CHAPTER 18

RECOMMENDED REHABILITATION WORKS

18.1 PAVEMENT REHABILITATION

(1) Road length to be rehabilitated

As discussed in Chapter 15, the road length identified for rehabilitation are as follows. See Table 15.4-1.

TABLE 18.1-1 ROAD LENGTH TO BE REHABILITATED

UNIT: km per lane

North Study Section	Length (Km)	RRI ≦ 2.5	2.5 ≦ RRI < 3.0	RRI < 3.0
Segment N-1 (Sta. Rita-Gapan)	46	48.25 (52)	21.45 (23)	22.30 (25)
Segment N-2 (Gapan-Cabanatuan)	35	30.35 (43)	16.60 (24)	23.05 (33)
Segment N-3 (Cabanatuan-San Jose)	42	9.98 (12)	12.09 (14)	61.93 (74)
Segment N-4 (San Jose-Dalton)	38	34.83 (46)	33.68 (44)	7.49 (10)
Segment N-5 (Dalton-Aritao)	39	37.39 (48)	27.37 (35)	13.24 (17)
Sub-Total	200	160.80 (40)	111.19 (28)	128.01 (32)
South Study Section				
Segment S-1 (Calamba-Tiaong)	42	4.51 (5)	14.38 (17)	65.11 (78)
Segment S-2 (Tiaong-Pagbilao)	54	8.13 (8)	9.70 (9)	90.17 (83)
Segment S-3 (Pagbilao-Plaridel)	46	34.90 (38)	13.70 (15)	43.40 (47)
Segment S-4 (Plaridel-Calauag)	39	21.78 (28)	28.78 (37)	27.44 (35)
Sub-Total	181	69.32 (19)	66.56 (18)	226.12 (63)
Total	381			

NOTE:
1) Sections with RRI less than 2.5 require the urgent rehabilitation (Stage 1 under Short Term).
2) Sections with RRI of 2.5 to 3.0 may require the rehabilitation within the short time period. (Stage 2 under Short Term)
3) Section with RRI more than 3.0 may not require the rehabilitation within the foreseeable period. (Medium Term)

(2) Recommended Rehabilitation Methods

Criteria in selecting rehabilitation methods are summarized as follows:

- Wherever possible, two lanes AC overlay is recommended even for the section where one side lane does not require rehabilitation except the following cases.

  - CBR value less than 4
  - CBR value more than 6 and remaining life of one side lane deems to be more than 4 years (RRI may be more than 3.5)

- Where two lane AC overlay is not applicable, one-lane PCC Reconstruction is recommended only for the lane requiring rehabilitation.

- For sections other than mentioned above, two-lanes PCC Reconstruction is recommended.

A rigid overlay over rigid existing is not recommended because of limited available performance data. However, test pilot work is highly recommended.

Engineering discussion on the adoptability of AC overlay over PCC pavement and pavement design are presented in Chapter 22.

It is noted that criteria mentioned above are based on the total discounted cost. If the initial construction costs are given higher priority than the total discounted cost, one lane PCC reconstruction is recommended.

18.2 DRAINAGE SYSTEM

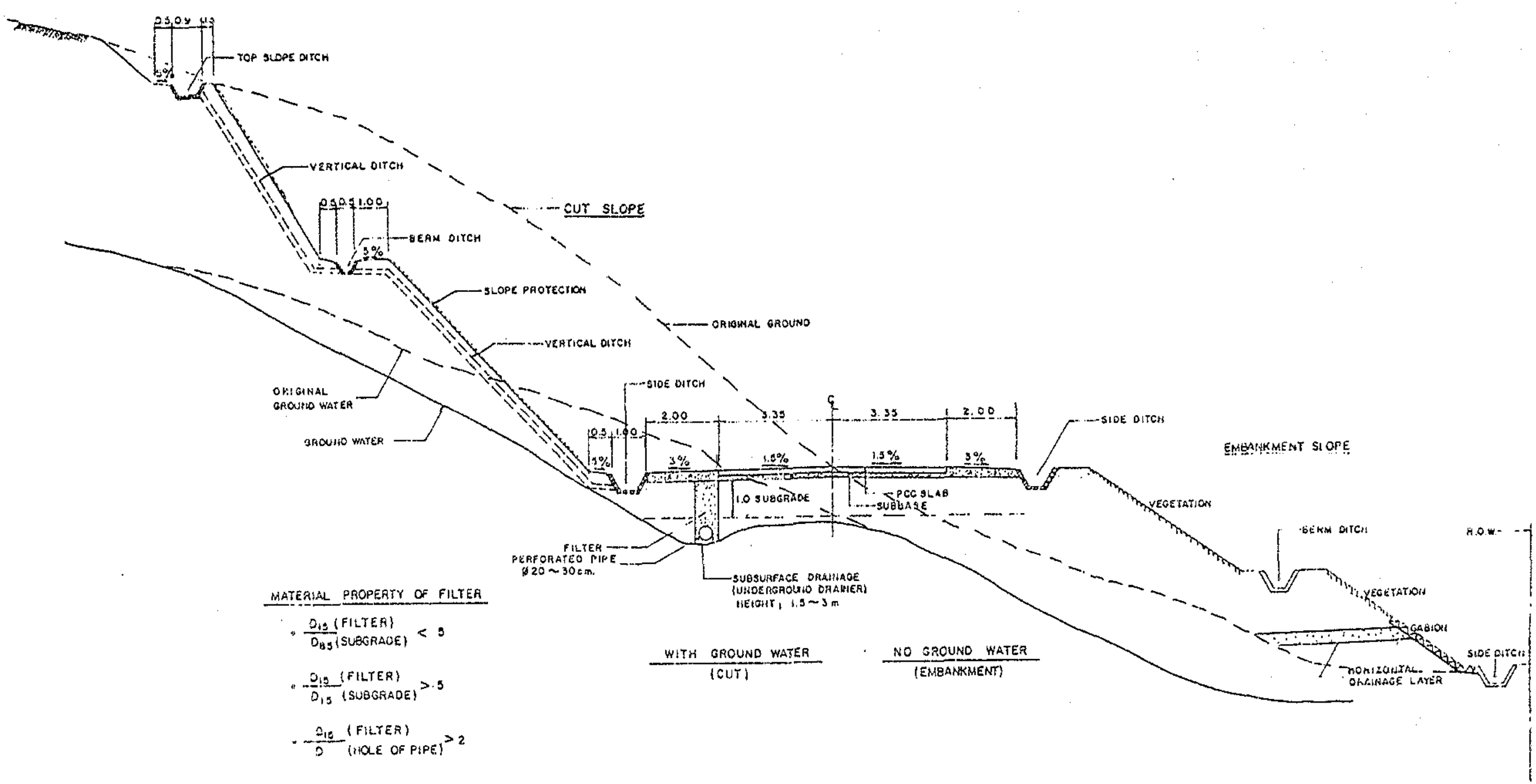
The construction of drainage system requires a lot of initial investment and periodical maintenance. The discussion with the representatives of DPWH were concentrated on the provision of drainage and concluded as follows.

- Surface drainage (side ditch) at the mountain side should be provided where the water from the mountain slope is anticipated to damage concrete pavement.

- Surface drainage (side ditch) at the embankment side may be provided where the scouring of embankment is anticipated.

- Subsurface drainage should be provided wherever the level of groundwater is high so that the subgrade and subbase may be saturated.

Figure 18.2-1 demonstrate the drainage system proposed.



MATERIAL PROPERTY OF FILTER

- $\frac{D_{15}\,(\text{FILTER})}{D_{85}\,(\text{SUBGRADE})} < 5$
- $\frac{D_{15}\,(\text{FILTER})}{D_{15}\,(\text{SUBGRADE})} > 5$
- $\frac{D_{15}\,(\text{FILTER})}{D\,(\text{HOLE OF PIPE})} > 2$

FIGURE 18.2-1 DRAINAGE SYSTEM

18.3 ESTIMATED COSTS

Table 18.3-1 shows the initial costs for pavement rehabilitation and drainage construction roughly estimated based on construction costs per kilometer shown in Table 16.2-1.

The road lengths and methods of pavement rehabilitation were assumed based on investigation data shown in Appendix 22-1. The lengths and types of drainage facilities were also roughly estimated based on the same data.

TABLE 18.3-1 (a) SUMMARY OF PAVEMENT REHABILITATION COST (NORTH STUDY SECTION)

(Unit: Million Peso)

Segment		STAGE 1						STAGE 2						
		Two-Lane PCC Recon-struction	One-Lane PCC Recon-struction (Manila Bound Lane)	One-Lane PCC Recon-struction (Cagayan Bound Lane)	Two-Lane AC Overlay	Improvement of Drainage	Sub-Total	Two-Lane PCC Recon-struction	One-Lane PCC Recon-struction (Manila Bound Lane)	One-Lane PCC Recon-struction (Cagayan Bound Lane)	Two-Lane AC Overlay	Improvement of Drainage	Sub-Total	Total
		Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)
Segment N - 1	Sta. Rita-Plaridel	1.93	2.97			0.24 0.88	105.73			1.89		0.36	34.63	140.36
l=46km	Plaridel-Gapan	28.01 9.03	45.02		9.58	2.60 5.47		3.86	1.48	2.79 3.75		0.50		
Segment N-2 l = 35 km		40.38	3.86	1.89	3.60 13.68	0.69 3.40	67.50	3.91 9.47	1.78	3.30		0.23	18.69	86.19
Segment N-3 l = 42 km		3.91	7.16 8.07			2.73	21.87	5.59	6.90 6.89	3.40		2.01	24.79	46.66
Segment N-4 l = 38 km		1.77 11.36	0.65 30.14		22.81 8.21	8.25 7.29	90.68	1.06 5.96	2.97	0.25 25.09		0.56 1.12	37.01	127.69
Segment N-5 l = 39 km		16.62 13.96	4.34 4.23		30.10	8.53 7.04 21.66	96.48	7.07 10.46	4.45	2.15 11.23	2.74	1.73 2.51	42.34	138.82
TOTAL		126.97	116.64	1.89	87.98	48.78	382.26	47.38	24.47	73.85	2.74	9.02	157.46	539.72

TABLE 18.3-1 (b) SUMMARY OF PAVEMENT REHABILITATION COST (SOUTH STUDY SECTION)

(Unit: Million Pesos)

Segment		STAGE 1						STAGE 2						
		Two-Lane PCC Recon-struction	One-Lane PCC Recon-struction (Manila Bound Lane)	One-Lane PCC Recon-struction (Bicol Bound Lane)	Two-Lane AC Overlay	Improvement of Drainage	Sub-Total	Two-Lane PCC Recon-struction	One-Lane PCC Recon-struction (Manila Bound Lane)	One-Lane PCC Recon-struction (Bicol Bound Lane)	Two-Lane AC Overlay	Improvement of Drainage	Sub-Total	Total
		Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)	Cost (MP)
Segment S-1	Calamba-Sto.Tomas	3.48				0.35 0.15	10.31	6.96	7.12			2.08 0.87	31.91	42.22
1=42km	Sto. Tomas -Tiaong	2.29	2.73			1.31		1.36 5.01	3.73	0.33 2.53		1.92		
Segment S-2 1 = 54 km		5.53 3.63	2.41		1.90 1.20	2.73	17.40	11.71 1.05	1.31	1.16 0.26		2.65	18.14	35.54
Segment S-3 1 = 46 km		56.37	1.05	1.82		3.41 5.27 0.77 3.20	71.89	18.51	4.88			1.27 1.56 0.87 2.56	29.65	101.54
Segment S-4 1 = 39 km		4.62 24.62	0.66 3.63		1.90	6.01	41.44	1.98 42.61		4.09		6.52	55.20	96.64
TOTAL		100.54	10.48	1.82	5.00	23.20	141.04	89.19	17.04	8.37	-	20.30	134.90	275.94

18.4 ECONOMIC INDICATORS

The economic indicators are summarized in Table 18.4-1. These figures were calculated based on the same assumption adopted for the case study.

TABLE 18.4-1 (a) EVALUATION OF PROPOSED PAVEMENT REHABILITATION WORKS (NORTH STUDY SECTION)

Segment		AADT in 1989 Light Veh. / Bus / Truck / Total	No. of ESALs in 1989 Manila Bound Lane/Cagayan Bound Lane ($x 10^6$)	Stage 1				Stage 2				Total			
				Const. Cost (MP)	IRR (%)	dl (km./veh.)	dt (min. veh.)	Const. Cost (MP)	IRR (%)	dl (km./veh.)	dt (min. veh.)	Const. Cost (MP)	IRR	dl (km./veh.)	dt (min. veh.)
Segment N-1 (Sta. Rita-Gapan) l = 46 km	Sta. Rita-Plaridel	9.070 950 2,490 12,510	3.50/1.45 (J/F)	105.73	121.0	13.0	19.6	34.63	168.2	6.6	9.5	140.36	124.6	19.6	29.1
	Plaridel-Gapan	4,540 950 1,770 7,260	2.91/1.10 (I/E)												
Segment N-2 (Gapan-Cabanatuan) l = 35 km		4,830 700 1,620 7,150	2.95/0.96 (I/E)	67.50	13.4	6.0	9.7	18.69	139.8	2.1	3.2	86.19	115.3	8.1	12.9
Segment N-3 (Cabanatuan-San Jose) l = 42 km		3,040 570 1,270 4,880	2.46/0.76 (H/D)	21.87	65.9	3.3	5.2	24.79	79.7	4.0	6.2	46.66	70.3	7.3	11.4
Segment N-4 (San Jose-Dalton) l = 38 km		1,600 240 940 2,780	1.79/0.52 (G/D)	90.68	36.5	11.1	15.3	37.01	51.0	7.1	9.3	127.69	39.3	18.2	24.6
Segment N-5 (Dalton-Aritao) l = 39 km		1,600 240 940 2,780	1.79/0.52 (G/D)	96.48	35.5	9.8	13.7	42.34	46.5	5.9	8.0	138.82	37.8	15.7	21.7
Total l = 200 km				382.26	69.5	43.2	63.5	157.46	83.2	25.7	36.2	539.72	71.6	68.9	99.7

TABLE 18.4-1 (b) EVALUATION OF PROPOSED PAVEMENT REHABILITATION WORKS (SOUTH STUDY SECTION)

Segment		AADT in 1989 Light Veh. Bus Truck Total	No. of ESALs in 1989 Manila Bound Lane/Bicol Bound Lane ($x10^6$)	Stage 1				Stage 2				Total			
				Const. Cost (M₱)	IRR (%)	dl (km./veh.)	dt (Min./veh.)	Const. Cost (M₱)	IRR (%)	dl (km./veh.)	dt (min./veh.)	Const. Cost (M₱)	IRR (%)	dl (km./veh.)	dt (min./veh.)
Segment S-1 (Calamba-Tiaong) l = 42 km	Calamba-Sto. Tomas	10,800 1,340 2,060 14,200	1.75/1.26 (G/F)	10.31	138.2	1.0	1.6								
				10.31	138.2	1.0	1.6								
	Sto. Tomas-Tiaong	5,260 580 1,300 7,140	1.09/0.64 (E/D)					31.91	187.5	3.9	5.9	42.22	156.4	4.9	7.5
Segment S-2 (Tiaong-Pagbilao) l = 54 km		3,310 610 1,120 5,040	0.97/0.58 (E/D)	17.40	79.5	1.8	2.7	18.14	85.0	1.9	2.7	33.54	81.1	3.7	5.4
Segment S-3 (Pagbilao-Plaridel) l = 46 km		1,390 510 750 2,650	0.79/0.48 (D/C)	71.89	41.5	6.8	9.0	29.65	42.2	3.1	4.1	101.54	41.6	9.9	13.1
Segment S-4 (Plaridel-Calauag) l = 39 km		1,130 300 710 2,140	0.71/0.41 (D/C)	41.44	33.5	4.5	5.9	55.20	37.0	5.8	7.7	96.64	35.1	10.3	13.6
Total l = 181 km				141.04	48.7	14.1	19.2	134.90	70.1	14.7	20.4	275.94	55.3	28.8	39.6

PART V PRIORITIZATION

CHAPTER 19

RELATIVE PRIORITY OF SEGMENTS

19.1 ESTABLISHMENT OF ROAD SEGMENTS

(1) Factors to be considered

In order to evaluate priority and then select segments for a feasibility study, the Study Section was divided into segments. In dividing the Study Section into homogenous segments, the following factors were considered:

1) Even length of a segment

In order to provide an even basis for evaluation, the Study Section should be divided into an equal length of segments as much as possible.

2) Boundaries

Boundaries of Region, Province or DPWH district engineering offices were considered appropriate for boundary of segment because their boundaries generally coincide with boundaries of project implementation agencies.

3) Topography/Terrain

Change in topography/terrain which causes different problems, is one of the factors for segmentation.

4) Traffic Volume

In characterizing and assessing a segment, traffic volume should be the same throughout a segment as much as possible.

5) Location of Problem Areas

Areas which have same kinds of problems or same kinds of causes of problem should be grouped as much as possible.

(2) Proposed Segments

Segments are established as shown in Table 19.1-1 and illustrated in Figures 19.1-1 and 2.

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TABLE 19.1-1 ESTABLISHED SEGMENTS

Segment No.	Km - Km	Segment Length (Km)	Remarks
North Section			
N – 1	Km 39 – Km 85	46	Sta. Rita-Gapan
N – 2	Km 85 – Km 120	35	Gapan-Cabanatuan
N – 3	Km 120 – Km 162	42	Cabanatuan-San Jose
N – 4	Km 162 – Km 200	38	San Jose-Dalton Pass
N – 5	Km 200 – Km 239	39	Dalton Pass-Aritao
South Section			
S – 1	Km 52 – Km 92	42[x]	Calamba-Tiaong
S – 2	Km 92 – Km 146	54	Tiaong-Pagbilao
S – 3	Km 146 – Km 188	46[x]	Pagbilao-Gumaca
S – 4	Km 188 – Km 227	39	Gumaca-Calauag

NOTE: x Net segment length is longer than length indicated by km. posts due to duplicated km. posts.

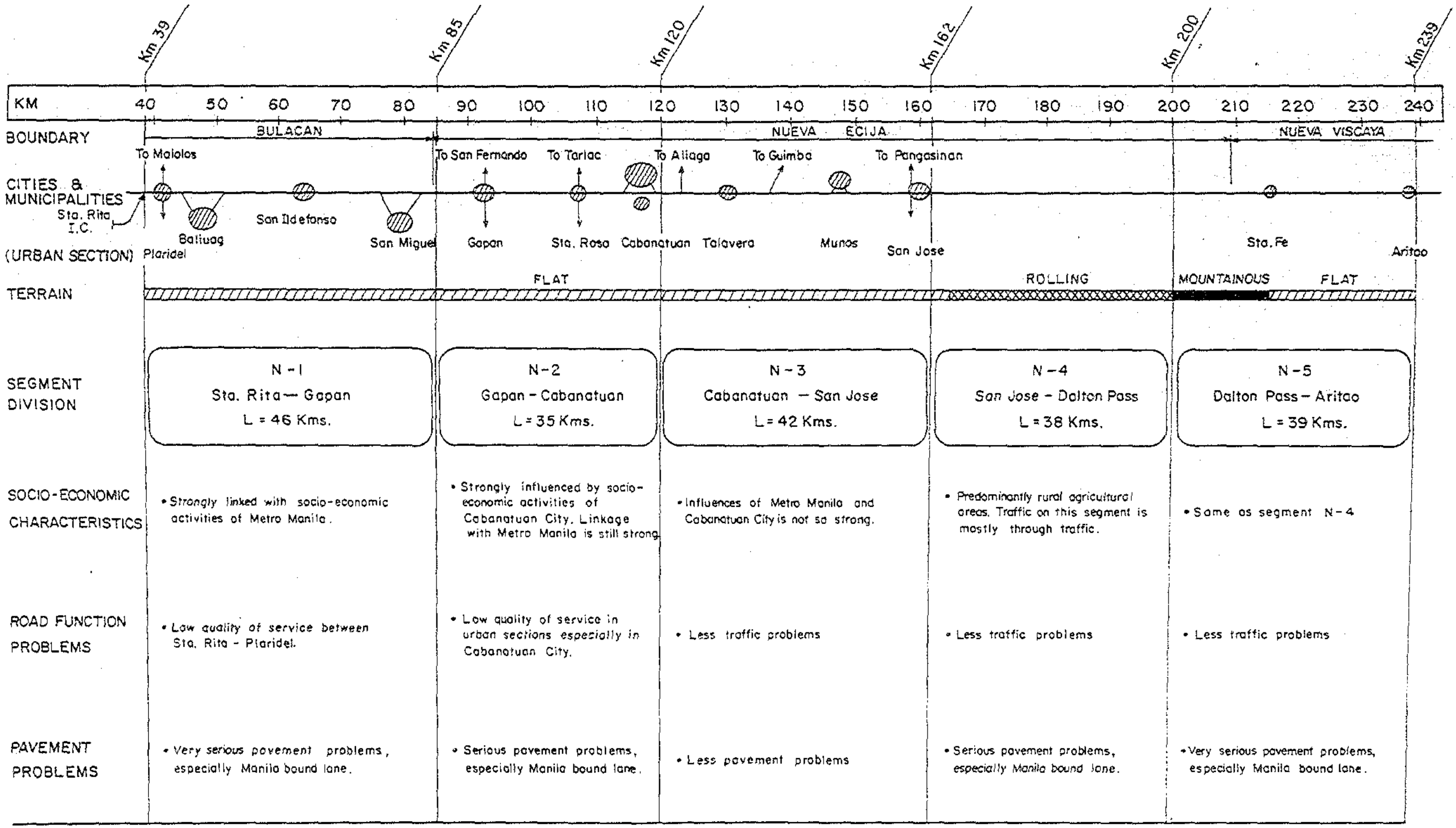
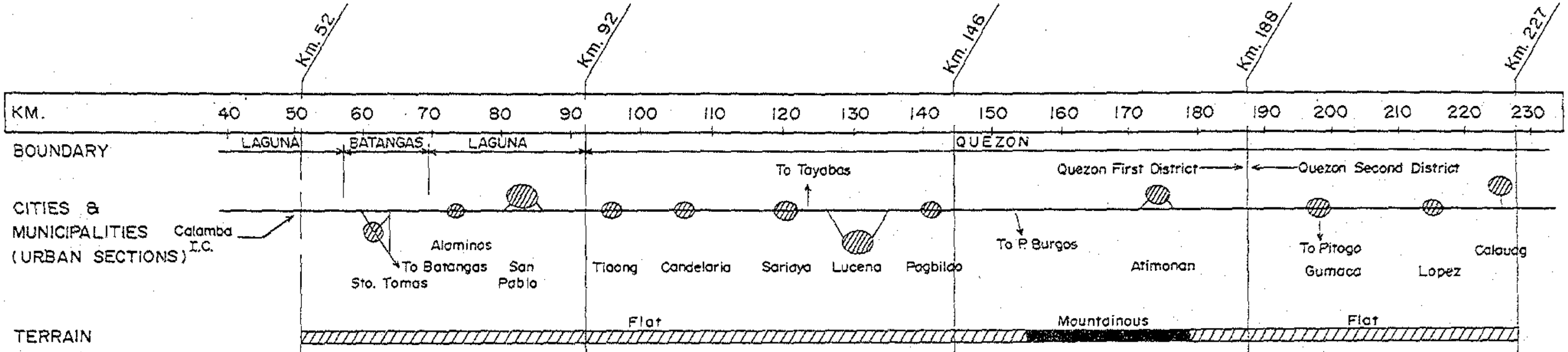


FIGURE 19.1-1 SEGMENTATION OF NORTH SECTION



	S – 1	S – 2	S – 3	S – 4
SEGMENT DIVISION	Calamba – Tiaong L = 42 kms.	Tiaong – Pagbilao L = 54 kms.	Pagbilao – Gumaca L = 46 kms.	Gumaca – Calauag L = 39 kms.
SOCIO – ECONOMIC CHARACTERISTICS	• Greatly influenced by Socio - economic activities of Metro Manila, Batangas City and San Pablo City.	• Strong influence of Metro Manila is up to Lucena City. Small urban areas are scattered at an interval of about 10 kms.	• Predominantly rural agricultural area. Traffic on this segment is mostly through traffic.	• Predominantly rural agricultural area. Small urban areas are formed at Gumaca and Lopez.
ROAD FUNCTION PROBLEMS	• Rural section between Calamba and Sto. Tomas has low quality of service.	• Less traffic problems.	• Less traffic problems.	• Less traffic problems.
PAVEMENT PROBLEMS	• Less pavement problems.	• Less pavement problems.	• Contains serious pavement problems.	• Contains pavement problems.

FIGURE 19.1-2 SEGMENTATION OF SOUTH SECTION

19.2 RELATIVE PRIORITY OF SEGMENTS

Dealt with in this Study are two (2) different nature of problems, i.e, road function problems and pavement deficiencies, both of which exist in each segment with variety of magnitude. To determine relative priority of segments, the relative priority on both problems of each segment were independently evaluated and then combined for the overall evaluation. Focused in evaluating are the following two (2) factors.

- Severity of Deterioration
- Economic Viability

(1) Independent Evaluation of Relative Priority

1) Relative Priority Based on Severity of Deterioration

With regard to severity of deterioration, road function sector and pavement sector were independently evaluated using the following criteria:

Road Function

Relative Priority	Length (in kms.) of sections of which level of service is lower than improvement level
a	more than 5.0
b	3.0 – 5.0
c	less than 3.0

Pavement

Relative Priority	Length (in lane-kms) of totally damaged section
a	more than 9.0
b	4.0 – 9.0
c	less than 4.0

2) Relative Priority Based on Economic Viability

Internal rate of return (%) was commonly used both for road function sector and pavement sector to evaluate relative priority. Criterion used was shown below.

Road Function and Pavement

Relative Priority	Internal Rate of Return (%)
a	more than 60
b	30 – 60
c	less than 30

The evaluation are summarized in Table 19.1-1 and 19.1-2 for the North and the South Study Sections, respectively.

(2) Relative Priority Combined for Road Function and Pavement

Based on the above criterion, road function sector and pavement sector were evaluated independently, then combined to determine relative priority of segments based on severity of deterioration and economic viability.

Relative Priority of Segments Based on Severity of Deterioration (Relative Priority — I)

		Pavement Priority		
		a	b	c
Road Function Priority	a	A	A	B
	b	A	B	C
	c	B	C	C

Relative Priority of Segments Based on Economic Viability

(Relative Priority — II)

		Pavement Priority		
		a	b	c
Road Function Priority	a	A	A	B
	b	A	B	C
	c	B	C	C

(3) Overall Relative Priority of Segments

Relative priorities I and II were combined to determine overall relative priority of segments. Evaluation criteria were established giving rather higher priority on severity of deterioration than economic viability.

Overall Relative Priority

		Economic Viability		
		A	B	C
Severity of Deterioration	A	1	1	2
	B	1	2	2
	C	3	3	3

Table 19.2-3 shows the relative priority combined for road function and pavement and summarizes the overall relative priority of segments, as shown below.

Overall Relative Priority	Segment	
1 (First Priority)	N-1:	Sta. Rita – Gapan
	N-2:	Gapan – Cabanatuan
	S-1:	Calamba – Tiaong
2 (Second Priority)	N-5:	Dalton Pass – Aritao
	S-3:	Pagbilao – Gumaca
3 (Third Priority)	N-3:	Cabanatuan – San Jose
	N-4:	San Jose – Dalton Pass
	S-2:	Tiaong – Pagbilao
	S-4:	Gumaca – Calauag

TABLE 19.2-1 INDEPENDENT EVALUATION OF RELATIVE PRIORITY – NORTH SECTION –

SEGMENT				N – 1 (Sta. Rita – Gapan)	N – 2 (Gapan – Cabanatuan)	N – 3 (Cabanatuan – San Jose)	N – 4 (San Jose – Dalton Pass)	N – 5 (Dalton Pass – Aritao)	TOTAL
SEGMENT LENGTH (Km.)				46	35	42	38	39	200
Road Function Improvement	Evaluation based on Improvement Requirements	Present Condition	Rural Section (Kms.): Latter stage of LOS D or below	2.0	—	—	—	—	2.0
			Urban Section (Kms.): Early stage of LOS E or below	1.5 + (1.0)	8.5 + (1.0)	1.5 + (1.0)	—	—	11.5 + (3.0)
			Intersection (each): Early stage of LOS E or below	1	3 + (1)	1	—	—	5 + (1)
		EVALUATION		b	a	c	c	c	—
	Evaluation from Economic Viewpoints	Effects and Economics of Improvement Measures	• Cost (Million ₱)	98.9	116.9	26.0	—	—	241.8
			• IRR (%)	18.1	53.1	18.5	—	—	31.2
			• dl Savings in 1989 (10^3 veh. km / day)	2.57	12.58	2.10	—	—	17.25
			• dt Savings in 1989 (10^3 veh. hr / day)	0.43	2.27	0.27	—	—	2.97
		EVALUATION		c	a	c	c	c	—
Pavement Rehabilitation	Evaluation based on Rehabilitation Requirements	Present Condition	Proposed Rehabilitation Section (lane – km) RRI ≦ 2.5	48.3	30.4	10.0	34.8	37.4	160.8
			Totally Damaged Section (lane – km) RRI ≦ 1.5	11.3	6.0	1.3	5.9	9.1	33.6
		EVALUATION		a	b	c	b	a	
	Evaluation from Economic Viewpoints	Effects and Economics of Rehabilitation	• Cost (Million ₱)	105.7	67.5	21.9	90.7	96.5	382.3
			• IRR (%)	121.0	134.2	65.9	36.5	36.5	69.5
			• dl Savings in 1989 (10^3 veh. km / day)	93.3	42.7	15.5	27.4	26.3	205.2
			• dt Savings in 1989 (10^3 veh. hr / day)	2.35	1.14	0.40	0.65	0.61	5.15
		EVALUATION		a	a	a	b	b	—

Note : Figure in ( ) shows length of section or number of intersection recommended for improvement, although level of service is still higher than improvement level.

