CHAPTER - 6

EXISTING CONDITION

OF

THE PROJECT ROAD

Chapter 6 Existing Conditions of the Project Road

6-1 General

The Project Road is part of the national road, stretching over a distance of about 500 km from Bogota, the capital of Colombia, to the Port of Buenaventura, and which crosses the Cordillera, mountain range for a distance of about 310 km. It is this 310 km portion which is the object of this study.

Melgar, the starting point of the Project Road, lies in the Rio Magdalena alluvial plains, at an elevation of about 320 m above sea level, while Buga, the terminating point of the Project Road, lies in the Rio Cauca alluvial plains, at an elevation of about 980 m above sea level. The section which runs across the hump of the Cordillera is about 80 km long, and connects Ibague (EL. 1,200 m) and Calarca (EL. 1,570 m). Its maximum elevation is 3,264 m.

The topography of this road includes numerous sharp curves as well as numerous road portions with steep grades. For the most part, the road is a two-lane highway, except for some segments with four lanes. It is paved with asphalt concrete and a large part is currently under extensive repair and rehabilitation carried out by the Colombian Government. The extent of the improvement plans emerging from this study depends heavily on the service level of the road after completion of this rehabilitation work. The road is divided into segments referred to by the MOPT as follows:

Melgar-Espinal	:	Route No.007	(Bogota-Neiva Road)	(44 km)
Espinal-Uribe	:	Route No.050	(Espinal-Uribe Road)	(219 km)
Uribe-Buga	:	Route No.046	(Cartago-Cali Road)	(44 km)
			Total	307 km

From the aspect of protection of the road against failure, the problems are concentrated in the Ibague-Calarca section and except for some retaining walls on the fill slope side, there is little slope protection on the cut side. As a result, following heavy rains, there are always rock falls and slope failures at various places. In the areas susceptible to landslides, no practical measures have been provided with the exception of sporadic provisions for drainage through horizontal boreholes.

6-2 Road Geometric Structure

6-2-1 Geometric Design Criteria

The geometric design criteria in Colombia were set up in 1970 following the AASHTO specifications. They take into account the traffic volumes and the terrain as parameters, and are presented in Tables 6-1 and 6-2. Table 6-1 shows the geometric design criteria for new roads, whereas Table 6-2 is applied to the improvement of existing roads.

The Project Road was constructed before the adoption of the geometric design criteria, and was paved in 1967. It has undergone minor improvements during the past years, but it still falls short of meeting the present day geometric design criteria. It can be seen from the terrain conditions described in Table 6-3 for the Ibague-Calarca section that heavy vehicles would be forced to run at a speed far below the design speed of 30 km/h even though the daily traffic volume is as high as 2,600 vehicles. The same Table also indicates that the geometry of the existing road in the mountainous area limits the vehicular running speeds to less than the minimum design speed of 30 km/h specified in the Colombian geometric design criteria.

The grade, however, is generally within 10%, which is the maximum set for a design speed of 30 km/h. On the other hand for the horizontal alignment, there are about one hundred curves whose radii of curvature are less than the minimum of 25 m required for a design speed of 30 km/h, indicating an extremely bad alignment.

In order to meet the current geometric design criteria, the road alignment in the mountainous terrain would require a minimum radius of curvature of 40 m, a maximum slope of 8%, and a design speed of 40 km/hr. These requirements would necessitate the construction of a road substantially different in alignment from the existing one, and would in effect require a completely new alignment which at present is not economically feasible. Therefore, to be able to produce a practical improvement plan it will be necessary to relax the geometric design criteria.

Fig. 6-1 shows the cross section of the existing road with a roadway width of 7.0 to 7.2 m except for the Calarca-Uribe section where the width is 6.0 m. The existing road has a soft shoulder of 2.0 m being maintained on each side, except for the Ibague-Calarca section where the shoulders are presently being paved for a width of 1.0 m on each side.

6-2-2 Description of the Road Conditions in the Various Segments

(1) Melgar-Ibague (99.5 km)

This segment crosses flat and rolling terrain. In general, the alignment appears to be acceptable, however, the following observations have been noted.

1) The Melgar-Chicoral portion which cuts a dog-leg through Girardot, runs through an unusually circuitous route.

2) Urban traffic congestion exists in the built-up areas of Girardot and Espinal.

3) The Espinal-Ibague section (km 23 - km 26) shows a high incidence of traffic accidents.

4) In the Mirolindo-Ibague section which runs through an urban area, the road widens to four lanes for a total length of 3

Table 6-1 GEOMETRIC DESIGN CRITERIA FOR CONSTRUCTION OF NEW ROADS

Group	LIGHT TRAFFIC								MEDIUM TRAFFIC								HEAVY TRAFFIC					
	TL-1				TL-2				TM-3				TM-4				TH-5			TH-6		
Future Traffic (VPD)	-250				250-500				500-1,000				1,000-2,000				2,000-5,000			5,000-		
Terrain	SM	M	R	P	SM	M	R	P	SM	M	R	P	SM	M	R	P	SM/M	R	P	SM/M	R	P
Classification Index	12	14	16	18	22	24	26	28	32	34	36	38	42	44	46	48	54	56	58	64	66	68
Design Speed (Km/h)	40	50	60	70	40	50	60	70	40	60	80	100	40	60	80	100	60/80	80/100	100/120	60/80	80/100	100/120
Carriageway (m)	6.00				6.00				7.00				7.00				7.00					
Shoulder (m)	0.50	1.00	1.00	1.50	1.00	1.00	1.00	1.50	1.00	1.00	1.50	2.00	1.50	1.50	2.00	2.50	2.50	2.50	3.00	0.50	0.50	1.00
Roadway width (m)	7	8	8	9	8	8	8	9	9	9	10	11	10	10	11	12	12	12	13	10	10.50	11
Separator (m)	-								-								-			4.00		6.00
Max. Gradient (%)	8	7	6	5	7	6	5	4	6	5	4	3	6	5	4	3	5	4	3	5	4	3
Min. Radius (m)	50	80	120	180	50	80	120	180	50	120	250	450	50	120	250	450	120 /250	250 /450	450/750	120/ 250	250 /450	450/750
Max. Superelevation (%)	10	9	8	7	10	9	8	7	10	8	6	4.5	10	8	6	4.5	8-6	6-4.5	4.5-3	8-6	6-4.5	4.5-3
Vertical Curve – Crest – Min. Length (m)	20	30	40	50	20	30	40	50	20	40	60	100	20	40	60	100	40/60	60/100	100/160	40/60	60/100	100/160
Vertical Curve – Crest – Parameter Kv=L/A(m/%)	4	9	14	20	4	9	14	20	4	14	30	64	4	14	30	64	14/30	30/64	64/121	14/30	30/64	64/121
Vertical Curve – Sag – Min. Length (m)	20	30	40	50	20	30	40	50	20	40	60	80	20	40	60	80	40/60	60/80	80/110	40/60	60/80	80/110
Vertical Curve – Sag – Parameter Kv=L/A(m/%)	8	12	15	18	8	12	15	18	8	15	22	32	8	15	22	32	15/22	22/32	32/44	15/22	22/32	32/44
Stopping Sight Distance (m)	220	280	320	370	220	280	320	370	220	320	420	520	220	320	420	520	320 /420	420 /520	520/620	-	-	-
Passing Opportunity in 5 Km	2				2				20%				40%				60%					
Structure Width (m)					The same as roadway width																	
	7		8		8				9				9				10			2 x 9		
Construction Gauge (m)	4.60																					

See Legend in Table 6-2

Table 6-2 GEOMETRIC DESIGN CRITERIA FOR EXISTING ROAD IMPROVEMENT

	LIGHT TRAFFIC								MEDIUM TRAFFIC								HEAVY TRAFFIC					
GROUP	TL-1				TL-2				TM-3				TM-4				TH-5			TH-6		
Future Traffic (VPD)	-250				250-500				500-1000				1000-2000				2000-5000			5000-		
Terrain	SM	M	R	P	SM	M	R	P	SM	M	R	P	SM	M	R	P	SM/M	R	P	SM/M	R	P
Classification Index	11	13	15	17	21	23	25	27	31	33	35	37	41	43	45	47	53	55	57	63	65	67
Real Velocity (km/H)	30	40	50	60	30	40	50	60	30	40	60	80	30	40	60	80	40/60	60/80	80/100	40/60	60/80	80/100
Carriageway (m)	5.00				5.00				6.00				6.00				7.00			2 x 7.00		
Shoulder (m)	0.50	0.50	0.50	1.00	0.50	0.50	1.00	1.00	1.00	1.00	1.50	1.50	1.00	1.00	1.50	1.50	1.50	2.00	2.50	Right - 2.00 Left - 0.50		
Roadway Width (m)	6.00	6.00	6.00	7.00	6.00	6.00	7.00	7.00	8.00	8.00	9.00	9.00	8.00	8.00	9.00	9.00	10.00	11.00	12.00	2 x 9.50		
Separator (m)	No				No				No				No				No					
Max. Gradient (%)	12	10	8	6	12	10	8	6	12	10	8	6	10	8	6	4	8	6	4	8	6	4
Min. Radius (m)	25	40	80	120	25	40	80	120	25	40	120	220	25	40	120	220	40/120	120/220	220/450	40/120	120/220	220/450
Max. Superelevation (%)	10	10	8	8	10	10	8	8	10	10	8	6	10	10	8	6	10/8	8/6	6/4.5	10/8	8/6	6/4.5
Vertical Curve – Crest – Min.Length (m)	40	40	40	40	40	40	40	40	40	40	40	60	40	40	40	60	40	40/60	60/80	40	40/60	60/80
Vertical Curve – Crest – Parameter Kv=L/A (m/%)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	25	15	15/25	25/35	15	15/25	25/35
Vertical Curve – Sag – Min.Length (m)	40	40	40	40	40	40	40	40	40	40	40	60	40	40	40	60	40	40/60	60/80	40	40/60	60/80
Vertical Curve – Sag – Parameter Kv=L/A (m/%)	15	15	15	15	15	15	15	15	15	15	15	25	15	15	15	25	15	15/25	25/35	15	15/25	25/35
Stopping Sight Distance (m)	30	50	60	80	30	50	60	80	30	50	80	140	30	50	80	140	50/80	80/140	140/200	50/80	80/140	140/200
Passing Sight Distance (m)	150	240	300	360	150	240	300	360	150	240	360	480	150	240	360	480	240/360	360/480	480/600	240/360	360/480	480/600
Passing Opportunity in 5 Km	2				2				20%				20%				40%			-		
Structure Width (m)	6				6				8				8				9			2 x 9.50		
Construction Gauge (m)	4.60																					

Note: SM: Steep Mountainous
M: Mountainous
R: Rolling
P: Plain

TABLE 6-3 Status of Geometric Structure on Existing Road

	Horizontal Curve	Longitudinal Gradient (Km)						
	10 ~ 25^{m}	0 ~ 2%	2 ~ 4%	4 ~ 6%	6 ~ 8%	8 ~ 10%	10% ~	Total Length
Melgar - Girardot	0	18.4	4.8	2.6	0	0	0	25.8
Girardot - Espinal	0	16.6	1.7	0	0	0	0	18.3
Espinal - Ibague	0	33.8	16.0	3.2	0.6	1.8	0	55.4
Ibague - Calarca	98	6.2	10.4	11.1	24.1	23.9	3.1	78.8
Calarca - Uribe	0	41.0	17.2	12.5	6.9	7.5	0	85.1
Uribe - Buga	0	37.1	6.5	0	0	0	0	43.6
Total	98	153.1	56.6	29.4	31.6	33.2	3.1	307.0
%		49.9	18.4	9.6	10.3	11.3	0.5	100.0

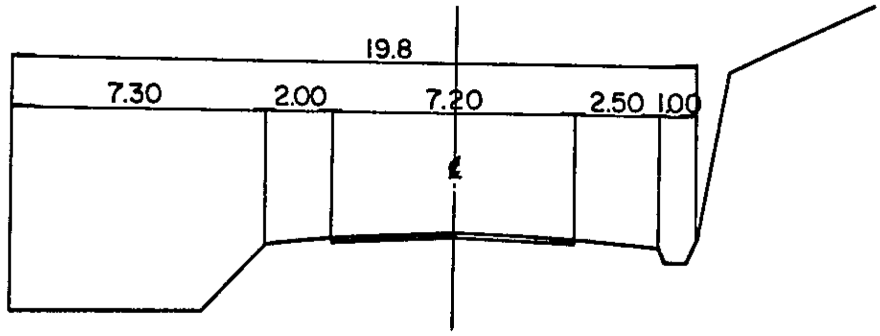
Note: Individual curves in the compound curves are added cumulatively

Source of Data

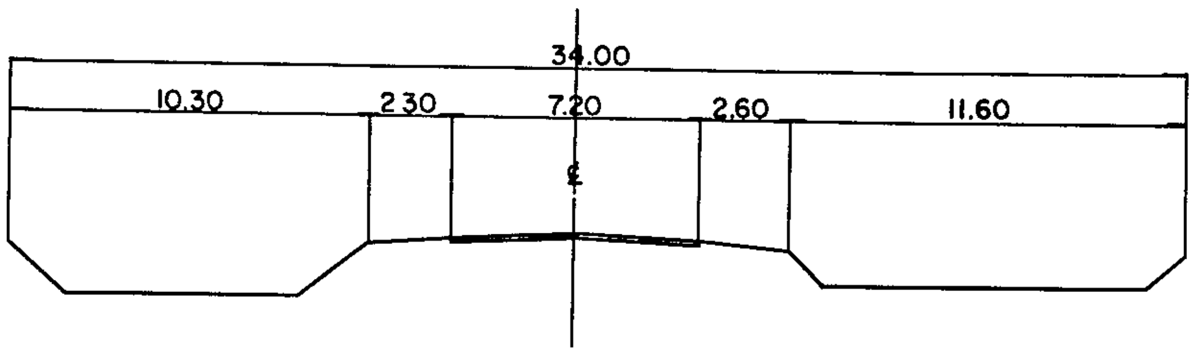
Section	Horizontal Curves	Longitudinal Gradient
Melgar - Ibague	Road Inventory in 1968 by MOPT	JICA Study Team (1/10000 Map)
Ibague - LaLinea	1/2000 MOPT Ground Survey	1/2000 MOPT Ground Survey
La Linea-Calarca	1/5000 JICA map	1/5000 JICA map
Calarca - Uribe	Road inventory in 1968 by MOPT	JICA Study Team (1/25000 Map)

Fig. 6-1 Typical Cross Section of Existing Road

Melgar – Girardot Km 112.9



Girardot – Espinal Km 132.630



Espinal – Ibagué Km 40.0

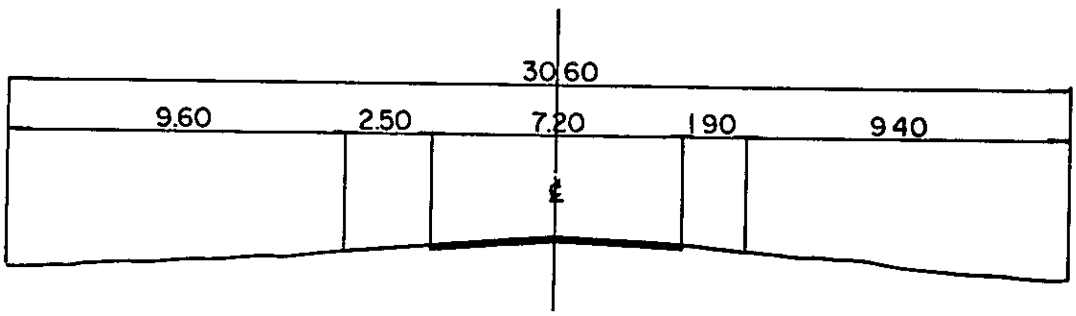
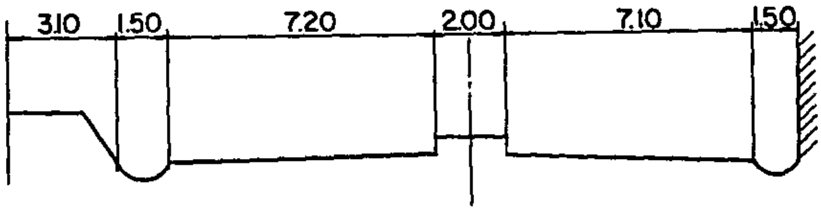
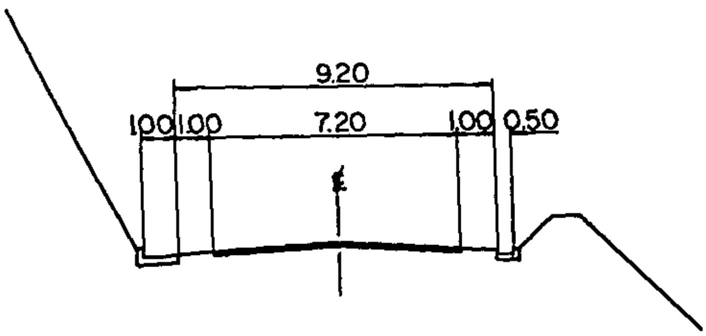


Fig. 6-1 Typical Cross Section of Existing Road (Cont'd)

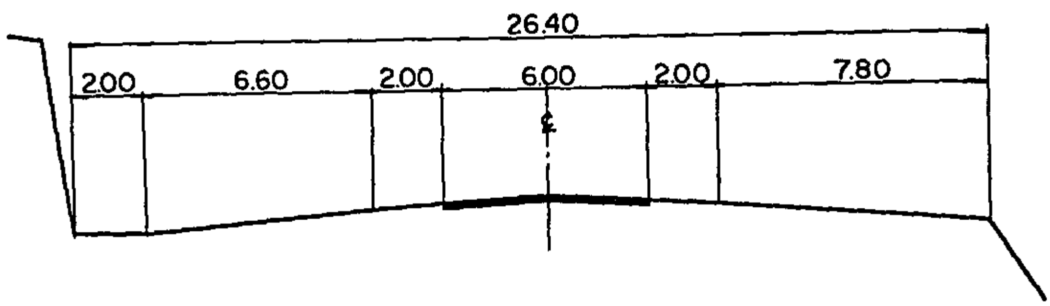
Mirolindo — Ibagué Km 50.0



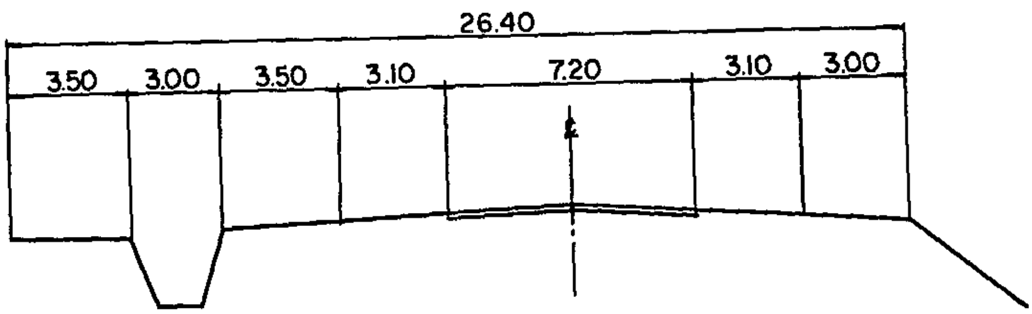
Ibague — Calarca Section



Calarca — Uribe Km 167.0



Uribe — Buga



km. At Ibague, this road passes closely by the city center serving for the through traffic and urban traffic as well.

