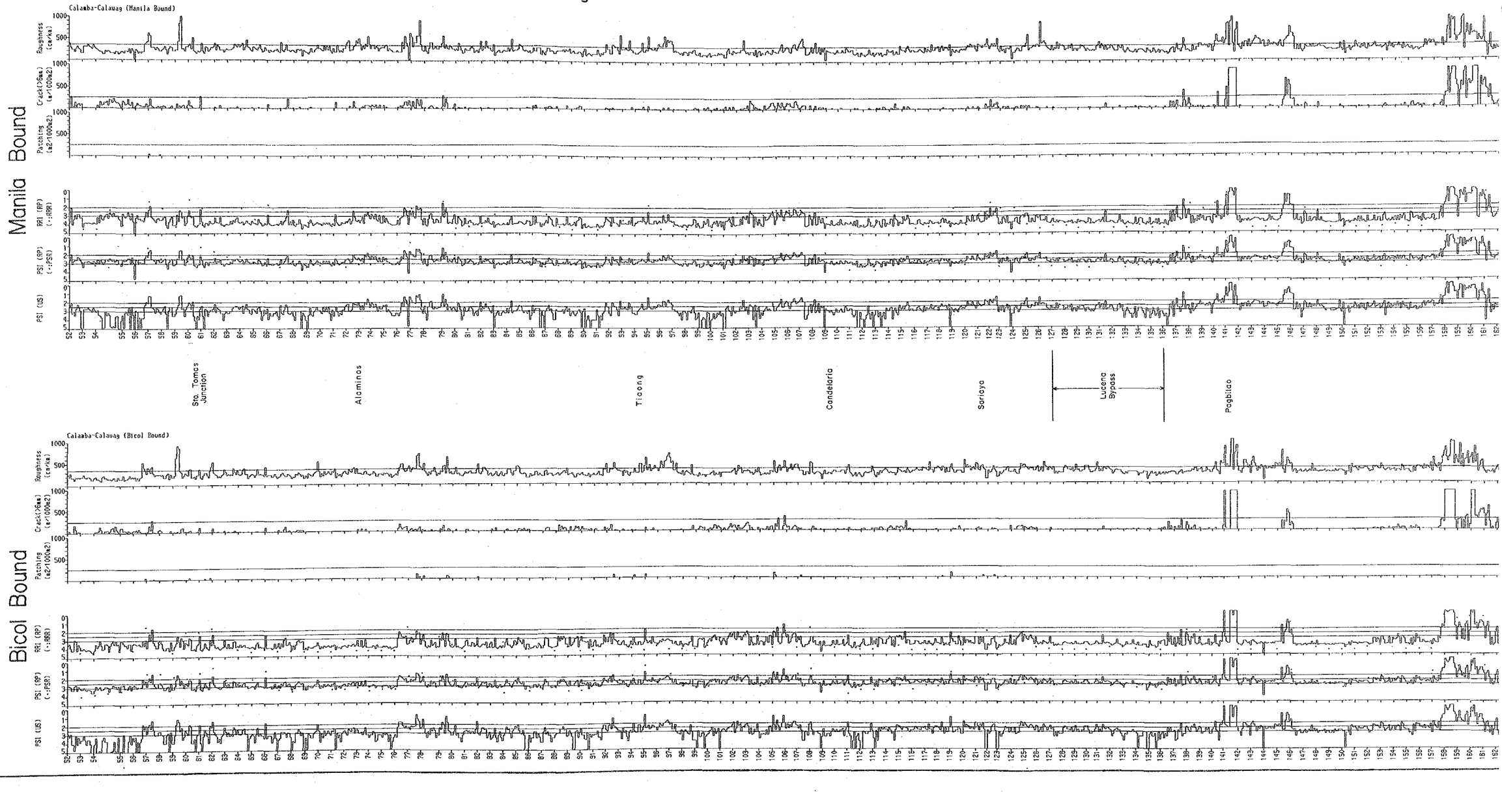
PAVEMENT SURFACE CONDITION AND EVALUATION

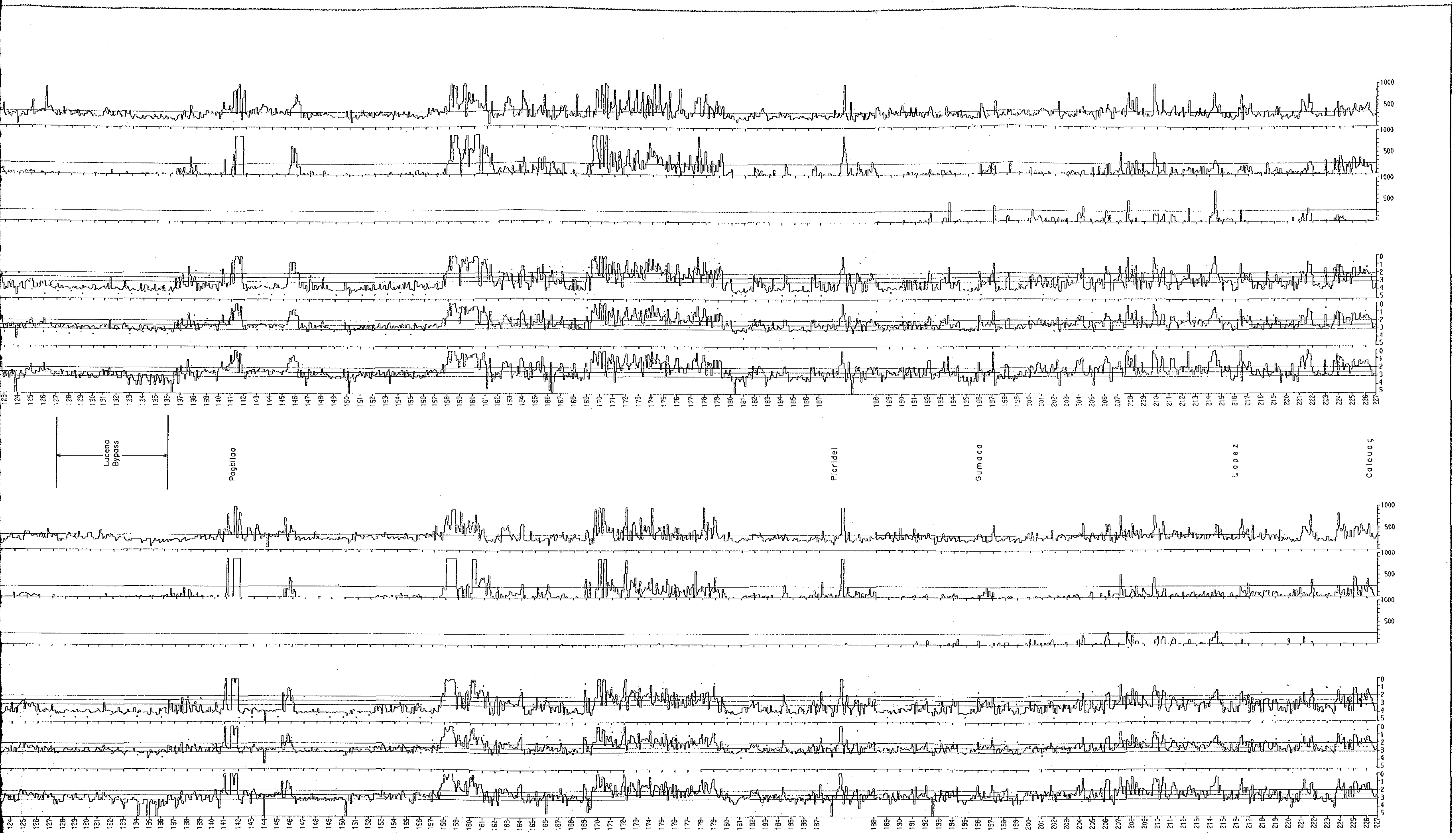
North Study Section ; Sta. Rita - Aritao




Talavera
San Jose
Boundary of Nueva Ecija Nueva Vizcaya
Sta. Fe
Aritao

PAVEMENT SURFACE CONDITION AND EVALUATION
South Study Section ; Calamba - Calauag





Lucena Bypass
Pagbilao
Plaridel
Gumaca
Lopez
Calauag
1000
500
0
1
2
3
4
5