TABLE 19.2-2 INDEPENDENT EVALUATION OF RELATIVE PRIORITY – SOUTH SECTION –

SEGMENT				S – 1 (Calamba – Tiaong)	S – 2 (Tiaong – Pagbilao)	S – 3 (Pagbilao – Gumaca)	S – 4 (Gumaca – Calauag)	TOTAL
SEGMENT LENGTH (Km.)				42	54	46	39	181
Road Function Improvement	Evaluation based on Improvement Requirements	Present Condition	Rural Section (Kms.): Later Stage of LOS D or Below	10.0	–	–	–	10.0
			Urban Section (Kms): Early Stage of LOS E or Below	(1.2)	(4.7)	–	(2.5)	(8.4)
			Intersection (each): Early Stage of LOS E or Below	(2)	–	–	–	(2)
		EVALUATION		a	c	c	c	–
	Evaluation from Economic Viewpoints	Effects & Economics of Improvement Measures	• Cost (Million ₱)	66.5	9.0	–	6.1	81.6
			• IRR (%)	39.8	–	–	–	39.8
			• dl Savings in 1989 (10^3 veh. km/day)	15.75	–	–	–	15.75
			• dt Savings in 1989 (10^3 veh. km/day)	0.65	–	–	–	0.65
		EVALUATION		b	c	c	c	–
Pavement Rehabilitation	Evaluation based on Rehabilitation Requirements	Present Condition	Proposed Rehabilitation Section (lane – km) RRI ≦ 2.5	4.5	8.1	34.9	21.8	69.3
			Totally Damaged Section (lane – km) RRI ≦ 1.5	0.1	2.0	11.0	4.0	17.1
		EVALUATION		c	c	a	b	–
	Evaluation from Economic Viewpoints	Effects & Economics of Rehabilitation	• Cost (Million ₱)	10.3	10.4	71.9	41.4	141.0
			• IRR (%)	150.2	79.5	41.5	32.5	48.7
			• dl Savings in 1989 (10^3 veh. km/day)	8.8	9.0	17.8	9.2	44.8
			• dt Savings in 1989 (10^3 veh. hr./day)	0.23	0.22	0.39	0.20	1.04
		EVALUATION		a	a	b	b	–

Note : Figure in ( ) shows length of section or number of intersection recommended for improvement, although level of service is still higher than improvement level.

TABLE 19.2-3 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 (55.4)	C	(2) 1*	F/S Segment
	S - 4	c (-)	b (4.0)	C	c (-)	b (44.4)	C	3	—

(EVALUATION CRITERIA) ⇨

Section Length of which LOS is lower than Improvement Level	Totally Damaged Section	Combined Evaluation	Internal Rate of Return (IRR)	Combined Evaluation	Combined Evaluation (Severity / Economic)
a : more than 5 Kms.	a : more than 9 Kms.	A : aa, ab, ba	a : more than 60%	A : aa, ab, ba	1 : A A, A B, B A
b: 3.0 Kms. - 5.0 Kms.	b : 4 Kms-9Kms	B : ac, bb, ca	b : 30% - 60 %	B : ac, bb, ca	2 : A C, B B, B C
c : less than 3.0 Kms.	c : less than 4 Kms.	C : bc, cb, cc	c : less than 30 %	C : bc, cb, cc	3 : C A, C B, C C

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

19.3 ECONOMIC INDICATORS OF IMPROVEMENT/REHABILITATION WORKS

Relations between economic indicators and improvement/rehabilitation works are summarized hereunder. These were developed based on case studies and could be utilized or used as reference for other similar nature studies.

19.3.1 Road Function Improvement Works

Figure 19.3-1 shows relationship between IRR and opening year traffic volume by type of improvement work. Widening of a 2-lane road to a 4-lane road would be economically feasible when traffic volume exceeds 10,000 veh./day under the normal condition. Construction of a bypass would be justified economically when opening year traffic volume exceeds 15,000 veh./day.

Figure 19.3-2 shows relationship between IRR and V/C ratio by type of improvement work. Widening of a 2-lane road to a 4-lane road would be economically viable when V/C ratio of existing road reaches to about 0.4 or at level of service D. Construction of a bypass would be economically feasible when V/C ratio of existing section reaches to 0.65 or at level of service E.

19.3.2 Pavement Rehabilitation Works

Figure 19.3-2 shows the relationship between construction cost and AADT. Construction cost is dependent on traffic loading class and subgrade CBR.

The internal rates of return (IRR) are plotted in Figure 19.3-4 against AADT in the opening year. From this figure, found are the following:

- IRRs are closely correlated with AADT in any rehabilitation method. They increase remarkably with the increase of AADT.

- Little difference is found between IRRs in 2-lane PCC reconstruction and in 1-lane PCC reconstruction.

- For the same AADT, 2-lane AC overlay shows a higher IRR than 2-lane/1-lane PCC reconstruction. It is due to lower initial construction cost.

Figures 19.3-5 and 19.3-6 show the relationships between dl/dt-values and AADT and between dl-/dt-values and heavy vehicle composition, respectively. The findings in these figures are as follows:

- Both dl- and dt-values per vehicle are well correlated with heavy vehicle composition. The dl-values increases and the dt-values decreases as heavy vehicle composition becomes higher.

  Both values are also correlated with AADT as a result of the correlation found in the study sections between AADT and heavy vehicle composition.

- The dl-and dt-values are the highest in case of 1-lane PCC reconstruction and the lowest in case of 2-lane AC overlay. The lower dl-and dt-values in AC overlay are due to its shorter performance period. The difference in the dl-and dt-values between 2-lane and 1-lane PCC reconstructions are

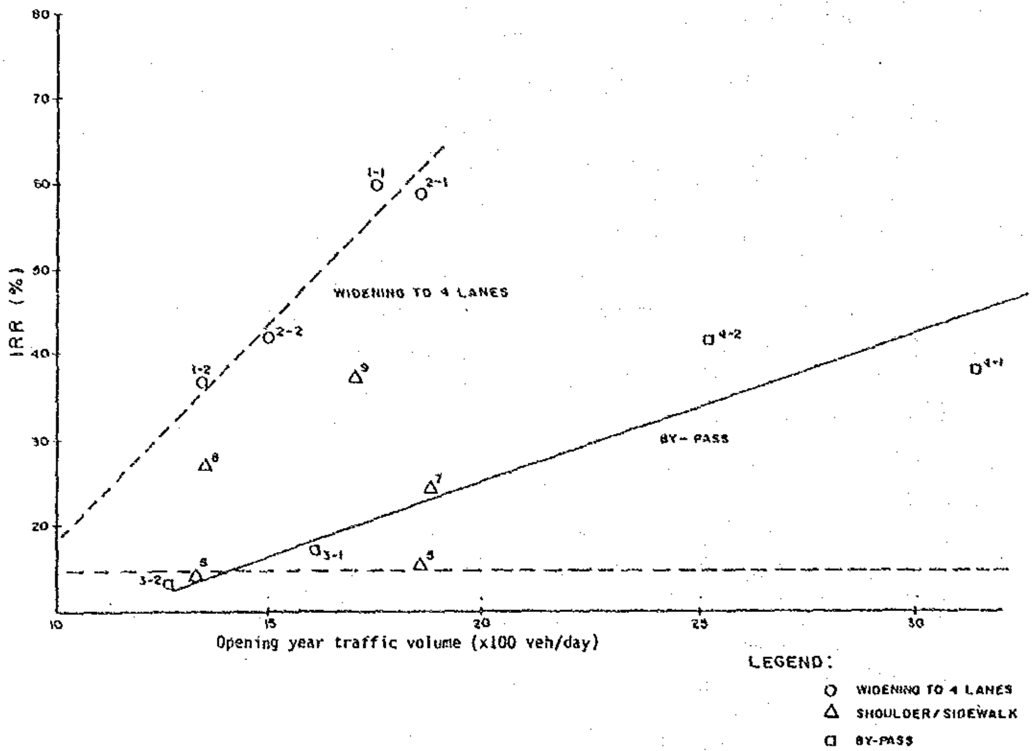


FIGURE 19-3-1 RELATIONSHIP BETWEEN IRR AND OPENING YEAR TRAFFIC VOLUME BY TYPE OF IMPROVEMENT WORK

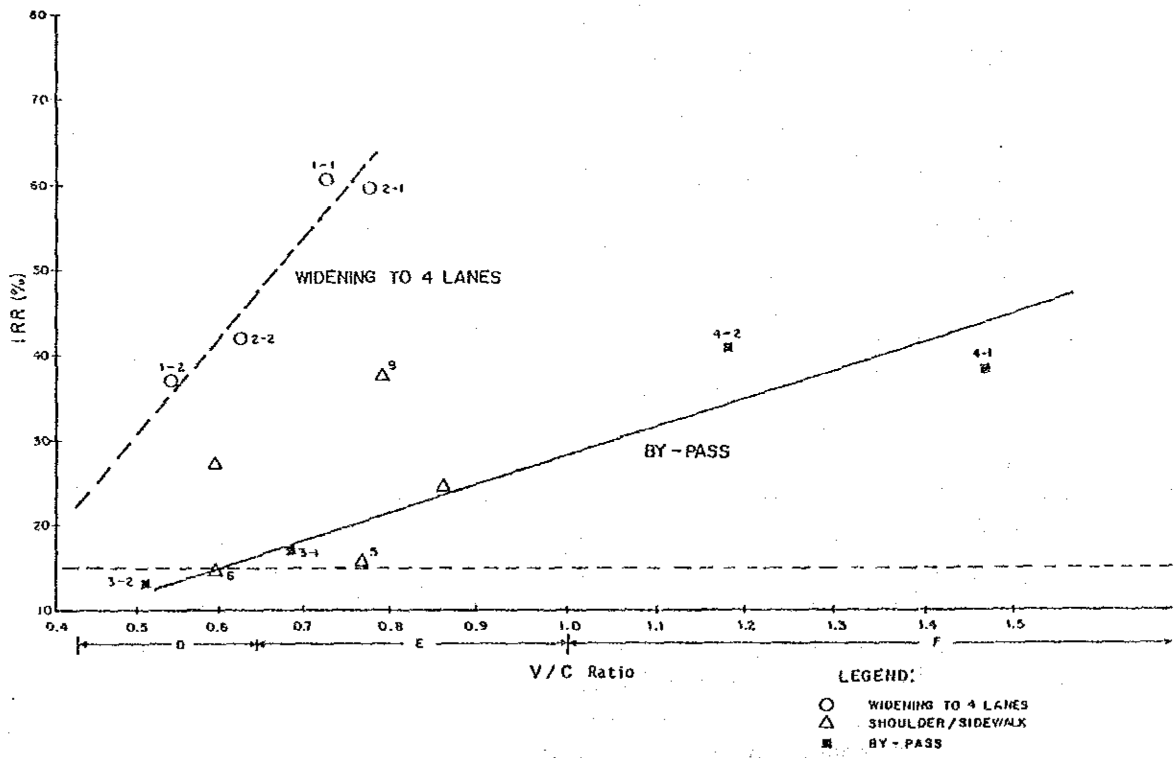


FIGURE 19.3-2 RELATIONSHIP BETWEEN IRR AND V/C RATIO BY TYPE OF IMPROVEMENT WORK

caused by the different assumptions made for the succeeding rehabilitation methods. In case of 2-lane PCC Reconstruction, the future rehabilitations are assumed to be carried out by AC overlay method, while in case of 1-lane PCC reconstruction, the same methods are assumed to be repeated individually for each lane. PCC reconstruction has a longer performance period than AC overlay and accordingly the average performance period in 1-lane PCC reconstruction is longer than that in 2-lane PCC reconstruction.

These figures may be used for planning of the similar projects to roughly estimate construction cost, IRR and dI-/dt values.

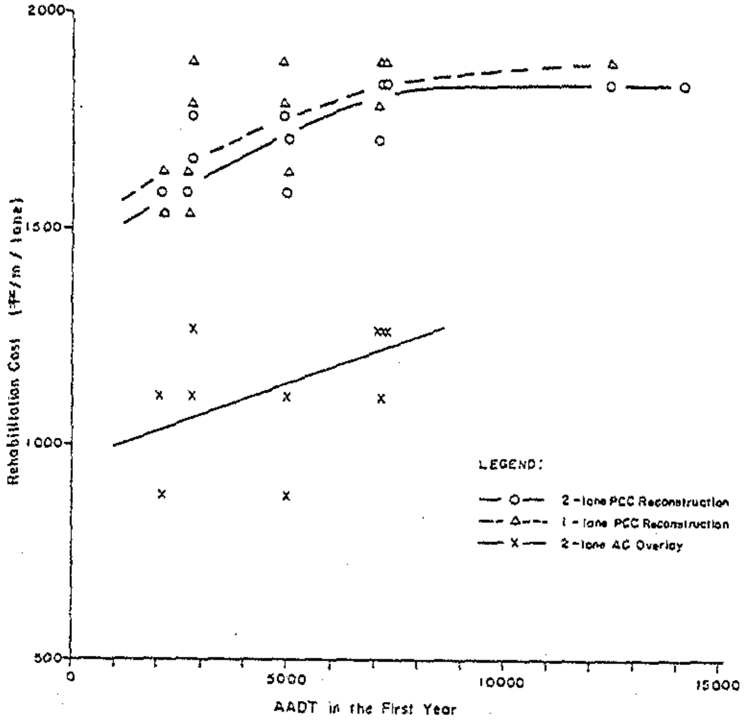


FIGURE 19-3-3 RELATIONSHIP BETWEEN AADT AND REHABILITATION COST

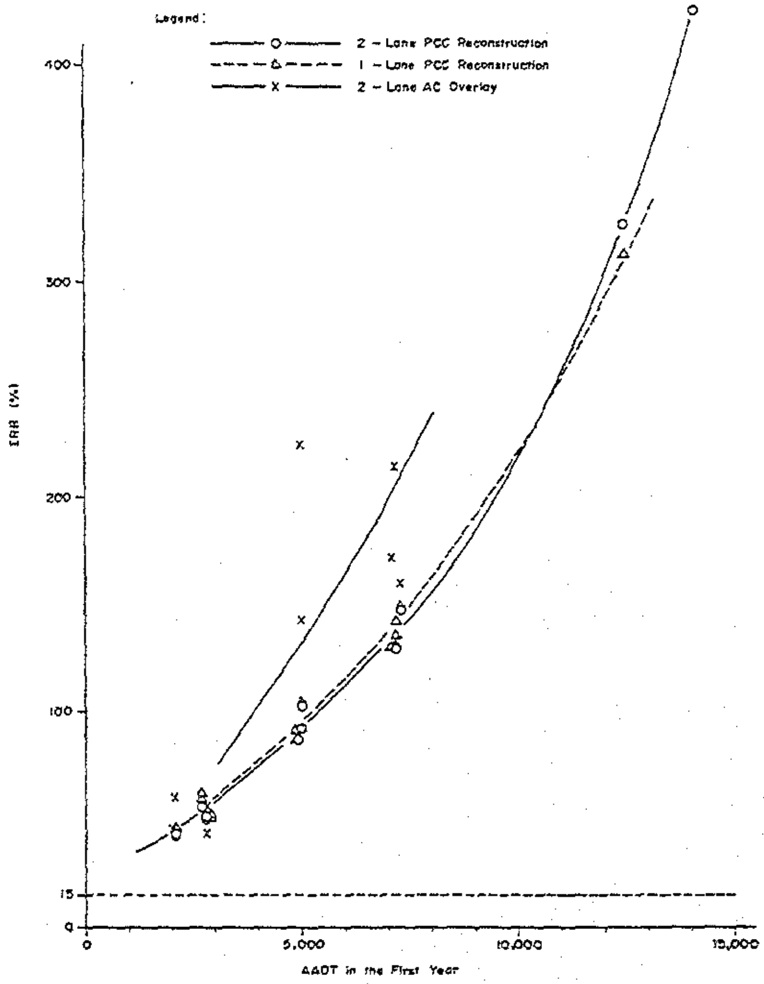


FIGURE 19.3-4 RELATIONSHIP BETWEEN AADT AND IRR

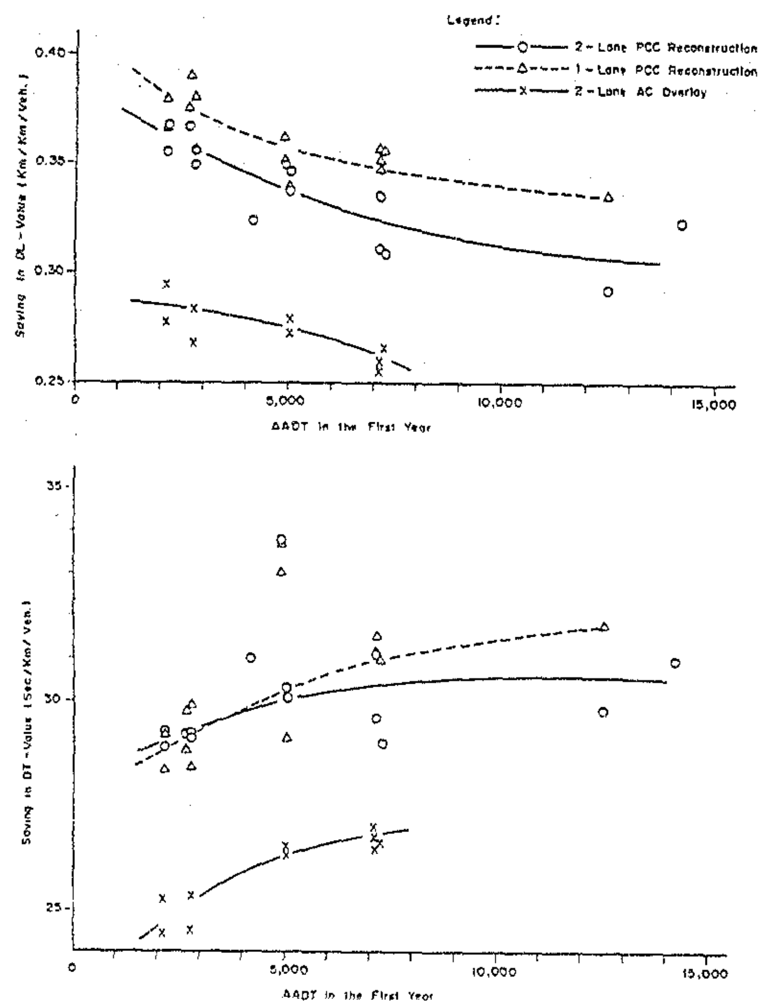


FIGURE 19.3-5 RELATIONSHIP BETWEEN AADT AND DL-/DT-VALUES

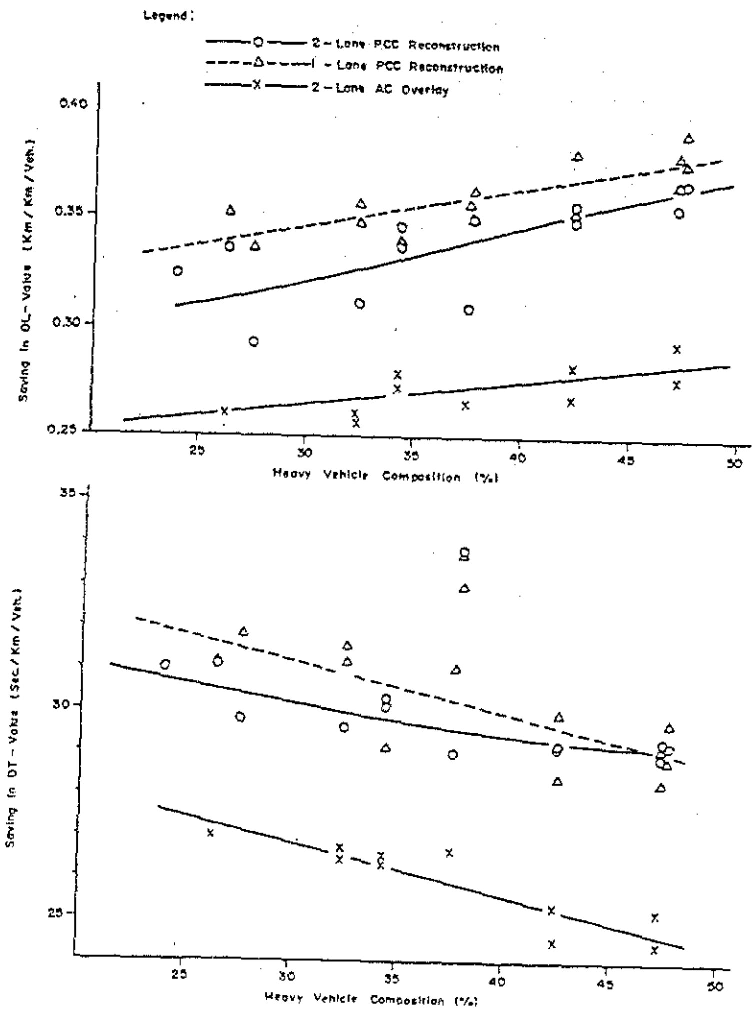


FIGURE 19.3-6 RELATIONSHIP BETWEEN HEAVY VEHICLE COMPOSITION AND DL-/DT-VALUES

CHAPTER 20

SELECTION OF SEGMENTS FOR FEASIBILITY STUDY

20.1 SELECTION CRITERIA

Among nine (9) segments, five (5) for the North and four (4) for the South Study Sections, the several segments were to be selected for the detailed Feasibility Study.

The following considerations were given priority in evaluating the segments.

(1) Segments with high relative priority

As discussed in Chapter 19.2, the following segments are listed in view of high relative priority.

N-1;	Sta. Rita – Gapan
N-2;	Gapan – Cabanatuan
N-5;	Dalton Pass – Aritao
S-1;	Calamba – Tiaong
S-3;	Pagbilao – Gumaca

(2) Segments with representative improvement/rehabilitation works

Road Function

As to the North Study Section, N-1 involves all improvement works. The detailed discussion on traffic function in Cabanatuan City (N-2) was desired.

While, S-1 includes all improvement works proposed for the South Study Section.

Pavement

As far as the road lengths proposed for the pavement rehabilitation, N-5 shows the longest section followed by N-1, N-4, and N-2. N-3 has the shortest among the North Study Section.

As to the South, S-3 and S-4 has almost the same length which is longer than S-1 and S-2.

The types of pavement deterioration of the North and South are quite different, primarily traffic loads related cracks for the former and material qualities related deterioration for the latter. The pavement rehabilitation methods may differ accordingly.

(3) Environmental Conditions

Other factors considered were the environmental conditions such as topographies, road types, traffic loadings, CBR values, drainage conditions, etc.

20.2 RECOMMENDED FEASIBILITY STUDY SEGMENTS

The characteristics of each segment are summarized in Table 20.2-1.

TABLE 20.2-1 CHARACTERISTICS OF SEGMENTS

Segment No.	Relative Priority	Improvement Works	Rehabilitation Works	Other Characteristics
N-1	1	. Intersection . Widening to a 4-lane . Bypass . Paving of shoulders and sidewalks	. 2-lane PCC Reconstruction . 1-lane PCC Reconstruction . 2-lane AC overlay	. Flat . Mostly embankment sections
N-2	1	. Intersection . Bypass . Paving of shoulders and sidewalks	. Same as N-1	. Same as N-1
N-3	3	. Intersection . Paving of shoulders and sidewalks	. 2-lane PCC Reconstruction . 1-lane PCC Reconstruction	. Same as N-1
N-4	3	No proposed improvement work	. Same as N-1	. Rolling . Cut sections or cut and embankment sections
N-5	2	No proposed improvement work	. Same as N-1	. Mountainous and flat . Cut sections or cut and embankment sections . Special consideration for subsurface drainage needed
S-1	2	. Widening to a 4-lane . Intersection . Paving of shoulder and sidewalks	. Same as N-1	. Flat . Road level is mostly same as existing ground level
S-2	3	. Paving of shoulders and sidewalks	. Same as N-1	. Same as S-1
S-3	1	. No proposed improvement work	. 2-lane PCC Reconstruction . 1-lane PCC Reconstruction	. Mountainous and flat . Cut and embankment sections or cut sections . Special consideration for subsurface drainage needed
S-4	3	. Paving of shoulders and sidewalks	. Same as N-1	. Flat . Embankment section

Through the discussion with representatives of DPWH based on findings, the following five (5) segments were recommended for the Feasibility Study.

Recommended Feasibility Study Segments

N-1: Sta. Rita – Gapan
N-2: Gapan – Cabanatuan
N-5: Dalton Pass – Aritao
S-1: Calamba – Tiaong
S-2: Pagbilao – Gumaca

PART VI FEASIBILITY STUDY

CHAPTER 21

FEASIBILITY STUDY ON ROAD FUNCTION IMPROVEMENT

21.1 PRELIMINARY DESIGN

21.1.1 Field Survey

Center line, profile, cross-section and topographic surveys were conducted along the proposed bypass routes.

- Plaridel Bypass .... L = 4.8 kms.
- Alternative route for Cabanatuan Urban Section. . . L = 7.2 kms.

Topographic surveys for the following intersections were also conducted:

North Study Section

- Plaridel Intersection (Km. 41 + 700)
- Baliuag Bypass Intersection (Km. 54 + 500)
- Gapan Intersection (Km. 93 + 900)
- Cabanatuan Intersection II, junction with Mabini Street (Km. 115 + 700)
- Cabanatuan Intersection IV, junction with del Pilar Street (Km. 116 + 600)

South Study Section

- Sto. Tomas Intersection I (Km. 60)
- Sto. Tomas Intersection II (Km. 61)

Straight road diagrams prepared by the Study Team were utilized for preliminary design of improvement projects of the existing section.

21.1.2 Rural Section

Improvement of two (2) sections were studied.

- Sta. Rita – Plaridel Section (Segment N-1)
- Calamba – Sto. Tomas Section (Segment S-1)

1) Sta. Rita – Plaridel Section

Present Condition

This section is the nearest section to Metro Manila (39 kms from Manila) in the North Section and linked with the North Luzon Expressway at Sta. Rita. The section extends only for two (2) kms between Sta. Rita and Plaridel.

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The section is a 2-lane highway with PCC pavement of 6.7 meters and shoulders of 2.0 meters. Existing road right-of-way ranges from 14.0 meters to 16 meters. Roadside development is medium density, mixture of residential houses and small stores are classified as suburban area.

In 1986, traffic volume was 10,750 vehicles per day. Cars have predominant share of 49%, followed by trucks (21%) and jeepneys (18%). Peak hour was observed between 9:00 A.M. to 10:00 A.M. and peak hour traffic volume was 727 vehicles. Peak hour ratio (ratio of peak hour traffic volume to total daily traffic) was 6.8%. Hourly traffic volume fluctuation from 7:00 A.M. to 7:00 P.M. was small, and almost same traffic volume (600-700 vehicles per hour) runs on the section. Difference of directional distribution of traffic was also quite small. Both directions have almost same traffic volume. Travel speeds ranged from 40 to 45 kms. per hour.

Traffic volumes and levels of services for years 1986, 1990, 2000 and 2010 are shown in Table 21.1-1.

TABLE 21.1-1 TRAFFIC VOLUME AND LEVEL OF SERVICE (STA. RITA – PLARIDEL SECTION)

Unit: Vehicle Per Day

Vehicle Type	Year 1986	1990	2000	2010
Car	5,248 (49)	6,468 (49)	11,903 (51)	21,840 (53)
Jeepney	1,954 (18)	2,343 (18)	3,832 (17)	6,120 (15)
Bus	825 (8)	982 (7)	1,570 (7)	2,456 (6)
Truck	2,248 (21)	2,813 (21)	4,907 (21)	8,830 (22)
Tricycle	475 (4)	604 (5)	964 (4)	1,570 (4)
TOTAL	10,750 (100)	13,228 (100)	23,176 (100)	40,816 (100)
Level of Service	D	D	E	F

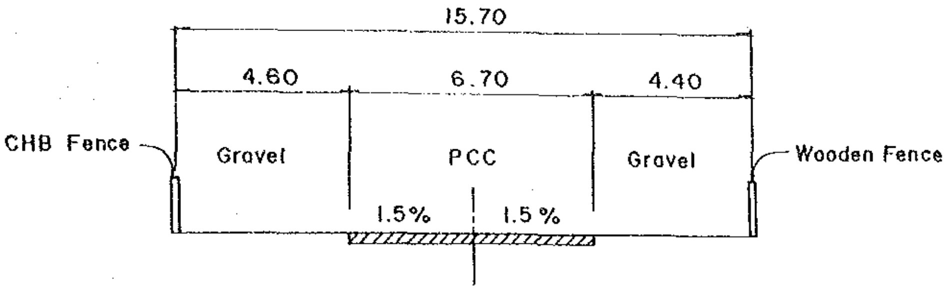
Proposed Improvement Measures

Widening to a 4-lane road was proposed for this section. Major factors considered for selection of improvement measures are as follows:

- Average width of existing right-of-way is only about 15 meters.
- Residential houses and small stores are built along the section.