(2) Ibague-Calarca (78.8 km)

This portion of the road traverses a rugged mountainous area and reaches a maximum elevation of 3,264m above sea level at La Linea.

Generally, this segment shows poor alignment as illustrated in Fig. 6-2 and Annex Table 6-1. The MOPT carried out rehabilitation work from 1979 to 1981, which included pavement overlays, shoulder paving, improvement of side ditches, and additional construction and improvement of retaining walls. Neither alignment improvement nor failure prevention measures were included in the rehabilitation program. Additionally, the following observations relative to the Ibague-Calarca segment have also been noted.

1) There are many curves which have radii of curvature less than the 25 m minimum stipulated for a design speed of 30 km/h. In fact the curves are so sharp that in many places it is impossible for large vehicles to pass each other. (Refer to Annex 7-1, "Widening of Road to Facilitate Passing of Large Vehicles at Curves" and Annex Table 7-3 "Present Status of Passing Condition and Summary of Improvement Plan"

2) In portions of the road with a steep grade and a small radius of curvature, large trucks and semi-trailer trucks are forced to slow down to 10 to 15 km/h.

3) Some curves are not provided with a sufficient sight distance to allow the driver a reasonable stopping distance. If the proper sight distance of 30 m for a design speed of 30 km/h is provided, nearly 50 curves need to be improved. (See Annex Table 7-2)

4) Soil piled up on edge of road acting as guard fence and over grown trees cause a serious obstruction to view and it is not possible to get the 150 m passing sight distance required for a design speed of 30 km/h. (See Fig. 6-3)

(3) Calarca-Uribe (85.1 km)

This segment runs over a plateau area where the alignment is generally acceptable and there are no serious problems hampering the traffic. The Armenia-Zarzal section is scheduled for improvement by MOPT in 1982. And probably, some part of the traffic on the Calarca-Uribe segment will be diverted to this section.

(4) Uribe-Buga (43.6 km)

This segment runs through the flat terrains of Valle Department. Bypasses have already been constructed at Bugalagrande, Tulua, and San Pedro. In Anda Lucia, the road runs through the center of

Fig. 6-2 Existing Status of Geometric Structure by km Between Ibagué – Calarca

(a) Horizontal Curve Distribution by km

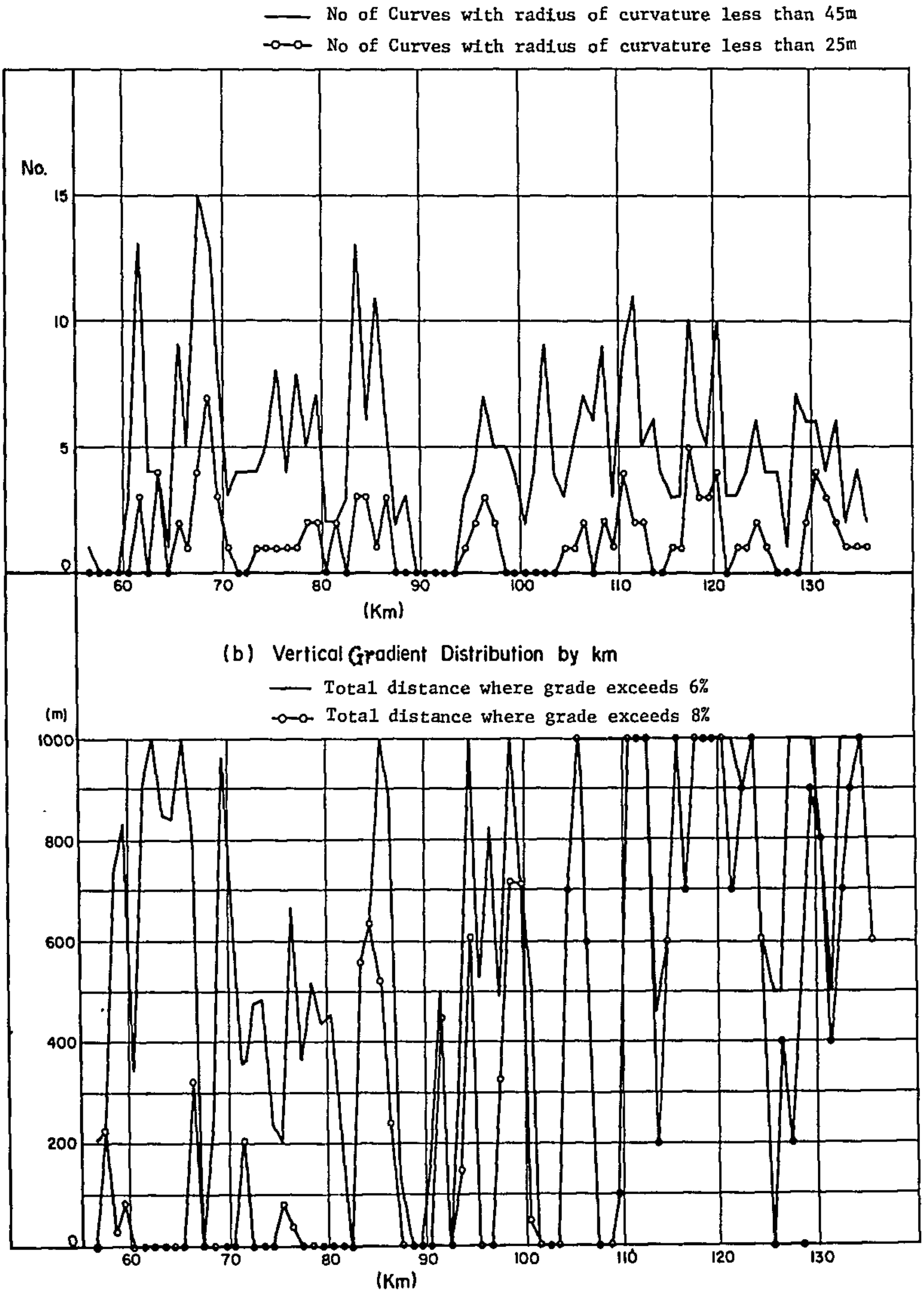
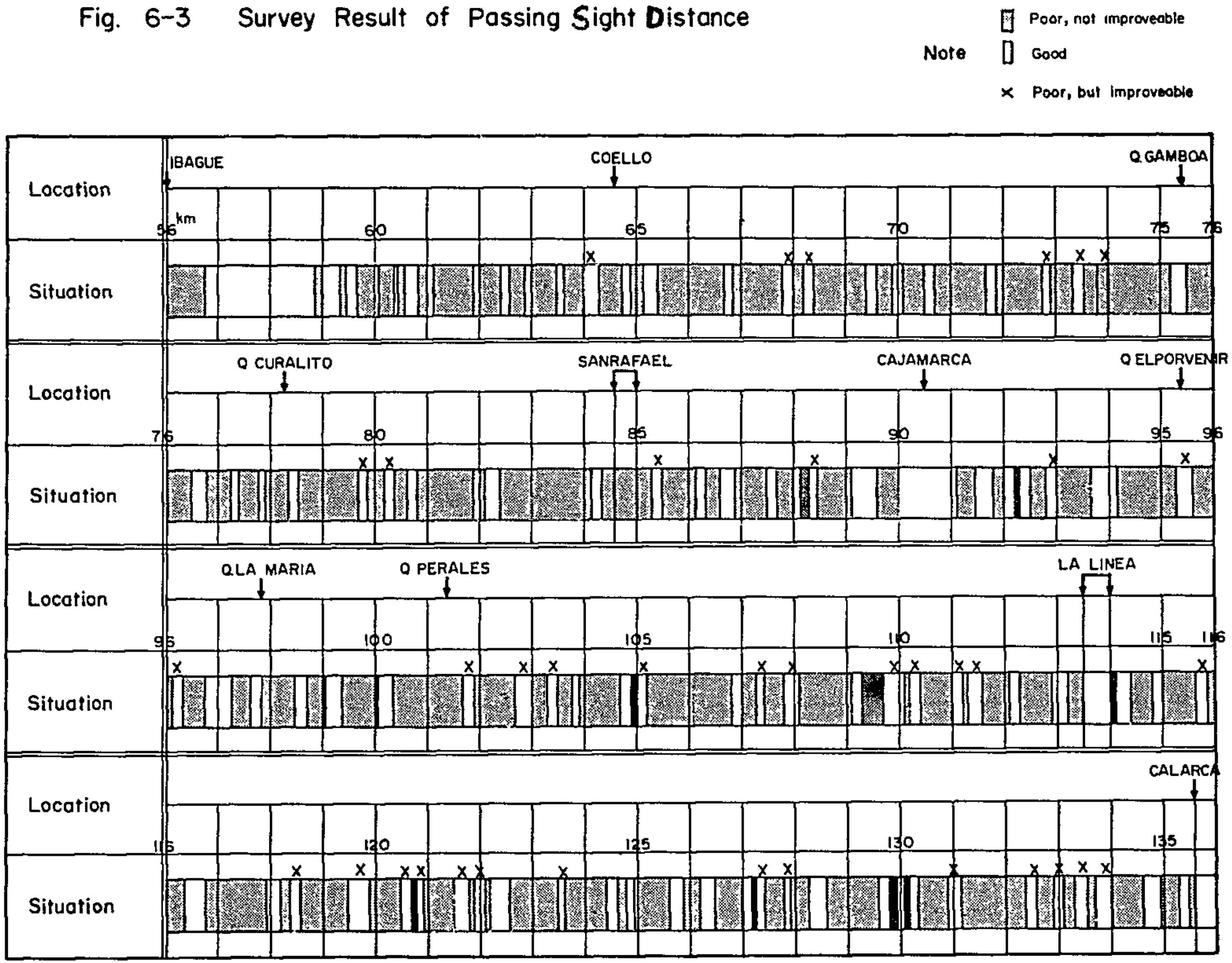


Fig. 6-3 Survey Result of Passing Sight Distance



a small town, and as yet no bypass has been constructed.

The alignment is generally acceptable. Part of this segment is undergoing rehabilitation work by the MOPT.

6-3 Pavement

6-3-1 Design Standard

The MOPT has two design standards of pavement. One is for new roads, and the other for overlays on existing road pavements.

For the construction of new roads for light traffic the MOPT has been applying standards taken from Road Note 29 and 31 of the TRRL (UK). (1)

To heavy-traffic-roads, the MOPT has applied the specifications (2) published by the Asphalt Institute of U.S.A.

For resurfacing of existing roads, the Asphalt Institute's Specifications (3) are used.

In most cases, however, the Manual para el Proyecto de Obras de Mejoramiento de Pavimentos Flexibles (Comision Permanente del Asfalto, cuarto Simposio, Buenos Aires, Argentina, 1972) is used.

6-3-2 Existing Condition of the Pavement of the Project Road

(1) Melgar-Girardot

During the 1977-79 period, pavement rehabilitation work was carried out in conjunction with the Girardot-Silvania Road Project. Due to the lack of routine maintenance the edges of the pavement have deteriorated.

(2) Girardot-Espinal

During the 1979-80 period, the Colombian Government undertook the resurfacing of that portion of the Girardot-Espinal road segment which has a width of 7.2 m. Currently, the construction of 3.0 m soft shoulders on both sides of the pavement is in progress. In general the present pavement condition is acceptable.

(3) Espinal-Ibague

At present, the Colombian Government is in the process of

---

(1) Transport and Road Research Laboratory (United Kingdom)
(2) The Asphalt Institute, Thickness Design, Maryland, U.S.A.
(3) The Asphalt Institute, Asphalt Overlays and Pavement Rehabilitation, Maryland, U.S.A. 1969.

resurfacing the 7.2m wide portion of this road segment. This rehabilitation work started in 1979, and is scheduled to end in 1982.

It is expected that the condition of the Espinal-Ibague segment will be greatly improved by this rehabilitation work.

(4) Ibague-Calarca

Currently, rehabilitation work by the Colombian Government is under way, and is scheduled to be completed near the end of 1981. This rehabilitation work, provides for two overlays, with a total thickness of 12.5 cm, over a roadway width of 7.2 m. Additionally a single asphalt concrete overlay on the existing soft shoulders extending up to 1.0 m in width is also being placed. Side ditches made of cast-in-place concrete are also being provided. For the purpose of draining ground water, underdrains are being installed at several subsections.

(5) Calarca-Uribe

Recently, resurfacing has been conducted for several subsections, and consequently the pavement over this segment seems to be in good condition.

(6) Uribe-Buga

Toward the end of 1980, the Colombian Government completed the rehabilitation work for the Uribe-Andalucia section and the San Pedro-Buga section. This rehabilitation work was carried out by the placement of the following.
Uribe-Andalucia:
2 overlays of asphalt concrete with a total thickness of 7.6 cm over a width of 7.2 m.

San Pedro-Buga:

2 overlays of asphalt concrete with a total thickness of 12.5 cm over a width of 7.2 m, and a 7.5 cm-thick single overlay of asphalt concrete on shoulders over a width of 2.0 m each side of the carriageway.

6-3-3 Maintenance System

The MOPT has assigned the maintenance work of the existing roads to four district offices in accordance with administrative jurisdictions. These are broken down as follows.

(1) Melgar-Girardot District No.8 26 km (Bogota office)

(2) Girardot-La Linea

a. Girardot-Espinal District No.17 18 km (Ibague office)

b. Espinal-La Linea District No.17 113 km (Ibague office)

(3)	La Linea-Calarca-Sevilla District No.23	76 km (Calarca office)
(4)	Sevilla-Uribe-Buga District No. 18	74 km (Palmira office)
Total		307 km

District Office No.17 (Ibague) has two D-5 bulldozers, and District Office No.23 (Calarca) has one wheeldozer. These dozers are always continuously used for removal of debris generated from landslides, washouts or rockfalls which are continuously taking place.

6-3-4 Soils and Materials

(1) Soils

The following soil tests for road pavement design were carried out in the laboratory on eight typical samples in the La Linea - Buga section based on AASHTO standards.

1) Atterberg Limit Test (AASHTO T-90)

2) CBR Test (AASHTO T-193)

The test results are shown in Table 6-4. These eight soils are good as embankment and subgrade materials. The CBR values are roughly estimated based on the quality of parent rocks in Table 6-5, since soils in Melgar - La Linea section are composed of weathered rocks on site. All the soils are suitable as embankment and subgrade materials, although the CBR of the volcanic ash is slightly low.

(2) Materials

There are numerous quarry sites in the Project Area providing ample availability of aggregates for road construction. A list of quarry sites is shown in Table 6-6. The following rock test results for the Ibague - Calarca section shown in Table 6-7 was conducted by MOPT.

1) Los Angeles Abrasion Test (AASHTO T-96)

2) Absorption (ASTM D-1228)

The results show that rocks of the existing quarry sites are not always good, however, there are several potential quarry sites for good quality aggregates in the Ibague - Calarca section.

6-3-5 Survey for Resurfacing Design of Existing Road

Depending on the traffic growth, the existing road will need to be resurfaced with asphalt concrete: Between 1979 and 1982 200 km out of the 307 km length of the road is scheduled to be rehabilitated. There are no plans for rehabilitating the remaining 107 km. In this study, data for the design of resurfacing is based on MOPT's existing

Soil Test Results

Table 6-4

No.	Sampling Spot	Liquid Limit (%)	Plastic Limit (%)	Plastic Index	Unit Weight (g/cm^3)	Natural Water Content (%)	AASHTO Classification	Modified CBR (%)
1	Espinal - Uribe Road Km 112+040	64	48	16	1.52	54.5	SM	2.7 - 5.5
2	Espinal - Uribe Road Km 116+000	NL	NP	-	1.47	50.2	SM	32.0 - 54.0
3	Espinal - Uribe Road Km 122+000	NL	NP	-	1.44	25.2	SM	35 - 40
4	Espinal - Uribe Road Km 132+230	50	31	19	1.70	41.6	CL-CH	2.5 - 3.1
5	Espinal - Uribe Road Km 113+450	45	32	13	1.72	32.0	CL	2.5 - 3.1
6	Cartago - Cali Road Km 73+200	NL	NP	-	1.62	14.4	SM	25
7	Cartago - Cali Road Km 84+000	43	18	25	1.79	21.4	CL	4.5 - 9.7
8	Cartago - Cali Road Km 97+000	41	23	18	1.74	16.1	SC	9

Note: NL - Non Liquid, NP - Non Plastic

Km indicated is that from in situ Km post

TABLE 6-5 ESTIMATED CBR OF SUBGRADE

Section and Improvement Plan		Type of Rock or Deposit	CBR
1.	Melgar - Chicoral 1-1. Large Scale Improvement Girardot Bypass	Quarternary Deposit	3-5
2.	Ibague - Calarca 2-1. Critical Curve Improvement 2-2. Minimum Scale Improvemt	1) 2)	
	2-3. Medium Scale Improvement Ibague - Km 70 Km 70 - Km 101	 Granodiorite Cristalline Schist	 More than 20 5 - 10
	2-4. Large Scale Improvement Coello Bypass La Linea - Bypass Ibague bypass	 Granodiorite Volcanic ash and others Terrace deposit	 More than 20 5 - 10 5 - 10
3.	Uribe - Buga	Terrace deposit	5 - 10

Note: 1) The same pavement thickness as the existing shoulder pavement.
2) The same pavement thickness as the existing carriageway pavement.

TABLE 6-6 QUARRY SITES OF THE PROJECT AREA Page (1)

Quarry Site	Road	Location	Characteristics	Possible Use	Estimated Volume
Tolemaida	Melgar-Girardot	Km 100+000	Stone, gravel sand	Base Pavement	>50.000 m3
103 + 700	" "	Km 103+700	Gravel, sand	" "	Approx. 15000m3
El Paso (Rio Sumapaz)	" "	Km 114 + 500	Stone, gravel	" "	>20000 m3
Isla del Sol (Rio Magdalena)	" "	Km 122 + 000	River-gravel, sand	" "	>50000 m3
Rio Coello, Puente de Chicoral	Espinal-Ibague	Km 16 + 000	Stone, gravel sand	" "	>50000 m3
Rio Coello, Gualanday	" "	Km 22 + 850	Stone, gravel sand	" "	>50000 m3
Hacienda El Paraiso	" "	Km 11.7 from Buenos Aires	Gravel, sand	" "	>50000 m3
Sia de San Serrario(Rio Combeina)	" "	Km 55 + 000	Gravel, sand	" "	>50000 m3
Boqueron	" "	Km 62.+ 200	Granular	Base	Approx.150000m3
Quebrada Cural	" "	Km 63	Igneous Rock	Base	100000 m3
Rio Coello	" "	Km 64 + 700	Gravel,sand of river	Base Pavement	
Rio Amaime	" "	Km 90 + 000	Gravel,sand	Sub-base,base pavement	100000 m3
Quebrada Cristales	Ibague-La Linea	Km 104 + 400	Sand,gravel	Base,Pavement	50000 m3
105 + 200	" "	Km 105 + 200	Igneous rock	" "	50000 m3
La Linea	" "	Km 114 + 300	" "	" "	50000 m3
La Congoja	La Linea-Calarca	Km 122 + 300	" "	" "	80000 m3 MOPT
Santo Domingo	" "	Km 134 1Km from Calarca	Gravel	" "	1000000 m3 MOPT
Rio Verde	Calarca-Sevilla	Km 155 + 400	Fine gravel	" "	200000 m3
La Niza	" "	9 Km from Km 155+400	River gravel, sand	Sub-base,base, Pavement	120000 m3
La Quebrada	" "	14 Km from Km 155+400	"	Sub-base	200000 m3 MOPT
Barragan(Rio Barragan)	" "	1 Km from Km 157+500	"	Sub-base,base Pavement	500000 m3 MOPT
Quebrada "La Aatelia"	Sevilla-Uribe	Km 200+000	"	" "	10000 m3
Quebrada "La Paila"	" "	Km 204+000	"	" "	3000 m3
Rio Bugalagrande	Cartago-Cali	Km73+400	"	" "	20000 m3
Quebrada Sabaletas	" "	Km81+700	"	" "	3000 m3

Note: Location indicated is that from in situ Km post

TABLE 6-6 QUARRY SITES OF THE PROJECT AREA Page (2)

Quarry Site	Road	Location	Characteristics	Possible Use	Estimated Volume
Rio Moralos	Cartago-Cali	Km87+100	River gravel, sand	Sub-base, base Pavement	3000 m3
Rio Tulua	" "	Km90+200	"	" "	20000 m3
Rio Cuadaiajara	" "	Km114	"	" "	10000 m3

Note: Location indicated is that from in situ Km post

Table 6-7 Rock Test Results

Quarry Site	Rock	Los Angeles Abrasion (%)	Absorption (%)	Estimated Volume (m3)	Suitability for Surface Course	Suitability for Concrete Aggregate
Km 63 (Q.Cural)	Granodiolite	56	1.6	more than 100,000	poor	poor
Km 105+200	Porphyrite	16	2.0	" " 50,000	good	good
Km 114+300 (La Linea)	Diabase	17	1.7	" " 50,000	good	good
Km 122+300 (La Congoja)	Hornblend Porphyrite	38	6.7	80,000	poor	poor
Km 134	Diabase	20	1.5	1,000,000	good	good

Source: Proyecto ferrocarril Ibague - Armenia Reconocimiento, Geologico y Geotecnico (1976)

Note: Km, insitu Km post.

General Rating as Aggregate

Item	Surface Course		Concrete Aggregate	
	good	poor	good	poor
Absorption(%)	< 3	≧ 3	< 3	≧ 3
Los Angeles Abrasion (%)	<40	≧40	<40	≧40

Notes: 1) The rating as "good" should meet the two conditions listed in each column.

Table 6-8 Present Pavement Situation along the Existing Road

Section	Distance (km)	Rehabilitation completed	Resurfacing Design data
1. Melgar-Girardot	26	1979	Existing data by MOPT
2. Girardot-Espinal	18	1980	"
3. Espinal-Ibague	55	1982	"
4. Ibague-Calarca	79	1981	"
5. Calarca-Uribe	85	Routine Maintenance	Benkelman Beam Test by Study Team
6. Uribe-Buga	44		
6-1 Uribe-Andalucia	(12)	1981	Existing data by MOPT
6-2 Andalucia-Sanpedro	(22)	Routine Maintenance	Benkelman Beam Test by Study Team
6-3 Sanpedro-Buga	(10)	1981	Existing data by MOPT
Total	307		

Note: 1) Benkelman Beam Test result is shown in Annex Fig. 6-1

2) Source - Comentarios y Conclusiones Sobre el Documento Jun/dt 117/Rev 1 - Julio/80 de la Junta del Acuerdo de Cartagena Documento MOPT-OP-Octubre 23 de 1980.

material test result for the 200 km section.

Data for the 107 Km section is based on Benkelman Beam Test Results by the MOPT Soil Laboratory. Present pavement situation is shown in Table 6-8. Benkelman Beam Test Results are given in Annex Fig. 6-1.

6-4 Bridges and Road Structures

6-4-1 Design Criteria

Currently, bridge structures are generally designed by the AASHTO's specifications. Many of the steel bridges have a plate stating the date of construction, the applied design standards, load capacity, etc., making them relatively easy to identify. There are also several old concrete bridges and culverts which have been widened or modified to meet the increased traffic volume, but are not easy to identify the applied design standards, date of construction, etc.

6-4-2 Existing Conditions

During the field inspection, the Study Team collected data relative to proposed repairs and reinforcement for some specific bridges, culverts and other structures. This data is tabulated in Table 6-11.

These Tables show that most structures on the Project Road are capable of handling ordinary traffic demand with reasonably sufficient load capacity. This paragraph also discusses specific damage problems caused by a variety of reasons related to certain individual structures.

The cost of the repair and reinforcement of the bridges is included in the routine maintenance and management costs, by MOPT and is not included in the cost of this improvement project work except those included in P-1 through P-3 described later. This is because that the regional offices were committed to the repair and rehabilitation necessary for these bridges and structures regardless of whether the feasible or not. The findings of this survey can be used in the planning of the new structures and bridges.

(1) Bridges

For the bridges, the Study Team prepared an inventory listing types and spans. The inventory records the pertinent data as well as the dimensions of the bridges. The bridges surveyed are as listed in Table 6-9.

Table 6-9 Type and Number of Existing Bridges

Type \ Span	5≤ L < 10	10≤ L < 30	30 ≤ L < 50	50 ≤ L	Total
Steel Bridge	-	-	1	4	5
R.C. Bridge	20	19	2	-	41
P.C. Bridge	-	2	2		4
Total	20	21	5	4	50

Note: R.C. - Reinforced Concrete
P.C. - Prestressed Concrete
Span in meters

Of the various elements, those which are considered noteworthy are discussed hereunder.

1) Melgar-Ibague section

The truss bridge across the Rio Sumapaz (Km 99 + 660) stands without its portal bracing which was erected originally, but which has later been removed. Its lateral ridigity has therefore been impaired.

The deckslab of the Girardot Bridge over the Rio Magdalena is severely damaged at the expansion joint, and should be repaired as soon as possible. The damage of this suspension bridge may have been caused by the vibration of the anchor span girder. Therefore, immediate measures must be taken to restrain and control its vibration.

2) Ibague-Calarca

From the technical point of view, the reinforced concrete T-beam located over the Quebrada Gamboa (Km 75+550) has high possibility to suffer the debris flow. Therefore, it is recommendable to make the long term inspection system and/or if possible to provide the proper disaster prevension measures or so. In the Ibague-Calarca section, where several bridges are constructed across the meanders, nearly all their handrails are damaged or missing. It is therefore recommended that new handrails with high rigidity be installed.

3) Calarca-Buga

The foundations of the bridges across the Rio Verde (Km 155+450) have been severely eroded by heavy water flows and scour. It is therefore necessary to carry out channel diversion in an effort to perform grouting of the riprap, and other measures where necessary.

The six RC T-beam bridges installed between Km 163+350 and Km 208+650 exhibit severe cracking of the wing walls due to earth pressure and subsidence.

This is due to the absence of proper connection between the abutments and wing walls. Thus it is recommended that the wing walls be properly anchored or secured in order to stabilize them.

It is indicated that the 3-span continuous steel girder bridge constructed at Km 167+500 (Rio Barragan) has a capacity rating of only a 14-ton truck (wheel load per axle; 5.6 tons). At present, however, vehicles of more than 20 tons are passing over the bridge in both directions. It is therefore urgent to post the bridge for smaller loads or reinforce the bridge to bring it to the proper design standards.

4) Inspection and Maintenance of Bridges and Structures

Maintenance and inspection of existing bridges and structures are as critical features of a highway program as the construction of new bridges and structures, and should be conducted at regular intervals. The records related to many bridges and structures (their dimensions, case histories of repairs, widening, rehabilitation, date of construction) were missing, and the survey could only conduct a cursory review thereof. Proper procedures should be implemented to maintain better records by all parties including MOPT, the consultants, the contractors, maintenance crews, etc.

(2) Road Structures

In connection with the road structures, a detailed inventory survey of Melgar-Buga section was completed by the district offices of the MOPT. The Study Team carried out inspections with emphasis on the investigation for structural deficiencies, maintenance conditions, and identification of problems. The structures investigated on the Project Road are listed below in Table 6-10. In the Ibague-Calarca section, a road rehabilitation project is under way by Colombian government, and retaining walls and drainage facilities are being constructed. The Study Team was able to investigate these construction activities.

Table 6-10 Type and Number of Existing Road Structures

Section	Box Culvert (Number)	Retaining Wall		Drainage Pipe (Number)
		(Number)	(Length)	
Melgar - Ibague	0	28	771 M	290
Ibague - Calarca	29	512	11318 M	642
Calarca - Uribe	23	19	408 M	385
Uribe - Buga	10	0	0	141
Total	62	559	12497 M	1458

The problems of the road structures in the Ibague-Calarca section are described below.

1) Retaining Walls

The retaining walls are classified into a concrete type (gravity type) and gabion-type. Very few of the concrete retaining walls are provided with weep holes, and most of concrete retaining walls will probably fail or slide due to water and earth pressure. The gabion-type retaining walls are installed to allow for proper drainage in the landslide-prone zone, however, some of these gabions have been cemented and are therefore impervious to water. There are some other gabions which have not been properly installed and presently are subjected to lateral movement and settlement.

2) Drainage System

The drainage system is composed of stormwater sewers, French drains, and pipe culverts crossing the road. In many cases, the slopes are not protected against erosion from the drainage water, and particularly the slopes lying below the road level which may be washed away in the future. Twenty percent of drainage pipes were found to be blocked up by debris.

3) Landslide Protection Walls

Along the Project Road, there are few, if any, protection provisions against landslides. As a result, the section is always suffering from disasters caused by rockfalls and slope collapses. For the purpose of protecting the slopes and at the same time ensuring the safety to traffic, it is urgently necessary to construct masonry or block type protective walls.

4) Engineering of Road Structures

The valley-side retaining walls, stormwater sewers, etc. are being constructed without providing proper protection for passing traffic. This condition creates great danger for the traffic as well as for the contractor. Furthermore, the concrete is mixed on the existing pavement to follow its poor quality and an additional obstruction to traffic. It is therefore recommended to review overall engineering operations. For example, a concrete plant and transit mixed concrete should be used in order to simplify the site work.

Table 6-11 Existing Status of the Bridges

MELGAR-ESPINAL

KM	BRIDGE NAME RIVER NAME	TYPE	SPAN (m)	PROPOSED IMPROVEMENT WORKS
K99 +660	RIO SUMAPAZ	WARREN TRUSS	60.0	
K101 +950	YUKANA	R.C.S	6.0	DO NOTHING
K102 +750	NARANJARA	R.C.D.G.	14.0	DO NOTHING
K107 +700	AGUA BLANCA	R.C.D.G.	8.0	DO NOTHING
K111 +350	RIO PAGUEY	R.C.D.G.	20.5 + 20.5 = 41.0	DO NOTHING
K122 +600	RIO BOGOTA	R.C ARCH	8.6 + 19.0 + 8.6 = 36.2	DO NOTHING
K125 +00	GIRARDOT	SUSPENSION BRIDGE	45.0 + 183.0 + 45.0 = 273.0	REPAIR AND IMPROVE SLAB-HOLE, PROVIDE SCOUR PROTECTION AT ABUTMENT
K132 +305	SATAHA	R.C.D.G.	8.0 + 12.35 + 8.0 = 28.35	DO NOTHING

Legend

R.C.S - Reinforced Concrete Slab
R.C.D.G - Reinforced Concrete Deck Girder (Tee-Beam)
P.C - Prestressed Concrete (I-Beam)
R.C. RAHMEN - Refer to Bridge Report included with Drawing.
Half Bridge where noted means half the roadway supported on the bridge and the others half on the road bed.

Table 6-11 Existing Status of the Bridges

ESPINAL-URIBE (Cont'd)

KM	BRIDGE NAME RIVER NAME	TYPE	SPAN (m)	PROPOSED IMPROVEMENT WORKS
K16 +043	RIO COELLO	WARREN TRUSS	75.4	PROVIDE SCOUR PROTECTION AT ABUTMENT
K23 +470	GUALANDAY	R.C.D.G.	9.5 + 25.9 + 9.5 = 44.9	DO NOTHING
K36 +487		R.C.D.G.	8.0	DO NOTHING
K56 +39	RIO CONVEIMA	R.C.D.G.	37.4	DO NOTHING
K62 +410	RIO LA CANTERA	R.C.S	6.0	REPAIR HANDRAILING
K63 +810		R.C.S	5.6	REPAIR ABUTMENT
K64 +670	RIO COELLO	R.C.D.G.	19.4	PROVIDE SCOUR PROTECTION AT ABUTMENT
K75 +550	GAMBOA	R.C.D.G.	6.0	THE LOCATION SHOULD BE REVIEWED
K78 +250	CURARITO	R.C.D.G.	15.5	REPAIR HANDRAILING
K81 +400	CERAJOSA	R.C.D.G.	8.2	REPAIR HANDRAILING IMPROVE DRAINAGE
K83 +150	TIGRE	R.C.D.G.	7.8	DO NOTHING
K85 +500		P.C. HALF BR.	35.1	DO NOTHING
K89 +794	CAJAMARCA	TRUSS	94.5 + 96.0 + 94.5 = 285.0	REPAIR EXPANSION AT 2ND ABUTMENT
K104 +398	RIO BERMELLON	R.C.D.G.	7.0	DO NOTHING
K110 +140		R.C. RAHMEN HALF BR.	4.5 + 4@ 5.0 = 24.5	DO NOTHING

See Legend with Table 6-11

Table 6-11 Existing Status of the Bridges

(Cont'd)

KM	BRIDGE NAME RIVER NAME	TYPE	SPAN (m)	PROPOSED IMPROVEMENT WORKS
K131 +760	SANRAFAEL	R.C. ARCH	8.5	REPAIR HANDRAILING
K155 +450	RIO VERDE	R.C.D.G.	11.0 + 21.5 + 11.0 = 43.5	REPAIR HANDRAILING, REPAIR AND IMPROVE GROUTED RIPRAP AT PIER
K156 +700		R.C.S	4.0	DO NOTHING

See Legend with Table 6-11

Table 6-11 Existing Status of the Bridges

ESPINAL-URIBE (Cont'd)