- The section extends for only 2 kms. and Plaridel Urban SEction which has serious traffic problems, is located adjacent to this section, improvement of this section should be implemented simultaneously with the improvement of Plaridel Urban Section.

Based on the straight road diagram, it was concluded that acquisition of an average 2.5 meters land on each side will be practically possible. Cross section of a 4-lane road was designed on the basis of right-of-way width of 20 meters, as shown in Figure 21.1-1.



Typical Existing Cross Section Along Sta. Rita – Plaridel Section

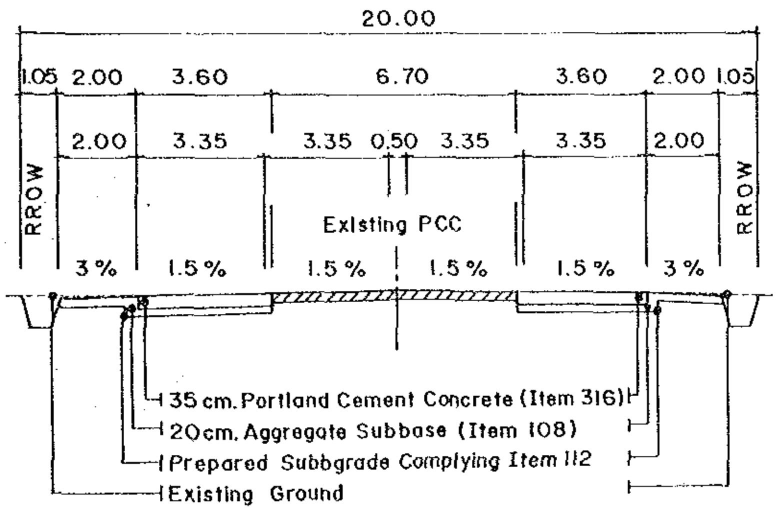


FIGURE 21.1-1 PROPOSED WIDENING TO FOUR LANES
STA. RITA – PLARIDEL SECTION

Effect of Improvement

Upon completion of widening, levels of service will be improved as shown below.

	Level of Service		
	1990	2000	2010
Do Nothing Case (Without Project)	D	E	F
Widening to a 4-lane Road (With Project)	A	B	C

2) Calamba-Sto. Tomas Section

Present Condition

The section is the nearest section to Metro Manila (52 kms from Manila) in the South Section and linked with the South Luzon Expressway at Calamba. The section extends for 10 kms from Calamba to Sto. Tomas.

The section is a 2-lane highway with PCC pavement of 6.10 meters (within Laguna province) or 6.70 meters (within Batangas Province) and shoulders of 2.0 meters. Existing right-of-way ranges from 16 meters to 19 meters. Roadside condition is a mixture of residential areas and agricultural areas. A few large scale factories are also developed in the area close to the expressway.

The section is a vital link not only between Metro Manila and cities along the Pan-Philippine Highway such as San Pablo City and Lucena City, but also between Metro Manila and Batangas City where oil refinery factories, ship building factories, etc., are located.

In 1986, traffic volume was 12,085 vehicles per day. Cars have quite high share of 66%, followed by trucks (15%) and buses (10%). Peak hour was observed between 2:00 PM and 3:00 PM and peak hour traffic volume was 811 vehicles. Peak hour ratio was 6.7%. Hourly traffic volume fluctuation was small, and almost same volume of traffic (650 to 800 vehicles per hour between 6:00 A.M. and 7:00 P.M.) runs on the section. Difference of directional difference is also small. Travel speeds ranged from 35 to 40 kms. per hour.

Traffic volumes and levels of service for years 1986, 1990, 2000 and 2010 are shown in Table 21.1-2.

TABLE 21.1-2 TRAFFIC VOLUME AND LEVEL OF SERVICE (CALAMBA – STO. TOMAS SECTION)

Unit: Vehicle Per Day

Vehicle Type	Year			
	1986	1990	2000	2010
Car	7,945 (66)	9,854 (67)	18,075 (70)	33,169 (72)
Jeepney	1,092 (9)	1,337 (9)	2,265 (9)	3,736 (8)
Bus	1,164 (10)	1,407 (10)	2,325 (9)	3,745 (8)
Truck	1,828 (15)	2,002 (14)	3,163 (12)	5,126 (12)
Tricycle	56 (–)	71 (–)	130 (–)	227 (–)
TOTAL	12,085 (100)	14,671 (100)	25,958 (100)	46,003 (100)
Level of Service	D	D	F	F

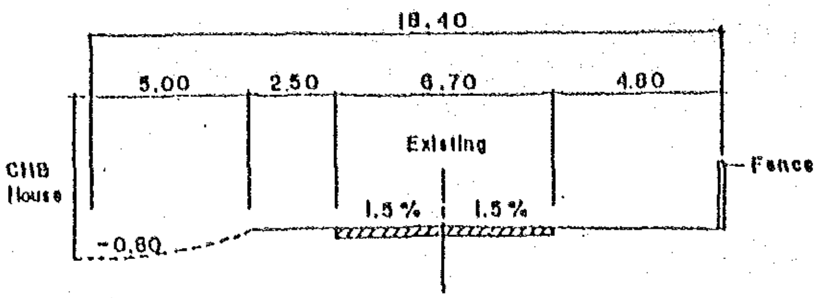
Proposed Improvement Measures

Widening to a 4-lane road was proposed for this section. Based on a straight road diagram with locations of houses and stores, right-of-way width of 20 meters was found most feasible. The typical existing and the proposed cross section are shown in Figure 21.1-2.

Effects of Improvement

Upon completion of the project, levels of service will be improved as shown below.

	Level of Service			
	1990	1995	2000	2010
Do Nothing Case (Without Project)	D	E	F	F
Widening to a 4-lane road (With Project)	A	A	B	D



Typical Existing Cross Section Along Calamba – Sto. Tomas Section

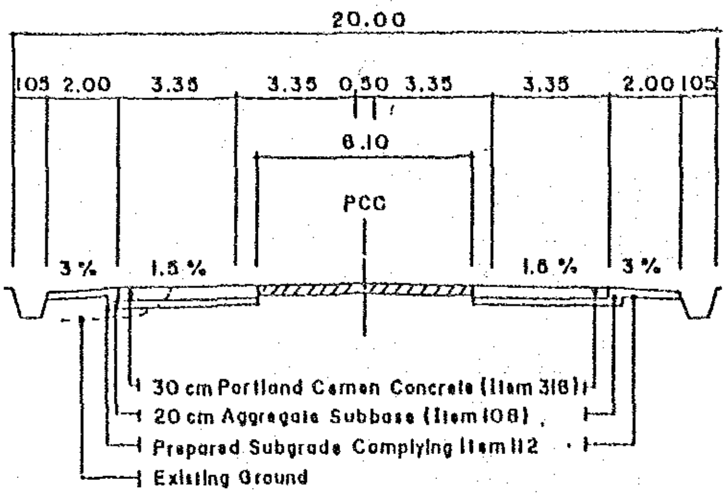


FIGURE 21.1-2 PROPOSED WIDENING TO FOUR LANES
CALAMBA – STO. TOMAS SECTION

21.1.3 Urban Section: Type 1

Following three (3) sections were studied:

Plaridel Urban Section (Segment N-1)
Gapan Urban Section (Segment N-2)
Cabanatuan Urban Section (Segment N-2)

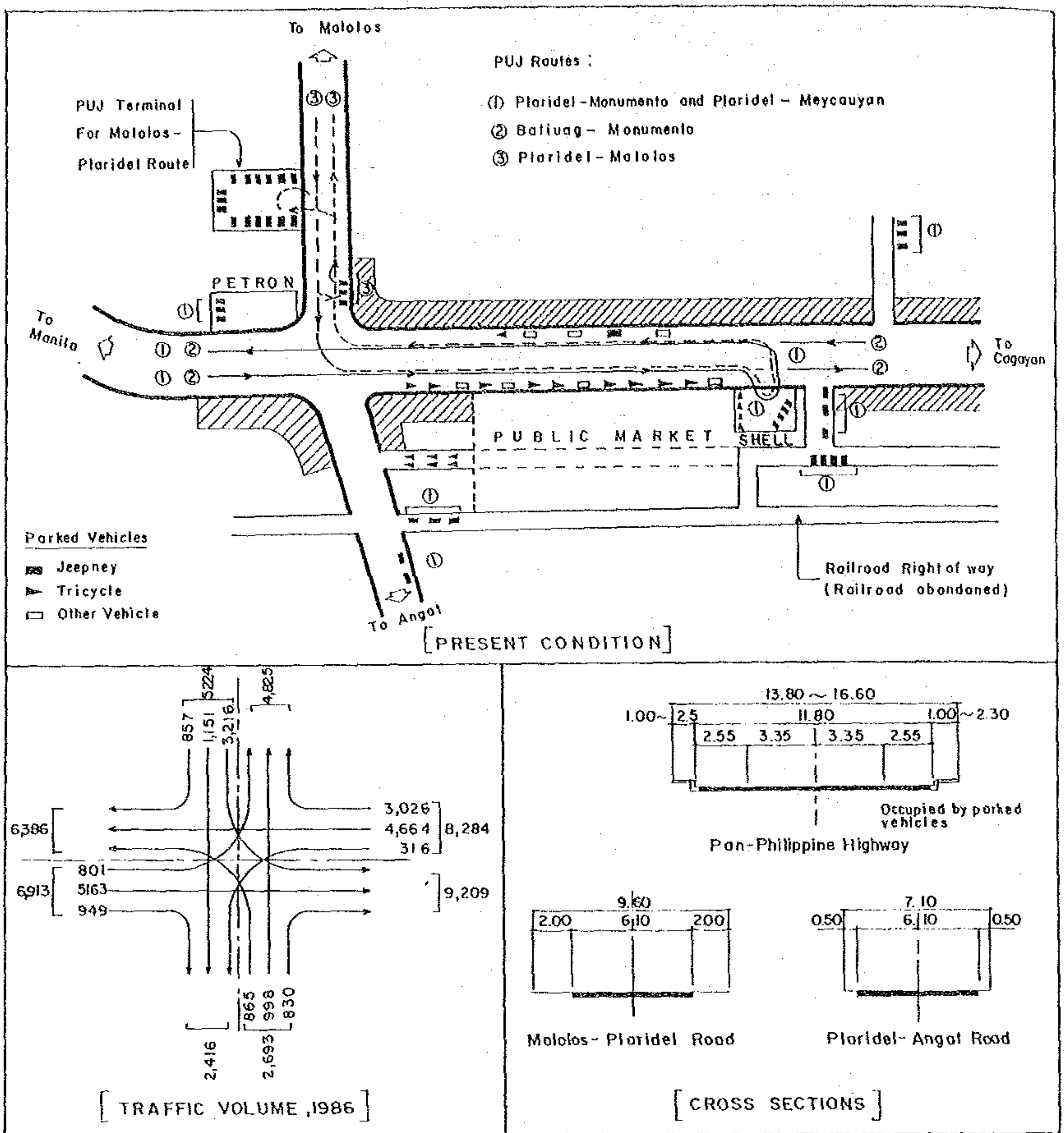
1) Plaridel Urban Section

Present Conditions

Present conditions and problems are presented in Figure 21.1-3. Roadside along this section is highly developed with commercial buildings. The section has a pavement width of 11.8 to 11.9 meters. Sidewalks of 1.0 to 2.5 meters wide are provided. It is practically impossible to widen the section beyond existing right-of-way, therefore, a little can be done on the existing section. Traffic volumes are shown in Table 21.1-3.

TABLE 21.1-3 TRAFFIC VOLUME AND LEVEL OF SERVICE (PLARIDEL URBAN SECTION)

Vehicle Type	Year			
	1986	1990	2000	2010
Manila Side				
Car	5,422	6,705	12,315	22,602
	(37)	(37)	(40)	(43)
Jeepney	3,236	3,972	6,433	10,359
	(22)	(22)	(21	(20)
Bus	810	(974	1,558	2,436
	(6)	(5)	(5)	(5)
Truck	2,143	2,334	4,064	7,304
	(14)	(13)	(13)	(14)
Tricycle	3,070	3,902	6,229	10,149
	(21)	(22)	(20)	(19)
TOTAL	14,681	17,887	30,599	52,850
	(100)	(100)	(100)	(100)
Level of Service	D	E	F	F
Cagayan Side				
Car	5,911	7,334	13,558	24,906
	(31)	(31)	(34)	(36)
Jeepney	4,499	5,665	9,113	14,847
	(24)	(24)	(23)	(22)
Bus	804	957	1,527	2,385
	(4)	(4)	(4)	(3)
Truck	2,097	2,612	4,516	8,040
	(11)	(11)	(11)	(12)
Tricycle	5,590	7,105	11,342	18,481
	(30)	(30)	(28)	(27)
TOTAL	18,901	23,673	40,056	68,659
	(100)	(100)	(100)	(100)
Level of Service	E	E	F	F



[PROBLEMS]

1) Heavy roadside friction due to public market and loading/unloading of PUV passengers
2) On-street parking of private/public vehicles especially near the public market
3) Jeepney/tricycle terminals near the intersection
4) U-turn of jeepneys assigned to Plaridel-Monumento/Meycauayan route
5) Irregular and slow movement of tricycles (tricycle traffic 3,070-5,590)
6) Frequent crossings of pedestrians at any place of the section

FIGURE 21.1-3 PRESENT CONDITION OF PLARIDEL SECTION

Recommended Improvement Measures

The following two (2) improvement measures were studied;

- Traffic Management
- Construction of a bypass

a) Traffic Management

Until the completion of a bypass, this is the only solution. Key to success of traffic management is strict enforcement of rules and regulations. Following regulations are recommended for implementation:

- On-street parking ban – although no parking along the section is imposed, there are always parked vehicles, especially infront of the public market. A parking area could probably be provided at the abandoned railway right-of-way.

- No loading/unloading of PUV passengers at least within 50 meters from the intersection.

- Re-routing of PUJ route – jeepneys assigned to Plaridel-Malolos route and Plaridel-Monumento/Meycauayan route are making U-turns at Shell gas station. Plaridel-Malolos route jeepneys could be terminated their trips at the existing PUJ terminal. Plaridel-Monumento/Meycauayan route jeepneys could be proceeded further, then make U-turns at the Baliuag by-pass where traffic is light.

- Tricycles waiting for passengers in front of the public market could be transfered to backside of the market, utilizing the abandoned railway right-of-way.

b) Construction of a bypass

Estimated bypass traffic

Through traffic on the Plaridel urban section is shown below.

	Through Traffic (Vehicle Per Day)				
	Car	Jeepney	Bus	Truck	Total
1986	3,681	726	789	1,869	7,065
1990	4,537	872	938	2,348	8,695
2000	8,290	1,458	1,497	4,104	15,347
2010	15,159	2,374	2,335	7,404	27,272

All through traffic will not be attracted by a bypass. It is assumed that all cars and trucks will select a bypass, buses of which destination is Baliuag will select the existing route and the rest of long-trip buses will select a bypass and all jeepneys will use the existing route. Bypass traffic volume are shown in Figure 21.1-4.

Bypass Route Selection

Mainly following factors were considered to select a bypass route:

— Compatability with land use

A route passing through commercial and residential areas should be avoided as much as possible.

— Connection with the existing route

As traffic going to Baliuag is heavy, a bypass should have access to the Plaridel-Baliuag Road. Linkage with Pulilan should also be considered, but with low priority.

— Bridge Location

Considering the directions of Angat River and the Pan-Philippine Highway, bridge location should be selected properly.

Four (4) possible alternative routes were selected for comparison as shown in Figure 21.1-5. Table 21.1-4 shows evaluation of alternative routes, and Route D was recommended for a Plaridel Bypass Route, due mainly to compatability with land use and easier access to Baliuag.

Field survey was conducted along Route D. Proposed cross section for a bypass is shown in Figure 21.1-6.

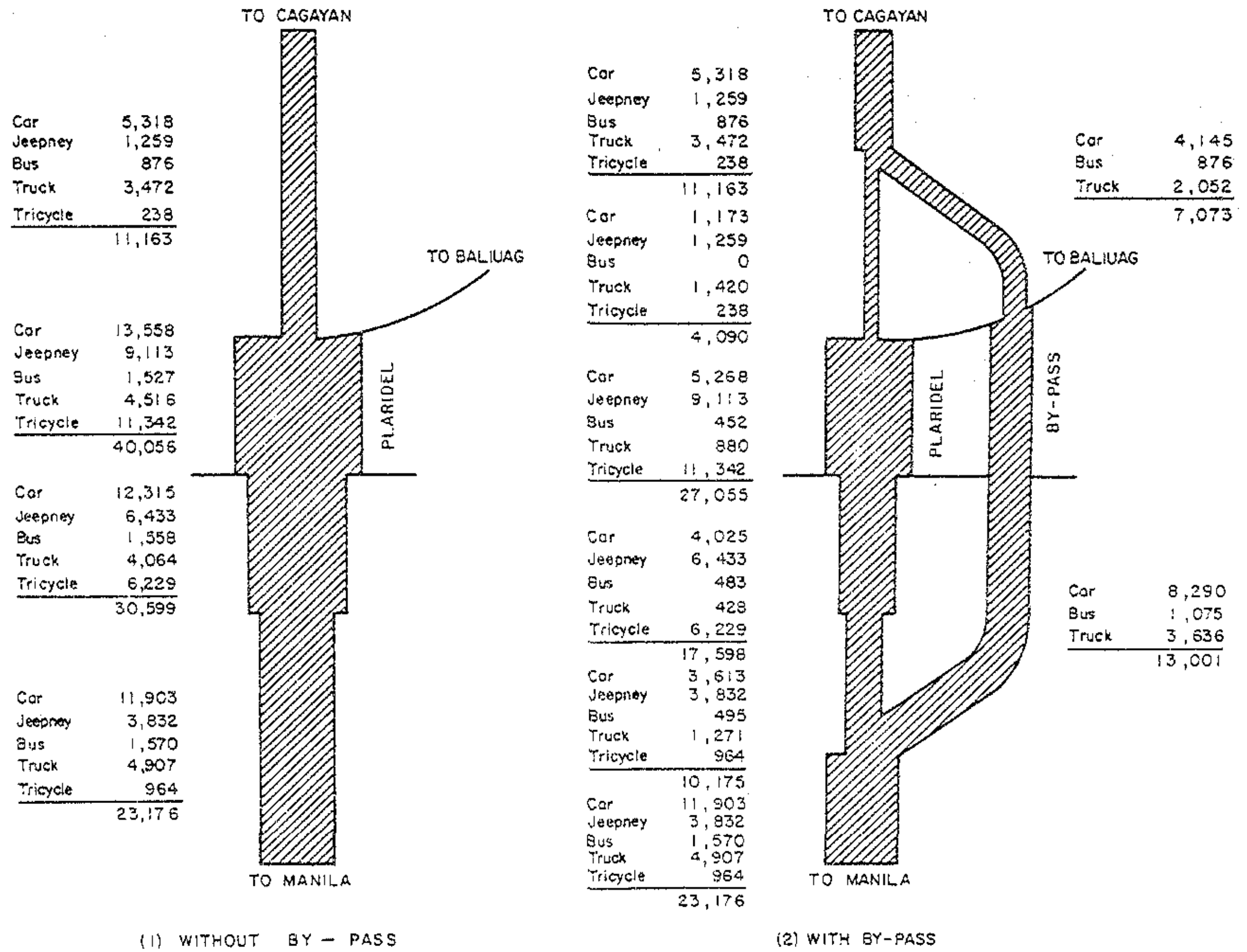


FIGURE 21.1-4 FUTURE TRAFFIC VOLUME ON PLARIDEL SECTION (2000)

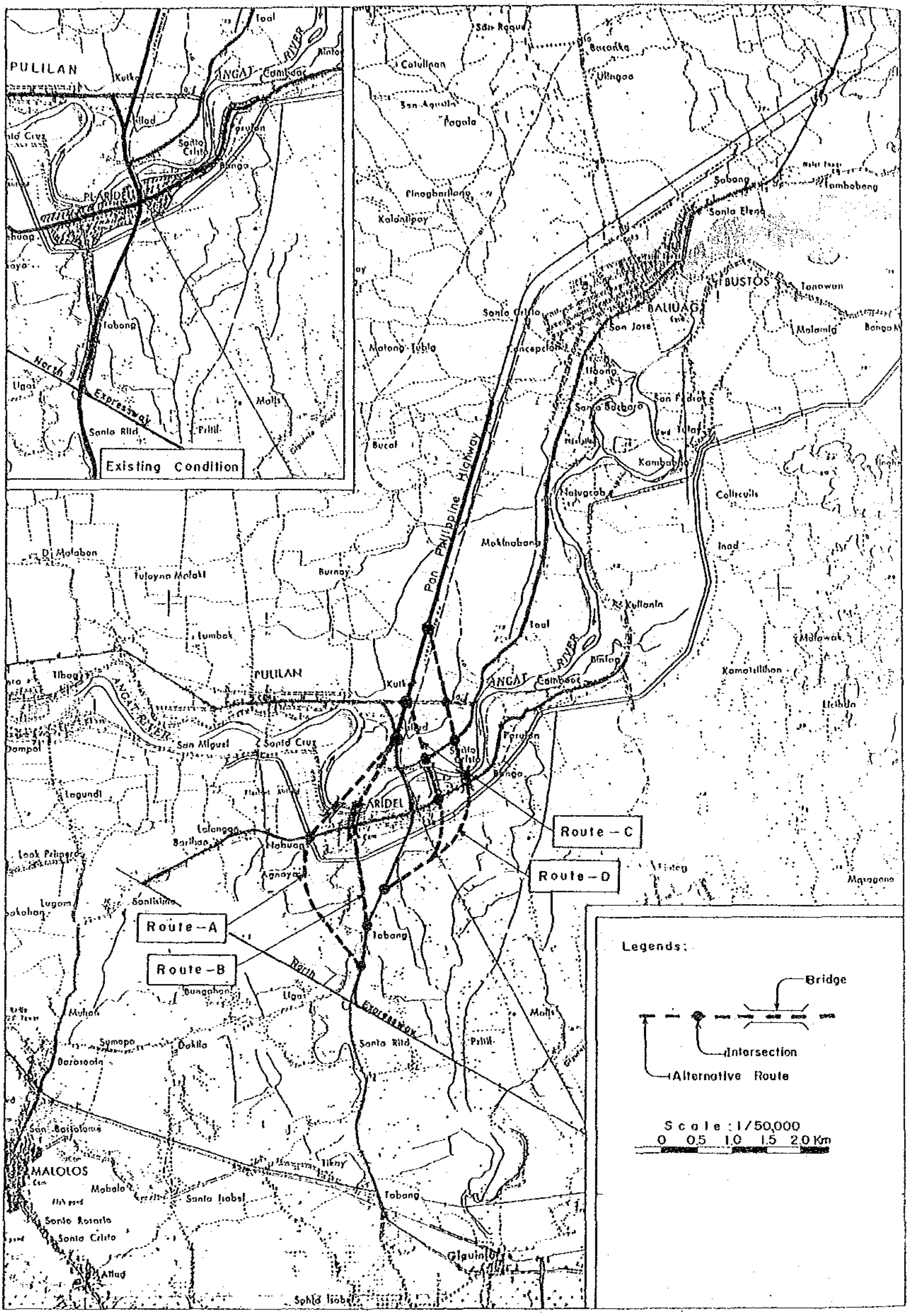


FIGURE 21.1-5 ALTERNATIVE ROUTES FOR PLARIDEL BYPASS

TABLE 21.1-4 ALTERNATIVE ROUTES COMPARISON: PLARIDEL BYPASS

Route	Major Objectives of Routing	Route Length (Km)	Corresponding Length of Existing Section (Km)	Difference + Longer - Shorter (Km)	Bridge Length (m)	Advantages/Disadvantages
A	. Avoid built-up areas . Linkage with Pulilan	4.2	3.5	+ 0.7	200	. No access to Plaridel-Baliaug Road, less traffic will be attracted . Too close to the interchange . The route is longer than the existing by about 0.7 kms . The route is located too close to the air-port.
B	. Shortest route . Utilization of a existing road	3.0	3.0	0	380	. Divide the existing residential and commer-cial area . Pass through built-up area . Utilization of a existing road is quite difficult due to right-of-way acquisition problems . Bypass must over-pass the Plaridel-Malolos Road
C	. Linkage with Plaridel-Bustos Road, Plaridel-Baliuag Road and a road going to Pulilan	3.2	2.9	+ 0.3	300	. Pass through built-up area . Divide the existing residential and commer-cial areas . Too close to existing route
D	. Avoid built-up area . Linkage with Plaridel-Baliuag Road	4.8	4.3	+ 0.5	365	. Most attractive route for traffic going to Baliuag . Most compatible with land use . Least problem of land acquisition . Bypass must overpass the Plaridel-Bustos Road

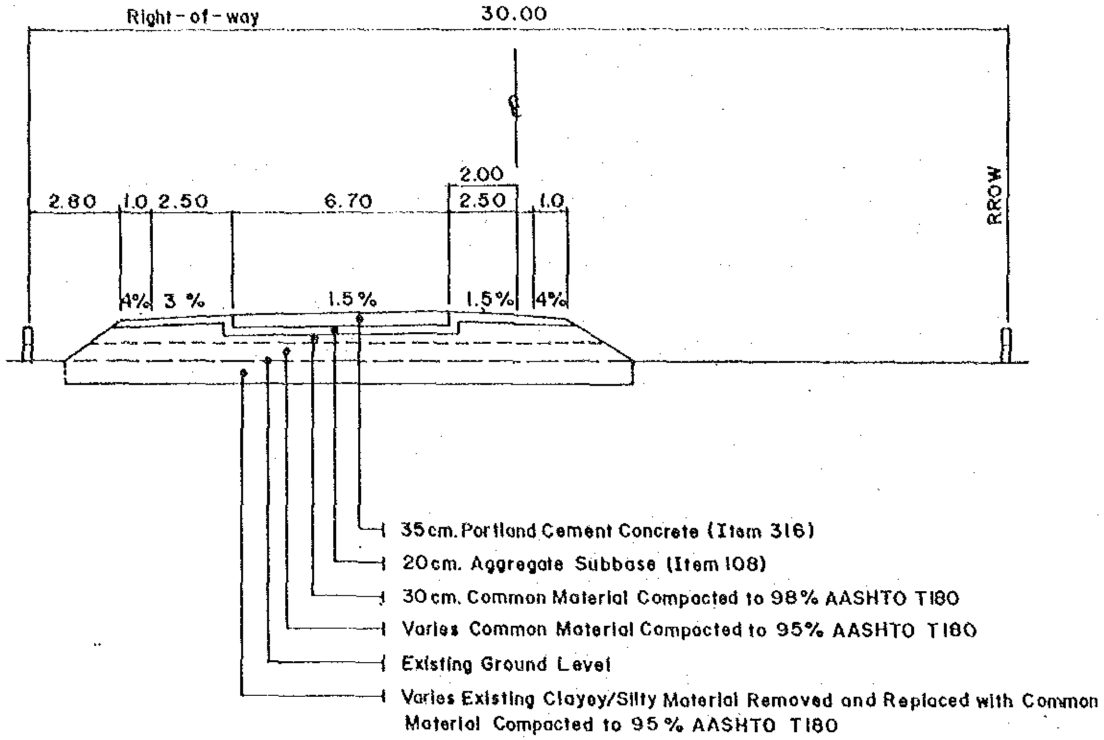


FIGURE 21.1-6 TYPICAL SECTION PLARIDEL BYPASS

Effect of Construction of a Bypass

Upon completion of a bypass, level of service will be improved as shown below.

	Level of Service					
	Manila Side			Cagayan Side		
	1990	2000	2010	1990	2000	2010
Do Nothing Case (Without Project)	E	F	F	E	F	F
Construction of a bypass (With Project)						
Existing Section	C	D	E	D	E	F
Bypass	B	C	E	B	C	E

2) Gapan Urban Section

Present Conditions and Recommended Improvement Measures

Road conditions of the Gapan Urban Section is shown in Figure 21.1-7. The section has a relatively wide right-of-way near the intersection compared with other urban sections, however, Manila side cross section (B-B section in Figure 21.1-7) is a rural type of 2-lane road. Traffic volumes and levels of service are shown in Table 21.1-5. Manila side section has heavier traffic volume than Cagayan side section. Tricycle traffic is dominant. With a total traffic volume of 16,700 vehicle per day in 1986 (Manila side section), tricycle traffic accounts for 56% (or 9,350 tricycles). Levels of service for do nothing case were estimated as shown below.