KM	BRIDGE NAME RIVER NAME	TYPE	SPAN	PROPOSED IMPROVEMENT WORKS
K163 +350	RIO LOS ANGELES	R.C.D.G.	10.4	REPAIR HANDRAILING REPAIR AND IMPROVE AT WINGWALL OF ABUTMENT
K166 +700	EL MACHO	R.C.D.G.	13.5	REPAIR AND IMPROVE AT WINGWALL OF ABUTMENT
K167 +500	RIO BARRAGAN	STEEL I BEAM	22.5 + 30.7 + 22.5 = 75.7	PROVIDE SCOUR PROTECTION AT 2ND ABUTMENT LOAD CAPA-CITY LESS THAN 14^t
K174 +200	LA CAMELIA	R.C.D.G.	7.8	REPAIR AND IMPROVE AT WINGWALL OF ABUTMENT
K175 +800	LOS ANGELES	R.C.D.G.	10.0	REPAIR HANDRAILING
K181 +00	RIO PIJAO	R.C.D.G.	15.3	REPAIR HANDRAILING
K193 +400	EL POPAL	R.C.D.G.	10.5	DO NOTHING
K206 +120	SAN MARCOS	R.C.D.G.	13.25	REPAIR AND IMPROVE AT WINGWALL OF ABUTMENT
K207 +650	SAM PABLO	R.C.D.G.	11.3	REPAIR HANDRAILING
K208 +300	PAILAR	R.C.D.G.	17.1	REPAIR AND IMPROVE AT WINGWALL OF ABUTMENT
K208 +600	NICOLAZA	R.C.D.G.	9.0	REPAIR AND IMPROVE AT WINGWALL OF ABUTMENT

See Legend with Table 6-11

Table 6-11 Existing Status of the Bridges

URIBE-BUGA

(Cont'd)

KM	BRIDGE NAME RIVER NAME	TYPE	SPAN (m)	PROPOSED IMPROVEMENT WORKS
K68 +178	EL OVERO	R.C.D.G.	8.8 + 10.2 = 19.0	DO NOTHING
K74 +183	RIO BUGALAGRANDE	R.C.D.G. RAHMEN	43.0	DO NOTHING
K81 +710	ZABALETAS	R.C.D.G.	3@ 9.0 = 27.0	DO NOTHING
K87 +00	RIO MOLALES	R.C.D.G.	12.10	PROVIDE SCOUR PROTECTION AT 1ST ABUTMENT THE LOCATION SHOULD BE REVEIWED
K87 +150	RIO LA RIVERA	R.C.D.G.	12.10	DO NOTHING
K90 +250	RIO TULUA	P.C.T RAHMEN	35.20	DO NOTHING
K98 +508	RIO SAN PEDRO	R.C. BOX	3@ 3.3 = 10.0	NEW 4 LANE 20M T BEAM BRIDGE
K100 +360	DEL YESO	R.C. BOX	8.4	DO NOTHING
K100 +980	TOPOS LOS SANTOS	R.C. BOX	14.0	DO NOTHING
K104 +968	MARSELLA	R.C.D.G. RAHMEN	2@ 8.75 = 17.50	DO NOTHING
K107 +400	LA MARIA	R.C.D.G. RAHMEN	2@ 8.4 = 16.80	DO NOTHING
K110 +720		P.C.T	3@ 13.1 = 39.3	DO NOTHING
K113 +650	GUADALAJARA	P.C.T	2@ 25.5 = 51.0	DO NOTHING

See Legend with Table 6-11

6-5 Geology of the Project Road Site

6-5-1 Outline of Site Geology

Rock formations of the Project Road are composed of sedimentary tertiary rocks, granodiorite, crystalline schist, dyke rocks, volcanic ash, with layers of sand and gravel forming fans or terraces.

The geological features of each segment are described below.

(1) Melgar-Espinal

This section has sedimentary deposits of gravelly sand in layers from the Pliocene to Holocene period over a base material consisting of alternating tertiary sandstone, shale and conglomerate.

The tertiary sediments are cemented, and have many cracks, joints and foldings. The bedding inclination is generally small.

In some places, there are cuesta forming marked dip slopes. At a road cut, the bedding plane and the joint plane normal thereto are exposed giving rise to rockfalls and rock avalanches.

Between Rio Apicala and Rio Magdalena is a terrace running north to south at an elevation of about 650 m above sea level. This terrace is also composed of sedimentary rocks of the Tertiary period.

The gravelly sand layer in the Melgar-Espinal section is loosely cemented, and was deposited by the Rio Magdalena and its tributaries. The layer contains many boulders, with poor grading distribution. The boulders exposed at the road cut near Rio Magdalena loosen up easily and are one cause of rockfalls.

(2) Espinal-Ibague

The formations at the Espinal-Ibague segment are composed of Tertiary sedimentary rock layers and granodiorite, covered with a thick layer of sand and gravel. The sand-and-gravel layer was generated from colluvial deposits carried by Rio Combeima and its tributaries from the Cordillera, and contains substantial quantities of boulders. The grading distribution is poor, but the ground is firm and stable. The existing road is located on this sand-and-gravel layer.

(3) Ibague-La Linea

Granodiorite and quartzdiorite are distributed over the Ibague-Km 71 section. These rocks are leucocratic in some places and melanocratic in other places, showing various rock types depending on the minerals contained. The ground surfaces have been weathered to a sandy state, particularly along the faults, however, the weathered state is fairly uniform. The major faults at this site include the Ibague Fault and Perico Fault, stretching in a northeast to southwest direction. The section from Km 62.5 to Rio Cocora along the Ibague Fault forms a large landslide zone. The base material from Km 71 to La Linea consists of black schist, green schist, hornblende schist with porphyrite intrusions. Atop the base materials are volcanic ash and terrace deposits. The crystalline schist showing a clear schistosity is liable to flake off into thin pieces and is heavily folded.

Black schist prevails on site. In the vicinity of Km 71 to Km 82, green schist is also found in quantity. Around Km 71, the green schist is penetrated by granodiorite and is hardened by silicification. Black schist is highly susceptible to fracture and weathering, and is found fractured to the depth where a fault is suspected to be. Ground water soaks easily into fractured zones and is prevented from further movement by fault clay. The increased pore water pressure triggers the landslide movement. Green schist tends to be fissured along the schistosity planes forming well-developed blocky joints which are liable to cause disasters such as rock avalanches and rockfalls.

At around Km 105.5, porphyrite forms a rather large rock mass, which occasionally collapses.

At the site, there are two types of volcanic ash, one which is seen along the valleys of Rio Bermellon and Rio Coello over the Ibague-Km 106 section, and it is partially fused having Columnar joints. The other which is distributed along the Km 106 to Calarca section.

The latter is pumice fall deposits having a maximum thickness of fifteen meters. It is loose, and covers a vast expanse of the mountainous region.

(4) La Linea-Calarca

This section is mainly composed of black schist and volcanic ash (pumice fall deposit), schist as a bedrock and volcanic ash as a top soil. Most of the landslides occur near the ridges where a thick layer of volcanic ash exists. The black schist around La Linea is highly weathered. There is metadiabase near Km 133 to 134 and hornblende porphyrite near Km 122.5. These areas have a firm bedrock.

The Km 126 to Km 135 section has the Navarco Fault, Planadas Fault and Calarca Fault, all running from northeast to southwest marking off the western edge of the Cordillera.

(5) Calarca-Uribe

The Calarca-Caicedonia section is composed of andesitic rocks, basaltic rocks and pyroclastic detritus of the Tertiary period with volcanic ash covering them. The topography shows a flat terrain, with the existing road running on top of it. The

Caicedonia-Uribe section consists of alternating layers of Tertiary sedimentary rocks such as mud flow deposits, tuff, sandstone, conglomerate, shale, etc. The dip of the strata is small, and the surface layer is heavily weathered. The Uribe-Buga section is composed of sand and gravel from the Pliocene period, and vast alluvial planes can be seen along the Rio Cauca.

6-5-2 Topography

The road between Melgar and Buga runs across the Cordillera of Colombia.

The road running in the mountains, especially where it crosses the principal ridge between Ibague and Calarca, has precipitous slopes on each side. The elevation difference between the La Linea-Calarca section and La Linea - Ibague section is not less than 2,000 m, and those parts of the road which cross the ridges have many sharp bends and steep slopes.

The topographical features along the Melgar-Buga section may be summarized as follows.

(1) Melgar-Espinal

The largest part of the site consists of lowlands, such as terraces, fans and alluvial plains, formed by the Rio Magdalena and its tributaries. The rivers have U-shaped valleys in places which have been formed by erosion.

(2) Espinal-Ibague

This section is composed of fans and flood planes formed by the Rio Combeima and its tributaries.

(3) Ibague-La Linea

This section stretches along Rio Coello, which for the most part is V-shaped.

The hillside slope is long; the slope length from the riverbed to the hill top ranges from 500 to 1,000 m.

The hillside slope is generally 20° to 35°, but is as steep as 40° in some places. In spite of the fact that the existing road skirts the steep hills along the valley, no slope protection plan has been implemented, and the area is highly vulnerable to collapses, landslides, destruction of shoulders, rockfalls, etc.

(4) La Linea-Calarca

Near La Linea, the crests and hillsides show a comparatively moderate slope because of pumice fall deposits. But the rivers have steep slopes and are gorged deep into V-shapes.

The difference in height between Calarca and La Linea, a distance of 21 Km, is as much as 1,700 m, and the mean slope of the existing road is approximately 8%.

(5) Calarca-Caicedonia

This is a predominantly piedmont plateau formed of pyroclastic flow deposits and volcanic ash. The terrains are not so steep as near La Linea.

(6) Caicedonia-Uribe

Toward Caicedonia is a plateau formed of pyroclastic flow deposits. There is a chain of hills of moderate slopes. Tertiary sediments consisting mainly of sandstone and conglomerate are found near Uribe. There are many plateaux which forming deep valleys. In some places, there are cliffs suggestive of terrace scarps.

(7) Uribe-Buga

The terrain is flat, and is composed of fans, terraces and flood plains developed by Rio Cauca and its tributaries.

6-5-3 Rainfalls in the Project site

The annual rainfalls on the Project site range from about 1,000 mm to 2,000 mm, and the isohyetal lines form a strip stretching northeast to southwest along the Cordillera. (See Fig. 6-4). At the Girardot-Chicoral section, the lowlands in and around the Tulua-Buga section, Cajamarca and its vicinities experience a small annual rainfall of about 1,000 to 1,400 mm. The Melgar, the Calarca-Uribe section, and their peripherals sometimes have an annual rainfall of 2,000 mm or more.

According to the precipitation data obtained in 1971 and 1972 (See Fig. 6-5), it is found that Ibague had more than ten rain-days a month, except in July. See Table 6-12.

Table 6-12 Number of Rain Days By Month in Ibague

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1971	14	17	12	11	23	14	4	15	17	21	11	15
1972	17	10	18	14	19	10	2	7	3	12	-	-

Source: MOPT, Division de Ingenieria de Geologia.

Most of the rainfall takes place between 7:00 p.m. and 7:00 a.m.; with little to no rainfall in the daytime.

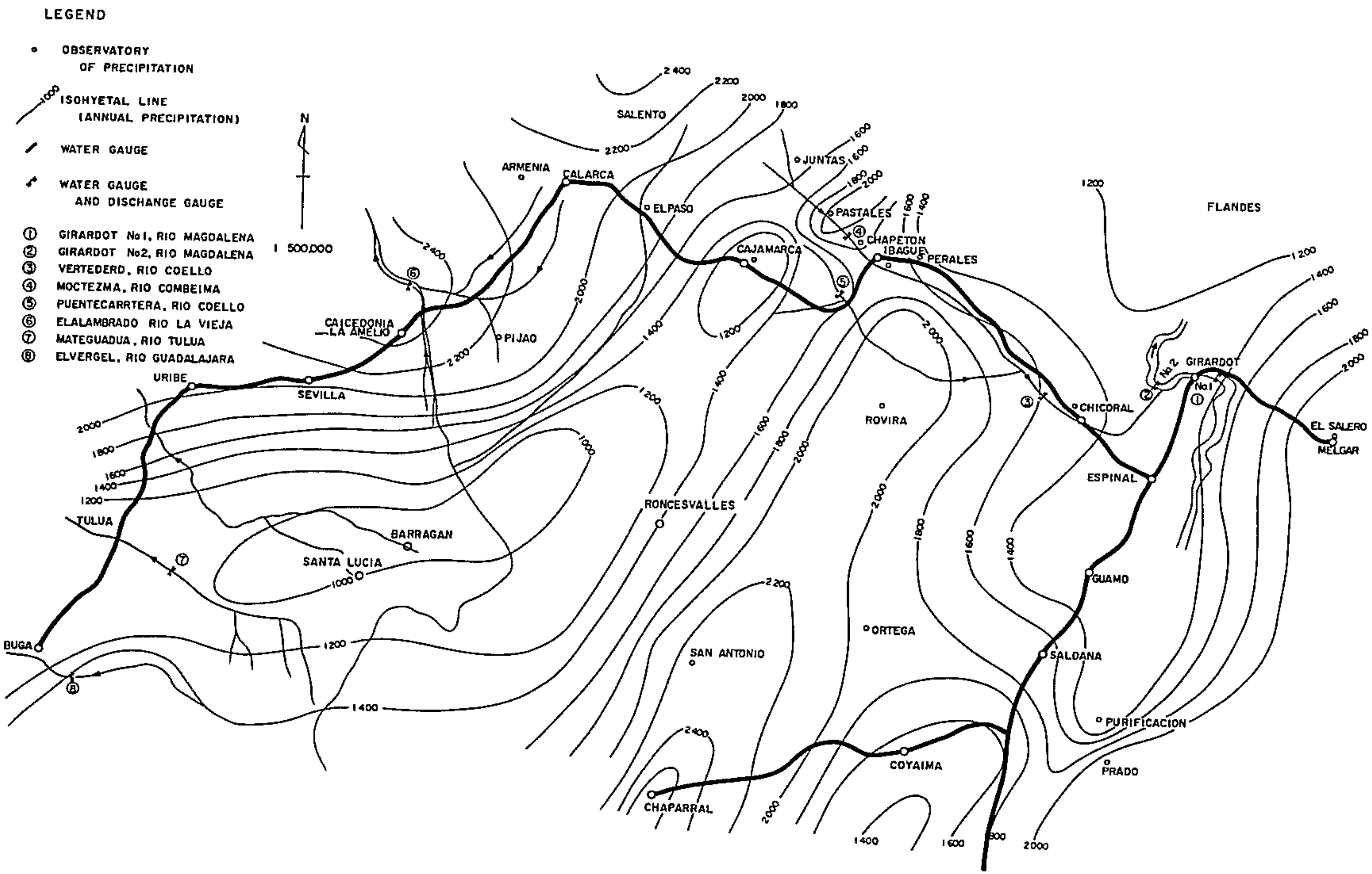
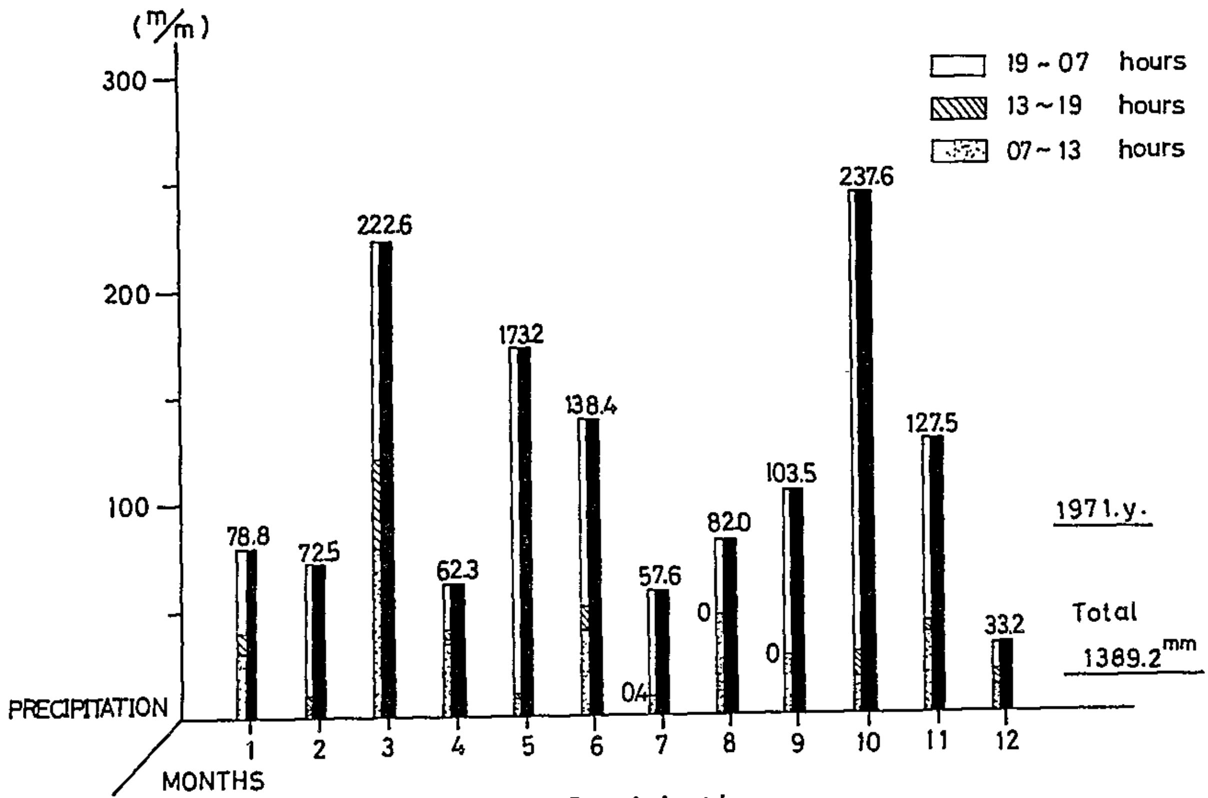


Fig. 6-4 ISOHYETAL MAP



Monthly Precipitation

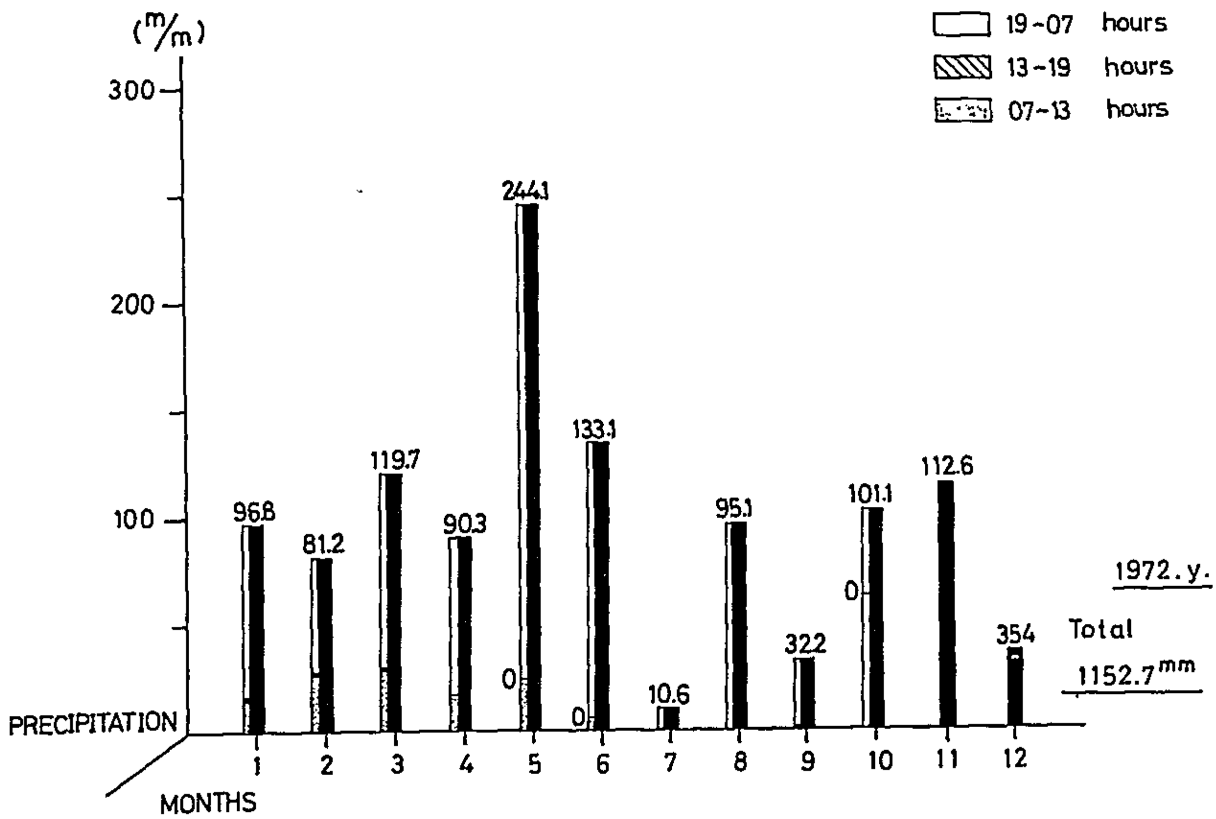


Fig 6-5 Monthly Precipitation

6-5-4 Types of Difficulties (Disasters) Occurring in the Ibague-Calarca Section of the Road.

The present field investigation has disclosed that the major difficulties are concentrated in the section which crosses the mountain range from Ibague to Calarca. The type, severity and probability of occurrence of such disasters have been grouped, and listed in Annex Table 7-2.

(1) Forms of Disaster (Modes of Failure)

The forms of disasters occurring along the present road are grouped into various types shown in Fig. 6-6.

1) Landslides (Fig. 6-6 (a) Table 6-14 & 6-15)

Landslide failures occur under the following conditions or circumstances.

a) The topography is characterised by the presence of a scarp and a sliding mass.

b) The materials are the result of past colluvial deposits.

c) There is an abundance of evidence of minor failures.

d) Stormwater erosion is producing marked gullies.

e) There are faults and fracture zones.

f) The toe of the landslide is subject to a high degree of erosion by fluvial action.

g) There is a thick layer of loose volcanic ash and substantial gully erosion.

2) Falls and Collapses

2)-1- Surface Layer Fall	(Fig. 6-6 (b)	Table 6-16)
2)-2- Rock Avalanche	(Fig. 6-6 (c)	Table 6-16)
2)-3- Rock Fall	(Fig. 6-6 (d)	Table 6-16)
2)-4- Collapse of Shoulder and Road Cave-In.	(Fig. 6-6 (e)	Table 6-17)

These failures occur under the following conditions or circumstances.

(a) The surface of the rock wall has been weathered to a high degree.

(b) The slope is steep.

(c) The slope is denuded except for some grass.

(d) The site is near a fault or in a fractured zone, and the bedrock is badly cracked.

Fig 6-6 Models of Failure

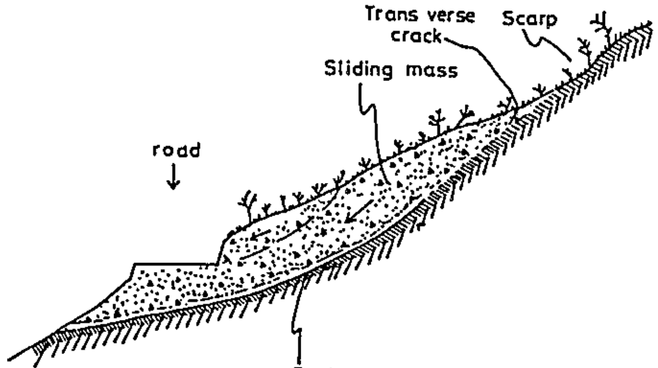


Fig 6-6 (a) Schematic Section of Landslide

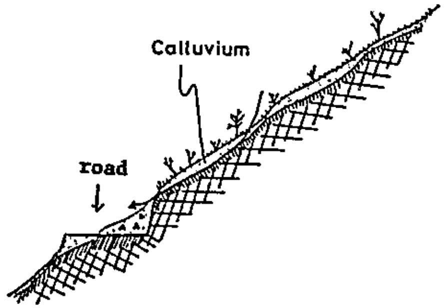


Fig 6-6 (b) Schematic Section of Surface layer fall

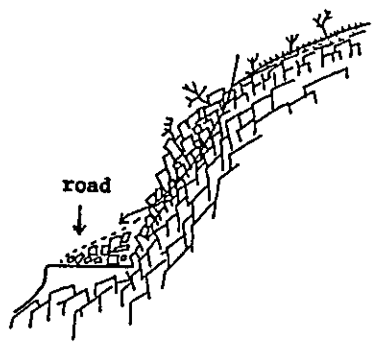


Fig 6-6 (c) Schematic Section Rock avalanches

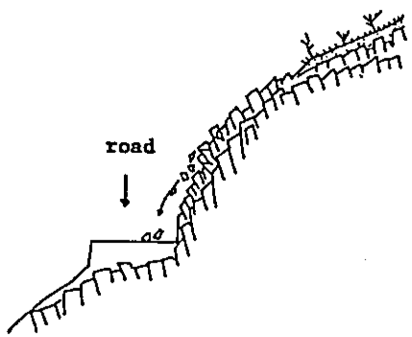


Fig 6-6 (d) Schematic Section of Rock fall

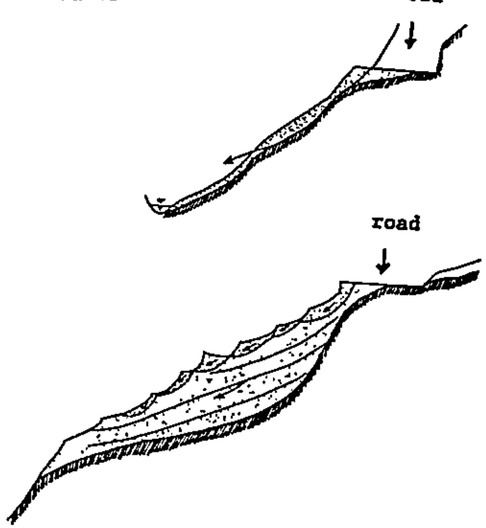


Fig 6-6 (e) Schematic Section of Failure of The Shoulder and Road

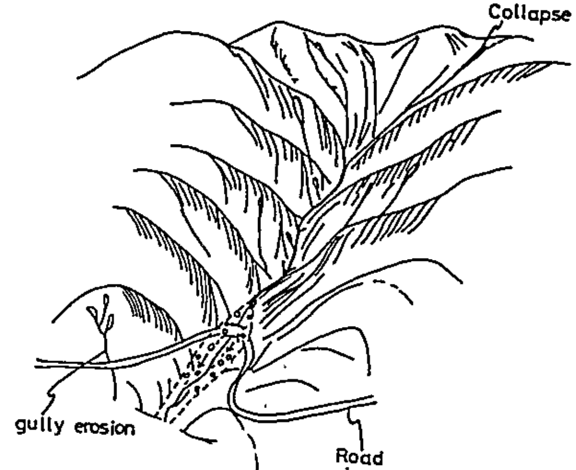


Fig 6-6 (f) Schematic Section of Debris Flow

(e) The site is so shaped that it collects stormwater.

(f) Newly developed failure.

3) Debris Flow From Valley (Fig 6-6(f) Table 6-18)

This type of failure occurs under the following conditions or circumstances:

a) The catchment basin is large.

b) There are many places with slope failure in the catchment area.

c) The river bed has extensive deposits.

d) The river bed has a steep slope.

(2) Classification of Damage Extent

The extent of damage was classified into the following three categories. The classification is based on topography of the landslide and the number and area of failures as interpreted from aerial photos and/or the results of field surveying such as the opening of cracks, frequency of cracks, width of fracture zone, etc.

L: Places with a high probability of large-scale damage which is likely to completely interrupt the traffic for approximately three days.

M: Places where medium scale damage is expected. Traffic flow will be suspended for one or two days.

S: Places where small-scale damage is expected. The volume of collapsed soil is not large and one lane is left open to traffic.

(3) Classification of Disaster Occurrence

By drawing on past experience, the occurrence of disasters has been projected as follows. These projections were done by considering the causes as mentioned above, the indications from aerial photographs, results of the present area study together with existing investigation data held by the MOPT.

A: Places where it is highly probable that disasters can happen in the near future, and where protective measures should be provided as soon as possible.

B: Places where there is a medium probability of a disaster.

C: Places where there is a low probability of a disaster.

(4) Extent and Occurrence of Disasters

The Ibague-Calarca section has as many as 517 danger spots where a disaster could occur. These spots are classified by probability of occurrence and extent of damage which is likely to result. They are shown in Table 6-13. The topography, geological details, causes and countermeasures are shown in Annex Table 7-4.

Table 6-13 Number of Danger Spots, and the Extent of Damage

(Number/length)

Probability of Occurrence	Extent of Damage			
	L	M	S	Total
A	35/4,020m	87/6,435m	47/3,032m	169/13,487m
B	17/1,065m	86/5,765m·	76/6,520m	179/13,350m
C	3/350m	59/5,090m	107/13,530m	169/18,970m
	55/5,435m	232/17,290m	230/23,082m	517/45,807m

The 517 potentially hazardous spots are classified into four types (landslide, collapse on the hillside, collapse on the valley side, and debris flow) as shown in Table 6-14 to Table 6-18.

Table 6-14 Number of Locations Susceptible to Landslide

(Number/Length)

Probability of Occurrence	Extent			
	L	M	S	Total
A	16/2,865m	2/100m	0	18/2,965m
B	2/550m	6/625m	0	8/1,175m
C	1/190m	2/240m	0	3/430m
Total				29/4,570m

Of the above, there are 17 places where the extent of damage would be large and have a significant effect on the present road. These are shown in Table 6-15. The plans and cross-sections of these are shown in annex Fig. 6-2 to 6-16 inclusive.

Table 6-15 Major landslide-prone places

No.	Location	width (m)	Major cause
*LS1	62k520-62k680	160	Fault, ground water
* 2	71k770-72k240	470	Fault, surface ground water
3	73k670-73k920	250	Fault, denaturalized black schist, schistosity
* 4	75k400-75k920	105	do
5	76k520-76k840	320	Fault, ground water
6	77k830-78k080	250	Fault, thick colluvial slope
* 7	81k430-81k500	70	Fault, joint
* 8	82k000-82k300	300	Topsoil running parallel to the ground; heavy weathering
* 9	97k730-97k820	90	Fault, intrusive rock
* 10	101k350-101k550	200	Volcanic ash layer, flood erosion
11	102k860-102k980	120	Volcanic ash layer, surface of unconformity
* 12	106k200-106k280	80	Volcanic ash layer, fault
* 13	106k470-106k540	70	Volcanic ash layer, ground water
14	108k570-108k800	230	do
* 15	112k340-112k520	180	do
* 16	113k000-113k200	200	do
17	119k550-119k650	100	do

Note 1. Locations shown thus (*) are points of active landsliding.

2. LS-1 is concerned with the Ibague fault, and is of the rotational slump type occurring at the fracture zone of the granodiorite.

3. The landslides, LS-2 through LS-9, are caused mainly by weathering of black schist, fracture due to fault, and growth of schistosity. They are mostly of the slide type, rockslide type and debris avalanche type.

4. The landslides, LS-10 through LS-17, are connected with the loose volcanic ash layer over the extensively weathered black Schist, and are caused chiefly by the slide of the volcanic ash layer.
They are similar to the so-called Loess flow type landslide.
The main external causes that trigger these landslides are
- erosion due to stormwater, and
- increase in pore water pressure in the sliding mass.
The cutting of slopes for road construction also is a factor aggravating a landslide situation.

Table 6-16 Collapse of Hillside (Rock Falls)

(Number/Length)

Probability of Occurrence	Extent			
	L	M	S	Total
A	6 / 595m	41 / 4,340m	35 / 2,825m	82 / 7,760m
B	2 / 130m	33 / 2,670m	59 / 5,845m	94 / 8,645m
C	0	32 / 3,195m	92 / 12,765m	124 / 15,960m
				300 / 32,365m

Note; These are collapses associated with the mountainside.

Table 6-17 Collapse of the Shoulder and Road.

(Number/Length)

Probability of Occurrence	Extent			
	L	M	S	Total
A	6 / 460m	25 / 1.405m	1 / 60m	32 / 1,025m
B	5 / 305m	39 / 2,370m	13 / 640m	57 / 3,315m
C	1 / 150m	22 / 1,615m	12 / 730m	35 / 2,495m
				124 / 7,735m

Note: These are collapses associated with the valley side.

Table 6-18 Debris flow (Numnber/Length)

Probability of Occurrence	Extent			
	L	M	S	Total
A	7 / 100m	19 / 590m	11 / 147m	37 / 837m
B	8 / 80m	8 / 100m	4 / 35m	20 / 215m
C	1 / 10m	3 / 40m	3 / 35m	7 / 85m
				64 / 1,137m

(5) Problems Associated with Disaster Prevention

These problems are grouped into eight subsections along the Ibague-Calarca section. The outline is given below.

1) Km 56,000 - Km 64,600

The rock mass of granodiorite has been partially fractured by the Ibague Fault. Moreover the surface is weathered to a sandy state and liable to collapse. Thus, collapses and rock falls of medium or small scale should be taken into account. A large active landslide zone is found at Km 62.6, and positive measures should be taken quickly to improve the condition. At about Km 64.8 there is erosion of the river bank (Rio Cocora) and likewise steps should be taken to prevent potential damage.

2) Km 64.600 - Km 73.000

Locations with a probability of occurrence of collapse, rock falls, etc. are concentrated at the hairpin curves between Km 65.600 and Km 66.500. Bank erosion by the river (Rio Cocora) is much in evidence and this is having a critical effect on the road. Slopes with extensive erosion are found between Km 71.5 and Km 72.6 forming a zone of landslides, rock falls and bedrock collapse. Here protection against erosion is urgently required. Countermeasures for debris flow between Km 71.750 and Km 72.800 (Ortega) should also be taken.

3) Km 73.000 - Km 83.400

Slope cuts at discontinuities of pumice flow deposits covering graphite schist produce unstable conditions. Measures against landslides as well as those against debris flow at Quebrada Gamboa are essential at Km 75.500. Many locations in danger of collapse, rock fall and debris flow are found between Km 77.000 and Km 80.000, where the rock mass is exposed and fractures are noted with extensive weathering. The probability of debris flow and large-scale collapse exists at Km 81.500 and Km 83.4 (Quebrada Tigre).

4) Km 83.400 - Km 90.000

Between Km 83.500 and Km 85.000 a discontinuity of pumice deposits with quartz schist will be exposed during slope cutting resulting in an unstable slope. In other parts of this section, collapse of the weathered graphite schist is expected. There is a danger of debris flow at Quebrada Cuba (Km 83.400).

5) Km 90.000 - Km 100.700

Fractured quartz schist zone due to faults is exposed between Km 93.100 and Km 94.200 as well as between Km 96.000 and Km 97.000, and may result in collapse and rock falls. Bank erosion by the Rio Bermellon is evident, and because it is critical to the road, countermeasures are necessary. Measures against debris flow from valleys as well as those against landslides are essential between Km 97.700 and Km 97.900.

6) Km 100.700 - Km 105.400

Both banks of the Quebrada Perales between Km 101.000 and Km 101.700 have serious problems. The left bank is in danger of slipping, while the right bank shows a danger of a large-scale potential collapse. Danger of landslide and cave-in of road is found also at about Km 102.900. The neighbourhood of the quarry site between Km 103.500 and Km 105.400 indicates an imminent collapse of the rock mass. Pumice deposits are seen around Km 105.400, where a number of landslides have taken place.

7) Km 105.400 - Km 125.000

As at Km 105.4, this section also shows a distribution of pumice deposits accompanied by the danger of slippages and gully erosions. Not being cemented, this layer will be eroded rapidly by rainfall. Since the existing route passes near the ridge, measures against landslide on slope near the shoulder are of special importance.