Do Nothing Case	Level of Service			
	1986	1990	2000	2010
Manila Side	E	E	F	F
Cagayan Side	D	D	E	F

Cagayan side section will be problem section in the medium term period at about 1995. In the short term period, improvement of Manila side section is required. Recommended improvement measures is to construct 3.0 - meter paved shoulder with sidewalk (refer to improvement of existing Cabanatuan Urban Section) for the purpose of tricycle travelway and loading/unloading zone for PUV and trucks. With improvement of this measures, Manila side section will provide the same level of service as the Cagayan side section.

Table 21.1-6 shows volume of through traffic. In 1990, total through traffic will reach to 5,900 vpd, and 10,400 vpd in 2000. Construction of a bypass should be planned between 1990 and 2000. A bypass has to cross Peñaranda River which runs just north of the Gapan town proper and requires about 300-meter bridge. As the case of a Plaridel Bypass, high construction cost will suggest implementation bypass construction at the middle stage of LOS E. It is recommended that construction of a bypass be implemented at about year 2000.

Recommended improvement measures are as follows:

- Improvement of the existing section (Manila Side) in the short term period.
- Construction of a bypass in the early stage of long term period.

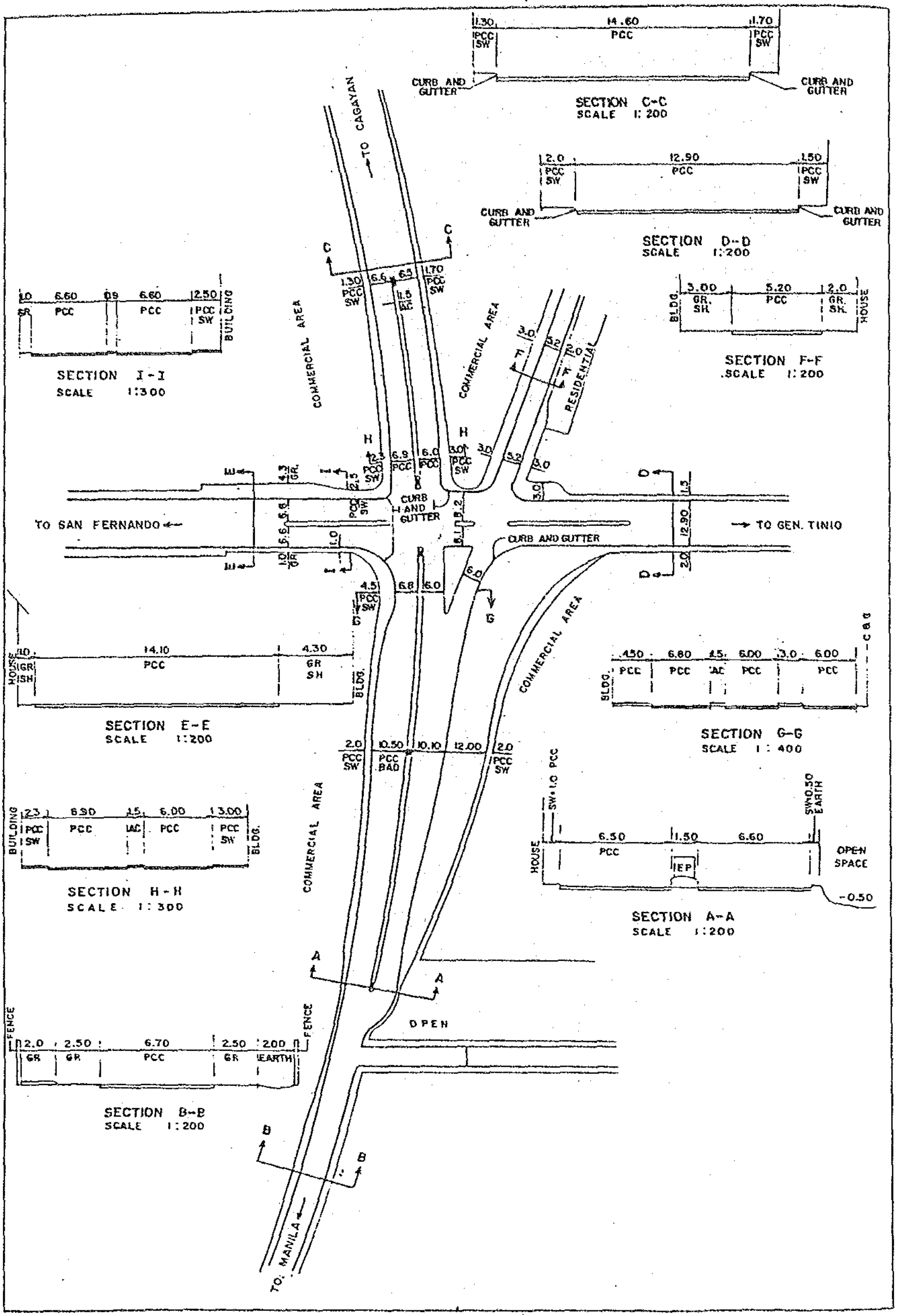


FIGURE 21.1-7 GAPAN URBAN SECTION

TABLE 21.1-5 TRAFFIC VOLUME AND LEVEL OF SERVICE (GAPAN URBAN SECTION)

	Year			
	1986	1990	2000	2010
Manila Side				
Car	3,761	4,696	8,862	16,572
	(22)	(22)	(25)	(27)
Jeepney	1,209	1,477	2,535	4,235
	(7)	(7)	(7)	(7)
Bus	635	758	1,226	1,938
	(4)	(4)	(3)	(3)
Truck	1,763	2,176	3,660	6,293
	(11)	(11)	(10)	(10)
Tricycle	9,350	11,463	19,672	32,949
	(56)	(56)	(55)	(53)
TOTAL	16,718	20,570	35,955	61,987
	(100)	(100)	(100)	(100)
Level of Service	E	E	F	F
Cagayan Side				
Car	2,824	3,489	6,489	12,000
	(24)	(24)	(25)	(27)
Jeepney	1,450	1,759	2,980	4,926
	(12)	(12)	(12)	(11)
Bus	611	728	1,197	1,920
	(5)	(5)	(5)	(5)
Truck	1,256	1,586	2,690	4,787
	(11)	(11)	(11)	(11)
Tricycle	5,755	7,056	12,109	20,281
	(48)	(48)	(47)	(46)
TOTAL	11,896	14,598	25,465	43,914
	(100)	(100)	(100)	(100)
Level of Service	D	D	E	F

TABLE 21.1-6 THROUGH TRAFFIC VOLUME (Gapan Urban Section)

		Through Traffic Volume				
		Car	Jeepney	Bus	Truck	Total
1986	Manila – Cagayan	1,324	35	412	855	2,626
	Manila – San Fernando	187	27	115	111	440
	San Fernando – Cagayan	599	707	199	174	1,679
1990	Manila – Cagayan	1,691	39	490	1,143	3,291
	Manila – San Fernando	229	32	137	137	535
	San Fernando – Cagayan	745	857	238	227	2,067
2000	Manila – Cagayan	2,982	70	784	1,985	5,821
	Manila – San Fernando	426	55	220	230	931
	San Fernando – Cagayan	1,387	1,435	413	382	3,617
2010	Manila – Cagayan	5,454	112	1,226	3,582	10,374
	Manila – San Fernando	772	91	344	411	1,618
	San Fernando – Cagayan	2,578	2,358	694	665	6,295

3) Cabanatuan Urban Section

Present Condition

Cabanatuan City is the capital of Nueva Ecija Province. Population in 1986 is estimated to be 159,500 and projected to be 174,500 in 1990, 211,900 in 2000 and 243,400 in 2010.

Cabanatuan City is the biggest traffic generation/attraction center along the Study Section. Most of long-distance trip traffic have either opinions or destinations at this city, therefore, through traffic is still small. Local traffic volume is quite high, especially tricycle traffic volume.

The Pan-Philippine Highway was originally constructed by-passing the city center, however, urbanization is now extended beyond the highway.

Traffic volumes in 1986, 1990, 2000 and 2010 are presented in Table 21.1-7. The middle section has smaller traffic volume than Manila side or Cagayan side sections. This is because most long-distance trips are generated/attracted at the City Center. Major traffic generating sources are shown in Figure 21.1-8.

Present and Future Trend of Urban Expansion

Present and future trend of urban expansion is illustrated in Figure 21.1.9. The northern area of the CBD is quite low land and is flooded every time the Pampanga River swells, therefore, not suitable for urban expansion.

Currently, urbanization is expanding towards the south-east direction along the Mabini Street Extension (going to General Tiño) and the south-west direction between CBD and the city hall. This trend will continue even in the future.

In the future, the Pan-Philippine Highway will be located just the center of the urbanized area. Traffic generated in the currently urbanizing areas is mostly accessed to the Pan-Philippine Highway, then distributed to CBD or city hall area. In the future, the Pan-Philippine Highway will function as very important distributor road and will be overburdened. A road parallel to the Pan-Philippine Highway will be needed to release the burden of the Pan-Philippine Highway as well as to support sound expansion of urbanization and socio-economic activities of the city.

Recommended Improvement Measures

Improvement measures studied were:

- Improvement of the existing section
- Construction of a bypass (or an alternative route)

TABLE 21.1-7 TRAFFIC VOLUME AND LEVEL OF SERVICE (CABANATUAN CITY)

	Year			
	1986	1990	2000	2010
Manila Side				
Car	6,144 (29)	7,672 (29)	14,374 (32)	26,752 (34)
Jeepney	2,634 (12)	3,193 (12)	5,369 (12)	8,832 (11)
Bus	687 (3)	820 (3)	1,348 (3)	2,164 (3)
Truck	1,556 (7)	1,926 (7)	3,253 (7)	5,665 (7)
Tricycle	10,290 (48)	12,492 (48)	21,012 (46)	34,605 (44)
T O T A L	21,311 (100)	26,103 (100)	45,356 (100)	78,018 (100)
Level of Service	E	F	F	F
Middle Section				
Car	3,904 (25)	4,884 (26)	9,210 (28)	17,165 (30)
Jeepney	732 (5)	885 (5)	1,494 (5)	2,459 (4)
Bus	229 (1)	274 (1)	446 (1)	714 (1)
Truck	1,405 (9)	1,725 (9)	2,867 (9)	4,878 (9)
Tricycle	9,340 (60)	11,339 (59)	19,072 (58)	31,410 (55)
T O T A L	15,610 (100)	19,107 (100)	33,089 (100)	56,626 (100)
Level of Service	D	E	F	F
Cagayan Side				
Car	3,886 (16)	4,838 (17)	9,065 (18)	16,859 (20)
Jeepney	3,469 (14)	4,198 (14)	7,031 (14)	11,532 (14)
Bus	742 (3)	896 (3)	1,485 (3)	2,414 (3)
Truck	1,614 (7)	1,989 (7)	3,326 (7)	5,713 (7)
Tricycle	14,220 (59)	17,263 (59)	29,037 (58)	47,822 (57)
T O T A L	23,931 (100)	29,184 (100)	49,944 (100)	84,340 (100)
Level of Service	E	F	F	F

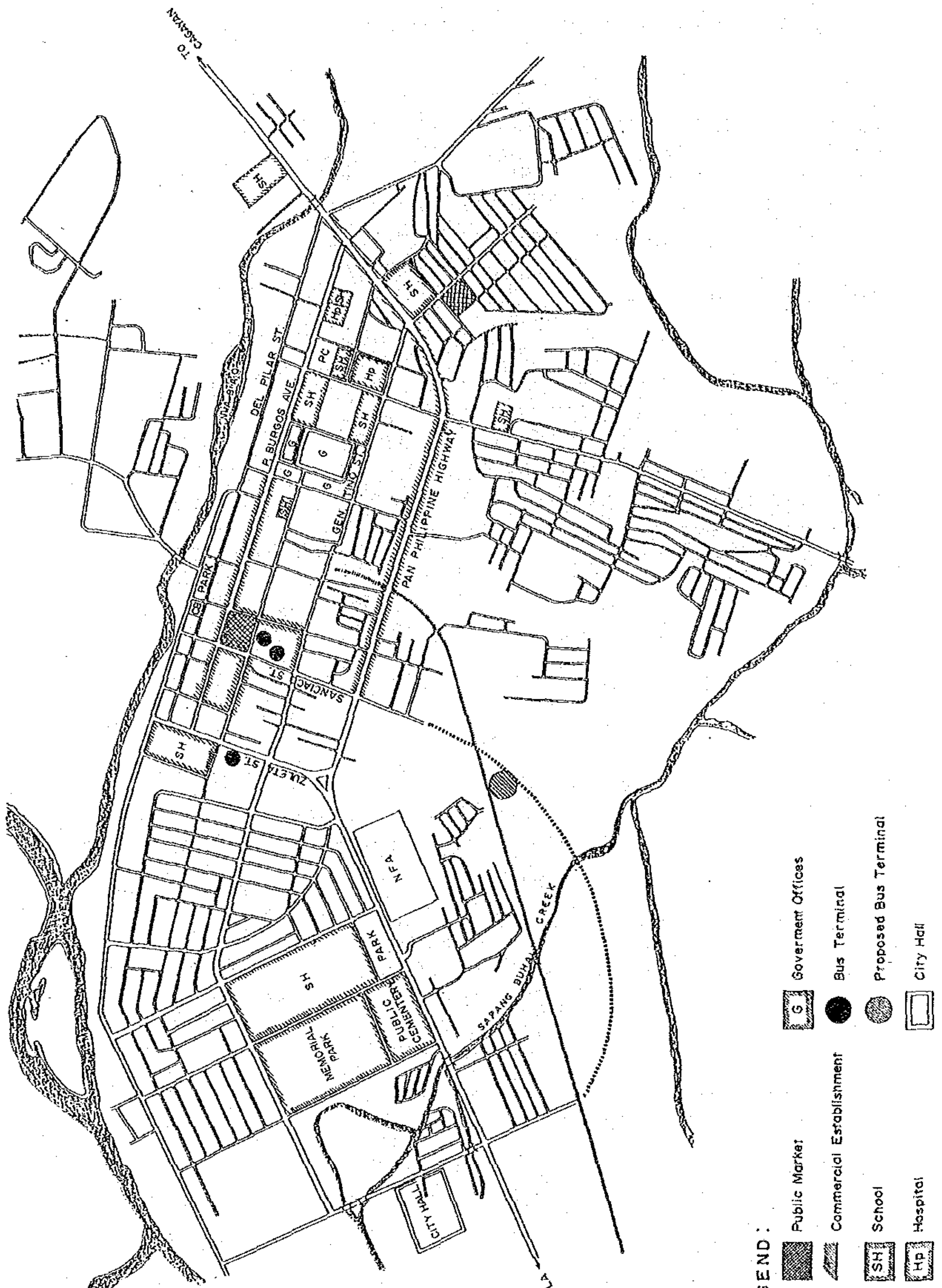


FIGURE 21.1-8 MAJOR TRAFFIC GENERATION CENTERS

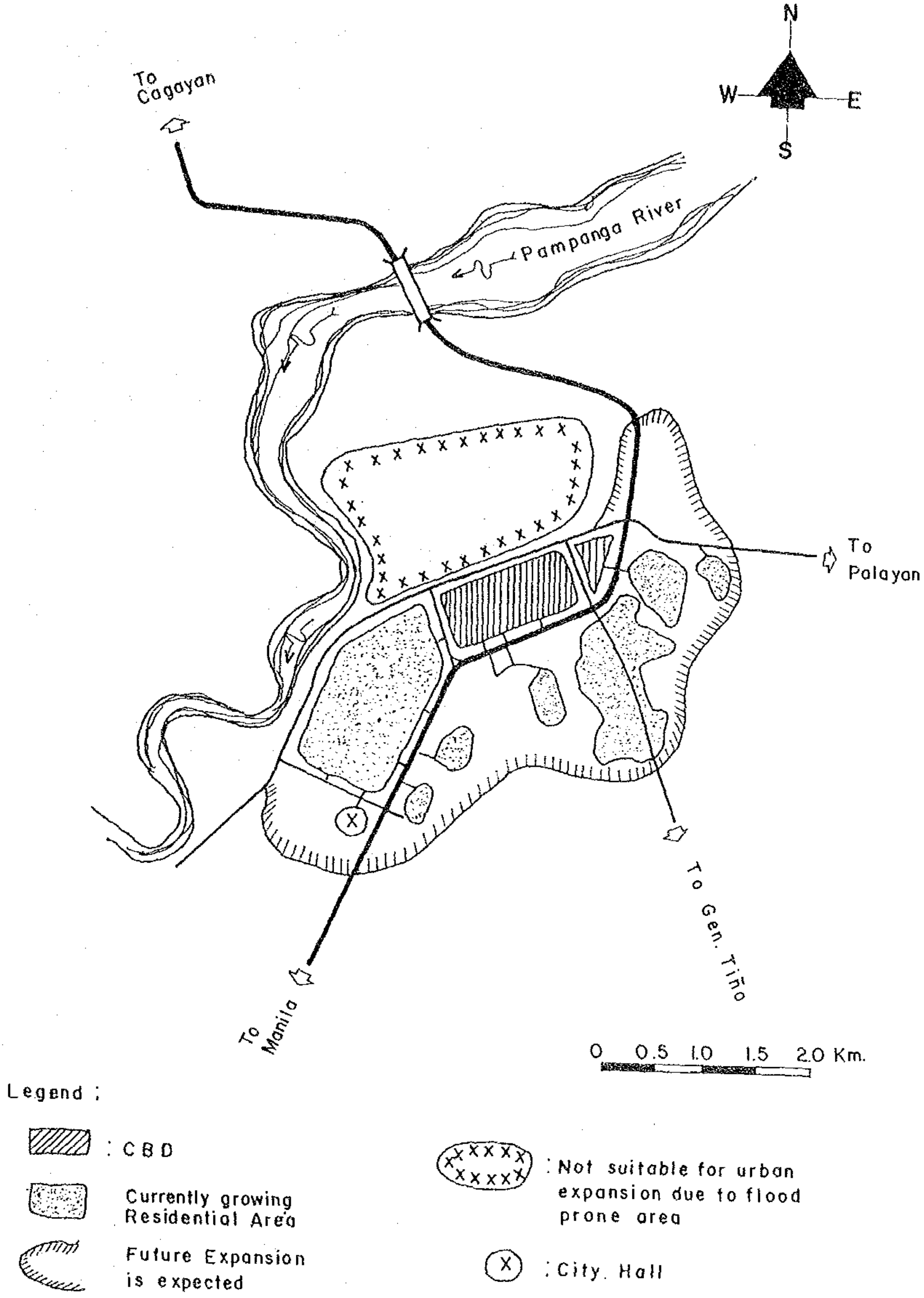
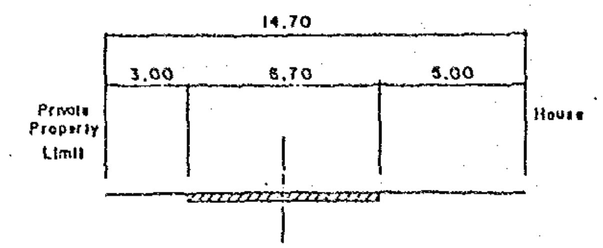


FIGURE 21.1-9 PRESENT AND FUTURE URBAN EXPANSION: CABANATUAN CITY

a) Improvement of the Existing Section

The existing section is a 2-lane road with PCC pavement of 6.7 meters and gravel shoulders of 2.0 to 2.5 meters. Although the section is located in the urban area, the cross section standard is still the rural type. Conditions of shoulders are aggravated, therefore, loading/unloading of PUV passengers are operated on the paved roadway, thus disturbing smooth flow of traffic. Sidewalks are not provided and shoulders are not paved, pedestrians tend to walk on the roadway which not only obstruct traffic flow, but is potential causes of traffic accidents.

Existing right-of-way width ranges from 15 meters to 18 meters. Based on the survey conducted by the Study Team, the 16-meter right-of-way width is proposed which requires minimal land acquisition. Proposed cross section is shown in Figure 21.1-10. Considering the high volume of public utility vehicles, especially tricycles, 3-meter shoulder was recommended which will be utilized for tricycle travel-way and loading/unloading zone for passengers as well as cargoes.



Typical Existing Cross Section Along Cabanatuan City Urban Secti

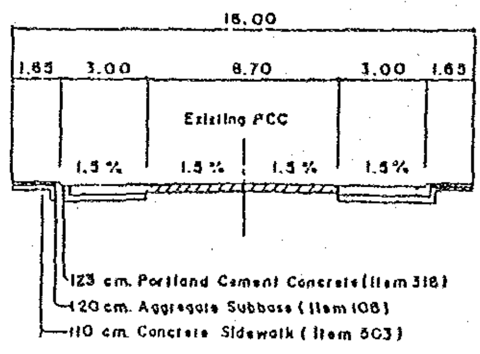


FIGURE 21.1-10 PROPOSED IMPROVEMENT ALONG CABANATUAN CITY URBAN SECTION

b) Construction of a Bypass

As the most long-distance trip traffic have their origins or destinations of Cabanatuan City, volume of through traffic is not heavy, as shown below.

		Through Traffic Volume				
		Car	Jeepney	Bus	Truck	Total
1986	Manila-Cagayan	648	16	161	726	1,551
	Manila-Palayan	70	1	13	86	170
	Cagayan-Palayan	16	1	0	7	24
1990	Manila-Cagayan	783	16	192	1,021	2,012
	Manila-Palayan	87	1	15	95	198
	Cagayan-Palayan	19	1	0	9	29
2000	Manila-Cagayan	1,470	32	307	1,761	3,570
	Manila-Palayan	161	2	27	167	357
	Cagayan-Palayan	40	2	0	18	60
2010	Manila-Cagayan	2,682	50	483	3,175	6,390
	Manila-Palayan	296	4	46	301	647
	Cagayan-Palayan	76	3	0	38	117

Proposed alternative routes are shown in Figure 21.1-11.

Route-A: This plan aims at constructing a bypass by short-cutting the existing route. This route has to cross Pampanga River requiring about 500 meter bridge. Construction cost is estimated to be quite high, whereas traffic volume which will be attracted on a bypass route will be still small. This plan could not be justified economically.

Route-B: This plan also aims at constructing a bypass by short-cutting the existing route. To be utilized are a part of the Pan-Philippine Highway and Zulueta Street, both of which have to be widened to a 4-lane road. Widening of both roads are not practical in view of roadside development. This plan requires construction relief traffic problems on the Pan-Philippine Highway between Zulueta Street and Del Pilar Street.

Route-C: This plan aims at constructing an alternative route located approximately parallel to and about 700 to 800 apart from the existing route. Considering that through traffic is small, but long distance trip traffic which start or end at the city as well as local traffic are quite heavy, construction of an another major urban road is more practical solution.

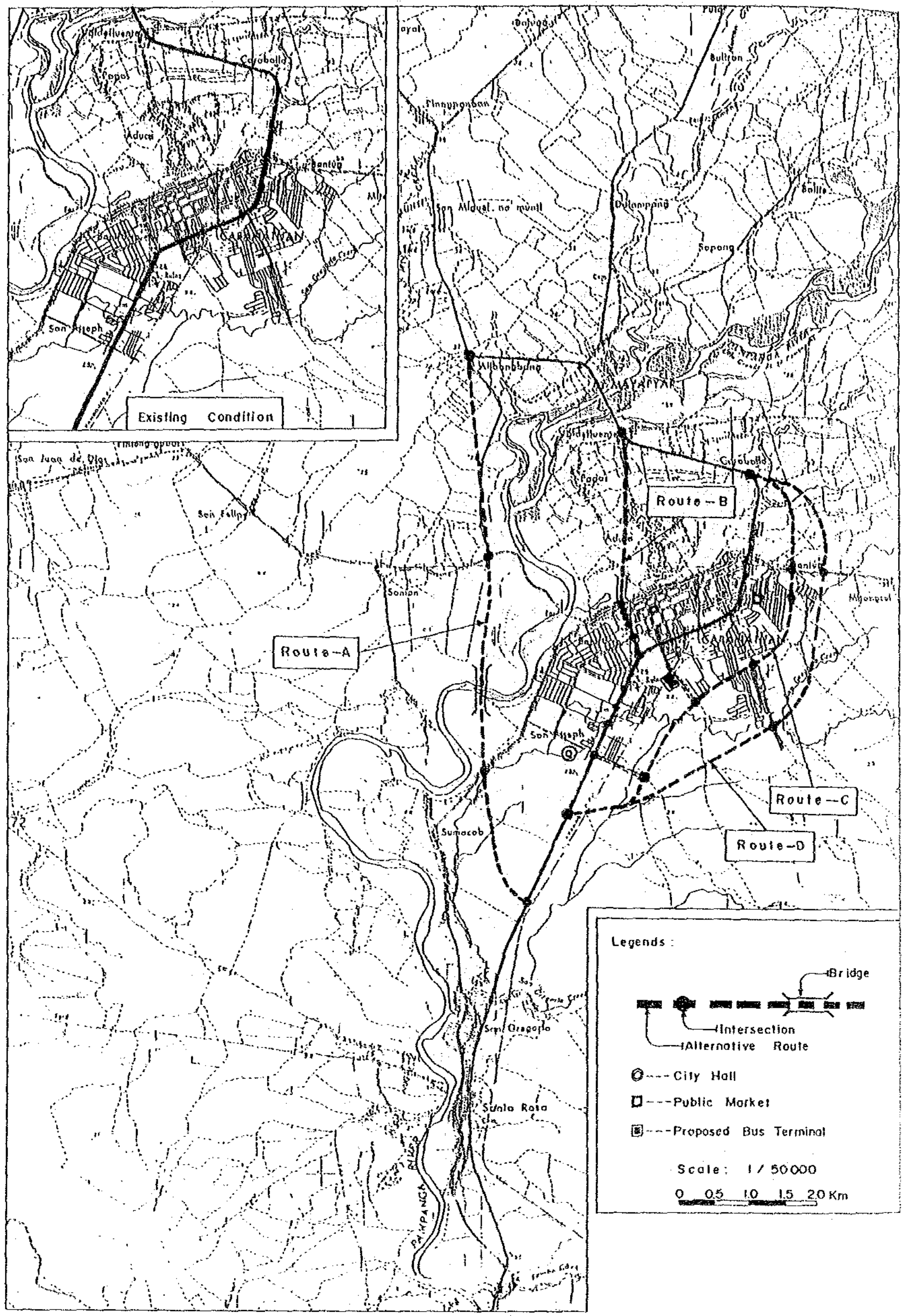


FIGURE 21.1-11 ALTERNATIVE ROUTES FOR CABANATUAN BYPASS

The route alignment is selected to pass mostly vacant areas. Good access to the city center and proposed bus terminal should be fully considered.

Route-D: This plan aimed at constructing a bypass by completely avoiding to pass through urbanizing areas and utilizing existing Pampanga Bridge. This route is longer by about 1.7 kms than the existing route. Only a few traffic will be attracted. It would not be justified economically.

Comparison of alternative routes is presented in Table 21.1-8.

Route-C was recommended as the most efficient scheme to solve traffic problems on this urban section. The field survey was conducted along Route-C. The same cross section as proposed for Plaridel Bypass was adopted. Figure 21.1-12 shows estimated traffic volume on the recommended route.

Effects of Improvement

Levels of service will be improved as shown below:

	Level of Service			
	1986	1990	2000	2010
Manila Side Section (City Hall-Zuleta St.)				
. Do Nothing Case	E	F	F	F
. Improvement of Existing Section	D	E	F	F
. Construction of an alternative route				
- Existing	-	D	E	F
- An Alternative Route	-	C	E	F
Middle Section (Zuleta St. - Del Pilar St.)				
. Do Nothing Case	D	E	F	F
. Improvement of Existing Section	D	D	E	F
. Construction of an alternative route				
- Existing	-	D	D	E
- An Alternative Route	-	B	C	E
Cagayan Side Section (North of Del Pilar St.)				
. Do Nothing Case	E	F	F	F
. Improvement of Existing Section	E	E	F	F
. Construction of an alternative route				
- Existing	-	D	E	F
- An Alternative Route	-	C	E	F

Improvement of existing section will improve quality of service, however, growing traffic will require construction of an alternative route by about 1995.