8) Km 125.000 - Km 135.500

This section shows less signs of large-scale problems. Collapse of the volcanic ash layer as well as that of the extensively weathered layer of graphite schist between Km 130.000 and Km 135.500 should be prevented by means of suitable measures.

6-6 Topographical Map

6-6-1 Topographical Map Availability

Topographical maps are indispensable for the formulation of improvement plans. Those maps which cover the project area and which are available are listed in Table 6-19.

Table 6-19 List of Topographical Maps Available

Place	Topographical map obtained by aero-photogrammetric survey		Surveyed map
Melgar - Espinal	1/10,000 (IGAC)		—
Ibague - Km 101	1/25,000 (IGAC)	1/2,000 (MOPT)	1/2,000 (MOPT) 1) Drawing of center line and profile (w/o contour lines)
Km 101 - La Linea	1/25,000 (with gaps)	1/5,000 2) (JICA prepared in 1980)	
La Linea - Calarca	1/25,000 (IGAC) (with gaps)		—
Calarca - Buga	1/25,000 (IGAC) (with gaps)		—

Notes: 1) Prepared for the purpose of the rehabilitation project by the Colombian Government.

2) The 1/25,000 topographical map covering the km 101-Calarca section has many gaps, and so JICA borrowed an aero-map of that section from the IGAC, and prepared a 1/5,000 topographical map.

6-6-2 Topographical Map for the Ibague-Calarca Section

The 1/25,000 topographical map for the Ibague-Calarca section (which is the target area of the project) is not precise enough to indicate all the small radius curves on the road. Accordingly, the study of the alignment improvement of the section was based on the MOPT's 1/2,000 topographical map, the JICA's 1/5,000 topographical map, and the plan and profile maps obtained by actual survey along the existing road.

The km posts on the surveyed plan for the Colombian Government's rehabilitation project are in disagreement with the in situ km posts. Consequently the drawings indicate two kinds of km posts. The relationship of these posts is shown in Annex Table 6-2.

6-7 Road Accessory Facilities

6-7-1 Traffic Safety Facilities

1) Guard rails

There are few or no guard rails along the project road. In the Ibague-Calarca section, soils left from excavations are used on the edge of the road in lieu of guard fences. They are also used to delineate the road edge on the valley side as though there is a curb.

2) Others

There are no pedestrian overbridges, road lighting facilities, delineators or corner mirrors.

6-7-2 Traffic Control Devices

1) Traffic signs

There are few, if any, guide signs, warning signs and regulatory signs. According to the rehabilitation project now being carried by the Colombian Government, new traffic signs will be provided and installed.

2) Road markings

The center line of the carriageway is marked white.

3) Traffic signals

A traffic signal in Girardot is the only signal found along the Project Road.

6-7-3 Emergency shoulders, etc.

In the mountain region between Ibague and Calarca, several vehicles are always found, parked on the pavement due to breakdowns. Some of these vehicles are left to be repaired for several days at a time. The breakdowns are caused primarily by engine failure or shaft breakage due to overloading. No provisions are made for wide areas to allow for emergency parking of vehicles which may have suffered such breakdowns.

A fact-finding survey should be conducted to determine the mean distance of breakdown vehicles climbing up steep slopes for the purpose of establishing the interval for proper turnouts or for emergency parking.

Photo 6-1

The Site in Danger of Rock Fall

Photo 6-2 The Site in Danger of Landslide

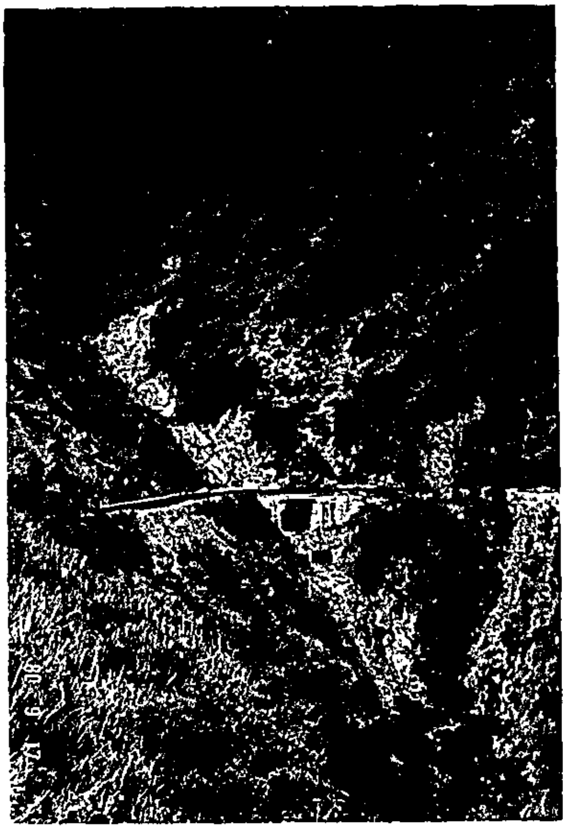


Photo 6-3

The Site in Danger of Debris Flow

Photo 6-4 The Site of Landslide which needed one day before Road Reopening.

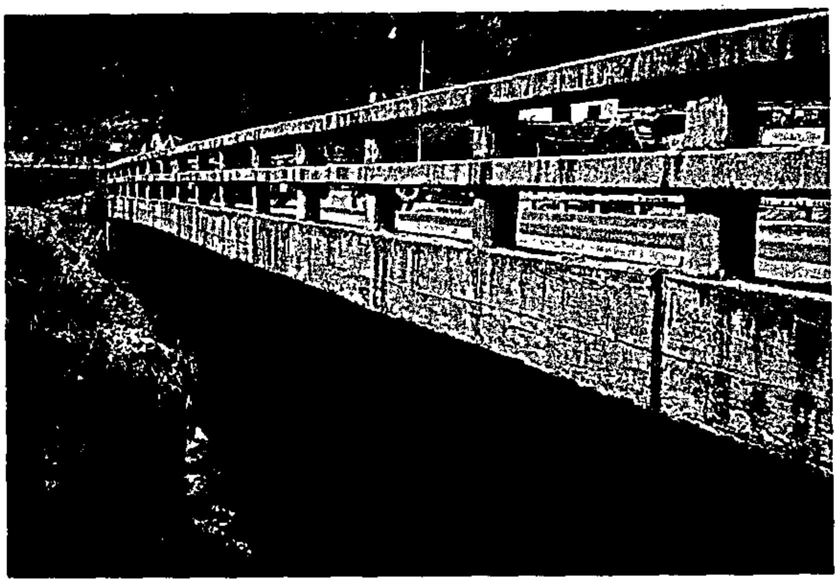


Photo 6-5   Prestressed Concrete Bridge over Rio Combeima

Photo 6-6   Steel Truss Bridge over Rio Sumapaz

Photo 6-7 Concrete T Beam Bridge at Q. Gamboa

Photo 6-8 Concrete Half Bridge at Km.110

CHAPTER - 7

ROAD IMPROVEMENT PLANS

Chapter 7. Road Improvement Plans

7-1 General

As discussed in Chapter 6, the road sections from Melgar to Ibague and from Calarca to Buga do not warrant a specific program of improvement. Consequently the road upgrading appears to be limited to the Ibague-Calarca section. If current Colombian geometric design criteria were to be applied directly to the improvement of the Ibague-Calarca section, the section would require a completely new alignment with a minimum radius of curvature of 40 m and a design speed of 40 km/h. This would require a very costly investment because of the severe topography of the area as well as difficult geological considerations. It is therefore recommended to adopt alternative plans modifying the geometric design criteria in order to select the most economically suitable solution.

In the past ten years, the Project Road has been rehabilitated in stages in order to meet the increase in traffic. There are ongoing rehabilitation works which are financed by the Government and other sources (See Chapter 6). In proposing the improvement plans (P-1-P-4), the current rehabilitation work (mostly resurfacing work) has been considered in the evaluation. It is therefore proposed to upgrade the road in stages by retaining the existing alignment as much as possible. Partial improvement plans have been studied and certain combinations for improvement are recommended for implementation.

Improvement plans for the existing road are classified into four plans: critical curve improvement plan (P-1), minimum scale improvement plan (P-2), medium scale improvement plan (P-3), and large scale improvement plan (P-4). They are described in paragraph 7-2 of this chapter.

Wherever bridges or structures were necessary to be improved, they have been included in the proper plan of improvement as described in paragraph 7-3 of this chapter.

In addition to the alignment problems, there are also problems of slope failures including landslides, collapses of valley-side shoulders, debris flows, etc., which often interrupt the traffic. The countermeasures against slope failures and their costs are handled in this chapter in paragraph 7-4. Since the data associated with the slope failures are not sufficient to present a recommendation which can be justified through the economic evaluation, the recommendation is presented mainly from the technical viewpoint, due to urgent necessity.

7-2 Road Improvements

7-2-1 Geometric Design Criteria

The geometric design criteria applicable to improvement plans P-2, P-3 and P-4 are shown in Table 7-1. In the case of P-1, the main feature of the improvement is the widening of sharp curves without modifying the alignment. Typical cross sections for improvement plans are shown in Fig. 7-1 and 7-2.

As found in Chapter 6, curves and road subsections which are found in need of improvement under the improvement plans P-2 and P-3 are located in the section between Ibague and Calarca. The large scale improvement plan is studied only for the bypassing of Girardot, Espinal, Ibague, Coello and La Linea.

7-2-2 Critical Curve Improvement Plan (P-1)

(1) Alignment

The present road is improved by keeping the horizontal and vertical alignments as they are and increasing the width of any sharp and narrow curves. Also use of the road shoulders allows large trucks and semi-trailers to pass each other. Passing condition of the curves is discussed in Annex 7-1 and the curves to be improved are given in Annex Table 7-3.

(2) Surfacing

In most cases, the widening of the curves under improvement plan P-1, is conducted by widening and surfacing the shoulders of the existing curve segment. The surfacing of the widened part will be similar to the other sections of the existing road.

(3) Exclusion from the Economic Evaluation

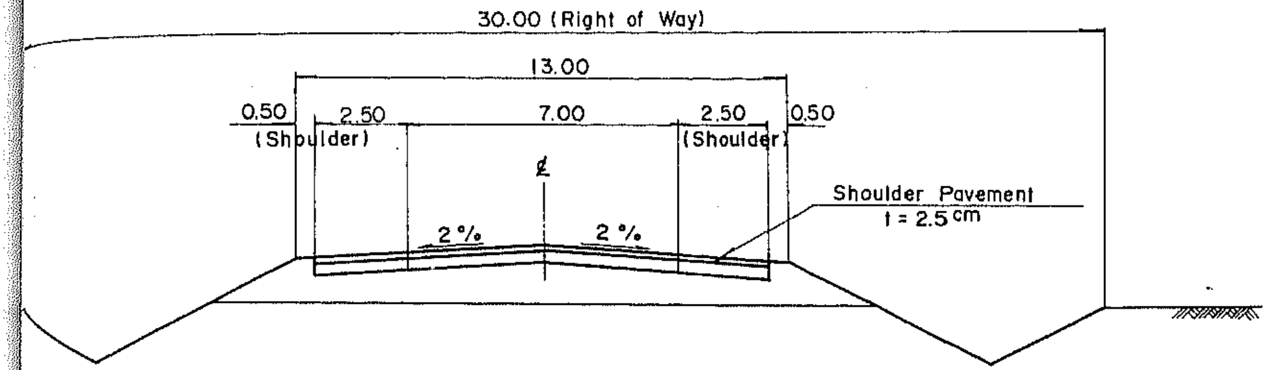
Although the critical curve improvement plan (P-1) was engineered together with other plans of improvement, it is found that the magnitude of the work under this plan is quite modest and that the plan (P-1) could be included in the higher levels of improvement such as the minimum scale improvement plan (P-2), and the medium scale improvement plan (P-3). Consequently, the critical curve improvement plan (P-1) has been eliminated from the economic evaluation.

7-2-3 Minimum Scale Improvement Plan (P-2)

(1) Alignment

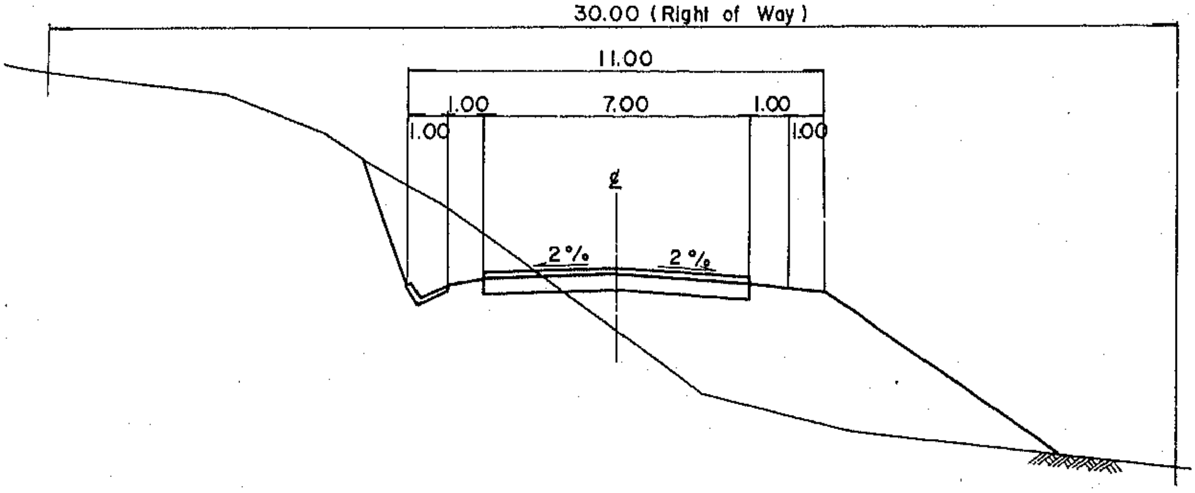
Under this plan (P-2), the sharp and narrow curves will be improved by applying the following criteria.

1) Radius of Curvature : The horizontal alignment will be upgraded to a minimum radius of curvature of 25 m for the design speed of 30 km/h. The



Girardot Bypass

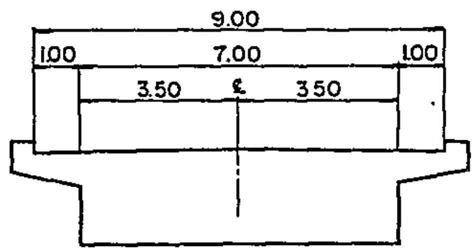
Scale 1 : 200



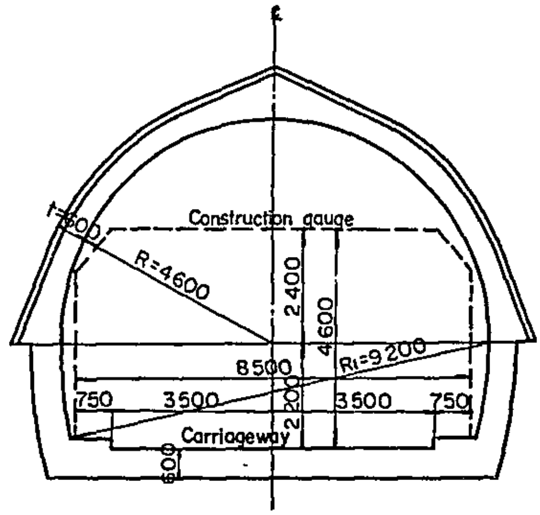
Ibague, Coello and La Linea Bypasses

Scale 1 : 200

Fig 7-1 Typical Cross Sections of Earth Work Segment



Section of Structures



Section of Tunnels

Fig 7-2 Typical Cross Section of Structures and Tunnels

Table 7-1 Geometric Design Criteria of The Improvement Plans

	Improvement of Existing Road	New Road Construction	
		Large Scale Improvement	
	Minimum Scale Improvement Plan Medium Scale Improvement Plan	Girardot bypass	Ibague, Coello and La Linea bypasses
Terrain	M	P	M
Design Speed (Km/h)	30	80	30
Roadway width (m)	7.00	7.00	7.00
Shoulder width (m)	1.00	2.50	1.00
Carriage way width (m)	9.00	12.00	9.00
Max. Vertical Gradient (%)	10	4	8 (10)
Min. Radius (m)	25	250	25
Convex Min. Length (m)	40	60	40
Parameter Kv-L/A	15	30	15
Vertical Curve			
Concave Min. Length (m)	40	60	40
Parameter Kv=L/A	15	22	15
Min. Stopping Sight Distance (m)	30	110	30
Passing Sight Distance (m)	150	420	150
Passing Opportunity in 5 km (%)	30	60	30
Structure width (m)	9	9	9
Construction Gauge (m)	4.60	4.60	4.60
Max. Superelevation (%)	10	6	10

Note: P - Plain, R - Rolling, M - Mountainous
L = Parameter, A = Algebraic difference in vertical gradient
Kv = Required vertical curve length

(Value) shows the value for special case.

longitudinal alignment will remain unchanged.

2) Width : Even in the case where the radius of curvature exceeding 25 m, widening will be carried out in accordance with the criteria of the existing curves wherever the width is found to be insufficient.

3) Cross Section : The cross section will be improved to permit two large trucks to pass each other on the roadway and two semi-trailers(tractomula) to pass each other by driving over the shoulders.

4) Stopping Sight Distance : When the radius of curvature of 25 m and proper widening is realized, the stopping sight distance of 30 m will be automatically adequate.

(See Annex 7-2 Maintenance of Stopping Sight Distances at Curves and Annex Table 7-3 Present Status of Passing Condition and Summary of Improvement Plans)

(2) <u>Surfacing</u>

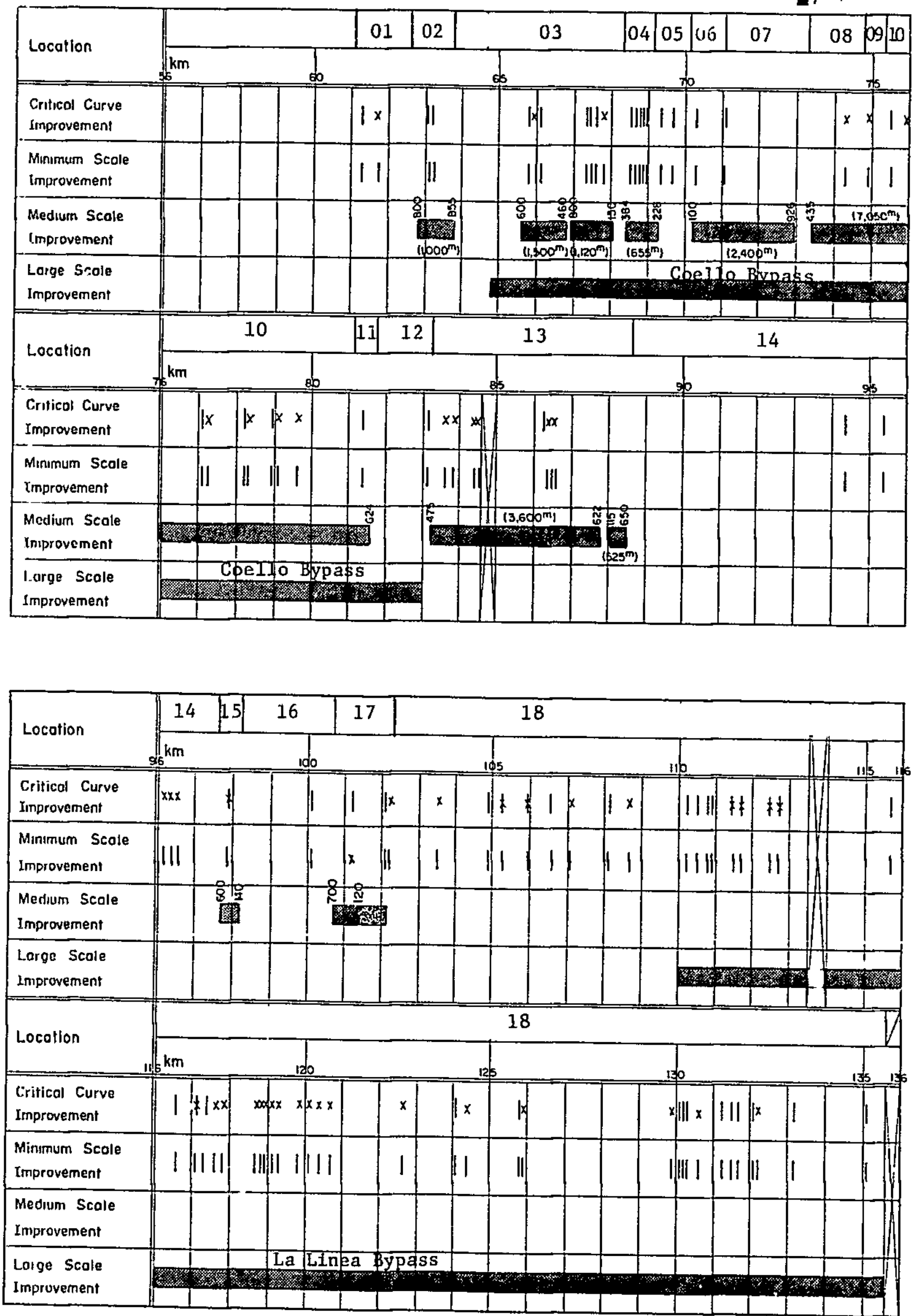
Since the plan proposes the realignment of the curve, the road lane will be reconstructed and surfaced in a similar way to the existing road. The affected portion of the shoulders will be surfaced in the same way as the shoulders of the other part of the existing road.

(3) <u>Curves to be improved</u>

The number of curves to be improved is shown in Table 7-2 and the detailed information in Annex Table 7-3. Location of Improvement Plan is shown in Fig. 7-3.

Fig -7-3 Location of Improvement Plans (Ibague-Calarca)

Note x No Improvement
|) Improvement



Note · Location is relative to construction km post.

Table 7-2 Number of Curves for Minimum Scale Improvement Plan by Subsection

Road Subsection	Location km - km	Number of curves for Minimum Scale Improvement Plan
01	61.3 - 62.8	2
02	62.8 - 63.9	2
03	63.9 - 68.4	7
04	68.4 - 69.2	5
05	69.2 - 70.1	2
06	70.1 - 71.3	2
07	71.3 - 73.4	0
08	73.4 - 75.2	2
09	75.2 - 75.7	1
10	75.7 - 81.1	7
11	81.1 - 81.6	1
12	81.6 - 83.5	1
13	83.5 - 88.7	7
14	88.7 - 97.6	5
15	97.6 - 98.2	1
16	98.2 - 100.7	1
17	100.7 - 102.1	2
18	102.1 - 135.6	54
	Total	102

Note : Details are shown in Annex Table 7-1

7-2-4 Medium Scale Improvement Plan (P-3)

(1) Alignment

The medium scale improvement plan (P-3) proposes a new alignment for a certain length of the existing road which is found in poor condition with high likelihood of slope failures. The new alignment will meet the design criteria applicable for this level of improvement (refer to Table 7-1). Location of improvement plans is shown in Fig. 7-3.

Radius : 25 m

Cross section : road lane 7 m width
shoulders 1 m width each on both sides

Grade : not more than 8%

Stopping Sight Distance : 30m or more

(2) Surfacing

The new alignment will have surfacing similar to the existing road. The shoulders will be surfaced in the same way as those of the existing road. The pavement thickness is designed by applying the criteria of the Asphalt Institute of the USA, since these criteria are generally used in Colombia.

The CBR values of the subgrade for the proposed new alignment under improvement plan P-3 are shown in Table 6-5 of Chapter 6. The determination of the pavement thickness is described in Annex 7-3 and the resultant thickness is shown in Table 7-3.

Table 7-3 Pavement Thickness Applied for the Medium Scale Improvement Plan

	Km56 - Km70	Km70 - Km102
Surface Course	5.0cm	5.0cm
Base Course	20.0cm	15.0cm
Sub base Course	-	20.0cm
Total	25.0cm	40.0cm

Remarks: The difference in thickness is due to the difference in CBR values of the subgrade.

(3) Slope Protection

To prevent the slope from failing, slope protective work is scheduled for each new alignment. The method of slope protection is shown in Fig. 7-4.

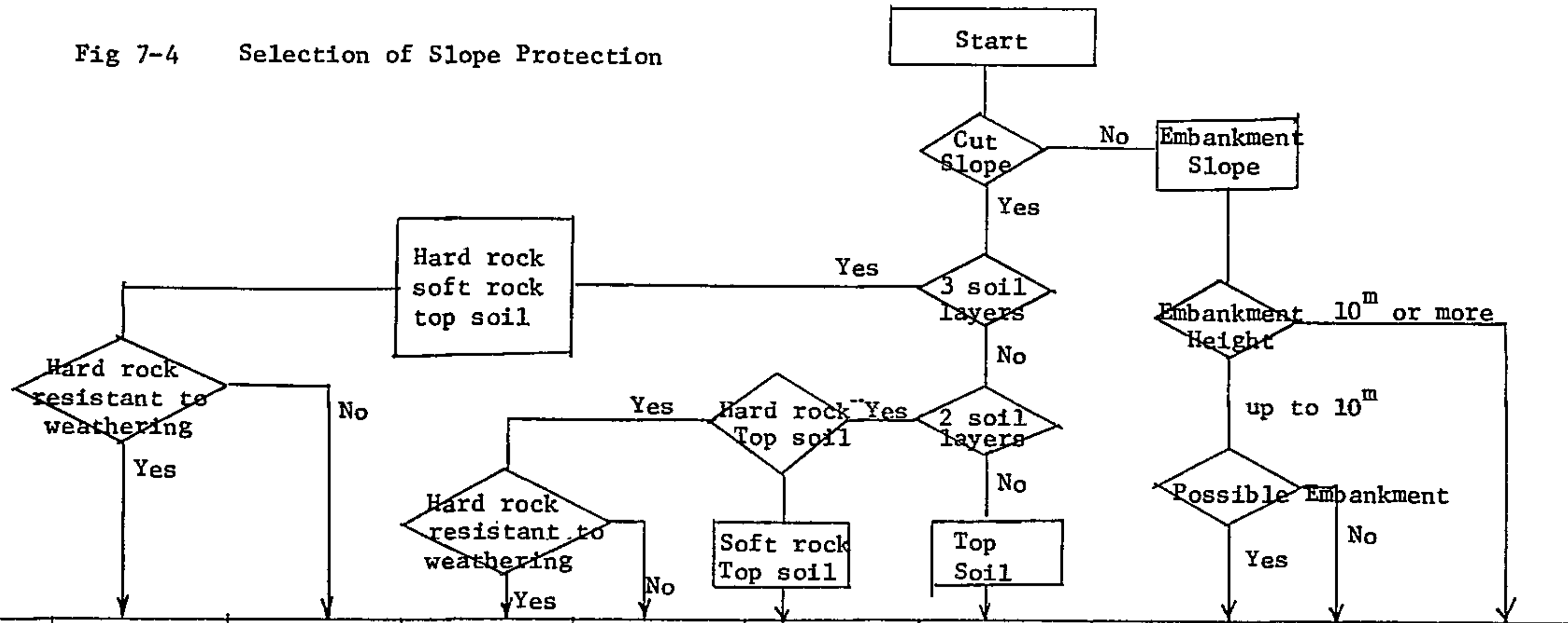
(4) Bridges and Road Structures

Planned major bridges and tunnels are shown in Table 7-7.

(5) Sections subject for the medium scale improvement plan (P-3)

The sections subject for the medium scale improvement plan are shown in Table 7-4.

Fig 7-4 Selection of Slope Protection



		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9
Hard rock	Slope Protection	Not Applicable	Concrete Spraying	Not Applicable	Concrete Spraying	—			Retaining Wall	Half Bridge
	Slope Gradient	1:0.3				—				
Soft rock	Slope Protection	Seed Spraying		—		Concrete Block Retaining Wall	—			
	Slope Gradient	1:0.6		—		1:0.5	—			
Top soil	Slope Protection	Seed Spraying								
	Slope Gradient	1:1.0						1:1.5		
Vertical height of Slope		7.0m						5.0m		
Width of terrace		1.0m						1.0m		

Table - 7.4 Geometric Structure of Medium Scale Improvement Plan

Section		02		03		03		04		06 — 07		08 — 11		13		13		15		17	
		Km 62,800 - 63,855		Km 65,600 - 66,760		Km 66,800 - 68,130		Km 68,384 - 69,228		Km 70,100 - 72,926		Km 73,435 - 81,624		Km 83,475 - 87,622		Km 88,115 - 88,650		Km 97,600 - 98,140		Km 100,900 - 102,120	
		E/A	N/A	E/A	N/A	E/A	N/A	E/A	N/A	E/A	N/A	E/A	N/A	E/A	N/A	E/A	N/A	E/A	N/A	E/A	N/A
Vertical Alignment (m)	0 - 2 %	0	0	0	0	273	0	0	0	354	1,005	585	2,590	161	300	52	0	194	280	0	0
	2 - 4	0	0	0	0	362	570	0	0	256	515	1,896	1,615	431	0	197	500	189	0	500	0
	4 - 6	157	0	0	0	695	550	376	0	786	140	2,148	2,035	140	3,300	286	0	0	0	920	0
	6 - 8	898	1,000	866	1,500	0	0	468	655	1,223	740	3,441	810	1,130	0	0	0	157	0	0	722
	8 - 10	0	0	294	0	0	0	0	0	207	0	119	0	1,924	0	0	0	0	0	0	0
	10 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1,055	1,000	1,160	1,500	1,330	1,120	844	655	2,826	2,400	8,189	7,050	3,786	3,600	535	0	540	280	1,420	722
No of Horizontal Curves	- 15 m	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
	15 - 20	2	0	2	0	0	0	4	0	1	0	4	0	3	0	0	0	0	0	0	0
	20 - 25	2	0	1	0	4	0	3	0	0	0	5	0	7	0	0	0	2	0	0	0
	25 - 30	1	0	1	0	3	0	2	0	2	0	10	0	3	0	0	0	0	0	3	3
	30 - 45	0	2	4	1	12	0	7	0	8	0	24	4	18	0	1	0	0	0	3	0
	Total	5	2	8	1	19	0	16	0	11	0	44	4	31	0	1	0	2	0	7	3

Note : E/A Existing Alignment

N/A New Alignment

Km Value is dependent on predetermined km post for construction.

7-2-5 Large Scale Improvement Plan (P-4)

The large scale improvement plan (P-4) is developed for the bypassing plan of the four sections selected from the Project Road. The purposes of these bypass plans are to avoid the traffic congestion in the urban area for both of the bypass plans in Girardot - Espinal and in Ibague, to have better alignment in the mountainous area for both of the bypasses in Coello and La Linea.

When they are constructed, they will result in the savings in the traffic cost for the Colombian economy. The design criteria applied for the large scale improvement plan are shown in Table 7-1.

(1) Girardot - Espinal Bypass

This bypass section is located in the Rio Magdalena alluvial plains passing through flat cultivated area, therefore the construction will be easy. Since the result of the route comparative study of the bypass as stated in Annex 9-4, indicates this bypass plan to be feasible for the route in the corridor between A-1 - B-1 and A-2 - B-2 as shown in Annex Fig. 9-4. The best alternative alignment of the bypass plan is determined after field inspection which is refined and shown in the Drawing of Volume 3.

For this alignment, the quantities and construction cost are estimated. They are presented in Annex Table 8-3-4 (1) of Volume 2.

(2) Ibague Bypass

Houses are densely built up in the urban area of Ibague which has no open spaces to expand towards north, south and west because of steep mountain slopes. After alternative plans of the Ibague bypass are studied applying varying design criteria to get rid of the traffic congestion in the urban area, it is found the plan is feasible. The study is shown in Annex 9-5. Plan A will result in the best economic consequence among the three plans studied.

The alignment of Plan A is shown in the Drawing of Volume 3. The quantity and the cost are estimated as shown in Annex Table 8-3-4 (2) of Volume 2.

(3) Coello Bypass

The section between Km 66 and Km 80 involves a number of sharp turning curves and slope failure prone places. The Coello bypass is planned to detour the existing alignment by finding an alignment on the opposite mountain side. The new bypass includes a tunnel of 950m and other bridges. Due to the given criteria, the bypass has to have longer distance than the existing section. Accordingly, the bypass will not result in the savings in traffic cost, while the construction cost is very high. The plan is not economically feasible. The alignment is shown in the Drawings of Volume 3 and the quantity and the cost in Annex Table 8-3-4-(3) of Volume 2.

(4) La Linea Bypass

The average gradient of the existing road between La Linea and Calarca for 21.6km long is approximately 8% with many sharp curves and failure prone slopes. La Linea bypass is planned to have the alignment more gentle with a tunnel of 970m long to cross the highest point of Central Cordillera together with other structures. However, this bypass is found not feasible because the plan with a better alignment results in longer road distance than the existing road.

There will be no savings in the traffic cost, the construction cost is very high because of difficult mountain terrain. The alignment is shown in the Volume 3, and the quantity and the cost in Annex Table 8-3-4-(4) of Volume 2.

The lengths of Large Scale Improvement Plan are arranged in accordance with 6 categories of road grades. Likewise the existing road is also indicated in the same Table 7-5. Pavement thickness is determined by the same method as that in the medium scale improvement plan with the result shown as in Table 7-6.

Table 7-5 Length by Gradient of Large Scale Improvement Plans

(Km)

	Girardot Bypass		Ibague Bypass		Coello Bypass		La Linea Bypass	
	Existing Road	Bypass	Existing Road	Bypass	Existing Road	Bypass	Existing Road	Bypass
0-2 %	35.5	25.0	2.7	0.7	1.78	3.15	0.66	2.20
2-4 %	3.4	2.1	2.8	2.0	3.23	4.30	1.68	3.25
4-6 %	1.4	0	1.35	1.4	4.81	3.05	0.70	4.35
6-8 %	0	0	1.1	0.8	7.51	4.80	3.66	17.35
8-10%	0	0	0.3	0	0.53	8.75	18.50	2.70
10- %	0	0	0	0	0.12	0	1.20	0
Total	40.3	27.1	8.25	6.6	17.98	24.05	26.40	29.85

Table 7-6 Pavement thickness used for the Large Scale Improvement Plan (P-4)

(cm)

	Bypass Plan			
	Girardot	Ibague	Coello	La Lines
Surface Course	7.5	7.5	5	5
Base Course	15	15	15	15
Subbase Course	40	20	20	20
Total	62.5	42.5	40	40

Note: 1) The difference in thickness is due to the difference in CBR values of the subgrade.

2) Pavement design procedure is shown in Annex 7-3.

To reduce initial investment, stage construction of pavement is considered for Coello and La Linea Bypass plans, these two plans, however are found to be not feasible for immediate construction as described in paragraph 9-5 of Chapter 9.

Slope protection work along the new bypass in the steep mountain area is proposed wherever it is found necessary. The method of slope protection is shown in Fig. 7-3.

7-2-6 Durable Life of the Overlay Work

As stated in 6-3-2 of the previous Chapter 6, there have been ongoing overlay work of the surface of the road. The assessment of the durable life of the overlay work indicates that the new overlay would be necessary in 7 years from now for Melgar - Ibague and 10 years for Ibague - Calarca, respectively, if daily maintenance work is conducted properly. The assessment is presented in Annex 7-3. Since it is found that the timing of the next overlay is very close to the timing of the implementation of the recommended project, MOPT will be able to arrange the two works to be done in the most efficient way.