TABLE 21.1-8 COMPARISON OF ALTERNATIVE ROUTES: CABANATUAN URBAN SECTION

Alternative	Objectives	Route Length (Km)	Corresponding Length of Existing Road (Km)	Difference + Longer - Shorter (Km)	Bridges (m)	Advantage/Disadvantage
Route - A	. Construction of a bypass by short-cutting the existing route	8.2	12.2	-4.0	500	. Bypass traffic is still small . High construction cost due to long bridge. . Economic viability doubtful.
Route - B	. Construction of a bypass by short-cutting the existing route	5.8	8.0	-2.2	200	. Pass through almost middle of the city. . Widening of existing roads to be used is quite difficult . Will not relief traffic problems of the section
Route - C	. Construction of a parallel road to the existing route to relief traffic problems on the existing section and to support sound development of urban areas and socio-economic activities	7.1	6.1	+1.0	80	. Best scheme among alternatives . Right-of-acquisition should be done as soon as possible . Efficient access to city center, proposed bus terminal and city hall be considered
Route - D	. Construction of a bypass	7.8	6.1	+1.7	100	. Less possibility to attract traffic due to longer length than the existing and too far from city center. . Economic viability doubtful

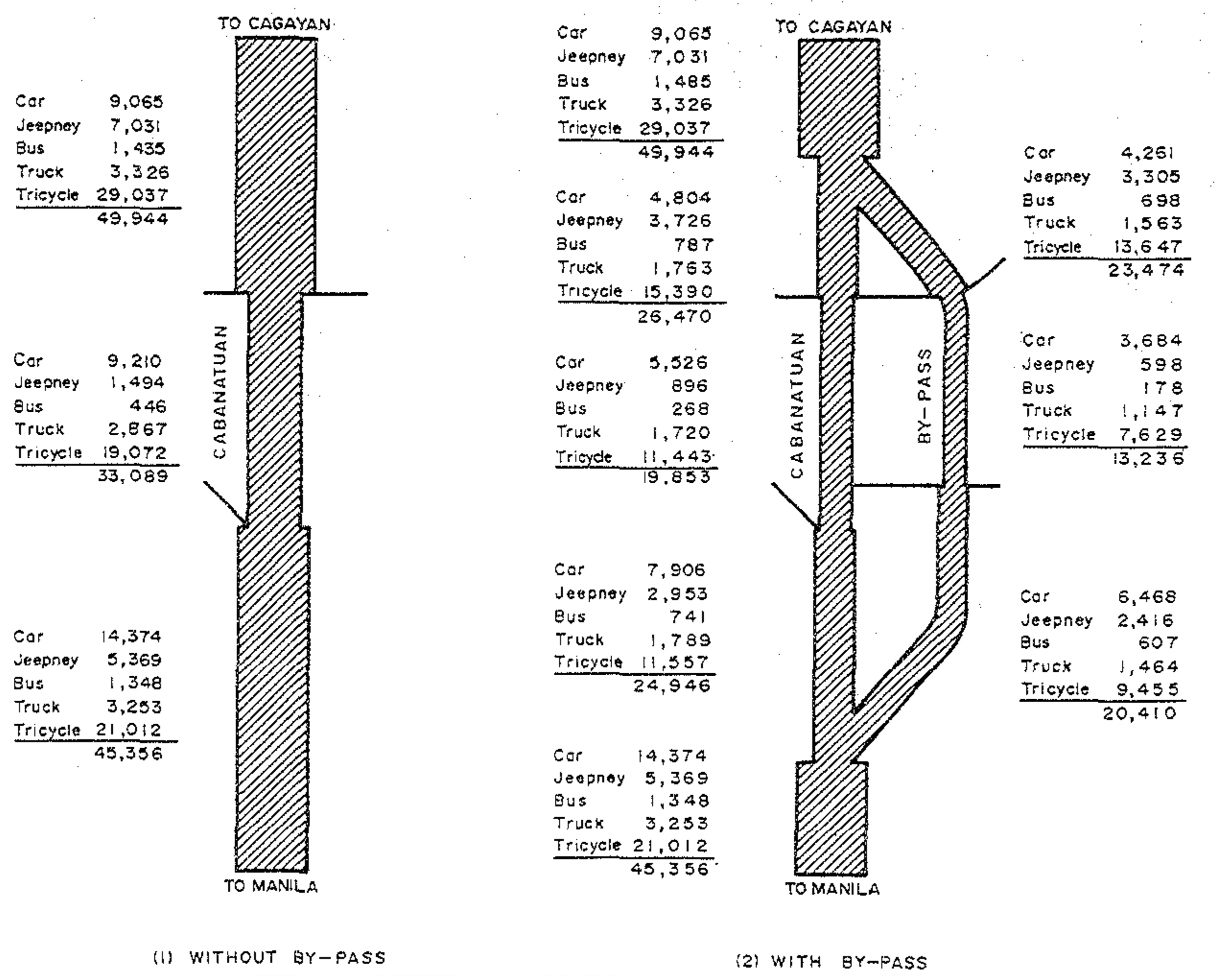


FIGURE 21.1-12 FUTURE TRAFFIC VOLUME ON CABANATUAN SECTION (2000)

21.1.4 Urban Section: Type 2

San Jose Urban Section were studied, although the said section is not included in the Feasibility Study Section.

Present Conditions

Traffic volumes for 1986, 1990, 2000 and 2010 and levels of services are presented in Table 21.1-9. Tricycle traffic has a quite high share, accounting for more than 60%. Instead, volume of through traffic is still small as shown in Table 21.1-10. In 1986, through traffic is only 743 vpd.

The section is currently a 2-lane divided road. Existing shoulders are either gravel or very deteriorated AC pavement. (See Figure 21.1-13).

Recommended Improvement Measures

Existence of a center median island does not allow overtaking, therefore, vehicles following slow vehicles such as trucks transporting logs and lumbers and tricycles are forced to drive slowly. Solution to this problem is either to remove a center median island or to widen or pave shoulders so as that overtaking can be possible. Another problem is high share of slow moving tricycles. Solution to this is utilization of shoulders for travel way of a tricycle. In view of the above, paving of shoulders and construction of a sidewalk were recommended for improvement measures. (See Figure 21.1-13).

TABLE 21.1-10 VOLUME OF THROUGH TRAFFIC
SAN JOSE URBAN SECTION

Unit: Vehicle/Day

	Vehicle Type				
	Car	Jeepney	Bus	Truck	Total
1986	244	3	107	389	743
1990	296	3	128	611	1,038
2000	551	6	205	1,079	1,861
2010	1,013	11	324	1,993	3,341

21.1.5 Urban Sections: Type 3

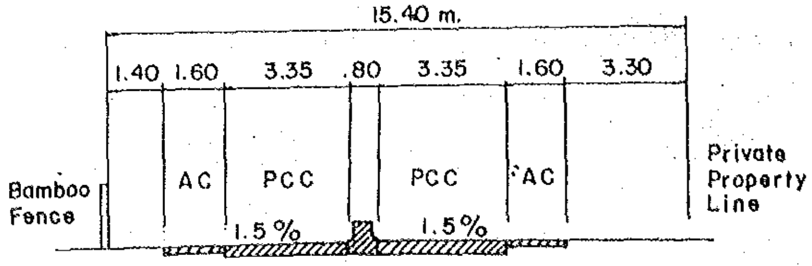
Urban sections which belong to Type-3 are those sections that (in terms of levels of service) have no problem yet, however, in view of poor conditions of shoulders and sidewalks, improvement was recommended.

Improvement measures proposed were paving of shoulders, or re-paving of deteriorated AC shoulders and construction of sidewalks, thus sections will be improved as an urban type road.

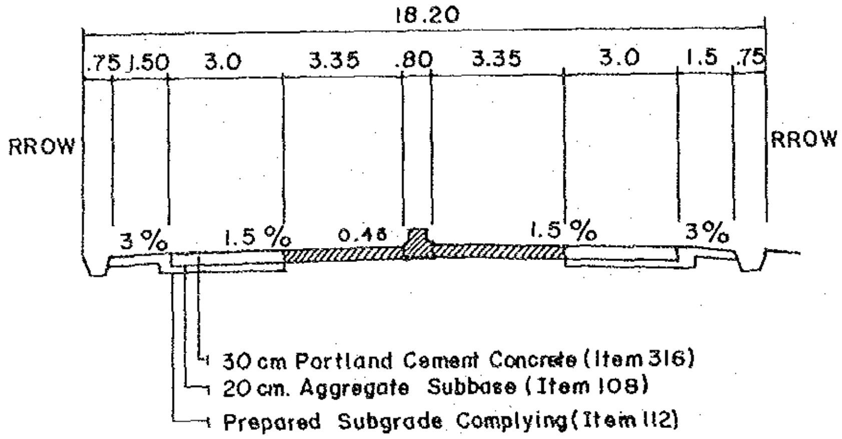
TABLE 21.1-9 TRAFFIC VOLUME AND LEVEL OF SERVICE (SAN JOSE URBAN SECTION)

Unit: Vehicle Per Day

Vehicle Type	Year 1986	1990	2000	2010
Manila Side				
Car	2,175 (15)	2,683 (15)	6,649 (18)	8,981 (18)
Jeepney	1,908 (13)	2,282 (13)	4,718 (12)	5,980 (12)
Bus	233 (2)	285 (2)	585 (2)	740 (2)
Truck	1,055 (7)	1,297 (7)	2,831 (7)	3,170 (8)
Tricycle	9,480 (64)	11,310 (63)	23,155 (61)	29,274 (60)
T O T A L	14,851 (100)	17,857 (100)	37,940 (100)	48,685 (100)
Level of Service	D	E	F	F
Cagayan Side				
Car	2,221 (14)	2,743 (14)	6,764 (17)	9,124 (17)
Jeepney	1,794 (11)	2,140 (11)	4,835 (11)	5,544 (11)
Bus	239 (1)	286 (1)	585 (1)	738 (1)
Truck	1,038 (6)	1,269 (7)	2,690 (7)	3,488 (7)
Tricycle	10,720 (67)	12,789 (67)	26,184 (64)	33,103 (64)
T O T A L	16,012 (100)	19,227 (100)	40,607 (100)	51,997 (100)
Level of Service	E	E	F	F



Typical Existing Cross Section: Suburban Section of San Jose City



Proposed Improvment: Suburban Section of San Jose City

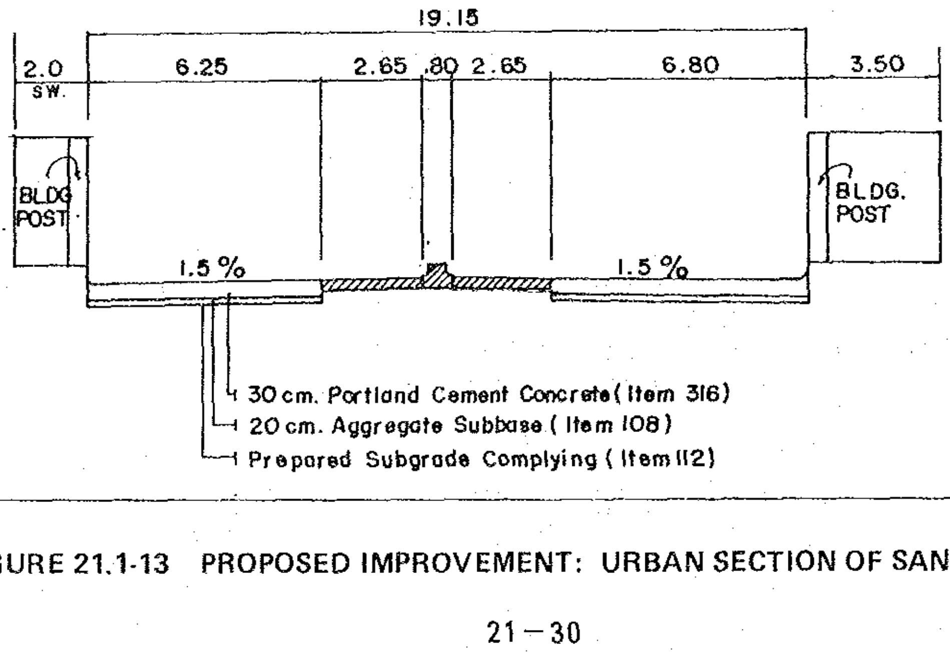


FIGURE 21.1-13 PROPOSED IMPROVEMENT: URBAN SECTION OF SAN JOSE CITY

Urban sections in the North Section usually have wide shoulders most of which are deteriorated. When these shoulders are improved and sidewalks are constructed, traffic capacity will be improved and less traffic accidents will be expected.

In case of urban sections in the South Section, however, existing shoulders are narrow (mostly 1.0 meter or less), therefore, even if shoulders are paved, benefits will be minimal. No economic evaluation was conducted for urban sections in the South Section.

21.1.6 Intersection

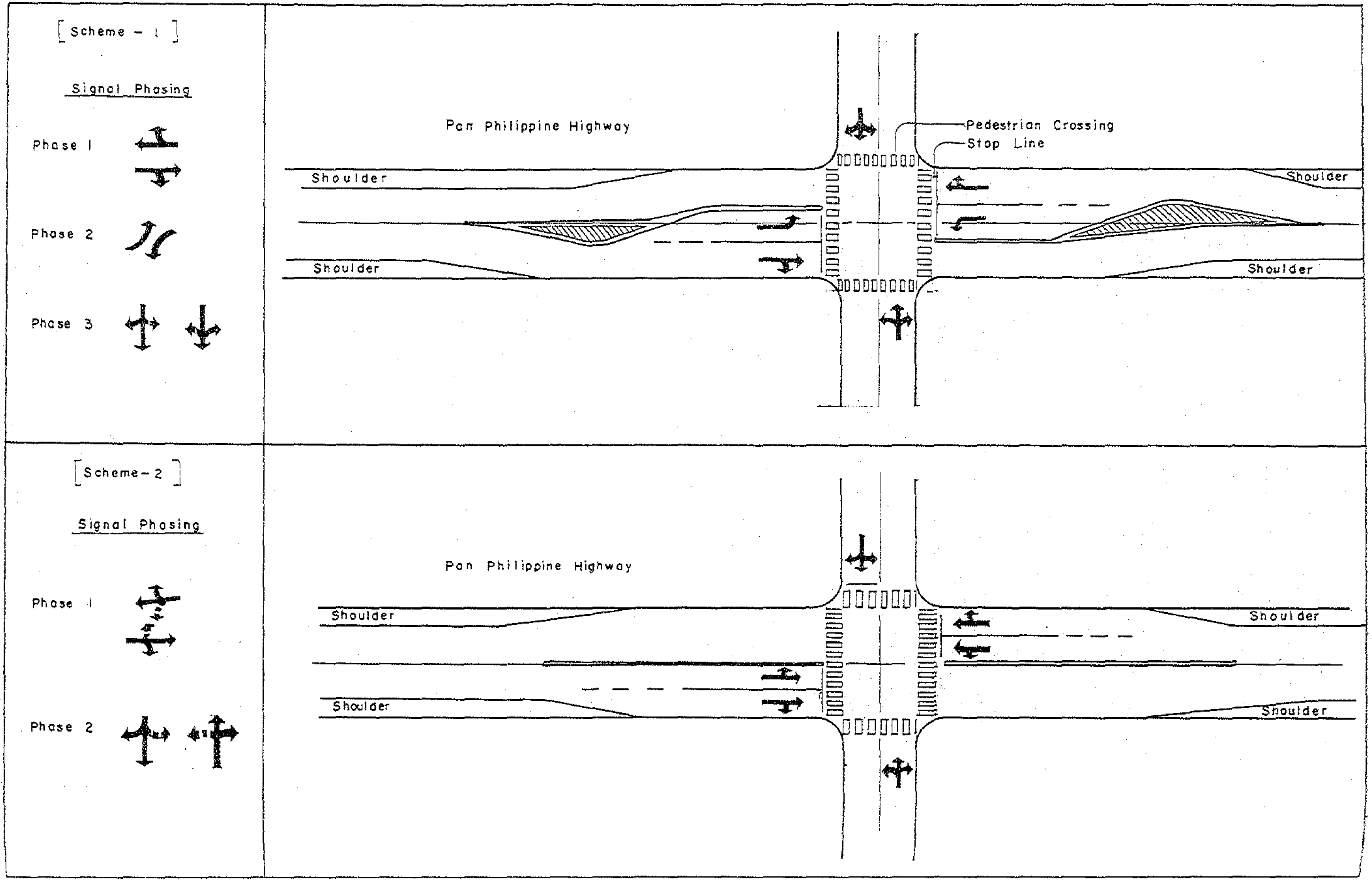
There is no signalized intersection in the Study Section. At the major intersections in the North Section, travel speeds are reduced to low at about 15 to 20 kms per hour. Slow travel speed is caused not only by heavy volume of traffic, but also by PUV's frequent spots at both an approach and an exit of an intersection for loading/unloading purposes. Quite irregular (or flexible) movements of tricycles also disturb orderly stream of traffic. Although no statistics of traffic accident at an intersection is available, many minor traffic accidents seem to occur at an intersection.

Intersections of which levels of service reach to E, improvement should be considered. Improvement measures should be planned within the existing right-of-way. Vicinity of urban intersections is already heavily built-up, widening is not practical solution. To attain maximum utilization of the existing roadway space as well as to attain overlay stream of traffic and traffic safety, signalization of an intersection was recommended.

Two schemes for signal phasing are presented in Figure 21.1-14. Considering frequent stops of PUVs at an approach as well as an exit of an intersection, scheme 2 will be desirable which provides wider space at an exit, on the condition that left turn vehicles will not obstract through traffic. When left turn traffic volume exceeds about 150 vehicles per hour, Scheme 1 should be considered with strict enforcement of no loading/unloading of PUV passengers as well as no parking at an exit of intersection.

Those intersections which have inadequate geometric design were recommended to be improved so that traffic on the Pan-Philippine Highway are given right-of-way.

FIGURE 21.1-14 TRAFFIC SIGNAL PHASING AND CHANALIZATION



21.2 PROJECT COST ESTIMATE

21.2.1 Unit Costs

A market price survey was conducted to obtain pertinent information on market prices of construction materials, equipment cost and labor cost. The unit cost of each construction item was estimated based on the market price survey findings, information from contractors and latest unit costs from other projects. Price levels of October 1986 were used. Exchange rates used were: ₱20.00 = $1.00 = ¥ 160.

Tables 21.2-1, 2 and 3 show unit prices of main materials, hourly cost of construction equipment and labor cost, respectively.

Based on these unit prices, price analyses were conducted to develop unit costs for construction items with breakdown of foreign and local currency components and tax component. Foreign currency component includes costs of imported equipment, and spare parts, foreign currency portion of locally purchased goods and services and remuneration of foreign expatriate personnels. Local currency component consists of costs of locally produced equipment, materials and supplies, remuneration of local personnels and local overhead. Table 21.2-4 shows unit costs of construction items. Unit price analyses are presented in Appendix 21-1.

Unit: Pesos at November 1986 Prices

Main Materials	Unit	Unit Prices (₱)	Component (%) F	L	T
Market Price of Purchase Material					
Portland Cement	bag	48.50	55	30	15
Steel Reinforcement	kg.	9.50	70	12	18
Plywood, 1/2" x 4' x 8'	each	210.00	25	61	14
Form Lumber	bd. ft.	6.50	25	61	14
C.W. Nails	kgs.	15.00	25	61	14
G.I. Pipe, 3" Ø x 12'	each	313.80	25	61	14
Bolts, Nuts, and Washers 3/8" Ø x 4"	set	4.00	25	61	14
Road Signs	cm^2	0.30	25	61	14
Traffic Sign (White)	gal.	335.00	25	61	14
Traffic Sign (Yellow)	gal.	365.00	25	61	14
Thinner	gal.	45.00	25	61	14
Brush	each	45.00	25	61	14
No. 16 G.I. Tie Wire	kg.	18.00	25	61	14
Wire Mesh # 10 (2" x 2")	m^2	31.40	25	61	14
PVC Pipe, 02.0 m Ø (perforated)	L.M.	250.00	25	61	14
PVC Pipe, 100 m Ø x 3 m	each	306.00	25	61	14
RCPC, 910 mm Ø	L.M.	420.00	25	61	14
RCPC, 760 mm Ø	L.M.	305.00	25	61	14
RCPC, 610 mm Ø	L.M.	256.00	25	61	14
Curing Compound	kg.	4.00	64	7	29
Asphalt Sealing Material	ton	5,660.00	64	7	29
MC-70 Cutback Asphalt	ton	4,000.00	64	7	29
Emulsified Asphalt	ton	4,000.00	64	7	29
Asphalt Concrete, Pen 85-100	ton	751.50	64	7	29
- Processsed Materials					
- Coarse Aggregate for Cement Concrete	m^3	90.35	64	22	14
- Fine Aggregate for Cement Concrete	m^3	79.95	63	23	14
- Crushed Gravel Aggregate for Base Coarse	m^3	108.75	64	21	15
- Crushed Stone Aggregate for Base Coarse	m^3	146.70	64	21	15
- Coarse Aggregate for Subbase Coarse	m^3	88.45	63	23	14
- Concrete Class "A", delivered	m^3	795.75	60	25	15
- Concrete Class "B", delivered	m^3	764.90	60	25	15

TABLE 21.2-1 UNIT PRICES OF MAIN MATERIALS

Unit: Pesos at November 1986 Prices

Construction Equipment	Hourly Cost
1. Tractor Crawler with Dozer, 11t, 110 HP	539.00
2. Tractor Crawler with Dozer, 21t, 200 HP	700.00
3. Wheel Loader, 0.57 m^3, 39 HP	168.00
4. Wheel Loader, 0.77 m^3, 50 HP	189.00
5. Wheel Loader, 1.24 m^3, 80 HP	308.00
6. Wheel Loader, 1.62 m^3, 100 HP	378.00
7. Backhoe Crawler, 0.08 m^3, 21.3 HP	147.00
8. Backhoe Crawler, 0.40 m^3, 82 HP	350.00
9. Backhoe Crawler, 0.6 m^3, 100 HP	392.00
10. Dumptruck, 6.1 m^3, 190 HP	238.00
11. Motorized Grader, 10t, 110 HP	378.00
12. Macadam Roller, 10-12t, 105 HP	266.00
13. Tandem Roller, 6-8t, 105 HP	259.00
14. Tandem Roller, 9-11t, 105 HP	266.00
15. Vibratory Roller, 12t, 175 HP	525.00
16. Penumatic Roller, 15t, 106 HP	224.00
17. Sheepsfoot Roller, Towed Type, 5-8t	259.00
18. Asphalt Sprayer	267.00
19. Asphalt Paver, 3.1 m	420.00
20. Transit Mixer, 5 m^3, 190 HP	483.00
21. Concrete Breaker	42.00
22. Concrete Saw, 180 kg. 5 HP	113.75*
23. Sand Blaster, 1.35t, 82 HP	110.00*
24. Concrete Vibrator (small works)	32.25
25. Concrete Pavement Vibrator with Engine, 145 kgs, 3 HP	160.70*
26. Vibratory Tamper, 80 kgs, 3 HP	70.00
27. Air Compressor	210.00
28. Generator, 100 kw	246.00
29. Mobile Screening and Washing Plant, 60 tph	1,175.00*
30. Batching Plant, 60 tph	809.55*
31. Crushing Plant, 60 tph	1,145.00*
32. Mixing Plant 60 tph	650.00
33. Water Truck, 6000 lit., 140 HP	567.00
34. Water Truck, 1000 USG	364.00
35. Water Pump	30.30
36. Joint Cleaner	55.00*
37. Joint Seal Remover	60.00*
38. Joint Sealer	65.00*
39. Mixer, 1 1/2 - 2 bagger	32.25
40. Mixer, 3 - 4 bagger	47.10
41. Pick-up, 41 HP	308.00
42. Bar Cutter	32.85

Hourly Cost

Associated Construction Equipment Lessors, Inc. Interim Equipment Rental Rates as of July 1984 (operated hour).

* Rental Rate Schedule of MPWH Equipment as of July 1986.

Cost Components

70% foreign, 15% local and 15% taxes, based on 10% custom duty, 10% advance taxes and 20% overhead and profit.

TABLE 21.2-2 HOURLY COST OF CONSTRUCTION EQUIPMENT

TABLE 21.2-3 LABOR COST

Unit: Pesos at November 1986 Prices

Labor Category	Hourly Rate	Daily Rate
Foreman	₱17.55	₱140.40
Assistant Foreman	16.50	132.00
Heavy Equipment Operator	15.50	124.00
Light Equipment Operator	12.85	102.80
Carpenter	14.00	112.00
Mason	14.00	112.00
Steelman	14.00	112.00
Skilled Laborer	14.00	112.00
Driver	12.15	97.20
Unskilled Laborer	8.35	66.80

Cost Component (%)

Item	Foreign	Local	Taxes
Skilled Local Labor	0	87	13
Unskilled Labor	0	95	5

TABLE 21.2-4 UNIT COSTS OF MAJOR CONSTRUCTION ITEMS

Item No.	Description	Unit	Unit Cost ₱	Components F	L	T
100	Clearing and Grubbing	ha.	18,702.85	58	29	13
102	Stripping	m^3	38.85	64	22	14
104	Removal of Miscellaneous Structure (Concrete Pavement Removal, Thickness = 23 cm)	m^3	114.22	69	16	15
105	Roadway and Drainage Excavation (Common Excavation)	m^3	48.80	66	20	14
106-1	Excavation for Structures Above Water Level	m^3	64.20	62	24	14
106-2	Excavation for Structures Below Water Level	m^3	102.35	65	21	14
107	Borrow	m^3	88.20	69	16	15
108	Aggregate Subbase	m^3	208.55	65	21	14
118-1	Repreparation of Previously Constructed Concrete Pavement (Thickness = 23 cm)	km	141,667.00	69	16	15
118-2	Repreparation of Previously Constructed Asphalt Concrete Pavement (Thickness = 5 cm)	km	96,710.00	69	16	16
200-1	Mechanically Stabilized Base Course (Thickness = 20 cm)	m^3	334.36	65	21	14
200-2	Crushed Aggregate Base Coarse	m^3	276.65	66	19	15
205	Bituminous Plant Mix Base Coarse (Thickness = 10 cm)	m^2	190.75	64	9	27
302	Bituminous Prime Coat	M.T.	7,272.15	63	17	20
303	Bituminous Tack Coat	M.T.	7,420.85	62	18	20
310	Bituminous Concrete Surface Coarse (Thickness = 10 cm)	h.	1,061.95	67	11	22
316	Portland Cement Concrete Pavement	m^3	1,196.70	58	27	15
	t = 13 cm	m^2	155.57	58	27	15
	t = 15 cm	m^2	179.51	58	27	15
	t = 18 cm	m^2	215.41	58	27	15
	t = 20 cm	m^2	239.34	58	27	15
	t = 23 cm	m^2	275.24	58	27	15
	t = 25 cm	m^2	299.18	58	27	15
	t = 28 cm	m^2	335.08	58	27	15
	t = 30 cm	m^2	359.01	58	27	15
	t = 33 cm	m^2	394.91	58	27	15
	t = 35 cm	m^2	418.84	58	27	15
405-A	Class A Concrete	m^3	1,967.50	58	27	15
405-B	Class B Concrete	m^3	1,928.40	58	27	15
405-1	R C D G	L.M.	65,000.00	54	32	14
405-2	R C D G	L.M.	70,000.00	58	27	15
412	Stone Masonry	m^3	745.90	40	49	11
413-1	Reinforced Concrete Pipe Culvert (610 mm ø)	L.M.	454.12	48	40	12
413-2	Reinforced Concrete Pipe Cross Drain (910 mm ø)					
SPL-1	Masonry Side Ditch (MSD-1)	L.M.	292.12	42	47	11
SPL-2	Masonry Side Ditch (MSD-2)	L.M.	302.52	48	40	12
SPL-3	Concrete Side Ditch (CSD-2)	L.M.	384.14	48	40	12
SPL-4	Concrete Side Ditch (CSD-2)	L.M.	353.06	48	40	12
413-3	Reinforced Concrete Pipe Cross Drain (910 mm ø)	L.M.	1,184.75	48	40	12
500	Riprap Grouted	m^3	676.65	42	47	11
502	Combination Concrete Curb and Gutter	L.M.	298.15	40	47	13
503	Concrete Sidewalk	m^2	168.30	56	29	15
505-1	Inlet Type A (610 mm ø)	each	4,973.30	55	30	15
505-2	Inlet Type B (750 mm ø)	each	5,716.05	55	30	15
508-1	Traffic Line Lacquer (0.20 m)	L.M.	4.35	66	19	15
509	Perforated PVC Pipe, 0.20 m ø (Underdrain)	L.M.	512.68	32	54	14

Unit prices for road right-of-way acquisition were developed based on assessed values prepared by the City/Municipal Tax Assessor's Offices, as shown below:

Section	Land Value (₱/Sq.m.)		Buildings (₱/Sq. m.)	
	Agricultural	Commercial Residential	Residential Stores	Commercial
Sta. Rita -Plaridel	100	100	800	850
Plaridel (Bypass Route)	20	50	800	850
Cabanatuan (Existing Route)	-	180	800	850
Cabanataun (Bypass Route)	20	50	800	850
Calamba-Sto. Tomas	100	100	800	850

21.2.2 Construction and Right-of-Way Acquisition Cost

Construction and right-of-way acquisition costs by segment and by implementation periods are summarized in Table 21.2-5.

TABLE 21.2-5 SUMMARY OF CONSTRUCTION COST

November 1986 Prices

Study Section	Segment	Construction/ROW Acquisition Cost (Million ₱)		
		Short Term (1987-1992)	Medium Term (1993-1998)	Total (1987-1998)
North	N - 1	13.37	85.50	98.87
	N - 2	57.46	59.43	116.89
	N - 3	25.97	-	25.97
	N - 4	-	-	-
	N - 5	-	-	-
	Sub-Total	96.80	144.93	241.73
South	S - 1	66.45	-	66.45
	S - 2	9.04	75.90	84.94
	S - 3	-	-	-
	S - 4	6.12	-	6.12
	Sub-Total	81.61	75.90	157.51
TOTAL		178.41	220.83	399.24

Total construction cost in the short term period was estimated at 178.41 million pesos, of which 96.80 million pesos (54%) are costs for projects in the North Study Section and the rest of 81.61 million pesos (46%) for the South Study Sections.

Total construction cost in the medium term period was estimated at 220.83 million pesos, of which 144.94 million pesos (66%) are for the North Study Section and the rest (75.90 million pesos or 34%) are for the South Study Section.

Total construction cost for improvement of road function for the road between 1987 and 1998 was estimated at 399.24 million pesos.

Table 21.2-6 shows construction and right-of-way acquisition costs by segment and by type of improvement. Construction costs by segment in the short and the medium term periods are presented in Tables 21.2-7 and 8, respectively.

21.2.3 Consultancy Cost

The consultancy cost for detailed engineering services usually accounts for 3 to 5% of construction cost. The average of 4% was adopted in the study. The consultancy cost for construction supervision services which generally accounts for 5 to 9%, was estimated at 6% of construction cost.

21.2.4 Project Cost

Project cost which consists of construction cost, right-of-way acquisition cost and consultancy cost were estimated as shown in Tables 21.2-9 and 10.

Total project costs in the short term period were estimated at 199.55 million pesos, of which 110.21 million pesos (55%) were for the North Study Section and the rest of 89.34 million pesos (or 45%) for the South Study Section.

Total project costs in the medium term period were estimated at 236.13 million pesos, 153.63 million pesos (65%) for the North Study Section and 82.50 million pesos (35%) for the South Study Section.

Project costs by type of improvement for the short and the medium term periods (1987-1998) are as follows:

	Project Cost (in million ₱)	Share
Rural : Widening to a 4 lane	78.77	18.1%
Urban : Construction of a bypass	249.94	57.4%
Urban : Paving of shoulders/sidewalks	93.15	21.4%
Intersection : Signalization/Improvement of Geometrics	13.82	3.1%
TOTAL	435.68	100%

TABLE 21.2-6 CONSTRUCTION COST BY SECTION AND BY TYPE OF IMPROVEMENT

November 1986 Prices

Segment No.	Type of Section	Section	Type of Improvement	Length (Km.)	Construction Cost (Million ₱) Foreign	Local	Tax	Total	Right-of-Way Acquisition Cost (Million ₱)	Remarks
	Rural (Type 1)	Sta. Rita-Plaridel	Widening to a 4-lane	1.5	5.28	2.61	1.31	9.20	1.61	Medium Term
N - 1	Urban (Type 1)	Plaridel	Construction of a bypass	4.6	47.06	17.99	11.25	76.30	5.50	Medium Term
(Sta. Rita	Urban (Type 3)	San Ildefonso	Paving of Shoulders/Sidewalks	1.0	2.35	1.21	0.60	4.16	-	
- Gapan)	Intersection	Plaridel	Signalization	-	0.98	0.37	0.22	1.57	-	
	Intersection	Baliuag Bypass	Improvement of Geometrics	-	0.28	0.17	0.08	0.53	-	-
	Urban (Type 1)	Gapan	Paving of shoulders/sidewalks	1.2	3.25	1.92	0.84	6.01	-	-
N - 2	Urban (Type 3)	Sta. Rosa	Paving of shoulders/sidewalks	1.1	3.37	1.99	0.88	6.24	-	-
(Gapan	Urban (Type)	Cabanatuan	Paving of shoulders/sidewalks	4.5	13.94	8.00	3.58	25.52	1.05	-
- Cabanatuan)	Urban (Type 1)	Cabanatuan	Construction of an alternative route (Bypass)	7.1	36.57	14.13	8.73	59.43	12.62	Medium Term
	Intersection	Gapan	Signalization	-	0.84	0.31	0.19	1.34	-	-
	Intersection	Sta. Rosa	Signalization	-	0.99	0.38	0.22	1.59	-	-
	Intersection	Cabanatuan II	Signalization	-	0.88	0.33	0.20	1.41	-	-
	Intersection	Cabanatuan IV	Signalization	-	1.04	0.40	0.24	1.68	-	-
N - 3	Urban (Type 3)	Talavera	Paving of shoulders/sidewalk	1.0	2.90	1.72	0.76	5.38	-	-
(Cabanatuan-	Urban (Type 2)	San Jose	Paving of shoulders/sidewalk	3.5	10.42	5.82	2.66	18.90	-	-
- San Jose)	Intersection	San Jose	Signalization	-	1.05	0.40	0.24	1.69	-	-
	Rural (Type 1)	Calamba-Sto.Tomas	Widening to a 4-lane	10.0	32.92	15.95	8.19	57.06	4.28	-
S - 1	Urban (Type 3)	Alaminos	Paving of shoulders/sidewalks	1.2	1.34	0.68	0.34	2.36	-	-
(Calamba -	Intersection	Sto. Tomas I	Improvement of Geometrics	-	0.72	0.28	0.16	1.16	-	-
- Tiaong)	Intersection	Sto. Tomas II	Improvement of Geometrics	-	0.97	0.40	0.22	1.59	-	-
	Urban (Type 3)	Tiaong	Paving of shoulders/sidewalks	1.2	1.15	0.63	0.29	2.07	-	-
	Urban (Type 3)	Tiaong	Construction of a bypass	3.0	11.10	4.28	2.62	18.00	2.70	Medium Term
S - 2	Urban (Type 3)	Candelaria	Paving of shoulders/sidewalks	1.0	1.48	0.84	0.38	2.70	-	-
(Tiaong -	Urban (Type 3)	Candelaria	Consruction of a bypass	4.0	14.70	5.70	3.60	24.00	3.60	Medium Term
Pagbilao)	Urban (Type 3)	Sariaya	Paving of shoulders/sidewalks	1.0	1.21	0.68	0.31	2.20	-	-
	Urban (Type 3)	Sariaya	Construction of bypass	4.0	14.70	5.70	3.60	24.00	3.60	Medium Term
	Urban (Type 3)	Pagbilao	Paving of shoulders/sidewalks	1.3	1.15	0.62	0.30	2.07	-	-
S - 4	Urban (Type 3)	Gumaca	Paving of shoulders/sidewalks	1.5	1.83	1.15	0.47	3.45	-	-
(Gumaca-Calauag)	Urban (Type 3)	Lopez	Paving of shoulders/sidewalks	1.0	1.43	0.87	0.37	2.67	-	-

TABLE 21.2-7 CONSTRUCTION COST IN SHORT TERM PERIOD

In Million Pesos (November 1986 Price)

Seg-ment 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)	-	5.50	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	26.57
	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	96.80
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	Sta. 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

TABLE 21.2-8 CONSTRUCTION COST IN MEDIUM TERM PERIOD

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

TABLE 21.2-9 PROJECT COST BY SEGMENT

Study Section	Segment No.	Short Term (1987-1992)				Medium Term (1993-1998)				Total (1987-1998)			
		Construction	ROW	Consultancy	Total	Construction	ROW	Consultancy	Total	Construction	ROW	Consultancy	Total
NORTH	N - 1	6.26	7.11	4.05	17.42	85.50	-	5.13	90.63	91.76	7.11	9.18	108.05
	N - 2	43.79	13.67	6.76	64.22	59.43	-	3.57	63.00	103.22	13.67	10.33	127.22
	N - 3	25.97	-	2.60	28.57	-	-	-	-	25.97	-	2.60	28.57
	N - 4	-	-	-	-	-	-	-	-	-	-	-	-
	N - 5	-	-	-	-	-	-	-	-	-	-	-	-
	Sub-Total	76.02	20.78	13.41	110.21	144.93	-	8.70	153.63	220.95	20.78	22.11	263.84
SOUTH	S - 1	62.17	4.28	6.22	72.67	-	-	-	-	62.17	4.28	6.22	72.67
	S - 2	9.04	-	0.90	9.94	66.00	9.90	6.60	82.50	75.04	9.90	7.50	92.44
	S - 3	-	-	-	-	-	-	-	-	-	-	-	-
	S - 4	6.12	-	0.61	6.73	-	-	-	-	6.12	-	0.61	6.73
	Sub-Total	77.33	4.28	7.73	89.34	66.00	9.90	6.60	82.50	143.33	14.18	14.33	171.84
T O T A L		153.35	25.06	21.14	199.55	210.93	9.90	15.3	236.13	364.28	34.96	36.44	435.68

TABLE 21.2-10 PROJECT COST BY TYPE OF IMPROVEMENT

November 1986 Prices

Study Section	Section Type	Type of Improvement	No. of Section/Length (Km.)	Project Cost (Million P) Construction	ROW	Consultancy	Total
North	Rural	. Widening to a 4-lane	1 - section L = 1.5	9.20	1.61	0.92	11.73
	Urban	. Construction of a bypass	2 - section L = 11.7	135.73	18.12	13.59	167.44
	Urban	. Paving of shoulders/sidewalks	6 - section L = 12.3	66.21	1.05	6.62	73.88
	Intersection	. Signalization/Improvement of Geometrics	7 - Intersection	9.81	-	0.98	10.79
		(Sub-Total)		220.95	20.78	22.11	263.84
South	Rural	. Widening to a 4-lane	1 - section L = 10.0	57.06	4.28	5.70	67.04
	Urban	. Construction of a bypass	3 - section L = 11.0	66.00	9.90	6.60	82.50
	Urban	. Paving of Shoulders/Sidewalks	7 - section L = 8.2	17.52	-	1.75	19.27
	Intersection	. Signalization/Improvement of Geometrics	2 - Intersection	2.75	-	0.28	3.03
		(Sub-Total)		143.33	14.18	14.33	171.84
TOTAL	Rural	. Widening of a 4-lane	2 - section L = 11.5	66.26	5.89	6.62	78.77
	Urban	. Construction of a bypass	5 - section L = 22.7	201.73	28.02	20.19	249.94
	Urban	. Paving of shoulders/sidewalks	13 - section L = 20.5	83.73	1.05	8.37	93.15
	Intersection	. Signalization/Improvement of Geometrics	9 - Intersection	12.56	-	1.26	13.82
		(T O T A L)		364.28	34.96	36.44	435.68

21.3 ECONOMIC EVALUATION

21.3.1 Condition of Analysis

Evaluation was done based on Net Present Value (NPV), Benefit-Cost Ratio (B/C) and Internal Rate of Return (IRR) which are commonly used as indicators in economic analysis of feasibility study and was carried out under the following assumptions.

- Project Benefits Considered

  Time savings, running cost savings, reduction in traffic accidents and stopped delay time at intersections are the considered Project Benefits which are derived from the various improvement measures proposed.

- The Opportunity Cost of Capital is at 15 Percent

- The project life for road construction/improvement (e.g. improvement of shoulder and sidewalk), is 25 years and the project life for improvement of intersections is 10 years.

- No salvage value of the structure after the project life

21.3.2 Benefit of Improvement Measures

1) General

The Pan-Philippine Highway, which traverses the Philippines and links Metro Manila with major regional towns and cities, plays a major role as the primary artery of the trunk road network in the country. At the same time, the Pan-Philippine Highway functions as the only trunk road, or one of the few, traversing the urban area of major regional towns and cities, thus, enhancing the development of urban and economic activities along the highway.

Cognizant with the above mentioned significant role of Pan-Philippine Highway, the Study Team considered various types of project benefit which will be derived from various improvement measures proposed for its already deteriotated sections. These project benefits are generally classified into direct and indirect benefits as follows:

Direct Benefits

- Savings in running cost
- Savings in fixed cost
- Savings in passenger time cost
- Reduction in traffic accidents
- Reduction in stopped delay time at intersection

Indirect Benefits

- Development of regional industries that create employment opportunities
- Land expansion for commercial and industrial use
- Stimulation of socio-economic activities in rural and urban areas
- Reduction of regional growth and disparities
- Maintenance of public peace and order

The direct benefits are quantified for each type of improvement measures and project sizes and use as basis for economic analysis in this study.

2) Quantified Benefits

Figure 21.3.1 shows the list of quantified benefits for this economic analysis. The methodology of quantification of benefit will be discussed in detail in the following paragraphs.

3) Savings in Travel Time Cost

Improvement of the roads will result to shorter travel time, and consequently provide benefits to road users and vehicle operators in the form of savings in fixed and passenger time cost. Thus, the decrease in road congestion, which is specially achieved by widening the road into four lanes and constructing new by-pass, would greatly influence the degree of time savings. Likewise, the reduction of roadside friction which brings about favorable environment to traffic flow are also considered to be one of the factors to derive time savings. The factor "fw" (adjustment factor for narrow lanes and restricted shoulder width) is one of the adjustment factors for road capacity given in "Highway Capacity Manual" in U. S. A. In this Study, the "fw" factor is applied to the condition of roadside friction and consequently to road capacity.

At first, the interrelationship between volume capacity ratios, which show the degree of road congestion, and vehicle travel speed was analyzed by typical road section based on the data on travel speed obtained from the survey conducted by the Study team. The above interrelationship is established in a curve and utilized in quantifying time savings corresponding to the decrease in volume-capacity ratio. The step by step procedure of analysis is as follows:

- Establishment of typical cross sections along Pan-Philippine Highway.
- Road capacity analysis by typical cross section
- Analysis on interrelationship between volume capacity ratios (V/C) and travel speeds by typical cross section
- Estimation of existing and future V/C ratios based on existing and future traffic volume for each improvement measures
- Estimation of existing road future travel speeds by adoption of interrelationship curve (V/C ratio to travel speed)
- Calculation of savings in travel time cost

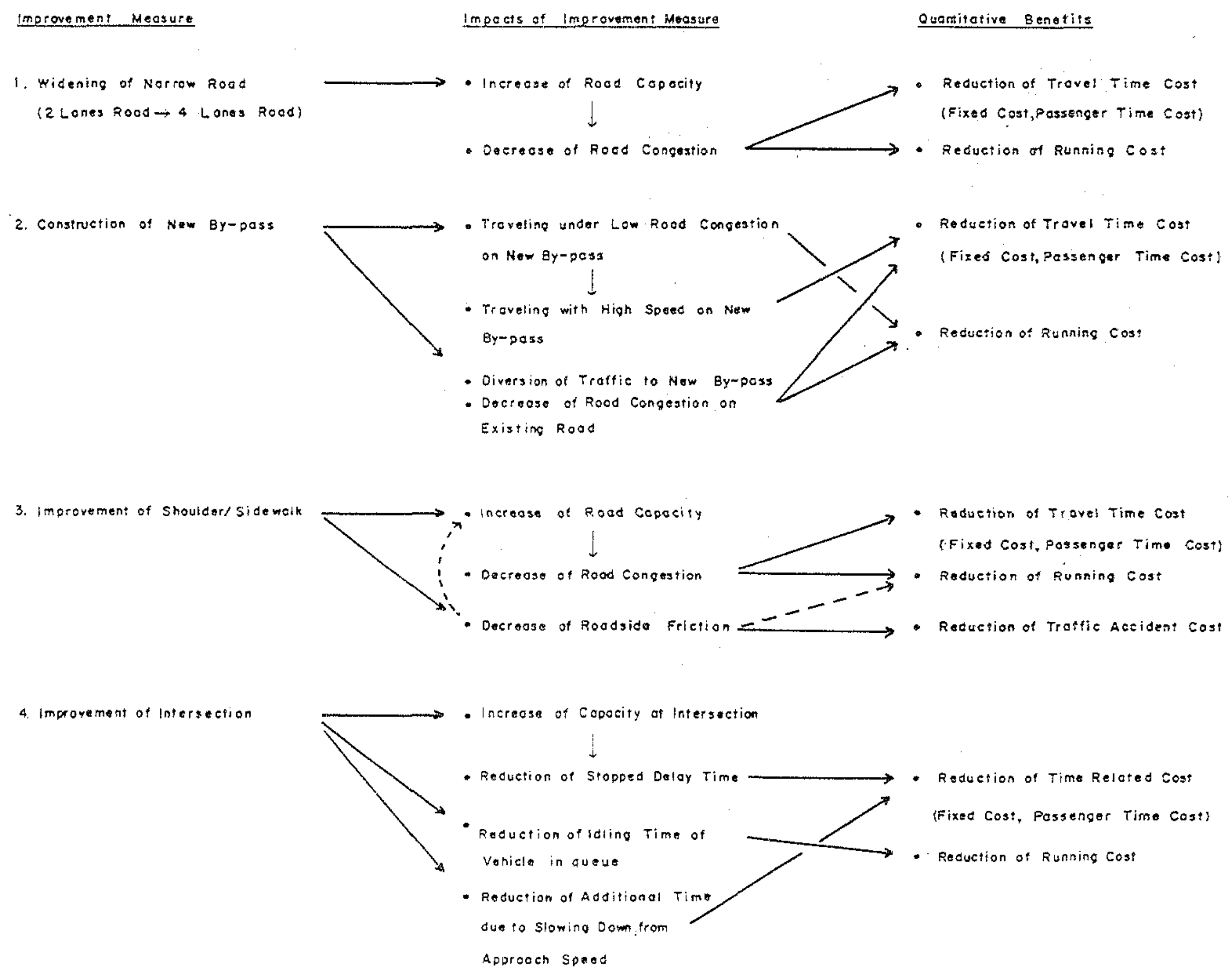


FIGURE 21.3-1 BENEFITS OF IMPROVEMENT MEASURE

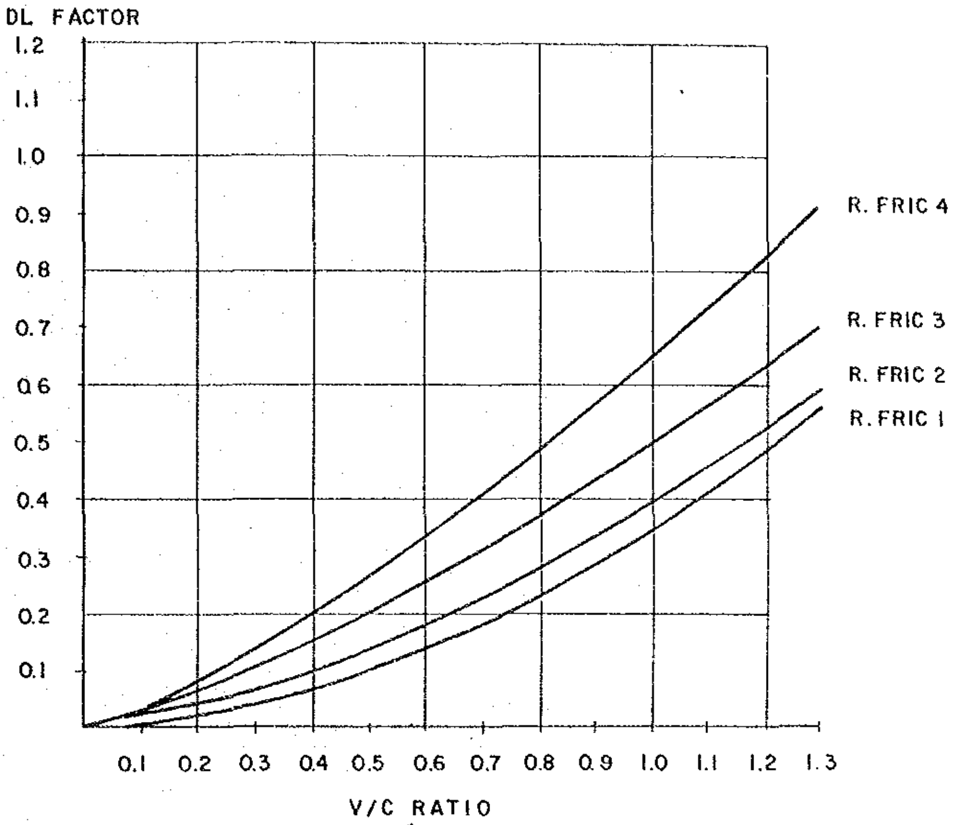
The detail of each steps are explained in Appendix 21-2.

4) Savings in Running Cost

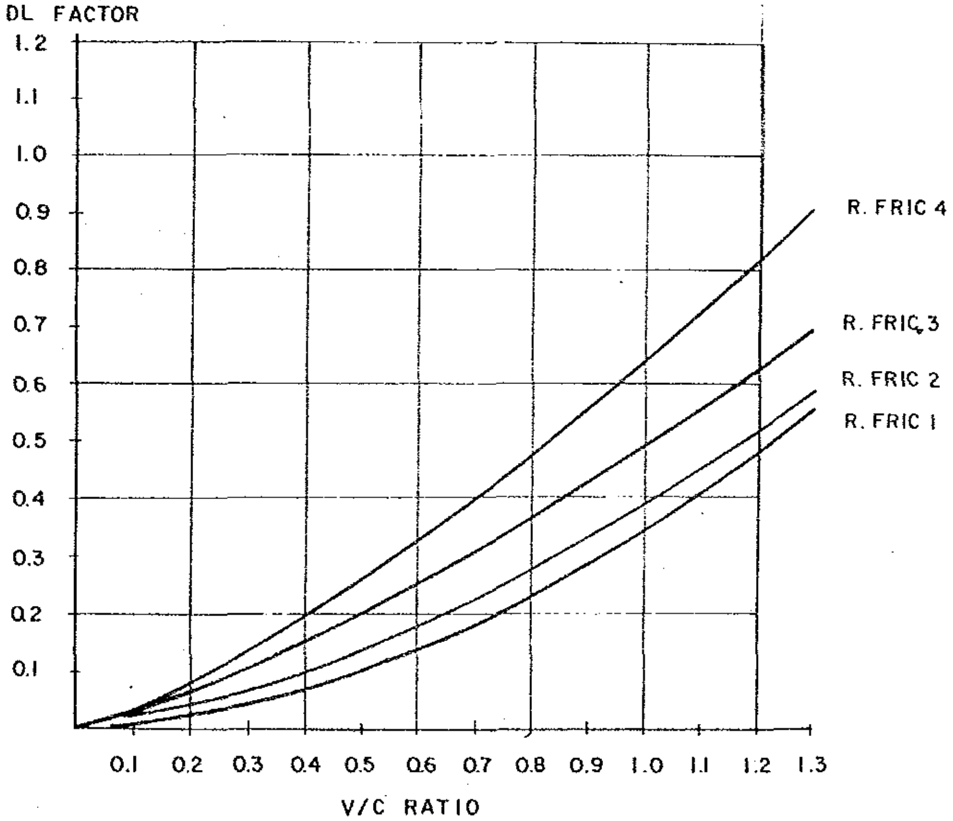
The main factors affecting the change in running cost under the actual road conditions are considered to be the conditions of traffic flow, roadside friction, pavement and grade. However, pavement and grade factors are not considered in this evaluation, because study on pavement and grades will mainly be discussed separately in the next chapter and besides, no improvement measures are planned on sections with heavy grade.

. On the other hand, high road congestion and severe roadside friction would consequently result to slow moving and unnecessary stop of vehicles, thus, the above factors can easily be recognized as important factors affecting running cost.

Highway Planning Manual of MPWH defines "dl" factor as an additional running cost incurred under the actual road condition due to road congestion and roadside friction, as some of the factors. In this Study, savings in running costs are quantified in accordance with the "dl" factor method given in Highway Planning Manual.



R. FRIC = ROADSIDE FRICTION
1 NONE 3 MEDIUM
2 LIGHT 4 HEAVY



R. FRIC = ROADSIDE FRICTION
1 NONE 3 MEDIUM
2 LIGHT 4 HEAVY

FIGURE 21.3-2 dl FACTOR UNDER THE VARIATION OF V/C RATIOS AND ROADSIDE FRICTIONS

5) Savings in Traffic Accident Cost

a) Number of Traffic Accidents

The statistical data on traffic accident was gathered and analyzed under the "Road Traffic Safety Study" in 1986. This study noted high involvement rate of pedestrians especially in cases of traffic accidents which happened in urban areas. In urban areas, about 34% of traffic accidents, 50% of fatalities, and 37% of injuries, involved pedestrians. These figures are relatively high compared with the ones in rural area.

Highway Planning Manual also take into consideration the fact that wider pavement and adequate shoulder width reduce the number of traffic accidents. As quoted in the Swedish Study, about 10% more traffic accidents occured on roads with inadequate shoulder width of less than 1.5 m, as compared with those roads with adequate shoulder width of more than 2.0m. The reduction effect on traffic accident due to the presence of roadside friction is considered and quantified in this Study.

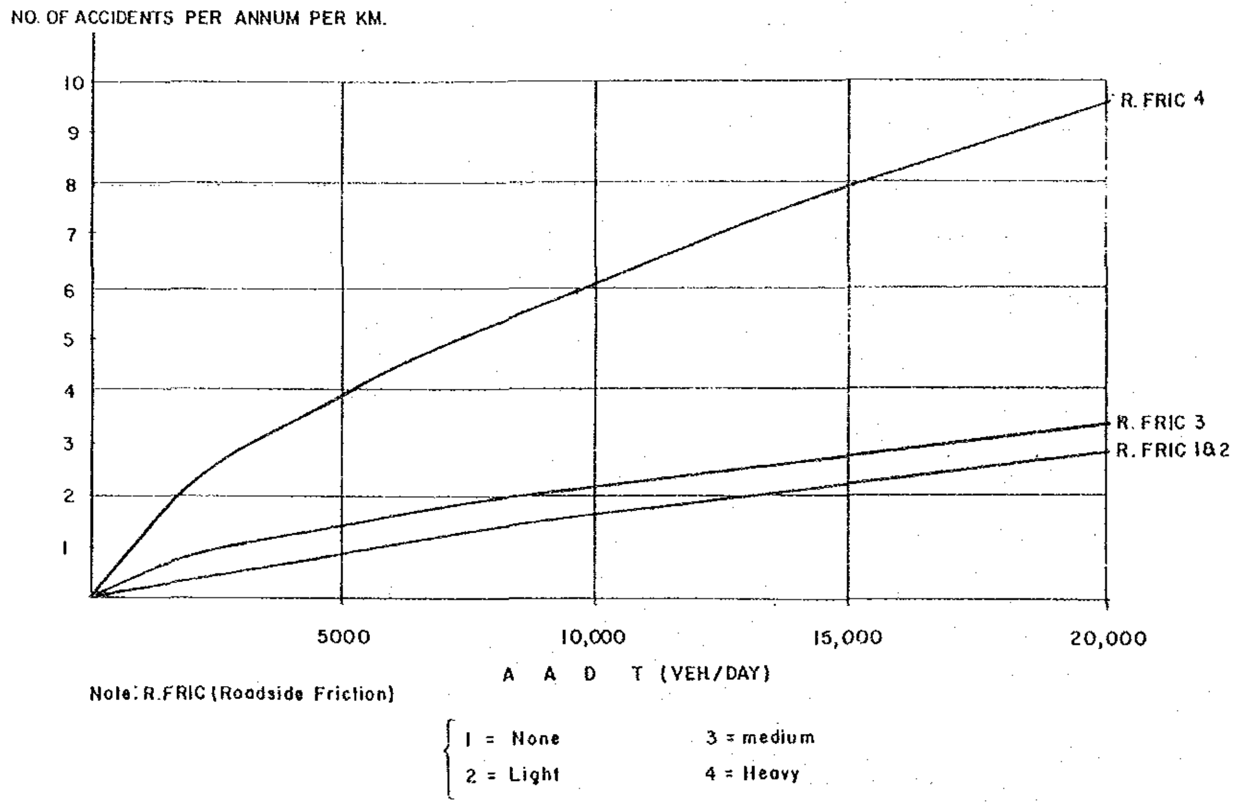


FIGURE 21.3-3 RELATIONSHIP BETWEEN NO. OF ACCIDENTS & TRAFFIC VOLUME

b) Cost per Traffic Accident

Road Traffic Safety Study (MPWH, 1986) estimated that average economic cost of traffic accidents amounted to 1,120 million pesos per year and that the total number of accidents reach to approximately 20,000 per year. These two figures imply a unit accident cost of 56,000 pesos per year, of which 72% is human capital cost. This average annual traffic accident cost is counterchecked with the estimate of MPWH, which gave almost the same estimate. The breakdown of accident cost by type of expenditure is as follows:

TABLE 21.3.1 ANNUAL TRAFFIC ACCIDENT COST (1986)

	(Million P/Year)	
Human Capital	806.4	72%
Medical Expense	12.4	1%
Property Damages	293.4	26%
Social Mechanism	8.0	1%
TOTAL	1,120.2	100%

6) Benefits at Intersection

a) Reduction in Stopped Delay Time

The stopped delay time for the "with" and "without" project cases are calculated based on the assessment of the level service at intersection carried out in accordance with the procedures given in the Highway Capacity Manual.

Up to now, the four-phase operation with protected left-turning type of intersection is very common in this country, even at light traffic intersection. However, the Metro Manila Traffic Engineering and Management Project (TEAM Project) planned and executed the trials which aim to upgrade the overall efficiency on signalized intersections through the introduction of permitted left-turning. Under the Study, several trials were made and the efficiency of phasing was checked. As a result of the study, the two phase operation with permitted left-turning was proven to be the most efficient phasing. Thus, the two phase operation is assumed to be adopted in the future at signalized intersections along the Project road. Average stopped delay time and level of service are therefore calculated for this phasing.

As noted in the Progress Report, the following items are specially taken into consideration:

- Ideal Saturation Flow Rate
- Right-turn traffic
- Passenger Car Equivalent Factor at Intersection

b) Reduction in Idling Time in Queue

The Highway Planning Manual of MPWH has quoted based on "Economic Analysis of Highways" in U.S.A., 1969, that a one minute idling time in queue at traffic signal equals 0.08 dl factor. In this evaluation, the above mentioned factor is adopted in order to estimate the additional running cost at intersection due to idling in queue.

c) Reduction in Travel Time lost due to Slow Down at Approach Lane

When approaching an intersection, vehicles reduce their driving speeds. In Highway Capacity Manual, it is estimated that the total time lost due to slow down approach at signalized intersection is equal to about 30% of stopped delay time. But, in the case of unsignalized intersection, the estimation of total time lost due to slow down approach is vague. The signalized intersection is supposedly advantageous in terms of time loss but since there is no concrete basis, the reduction in loss of travel time due to slowing down approach at intersection are not quantified.

21.3.3 Basic Traffic Cost

The basic vehicle operating cost (BVOC) of owning and operating road vehicles (net of taxes and duties) is composed of the following costs:

- Running Cost: That portion of the vehicle operating cost which is calculated in units of distance (kilometers) travelled.

- Basic Fixed Cost: That portion of the vehicle operating cost which is calculated in units of time travelled.

- Passenger Time Cost: Passenger time value including the time value of the car driver.

The above mentioned basic costs, which are used as basis for this study, were updated by the Planning Service of the Ministry of Public Works and Highways (MPWH) to June 1986 prices in accordance with the procedure outlined in MPWH's Highway Planning Manual. Such Costs were assumed to be incurred by vehicles operating under the basic ideal Philippine condition, cost estimates for motorcycles were also included in the original BVOC estimates.

A summary of the BVOC for the north and south sections is given in Table 23.3.2.

TABLE 21.3-2 BASIC VEHICLE COSTS BY VEHICLE TYPE

Vehicle Type	Basic Running Cost (₱/Vehicle-Km)	Basic Fixed Cost (₱/Vehicle-Hr.)	Passenger Time Cost (₱/Vehicle-Hr.)
Car/Van	1.069	2.898	11.334
Jeepney	791	21.898	13.711
Bus	2.210	30.472	65.812
Truck	2.366	32.638	0.000
Motorcycle	.084	1.332	1.164
Tricycle	.110	5.042	.117

21.3.4 Economic Evaluation

Results of the cost-benefit analysis are summarized in Table 21.3-3 (Also refer to Appendix 21-4).

(1) Rural Section: Widening to a 4-lane

Two (2) cases were subjected to cost-benefit analysis, i.e. a) implementation at the early stage of level of service E and b) implementation at the latter stage of level of service D. Both cases were economically feasible with high IRRs ranging from 35 to 49%. Implementation at the latter stage of level of service D was recommended in view of high rate of economic return.

(2) Urban Section, Type 1 : Construction of a bypass

Plaridel Bypass

Two (2) cases as in the case of rural section were studied. Implementation of this project at the early stage of level of service E (opening year 1990) was not economically justified due to high cost of construction. A bypass route has to cross Angat River and overpass the Plaridel-Angat Road, which requires a 335-meter bridge, resulting in high construction cost. This project was recommended to be implemented in the middle stage of level of service E (opening year 1995), which was economically justified with IRR of 16.4%.

Cabanatuan Urban Section

The following three (3) cases were studied:

(a) Improvement of the existing section by paving shoulders and sidewalks at the early stage of level of service E (opening year 1990)

(b) Construction of an alternative route (bypass) at an early stage of level of service E (opening year 1990)

(c) Stage implementation of a) and b) i.e. a) at the early stage of level of service E (opening year 1990) then b) at the middle stage of level of service E (opening year 1995)

Three (3) cases were found economically feasibile with IRRs more than 35%. It was recommended that case c) : stage implementation of two (2) projects be adopted.

(3) Urban Section, Types 1, 2 and 3 : Paving of shoulders/sidewalks

Implementation of this type of improvement at the early stage of level of service E was economically justified.

(4) Intersection : Signalization

Signalization of an intersection at the early stage of level of service E was also economically feasible.

Cost-benefit analysis by segment was also conducted under the condition that all projects are implemented in the short term period, except Plaridel bypass and Cabanatuan bypass which are implemented in the medium term period. Results are presented below:

Segment	Economic Indicators		
	IRR (%)	B/C	NPV (million ₱)
N-1	23.2	1.8	171.5
N-2	53.1	4.6	295.8
N-3	18.5	1.3	7.9
S-1	39.8	5.6	253.1

TABLE 21.3-3 SUMMARY OF COST BENEFIT ANALYSIS

Section Type	Section	Type of Improvement	Implementation	Opening Year	Economic Indicators IRR (%)	B/C	NPV (Million ₱)
Rural	Sta. Rita-Plaridel	Widening to a 4-lane	At early stage of LOS E	1995	45.8	6.3	59.7
			At latter stage of LOS D	1990	35.9	4.4	34.5
	Calamba-Sto. Tomas	Widening to a 4-lane	At early stage of LOS E	1995	48.9	7.6	382.0
			At latter stage of LOS D	1990	39.8	5.6	253.1
Urban: Type 1	Plaridel	Construction of a bypass	At middle stage of LOS E	1995	16.4	1.1	9.4
			At early stage of LOS E	1991	13.2	0.83	-12.8
	Cabanatuan	Paving of Shoulders/Sidewalks	At early stage of LOS E	1990	36.4	3.6	66.1
		Construction of a bypass	At early stage of LOS E	1990	35.6	3.8	185.
		(Paving) + (bypass)	At early and middle stage of LOS E	1990, 1995	38.0	3.9	188.8
	Gapan	Paving of Shoulders/Sidewalks	At early stage of LOS E	1990	23.9	1.7	4.1
Urban: Type 2	San Jose	Paving of Shoulders/Sidewalks	At early stage of LOS E	1990	15.0	1.0	0
Urban: Type 3	San Ildefonso	Paving of Shoulders/Sidewalks	At latter stage of LOS D	1992	14.9	1.0	0
	Sta. Rosa	Paving of Shoulders/Sidewalks	At early stage of LOS E	1990	26.8	2.7	9.8
	Talavera	Paving of Shoulders/Sidewalks	At early stage of LOS E	1990	24.6	2.4	7.0
Intersection	Plaridel	Signalization	LOS F	1990	81.1	5.2	7.4
	Gapan	Signalization	LOS E	1990	299.6	22.0	33.3
	Sta. Rosa	Signalization	LOS D	1990	12.6	0.9	-0.2
	Cabanatuan II	Signalization	LOS E	1990	215.7	17.4	27.0
	Cabanatuan IV	Signalization	LOS E	1990	236.8	18.4	32.9
	San Jose	Signalization	LOS E	1990	25.5	1.5	0.9

21.4 ENVIRONMENTAL ASSESSMENT

The Supplement to Official Gazette, Volume 78, No. 25, issued by National Environmental Protection Council (NEPC) June 21, 1982 proclaims certain areas and types of projects as environmentally critical and within the scope of the environmental impact statement (EIS) system.

According to this Official Gazette, major infrastructure projects are categorized as environmentally critical projects, among which major roads and bridges are included. These are defined in the Official Circular No. 3 by the Ministry of Public Works and Highways, August 1984, as follows:

Major Roads and Bridges

This shall refer to the construction of all national and provincial roads and bridges and any significant extension of improvement thereof which will;

a) Traverse any highly developed urban area(s);
b) Affect the hydrology of the traversed area(s);
c) Substantially increase or impede traffic flow.

Environmental Compliance Certificate

According to the Official Gazette mentioned above, the procedure to obtain an Environmental Compliance Certificate (ECC) are as follows:

> The project proponent initially determines whether or not a project falls within the EIS System. In case of uncertainty, the project proponent shall request the assistance of the lead agency to make such determination;
>
> In case of negative determination, the project proponent may proceed with the project;
>
> In case of a positive determination, the project proponent shall be required to file a Project Description with the NEPC in the form prescribed for this purposes;

Environmental Impact Evaluation

Two (2) major types of improvement projects were assessed on their environmental impacts. Table 21.4-1 shows environmental impact statement for the widening to a 4-lane road project. Considering nature and objectives of the project, this type of project generally provides favorable impacts with minimal adverse impacts.

Table 21.4-2 shows environmental impacts statement for a construction of a bypass project. Minor and medium adverse impacts are acquisition of land for road right-of-way and demolition of houses, which shall be done in accordance with existing laws and regulations. Although this type of projects have adverse impacts mentioned above, they generally provide major favorable impacts as shown in the Tables.

TABLE 21.4-1 WIDENING TO A 4-LANE ROAD PROJECT – ENVIRONMENTAL IMPACT STATEMENT –

Favorable Impact	Adverse Impact
◎ High	xxx High
o Medium	xx Medium
Δ Minor	x Minor
- No	- No

Evaluation Item	During Construction Favorable Impact	During Construction Adverse Impact	After Improvement Favorable Impact	After Improvement Adverse Impact	Remarks
1. Natural Environment					
1.1 Land	-	-	o	-	. Land value may increase.
1.2 Water	-	-	-	-	. No change is expected.
1.3 Atmosphere	-	x	o	-	. Smooth flow of traffic will decrease air pollution, even though traffic may increase. During construction, minor affect may be expected.
1.4 Terrestial Life	-	-	-	-	. No impact
1.5 Aquatic Life	-	-	-	-	. No impact
1.6 Ecological Balance	-	-	-	-	. No impact
2. Socio-economic Condition					
2.1 Demographic	-	-	Δ	-	. Migration from urban to project site may be expected.
2.2 Lifestyle	-	-	Δ	-	. Effect on cultural communities near/ within project site may be expected.
2.3 Amenities	-	-	o	-	. Quality of residential, cultural and spiritual community may be improved.
2.4 Cultural Minorities	-	-	-	-	. No impact
2.5 Historical Sites	-	-	-	-	. No impact
2.6 Health	-	-	o	-	. Comfortable/safe transportation . Less air pollution
2.7 Social	-	xx	-	-	. 52 houses (Sta. Rita-Aritao Section) 63 houses(Calamba-Sto. Tomas Section, are affected.
2.8 Economics	-	x	◎	-	. Travel cost will remarkably decrease . Additional economic activities may be encouraged.
3. Traffic					
3.1 Traffic Flow	-	x	◎	-	. During construction, traffic flow may be slightly disturbed. . Traffic flow will greatly improved and travel will be fast and comfortable.
3.2 Traffic Safety	-	-	◎	-	. Traffic safety will be increased.

TABLE 21.4-2 CONSTRUCTION OF A BYPASS OR AN ALTERNATIVE ROUTE PROJECT – ENVIRONMENTAL IMPACT STATEMENT –

Favorable Impact		Adverse Impact	
◎	High	xxx	High
o	Medium	xx	Medium
△	Minor	x	Minor
-	No	-	No

Evaluation Item	During Construction Favorable Impact	During Construction Adverse Impact	After Improvement Favorable Impact	After Improvement Adverse Impact	Remarks
1. Natural Environment					
1.1 Land	-	x	◎	-	. Agricultural land must be acquired. . Land expansion for commercial and residential use will be expected. . Better urbanization will be expected. . Land value will increase.
1.2 Water	-	-	-	-	. No change is expected
1.3 Atmosphere	-	-	◎	-	. Traffic will be diverted to 2 routes, therefore, air pollution, noise and vibration will drastically decrease.
1.4 Terrestial Life	-	-	-	-	. No impact
1.5 Aquatic Life	-	-	-	-	. No impact
1.6 Ecological Balance	-	-	-	-	. No impact
2. Socio-economic Condition					
2.1 Demographic	-	-	o	-	. Migration from CBD to project site may be expected.
2.2 Lifestyle	-	-	△	-	. Effect on cultural communities near/within project site may be expected.
2.3 Amenities	-	-	o	-	. Quality of residential, cultural and spiritual community may be improved.
2.4 Cultural Minorities	-	-	-	-	. No impact
2.5 Historical Sites	-	-	-	-	. No impact
2.6 Health	-	-	o	-	. Comfortable/safe transportation . Less air pollution
2.7 Social	-	xx	-	-	. 25 houses (Plaridel Bypass), 64 house (Cabanatuan City alternative route) are affected.
2.8 Economics	-	x	◎	-	. Travel cost will remarkably decrease . Additional economic activities may be encouraged.
3. Traffic					
3.1 Traffic Flow	-	x	◎	-	. During construction, traffic flow may be slightly disturbed. . Traffic flow will greatly improved and travel will be fast and comfortable.
3.2 Traffic Safety	-	-	◎	-	. Traffic safety will be increased.

CHAPTER 22

FEASIBILITY STUDY ON PAVEMENT REHABILITATION

22.1 PRELIMINARY DESIGN

22.1.1 Detailed Investigation

For the Feasibility Study Section selected in Chapter 20, the detailed investigation was conducted with the following aims.

1) Pavement Deterioration

- To identify types of deterioration and place in categories according to the classification described in the Appendix of Volume VI of this Study.
- To assess deterioration severities and to note level of severity according to classification mentioned above.
- To estimate deterioration amount based on area affected by each combination of deterioration types and severity.
- To assess possible causes of deteriorations based on findings through pavement deterioration survey and anlysis reported in Chapter 14.

2) Subgrade and subbase.

- To assess CBR value based on findings through geo-technical survey, CBR test and deflection survey reported in Chapter 14.
- To presume loss of support beneath deteriorated concrete slabs.

3) Drainage Conditions.

- To assess degree of permeability of subgrade based on types of materials and environmental conditions.
- To investigate influence of water by road geometrics.

4) Verification of Rehabilitation Requirement Index (RRI)

- To verify adoptability of RRI established in Chapter 13 in terms of degree (severity) and extent (amount) of deterioration.

The findings of detailed investigation were incorporated in the preliminary design. For the sections other than the Feasibility Study Section, the results of surface condition survey reported in Chapter 13 were utilized for the preliminary design. The investigation/survey results used for design are presented together with the proposed rehabilitation methods in Appendix 22-1. Refer to Volume V I of the Study.

22

22.1.2 Pavement Design Requirements

Design requirements adopted for the basic structural design were also used for pavement design of the preliminary design, as described hereunder.

1) Design Criteria

The analysis period of 25 years was adopted. The major design criteria are summarized in Table 22.1-1.

2) Traffic Loading Classes

Traffic loading classes were assigned for each segment as shown in Table 22.1-3, classified by standard traffic loading classes listed in Table 22.1-4 which was discussed in Chapter 11.3.

3) Performance Periods of Initial Pavement Structures

Table 22.1-5 summarizes the performance period of the initial pavement structures recommended based on life-cycle economic analysis as discussed in Chapter 16.3.

4) Rehabilitation Strategy

Because of heavy traffic loads, the initial pavement structures required involve the huge amount of the initial investment. Therefore, the stage construction (the planned rehabilitation) strategy was recommended in order to save the initial investment, thus facilitate rehabilitation project at the earliest possible time.

After the serviceability of initial pavements reaches at RRI of 2.5 (design performance period of initial pavement structure), the second rehabilitation work will be performed as shown in Table 22.1-6.

Figure 22.1-4 demonstrates the planned rehabilitation strategy. A 2-Lane AC Reconstruction was not proposed because of the high initial cost, as shown in Table 22.1-6 and Figure 22.1-5 for reference.

22.1.3 Selection of Pavement Rehabilitation Methods

As discussed in Chapter 17, AC overlay, One-lane PCC Reconstruction and Two-lane PCC Reconstruction were recommended as the pavement rehabilitation methods. Among the three, AC overlay is the most economical followed by One-Lane PCC and Two-lane PCC reconstruction.

However, selection of pavement rehabilitation methods is a very complex engineering problem. There is no infalliable method even for selecting the most prefered alternatives, rather, the selection process requires considerable engineering judgement, creativity and flexibility.

Decision factors when choosing the prefered solution involved the following, among others.

TABLE 22.1-1 MAJOR DESIGN CRITERIA

	Concrete/PCC Pavement	Asphalt/AC Overlay
Performance Period	Traffic Loading A-E; 15 yrs. Traffic Loading H-J; 12 yrs.	Traffic Loading A,B; 12 yrs. Traffic Loading D-G; 8 yrs. Traffic Loading H-J; 5 yrs.
Traffic Loading Class	See Table 22.1-3	See Table 22.1-3
Serviceability	Initial; 4.5 Terminal; 2.5	Initial; 4.2 Terminal; 2.5
Effective Roadbed Soil Resilient Modulus	———	MR assumed by CBR See Table 22.1-2
Effective Modulus of Subgrade Reaction	K value assumed by CBR See Table 22.1-2	———
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	525 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 Stabilized " = 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 22.1-2 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

TABLE 22.1-3 TRAFFIC LOADING CLASSES OF THE STUDY SECTIONS

Segment	Section	Lane	Number of ESALS in 1989 (x 10^6)	Traffic Loading Class	
N - 1	Sta. Rita-	A	3.495	J	(3.1 - 3.5 x 10^6)
	Plaridel	B	1.451	F	(1.1 - 1.5 x 10^6)
	Plaridel -	A	2.908	I	(2.6 - 3.0 x 10^6)
	Gapan	B	1.098	E	(0.71 - 1.0 x 10^6)
N - 2	Gapan -	A	2.946	I	
	Cabanatuan	B	0.964	E	
N - 3	Cabanatuan -	A	2.459	H	(2.1 - 2.5 x 10^6)
	San Jose	B	0.763	D	(0.41 - 0.7 x 10^6)
N - 4	San Jose -	A	1.787	G	(1.6 - 2.0 x 10^6)
N - 5	Aritao	B	0.520	D	
S - 1	Calamba -	A	1.747	G	
	Sto. Tomas	B	1.258	D	
	Sto. Tomas -	A	1.090	G	
	Tiaong	B	0.637	F	
S - 2	Tiaong -	A	0.967	E	
	Lucena	B	0.577	D	
S - 3	Lucena -	A	0.796	D	
	Gumaca	B	0.480	C	(0.21 - 0.4 x 10^6)
S - 4	Gumaca -	A	0.706	D	
	Calauag	B	0.407	C	

NOTE: A; Manila Bound
B; Cagayan/Bicol Bound

TABLE 22.1-4 STANDARD TRAFFIC LOADING CLASSES

	Traffic Loading Class	Number of ESAL At Initial Year
Light Loading Traffic	L - 1	0.005 x 10^6
	L - 2	0.01
	L - 3	0.03
Heavy Loading Traffic	A	0.03 - 0.1 x 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 x 10^6
	G	1.6 - 2.0
	H	2.1 - 2.5
	I	2.6 - 3.0
	J	3.1 - 3.5

TABLE 22.1-5 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 ≦ 0.03×10^6	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")

TABLE 22.1-6 STAGE CONSTRUCTION (PLANNED REHABILITATION)

Rehabilitation Methods	Initial Rehabilitation (at the stage)	Second Rehabilitation	Third Rehabilitation
2 – Lane PCC Reconstruction	PCC Reconstruction (15 years) [1)]	10 cm AC Overlay	5 cm AC Overlay
1 – Lane PCC Reconstruction	PCC Reconstruction (15 years) [1)]	PCC Reconstruction	PCC Reconstruction
2 – Lane AC Overlay	10 cm AC Overlay (8 years) [1)]	5 cm AC Overlay	5 cm AC Overlay
2 – Lane AC Reconstruction	AC Reconstruction (12 years) [1)]	5 cm AC Overlay	5 cm AC Overlay

Note: 1) Design Performance Period of Initial Pavement Structure Variable depending on traffic loading class.

Technical Considerations

- Existing pavement conditions
- Types, severity and extents of pavement distress

Monetary Considerations

- Initial Cost
- Total discounted cost based on life-cycle cost analysis

Non-Monetary Considerations

- Service life
- Duration of construction
- Traffic control problems
- Reliability
- Constructibility
- Maintainability

Monetary and Non-Monetary Considerations were discussed in the previous Chapter. Detailed in this Chapter is the judgement or applicability of AC overlay.

(1) Criteria based on Observation on Pavement Condition

Rehabilitation for restoration/strengthening of structural capacity is divided into two major categories; reconstruction and overlay. While reconstruction does not involve any technical problem in its application provided that it is properly constructed, overlay should be investigated on its applicability. Roadbed and subsurface drainage conditions are major factors to be considered in investigating the applicability of overlay. Final judgement shall be based on detailed pavement condition data.

In the absence of such detailed data, the following criteria were adopted in the Study to determine if overlay rehabilitation can be applied or not.

Conditions of Pavement distress on which overlay can be applied.

Distress primarily caused by traffic and by concrete slab material are considered in this group, as follows:

- Blow-up (Infiltration of the compressive materials)
- Corner Break
- Faulting of Transverse Joints and Cracks
- Joint Seal Damage of Transverse Joint
- Longitudinal Cracks (only those of cracks caused by traffic loading or poor slab materials)
- Longitudinal Joint Faulting
- Popouts
- Reactive Aggregate Distress
- Sealing and Map Cracking or Crazing (Line cracks on upper surface of slab)

- Spalling (Transverse and Longitudinal Joint/Cracks)
  (only those of cracking, breaking or shipping of slab edge caused by infiltration of incompressible materials)
- Transverse and Diagonal Cracks
  (only low to medium severity level of cracks)
- Peeling (Removal of Surface)
- Pathole
- RRI more than 2 without evidence of 2) mentioned below
- Preferable minimum length of overlay section is more than 500 m.

Conditions/Pavement Distress on which overlay may be hardly applied.

Distress primarily caused by subgrade/subbase materials and drainage are considered in this group, as follows:

- Heavy depression (localized settlement area) in one slab. (caused by settlement or consolidating of subgrade/subbase)
- Lane/shoulder Drop-off (suspicious to settlement or consolidation of subgrade/subbase)
- Pumping and Water Bleeding (suspicious to voids causing loss of support)
- Block Cracking (Random Crack, Third Stage Cracks) (Multiple irregular breaks or the separation of slab) caused by localized break subgrade/subbase)
- Slab Rocking (suspicious to bearing capacity and uneven settlement)
- Subgrade with CBR values less than 6 (because of short performance period less than 5 years especially, for loading classes heavier than F.)
- RRI less than 1.5
- *No remarkable difference in elevation between fragments in one* slab
- Bad drainage conditions

It is, however, noted that if deficiencies mentioned above will be improved/removed, the overlay may be applied.

(2) Criteria based on Cracking Index and Deflection

Japan Road Association proposes the rehabilitation criteria for reinforced concrete pavement based on cracking index and deflection measured by Benkelman Test. See Figure 22.1-1.

22.1.4 Pavement Rehabilitation Design

(1) General

The pavement rehabilitation technology adopted in the Study is AASHTO Guide for Design of Pavement Structure, 1986, American Association of State Highway and Transportation Officials.

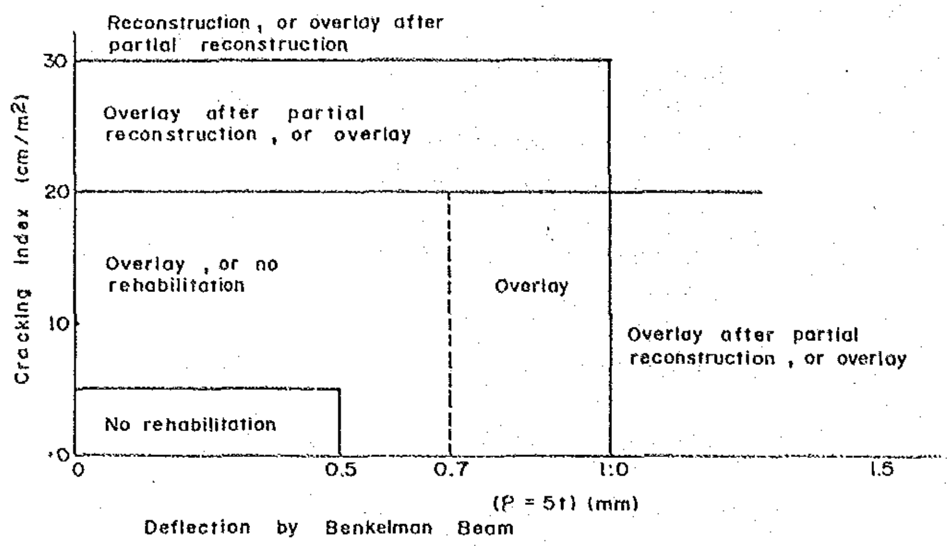


FIGURE 22.1-1 CRITERIA FOR SELECTION OF REHABILITATION METHOD RECOMMENDED BY JAPAN ROOD ASSOCIATION

The overall philosophy of the design approach in this Guide based upon the AASHTO serviceability-performance concepts was derived from the AASHO Road Test. The AASHO Road Test Performance Test prediction equation was retained as the basic model to be used for pavement design. The present serviceability index (PSI), therefore, is adopted as the performance variable upon which design would be based.

In this Guide, the new concepts such as reliability, environmental impact, drainage and load transfer, have been introduced.

The reliability is described by the following definition. The reliability of a pavement design-performance process is the probability that a pavement section designed using the process will perform satisfactorily over the traffic and environmental conditions for the design period.

(2) New construction/Reconstruction of PCC Pavements.

The basic design equation (performance prediction equation) for rigid pavement is given on the following pages. The detailed explanation on design procedure is reported in Volume VI of this Study.

In the Study, a computer program to solve this equation was developed. The outputs of design for PCC Pavement reconstruction are summarized in Figure 22.1-2. Refer to Basic Structural Design.

Rigid Pavements

$$\log_{10}(W_{18}) = Z_R \times S_o + 7.35 \times \log_{10}(D+1) - 0.06 + \left[\frac{\log_{10} \frac{\Delta PSI}{4.5-1.5}}{1 + \frac{1.624 \times 10^7}{(D+1)^{8.46}}} \right]$$

$$+ (4.22 - 0.32 \times p_t) \log_{10} \left[\frac{S_c \times C_d \times (D^{0.75} - 1.132)}{215.63 \times J \left(D^{0.75} - \frac{18.42}{(E_c/k)^{0.25}} \right)} \right]$$

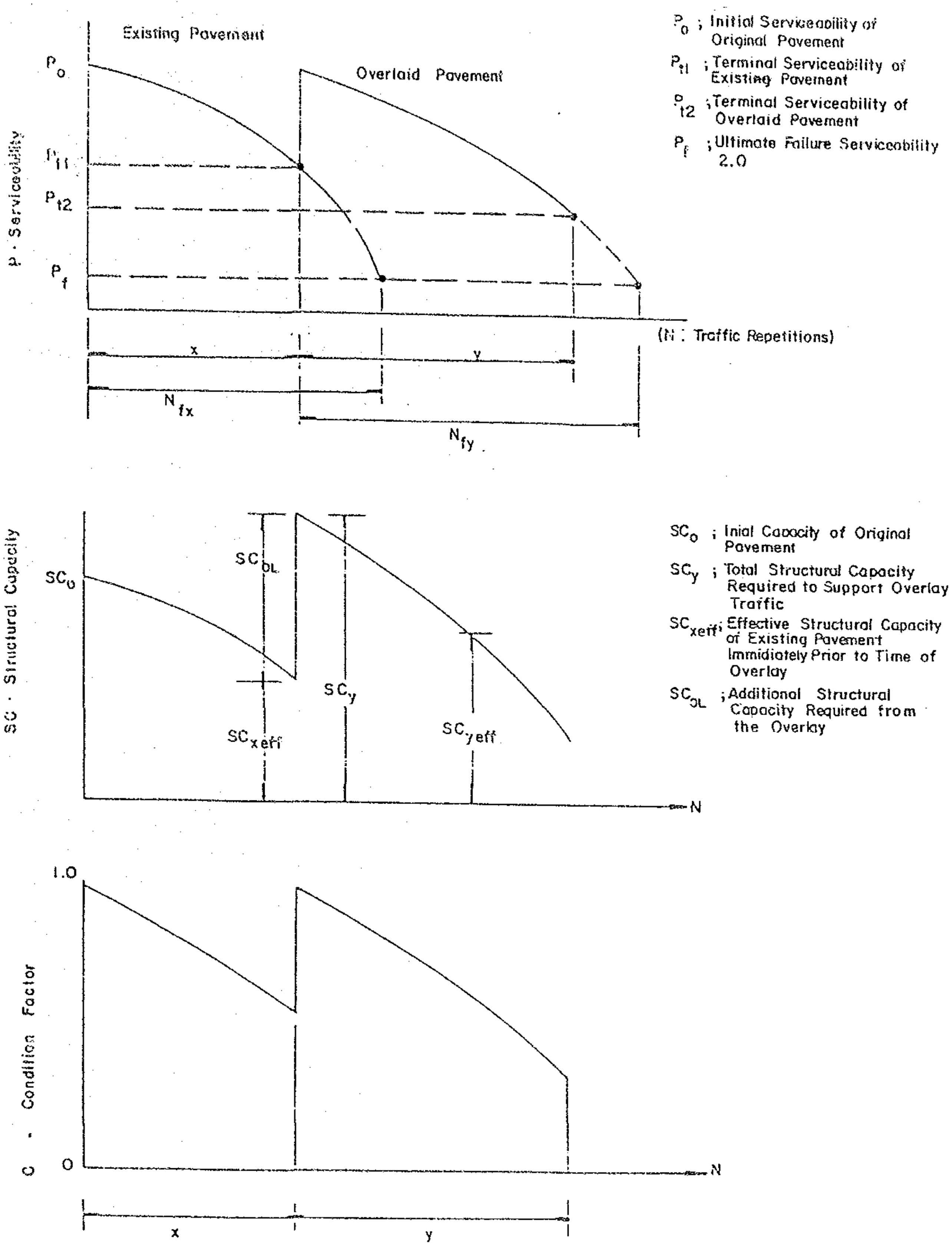


FIGURE 22.1-2 RELATIONSHIP BETWEEN SERVICEABILITY – CAPACITY CONDITION FACTOR AND TRAFFIC

Where:

W_{18}	=	predicted number of 18-kip equivalent single axle load applications.
Z_R	=	standard normal deviate,
S_o	=	combined standard error of the traffic prediction and performance prediction,
D	=	thickness (inches) of pavement slab,
Δ PSI	=	difference between the initial design serviceability index, P_o, and the design terminal serviceability index, P_t,
S_c	=	modulus of rupture (psi) for portland cement concrete used on a specific project
J	=	load transfer coefficient used to adjust for load transfer characteristics of a specific design
C_d	=	drainage coefficient
E_c	=	drainage coefficient
E_c	=	modulus of elasticity (psi) for portland cement concrete, and.
k	=	modulus of subgrade reaction (pci)

(3) AC Overlay

When the concept of remaining life is considered, the general overlay equation becomes:

$$SC_{OL}^{n} = SC_{y}^{n} - F_{RL}(SC_{xeff})^{n}$$

Where:

F_{RL}	:	The remaining life factor which accounts for damage of the existing pavement as well as the desired degree of damage to the overlay at the end of the overlay traffic. It is always less than or equal to a value of 1.0.
Sc_o	:	See Figure 22.1-4
SC_{OL}	:	See Figure 22.1-4
SC_y	:	See Figure 22.1-4
SC_{xeff}	:	See Figure 22.1-4

Overlay equation for AC overlay-PCC Existing to be used for normal approach based on visual condition factor is expressed:

$$SN_{ol} = SN_y - F_{RL}(A_{2r}D_o + SN_{xeff\text{-}rp})$$
$$h_{ol} = SN_{ol}/A_{ol}$$

Where:

D_o	:	Existing PCC layer thickness D_o = 23 cm
A_{2r}	:	The structural layer coefficient of the existing cracked PCC pavement layer. This value has been related to the value of the visual condition factor C = 0.4

$SN_{xeff\text{-}rp}$	:	The effective (in situ) structural capacity of all remaining pavement layers above the subgrade except for the existing PCC layer (Subbase)
A_{ol}	:	Structural layer coefficient of overlay material A_{01} = 0.39
A_{ol}	:	Required thickness of Asphalt Overlay

Reflective cracking of asphalt overlays over existing rigid pavement is a complex phenomena. To account for the possibility of reflective cracking, the value of overlay thickness must be compared to minimum asphalt overlay thicknesses which, in general, have been effective in minimizing the effect of reflective cracking. These minimum thicknesses are functions of the existing PCC slab length and maximum temperature difference expected within a year. The Asphalt Institute recommends 4 inches (10 cm) which is also recommended for the country.

The detailed procedures on overlay design are reported in Volume VI of this Study.

(4) Design Outputs

Recommended Structural Capacity of Pavement

Figure 22.1-3 summarizes the structural capacity of pavement recommended based on the basic structural design and economic pavement type discussion as well as other engineering considerations.

For new/reconstructed PCC pavement, the minimum thickness of 20 cm is recommended even for light traffic loading class because of the concrete strength and probable construction error. And for the extra heavy traffic loading class, the thickness of PCC slab should be decided upon the consideration on policy of traffic regulation implementation and performance periods of initial pavement structures. It is noted that the PCC pavement with 30 cm thickness will last for 15 to 20 years if the traffic regulation will be strictly implemented. In the preliminary design, however, the thicknesses of PCC slab were decided based on the present traffic loading, through the discussion with the representatives of DPWH.

As for new/reconstructed AC pavement, the structural number of 4.5, 5.0 or 5.5 should also be decided following the consideration mentioned above. AC pavement was not used in the preliminary design.

As to AC overlay-rigid existing, the minimum thickness of 10 cm AC overlay was adopted considering reflective cracking as discussed in the previous section. Special caution should be paid to 5 cm AC overlay adopted for light traffic loading. This thickness of AC overlay has a limited experience, therefore, the performance may not be warranted.

Example of Cross Section Design

Figure 22.1-4 shows the example of cross section designed for PCC and AC pavements and AC overlay.

For PCC pavements, the thickness of subbase is always constant, 20 cm. This thickness was recommended based on analysis of the combined effectiveness of subgrade and subbase. Refer to Volume VI of the Study.

PCC New / Reconstruction

PCC THICKNESS

TRAFFIC LOADING CLASS (X10⁶)	CBR	2	3	4	6	8	10	15	20	PERFORMANCE PERIOD
LIGHT TRAFFIC LOADING	L-1 (0.005)									MORE THAN 25 YEARS
	L-2 (0.01)	APPLY MIN. THICKNESS 20cm								
	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

STRUCTURAL NUMBER

TRAFFIC LOADING CLASS (X10⁶)	CBR	2	3	4	6	8	10	15	20	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

OVERLAY THICKNESS (cm)

TRAFFIC LOADING CLASS (X10⁶)	CBR	2	3	4	6	8	10	15	20	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)	NOT RECOMMENDED			APPLY MIN.THICKNESS 10cm.					12~30 YEARS
	B (0.2)									
	C' (0.4)									
	D (0.7)									
	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*

FIGURE 22.1-3 RECOMMENDED STRUCTURAL CAPACITY

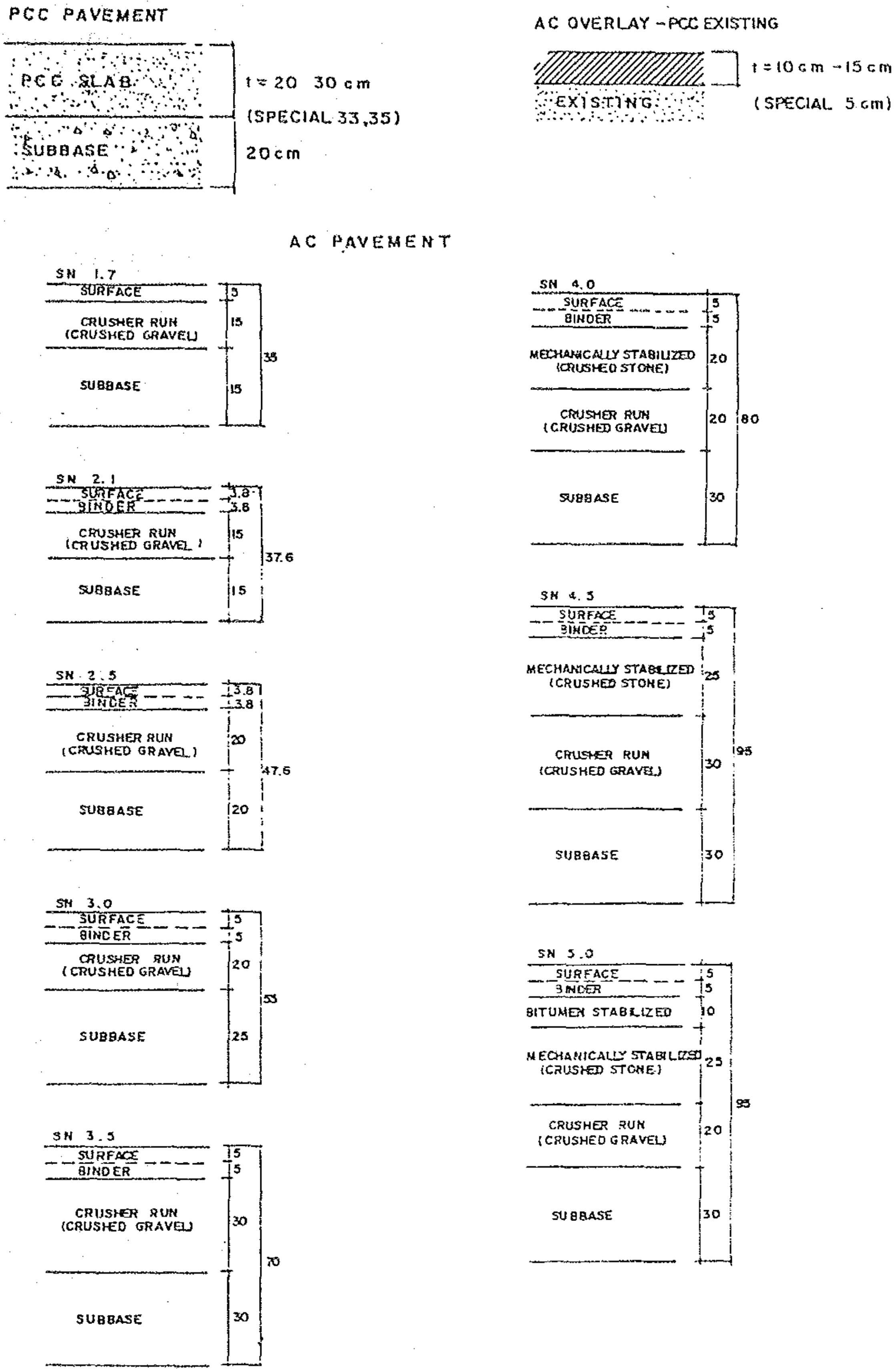


FIGURE 22.1-4 EXAMPLE OF CROSS SECTION DESIGN

As for AC pavement, the typical cross section with various values of structural number are presented for reference. The layer thickness analysis should be performed taking into consideration unit cost of each layer.

As to AC overlay, thickness used in the preliminary design are more than 10 cm.

Planned Rehabilitation

Figure 22.1-5 demonstrate the planned rehabilitation strategy. As an example, the rehabilitation sequences are graphically shown for the case with CBR value of 6 and traffic loading class of D.

22.1.5 *Treatment of Weak Subgrade*

The definition of weak subgrade is not clearly termed, but the Japan Road Association defines it as subgrade with CBR values less than 2, particularly for asphalt pavement design.

In general, weak subgrades include soft soil composed largely of silt or clay, soil with void ratio such as organic deposits or peats, and loose sand. All of them have high water contents.

Common methods widely adopted for treatment of such weak subgrades are embankment method, soil replacement, soil stabilization and sandwich. Embankment method is advisable for new construction of roads. The latter three methods are therefore discussed in Volume VI of this Study.

In concrete pavement design, the provision of filter layer is recommended where CBR values are higher than 2 but less than 3.

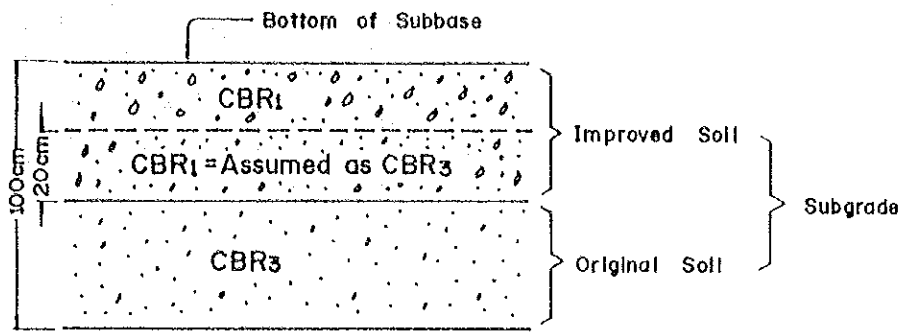
Where CBR are less than 2, the application of methods mentioned above are recommended.

(1) Filter Layer

The filter layer of 15 to 30 cm thick is effective to prevent weak subgrades from piping and migrating into subbases. Materials used as filter layer are sand containing small volume of silt in general, but crusher-run for some cases. In this Study, sand of 30 cm thick was proposed.

(2) Average CBR

Where filter layer is applied, the average CBR can be calculated using the following formula with the assumption that the CBR value of the bottom, 20 cm layer of the improved soil is still assumed to be same as that of the original soil.



$$\text{Average CBR} = \left[\sum_{n=1}^{n} \frac{hi \cdot CBRi^{1/3}}{100} \right]^3$$

where:

hi ; thickness of i layer (cm.)

$\Sigma hi = 100$ cm

CBRi ; CBR value of i layer

FIGURE 22.1-6 AVERAGE CBR

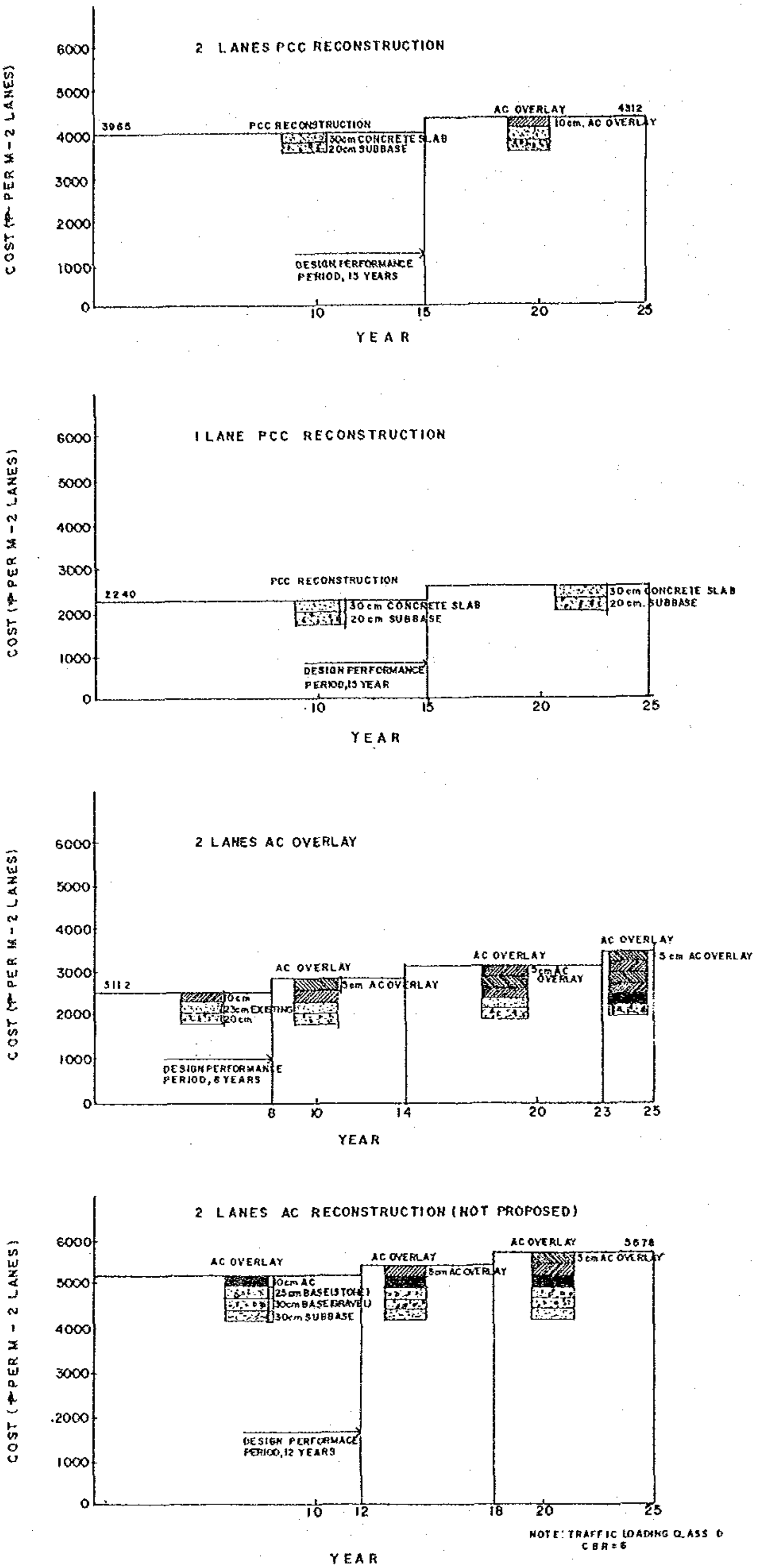


FIGURE 22.1-5 PLANNED REHABILITATION STRATEGY
TRAFFIC LOADING CLASS D
CBR – 6

22.1.6 Drainage Design

Drainage of water from pavement has always been an important consideration in road design. Method for treating water in pavements have generally consists of three methods, 1) preventing water from entering the pavements, 2) providing drainage to remove excess water quickly, and 3) building the pavement strong enough to resist combined effect of load and water.

Discussed in this Chapter are surface drainage (side ditch) and subsurface drainage.

(1) Surface Drainage

Run-off

Run-off is calculated by the following Rationale Formula.

$$Q = \frac{1}{3.6 \times 10^6} \cdot C \cdot I \cdot A$$

Where:

Q = Run-off (m^3/sec)
C = Coefficient of run-off
I = Rainfall Intensity within time of concentration (mm/h)
A = Catchment Area (m^2)

Water Velocity

The running water velocity is calculated using Manning's Formula.

$$V = \frac{1}{n} \cdot R^{2/3} \cdot i^{1/2}$$

Where:

n : Coefficient of roughness
i : Hydraulic Gradient
R : Hydraulic radius (A/P)
A : Area of running water
P : Wetted perimeter

Required Cross Sectional Area

Required cross sectional area of water course (side ditch) is calculated using the following formula.

$$Q = A \cdot V$$

Where:

- Q : Discharge of side ditch
- A : Cross-sectional area of side ditch
- V : Mean velocity of stream

Types of Side Ditch

Types of side ditch were determined by rolling/mountainous area and mansonry/concrete as shown in Figure 22.1-7.

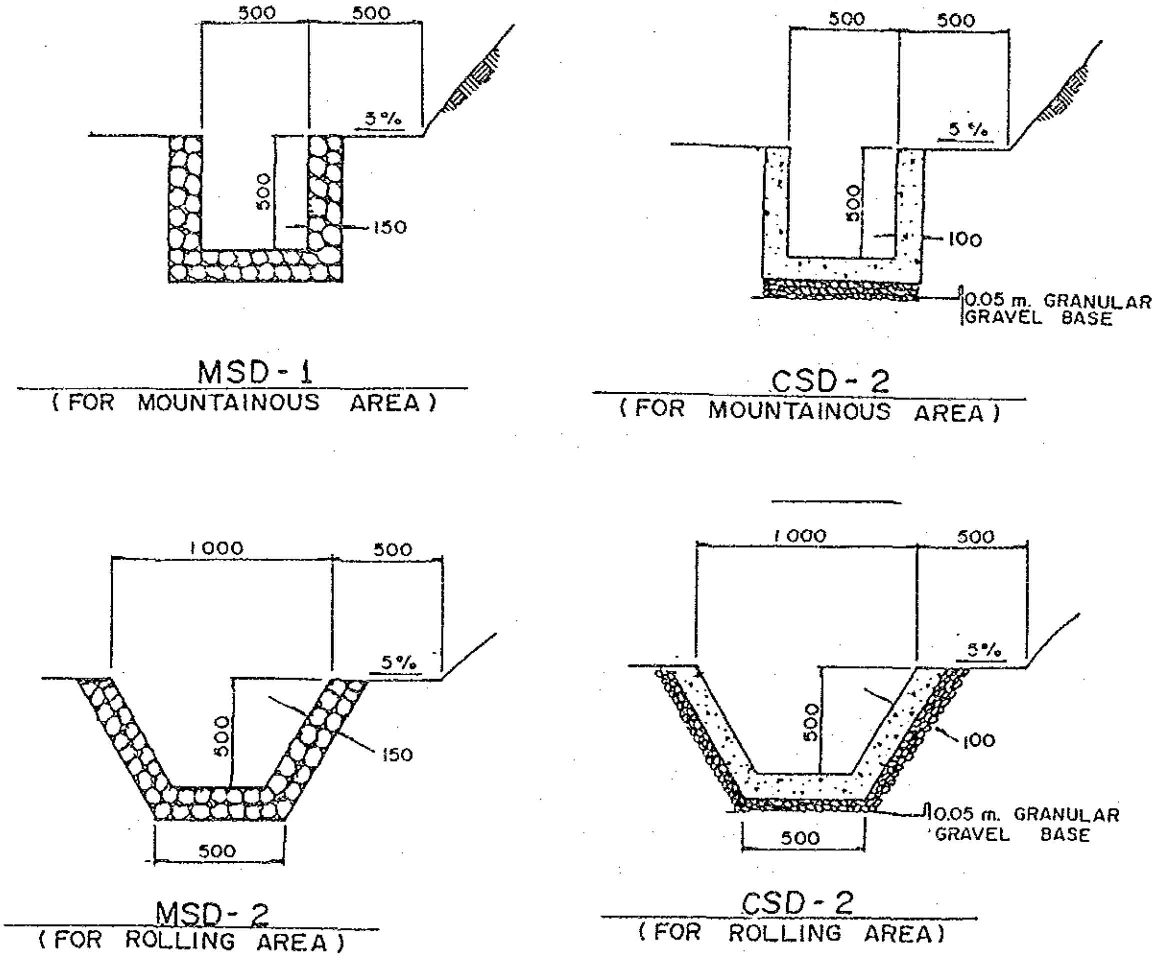


FIGURE 22.1-7 TYPICAL CROSS SECTION OF SIDE DITCH

(2) Subsurface Drainage

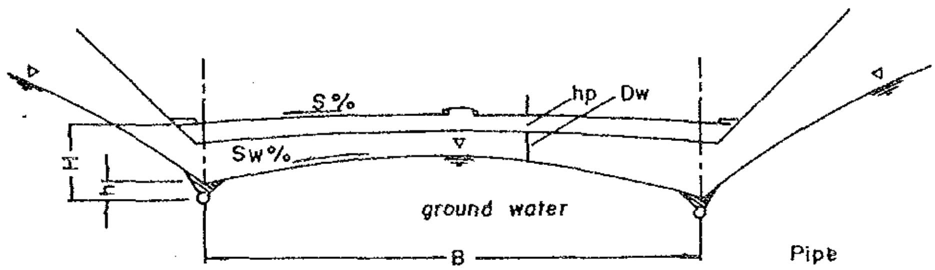
Minimum Depth of Pipe Under Ground

The minimum depth to lay a pipe under the ground is analyzed by the following formula.

$$H = \frac{(Sw - S)\ B}{200} + h + Dw + hp$$

Where:

H	:	Minimum depth of pipe under ground (m)
Sw	:	Minimum gradient of ground water (%)
S	:	Cross sectional gradient of road surface (%)
h	:	depth of ground water near pipe (m)
B	:	Spacing of pipe (m)
Dw	:	0.6 m
hp	:	Difference in elevation between road surface and bottom of subbase



h; depth of ground water near pipe (m)
B; spacing of pipe (m)
Dw; 0.6 meter
hp; difference in elevation between road surface and bottom of subgrade

FIGURE 22.1-8 MINIMUM DEPTH OF PIPE UNDERGROUND

Run-off

Run-off is calculated by the following formula.

$$q = k \cdot i \cdot H_o$$

or $$q = k \cdot \frac{Ho^2}{2R} \quad : R = s.\sqrt{K} \cdot \sqrt{H_o}$$

or $$q = 0.8 \frac{K \cdot H_o}{2.3 \log R/ r_o} \quad : K = 2\ H_o \cdot \sqrt{K} \cdot \sqrt{H}$$

The detailed discussion are presented in the Volume of the Study.

Type of Subsurface Drainage

Figure 22.1-9 shows the typical cross section of subsurface drainage.

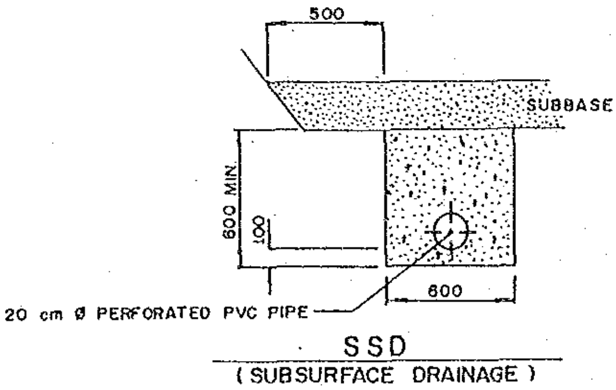


FIGURE 22.1-9 TYPICAL CROSS-SECTION OF SUBSURFACE DRAINAGE

22.1.7 Summary of Rehabilitation Works

As previously discussed in Chapter 15, the sections for rehabilitation were identified and verified by the detailed investigation. See Table 15.4-1 and 18.1-1. The implementation of those rehabilitated were proposed as follows:

1) Pavement Rehabilitation

Short Term

- Sections with RRI less than 2.5 (Stage 1)
- Sections with RRI of 2.5 to 3.0 (Stage 2)
  Stage 1 and 2 were combined for implementation considering the progress of cracks and timing of rehabilitation works.

Medium Term

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

Long Term

- Study on pavement condition

2) Drainage Improvement

Short Term

- 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.

Medium Term

- Surface drainage with very bad/bad conditions (estimated about road length (one side) including short term drainage)

Long Term

- Study on possible installation of drainage system for both sides.

3) Summary of Rehabilitation Works

Table 22.1-7 summarizes the length of pavement rehabilitation and drainage improvement under the short and medium terms. Table 22.1-8 shows the length broken-down by types of rehabilitation adopted.

Under the short term, the one-lane PCC reconstruction of 113.96 km was applied for the north study section, followed by two-lane PCC reconstruction of 45.96 km (both lanes, 91.92 km as estimated one-lane) and AC overlay of 34.5 km (69.00 km as one-lane).

As to the south study section, the predominant is two-lane PCC reconstruction with 55.34 (both lanes, 110.68 km as one-lane), followed by one-lane PCC reconstruction of 21.12 km and AC overlay with 2.5 km (5.0 km as one-lane).

As for drainage improvement, the installation of side ditches of 109.73 km or 27.4% of the total length of both road sides (400 km) was recommended for the north study section and 74.52 km or 20.6% of the total length (362 km).

Treatment of subgrade was applied in N-1 segment and the provision of subsurface drainage in S-3.

Quantities of major items estimated for these proposed works were calculated and are reported in Appendix 22-2.

TABLE 22.1-7 SUMMARY OF LENGTH FOR PAVEMENT REHABILITATION/ DRAINAGE IMPROVEMENT BY TERMS

Unit: Lane–km

Segment	Segment Length (Km)	Short Term (1987-1992)	Medium Term (1993-1998)	Total (1987-1998)
North Study Section				
Segment N-1	46	90.00	50.00	140.00
N-2	35	55.10	49.90	105.00
N-3	42	31.82	94.18	126.00
N-4	38	102.69	11.31	114.00
N-5	39	110.25	10.00	120.25
Sub-Total	200	389.86	215.39	605.25
South Study Section				
Segment S-1	42	31.85	94.15	126.00
S-2	54	29.59	132.41	162.00
S-3	46	85.30	63.95	149.25
S-4	39	75.83	41.17	117.00
Sub-Total	181	222.57	331.68	554.25
TOTAL	381	612.43	547.07	1,159.50

TABLE 22.1-8 SUMMARY OF LENGTH FOR PAVEMENT REHABILITATION/DRAINAGE IMPROVEMENT BY TYPE OF WORKS

Unit: Lane-Km

Section	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	Segment N-1	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
	Segment N-2	35	27.90	2.85	2.75	13.00	46.50	–	8.60	–	8.60	23.50	26.40	70.00	35.00
	Segment N-3	42	5.10	15.02	1.95	–	22.07	–	9.75	–	9.75	61.93	32.25	84.00	42.00
	Segment N-4	38	10.90	17.18	14.53	25.00	67.61	–	35.08	–	35.08	8.39	2.92	76.00	38.00
	Segment N-5	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	Segment S-1	42	10.22	7.03	1.65	–	18.90	–	12.95	–	12.95	65.10	29.05	84.00	42.00
	Segment S-2	54	12.76	2.13	0.85	3.00	18.74	–	10.85	–	10.85	89.26	43.15	108.00	54.00
	Segment S-3	46	44.10	3.40	1.10	–	48.60	–	25.45	11.25	36.70	43.40	20.55	92.00	57.25
	Segment S-4	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