Table 7-7 Planned Major Bridges and Tunnels

1. Critical Curve Improvement Plan ...... Not Applicable

2. Minimum Scale Improvement Plan

Section	Station	Distance along existing road	Location	Length	Type
10	-	Km 78.2	Q.Curalito	30m	PC
11	-	Km 81.4	Q.Cerajosa	40m	PC

3. Medium Scale Improvement Plan

Section		Station	Distance along existing road	Location	Length	Type
Km 65,600 -	03	No. 3	Km 65.7	Q.	30m	PC
Km 66,760	03	No. 12	Km 65.8	Q.	40m	PC
Km 66,800 -	03	No. 2	Km 66.9	Q	15m	PC
Km 68,130	03	No. 3	Km 67.0	Q	20m	PC
	03	No. 5	Km 67.1	Q	40m	PC
	03	No. 14	Km 67.5	Q	50m(20+30m)	PC
	03	No. 18	Km 68.1	Q	80m(2x40m)	PC
Km 68,384 -	04	No. 2	Km 68.6	Q	20m	PC
Km 69,228						
Km 70,100 -	06	No. 3	Km 70.3	Q	40m	PC
Km 72,926	06	No. 17	Km 71.1	Q	80m(2x40m)	PC
	07	No. 31	Km 72.0	Landslide	730m	Tunnel
Km 73,435	08	No. 10	Km 74.0	Q	30m	PC
-	08	No. 16	Km 74.2	Q	30m	PC
Km 81,624	08	No. 27	Km 74.8	Q	40m	PC
	08	No. 30	Km 75.0	Q	20m	PC
	09	No. 36	Km 75.5	Q.Gamboa	170m(50m+70+50)	PC
	10	No. 44	Km 75.9	Q	80m(2x40m)	PC
	10	No. 52	Km 76.3	Landslides	790m	Tunnel

Note: major Bridge means 20m or more long bridge.

Table- 7- 7 Planned Major Bridges and Tunnels

(Cont'd)

Section		Station	Distance along existing road	Location	Length	Type
Km 73,435	10	No.68	Km 77.2	Q.	20 m	PC
	10	No.71	Km 77.4	Q.	60m(2x30m)	PC
—	10	No.74	Km 77.6	Q	50m(20m+30m)	PC
Km 81,624	10	No.81	Km 77.9	Q	40 m	PC
	10	No.84	Km 78.2	Q.Curalito	70m(30m+40m)	PC
	10	No.86	Km 78.4	Q	20 m	PC
	10	No.87	Km 78.5	Q	60m(2x30m)	PC
	10	No.91	Km 78.8	Q	130m(40+3x30m)	PC
	10	No.95	Km 79.0	Q	110m(30+2x40m)	PC
	10	No.101	Km 79.2	Q	60m(2x30m)	PC
	10	No.105	Km 79.6	Q	80m(2x40m)	PC
	10	No.109	Km 79.7	-	30 m	PC
	10	No.113	Km 80.0	-	60m(2x30m)	PC
	10	No.116	Km 80.2	Q	50m(20m+30m)	PC
	10	No.118	Km 80.3	Q	70m(40m+30m)	PC
	10	No.125	Km 80.6	Q	90m(3x30m)	PC
	11	No.138	Km 81.3	Q.Cerajosa	60m(2x30m)	PC
Km 83,475	13	No. 8	Km 83.9	Q	140m(3x40m+20m)	PC
	13	No.19	Km 84.9	-	40 m	PC
—	13	No.21	Km 85.0	Q	60m(2x30m)	PC
	13	No.25	Km 85.1	Q	50m(30m+20m)	PC
Km 87,622	13	No.29	Km 85.4	Q	40 m	PC
	13	No.36	Km 86.0	Q	90m(3x30m)	PC
	13	No.42	Km 86.2	Highland	250 m	Tunnel
	13	No.53	Km 86.7	Q	70m(40m+30m)	PC
	13	No.60	Km 87.0	Q	20 m	PC
	13	No.64	Km 87.2	Q	50m(20m+30m)	PC
Km 97.6 — Km 98.2	15	No. 3	Km 97.8	Q.Los Marias	170m(50m+70m+50m)	PC
Km 100.7 — Km 102.1	17	No. 3	Km 101.5	Q.Perales	170m(50m+70m+50m) + 188m(10m+5x14m + 10m+3x30m+8m)	PC

Note: Long span bridge means 20 m or more long bridge.

Q: Quebrada means mountain stream in Spanish.

Table 7-7 Planned Major Bridges and Tunnels

(Cont'd)

Section	Station	Location	Length	Type
Girardot Bypass	0+800	Rio Sumapaz	110m(30m+50m+30m)	PC
	6+850	Rio Magdalena	260m(60m+140m+60m)	PC
Ibague Bypass	0+510	-	80m(40mx2)	PC
	1+480	Rio Combeima	110m(30m+50m+30m)	PC
	4+240	-	80m(40mx2)	PC
	5+510	-	20m	PC
Coello Bypass	2+340	Q	20m	PC
	3+700	Q	20m	PC
	13+200	-	950m	Tunnel
	19+010	Q	30m	PC
	21+600	Q	20m	PC
La Linea Bypass	3+350	-	70m(40m+30m)	PC
	3+800	-	890m	Tunnel
	4+350	-	110m(40m+40m+30m)	PC
	7+850	-	100m(40m+40m+20m)	PC
	11+600	-	100m(40m+40m+20m)	PC

7-2-7 Quantity Estimates

The work quantities of the above improvement plans from P-1 to P-4 are estimated by using the plan and profile maps with the scale described bellow:

Improvement Plan	Road Section	Scale of the maps
P-1 to P-3	Ibague- Km 100.7	1:2,000
	Km 100.7-Calarca	1:5,000
P-4	Girardot bypass	1:25,000
	Ibague bypass	1:10,000
	Coello bypass	1:25,000
	La Linea bypass	1:5,000

The estimated quantities are imcorporated into the estimate of the cost of the improvement plan which are stated in Chapter 8.

7-3 Improvement of Bridges and Structures

7-3-1 Design Criteria and Materials

In Colombia, the AASHTO specifications are used for the design of bridges and structures.

The Study Team compared the Japanese structural standards with the ASSHTO specifications, and found that there is little difference between them as far as loading system and allowable stresses are concerned. For this reason, it was decided to use the Japanese structural standards in the design of new bridges and structures.

Materials to be used in the improvement of the Project Road and for designing new bridges and structures were determined by agreement with the MOPT.

(1) Materials and Allowable Stresses

Structural concrete (design compressive strength)

f'_c = 210 kg/cm^2 for substructures and culverts

f'_c = 270 kg/cm^2 for bridge decks and piers

f'_c = 350 kg/cm^2 for prestressed concrete

f'_c = 400 kg/cm^2 for cantilever method, high early strength

1) PC tendon

According to Freyssinet's guidelines

2) Reinforcement bars

Yield point stress intensity, f_y = 3,000 kg/cm^2

(2) Design Load

1) Dead Load

The dead load includes the weight of every part of the structural member. The future wearing surface is estimated at 230 kg/m^2.

2) Live Load

For live load, AASHTO HS-20 is used in Colombia. In the designing of bridges and structures, however, the Japanese equivalent live load is applied.
See Annex Fig. 7-12.

3) Sseismic Design Standard

In Japan, the equivalent static force method, modified equivalent static force method, and dynamic force method are used selectively to meet the physical scale and sseismic requirements of a given structure.

For the Project Road, it was decided to use the equivalent static force method. The .Study Team discussed this with the MOPT, and it was agreed that the maximum expected acceleration at bedrock at site be set at 0.09G (Zone III), and that the minimum horizontal seismic coefficient be 0.1.

7-3-2 Basic Approach to the Improvement Plans

Structural improvement plans were formulated according to the following catagories.

(1) Minimum Scale Improvement Plan

The minimum scale improvement plan pertaining to bridges considered the widening of bridges and structures at places where the existing road geometry is substandard. However, no bridge widening was included in the minimum scale improvement·plan.

(2) Medium Scale Improvement Plan

In the medium-scale improvement plan, widening and construction of new bridges and structures are planned as related to the alignment improvement.

At Km 75.500, 97.500 and 101.200 bridges are planned at a changed alignment to avoid landslide-prone zone.

(3) Large Scale Improvement Plan

In the large-scale improvement plan, the Girardot bypass (bridge length, 260m) and the Ibague bypass (bridge length, 110m) were studied as additional work to that contemplated under the large scale improvement plan above. Furthermore, small and medium span bridges were studied for the alignment improvement of the La Linea bypass.

7-3-3 Description of Procedures to follow in the Design of New Structure for the Improvement Plans

(1) Quantities used for new bridges and structures for the improvement plans on the Project Road are listed in Tables 7-8, 7-9 and 7-10. Other data are included in Annex Fig. 7-6 to 7-10.

(2) Ordinary bridges and structures

The Study Team endeavored to standardize structures as much as possible. Standardization should result in savings in design and construction.

1) Most of the bridges can be included within the standard designs. The number of special designs will be kept to a minimum due to economic considerations.

2) During the construction stage, the contractors can use the same forms, bar arrangement and construction processes, and at the same time can improve their skills and effectuate savings in labor and materials.

The reconnaissance survey and the discussions with the staff of the MOPT made it clear that in most cases concrete bridges are the most economical structures to construct in Colombia. After close study of the Japanese and Colombian standard design practices, the Study Team proposes the following types of structures.

(i) Reinforced concrete slab bridge for spans of 5.0 m or 10.0 m.

(ii) Precast prestressed concrete girder bridge for spans of 20, 30 and 40 m.

(iii) Block type retaining wall (H = 5 m, 7 m)

(iv) Cantilever type abutment (H = 7 m, 10 m) for use with reinforced concrete or precast prestressed concrete bridges

(v) Cantilever type retaining wall (H = 5 m, 7 m)

(vi) Reinforced concrete box culverts

(vii) T-shaped piers supporting bridge decks (Half Bridge)

These structures are used in the cost estimates of the improvement plans. Drawings of the structures above mentioned are included in the report of Drawings, Vol. 3.

(3) Special bridges and structures

1) Structures Installed within the Landslide Zone

The Ibague-Calarca section of the Project Road is located in the mountainous region and is often the scene of landslides. In order to minimize the detrimental effects of these landslides upon the traffic, the Study Team studied various schemes in an effort to improve the conditions.

2) Bridges

At the three landslide-prone areas, namely, Km 75+500 (Quebroda Gamboa), Km97+500 (Quebrada Los Marias), and Km101+200 (Quebrada Perales), improvement plans using bridges were studied mainly because of the topographic problems involved in this area, and structures were proposed after careful study of structural justifiability, economics , bearing value, potential problems associated with the landslides, bearing topographic conditions, geological conditions, radius of curvature, longitudinal road characteristics.

(i) Km75 + 500 (Quebrada Gamboa)

In the past this bridge has been damaged twice by debris flow. This location remains as one of the most dangerous areas. In order to avoid the landslide-prone zone and at the same time to minimize the bridge span, a curved box girder is being proposed.

(ii) Km97 + 500 (Quebrada Losmarias)

The location is the most susceptible one to subsidence. In the past, the site has been built up more than one meter due to the subsidence. Based on the topography and boring data, a PC box girder was formed to be most economical and is being proposed.

(iii) Km101 + 200 (Quebrada Perales)

This site is located within a large-scale landslide prone zone, and is always considered dangerous. Because the longitudinal grade is steep and because of foundations considerations, a prestressed concrete box girder bridge and a half bridge is proposed at a location away from the landslide-prone zone.

The above bridges are shown in Drawings of Vol. 3.

3) Half Bridges

In landslide-prone zones, structures should be made as light as possible, because it is necessary to minimize the forces that may induce a landslide. Accordingly the use of half bridges is recommended for the landslide-prone zone. (Refer to bridge drawings included in Vol. 3.

(4) Structures Studied under the Large Scale Improvement Plan

Regarding the bridge of 260m length which crosses over the Rio Magdalena as part of Girardot bypass,comparative studies were carried out in steel and concrete (See Annex Fig. 7-11). It was found that the concrete bridge was more economical than the steel one. For the bridge considered on the Ibague bypass over the Rio Combeima similar evaluations were made.

Table 7-8 Quantities of Materials Used in Ordinary Type Structure

Superstructure (Post-tensioned Bridge)

Kind		Pavement (m^2)	Concrete (m^3)	Reinf. Steel Def. (t)	P.C Wire (t)	Form (m^2)	Girder (number)	Remarks
L=40m	Per One Girder	-	36.5	4.0	1.8	226	-	Design Concrete Strength 350kg/cm^2
	Per One Bridge	360	37.8	3.1	1.6	211	5	Design Concrete Strength 300kg/cm^2
L=30m	Per One Girder	-	22.9	2.8	1.1	134	-	Design Concrete Strength 350kg/cm^2
	Per One Bridge	270	24.7	2.2	1.2	136	5	Design Concrete Strength 300kg/cm^2
L=20m	Per One Girder	-	13.2	1.8	0.4	74	-	Design Concrete Strength 350kg/cm^2
	Per One Bridge	180	16.2	1.4	0.8	84	5	Design Concrete Strength 300kg/cm^2

Superstructure (Reinforced concrete Slab Bridge)

Kind		Pavement (m^2)	Concrete (m^3)	Reinf. Steel Def. (t)	Form (m^2)			Remarks
L=10m	Per One Bridge	90	32	7.0	148			Design Concrete Strength*210kg/cm^2
L=5m	Per One Bridge	45	14	2.2	58			Design Concrete Strength*210kg/cm^2

* From the standard design of Colombia.

Table 7-9 Quantities of Materials Used in Ordinary Type Structure

Substructure

Kind		Unit	Concrete (m^3)	Reinf. Steel Def. (t)	Form (m^2)	Excavation (m^3)		Remarks
H=10m abutment		Per One	202	10	327	330		Design Concrete Strength 210kg/cm^2
H=7m abutment		Per One	95	6	191	254		"
H=10m Half Bridge		10m	80	5	267	164		"
H=7m Retaining Wall		10m	59	4	140	110		"
H=5m Retaining Wall		10m	32	2	100	70		"
Pile ϕ=2.0m		10m	31	2	63	31		Cast in place pile
Pier	H=10m	Per One	135	12	150	170		
	H=15m	"	230	16	227	224		
	H=20m	"	325	20	302	288		
	H=25m	"	420	24	380	352		
	H=30m	"	515	28	460	416		

Table 7-10 Quantities of Materials Used for Cast in place Concrete Bridge

Superstructure

Name	Pavement (m^2)	Concrete (m^3)	Reinf. Steel Def. (t)	P.C Wire (t)	Form (m^2)	Steel (t)	Remarks
Magdalena Br	2340	2930	187	257	9830	-	Cantilever Method (ℓ=260m)
Ibague Br	990	790	30	40	2770	-	Incremental Launching (ℓ=110) Method
k75 + 500 Br	1590	1263	75	75	4280	-	" (ℓ=170)
k97 + 500 Br	1590	1148	77	77	3978	-	Cantilever Method (ℓ=170)
k101 + 200 Br	1590	1530	92	107	4896	-	Cantilever Method (ℓ=170)

Substructure

Name	Concrete (m^2)	Reinf. steel Def. (t)	Form (m^2)	Excavation (m^3)	Pile ϕ2m (m)	Remarks
Magdalena Br	1850	130	1360	960	-	
Ibague Br	944	76	888	580	-	
K75 + 500 Br	2190	92	1890	880	64	Pile ℓ = 8.0 m x 8
K97 + 500 Br	1095	68	1335	1350	128	ℓ = 8.0 x 16
K101 + 200 Br	2502	147	4355	3526	176	Pile ℓ = 8.0 x 22

7-4 Geotechnical Examination of Survey Area

7-4-1 Areas Reviewed for the Alignment Improvement

(1) Choice of Cut Slope Protection

From geological survey the rock properties, extent of weathering are shown in Table 7-11. The slope cutting method, slope gradient and erosion control method were studied considering the existing geological conditions.

(2) Cut Slope Protection for Large Scale Improvement Plans

1) Girardot Bypass Route

Since this route passes through only flat terrain, no cutting is expected.

2) Ibague Bypass Route

The Ibague bypass route runs along the foot of the mountain, passes an area of terrace and fan, where granodiorite prevails, and continues across terrace scarp and some minor rivers. The surface of granodiorite in this zone is weathered to a sandy state, while the terrace and the fan are composed of layers of non-conglomerate sand and gravel. (Fig. 7-5)

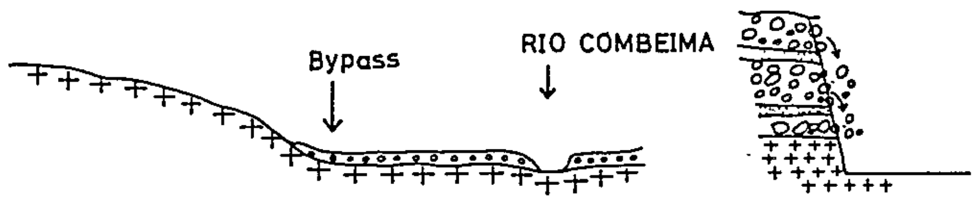


Fig 7-5 Schematic Model of IBAGUE Bypass

Table 7-11 <u>Choice of Erosion Control for Cuts and Slopes</u>

I T E M				Ibague - Calarca	Other Sections
Cut Slope Vert. : Horiz.	Cutting Method	Classification	Erosion Control	Critical Curve, Minimum Scale, and Medium Scale Improvement Plan Coello Bypass La Linea Bypass	Ibague Bypass
1 : 1.0	Bulldozer	Unconsoilidated Earth	Spray applied seed	Earth	Earth
1 : 0.5-0.6	Ripper	Soft rock	Concrete block retaining wall or spray applied seed	Black Schist (Km 70 - Km 135.6)	Sand and Gravel Terraces
1 : 0.3	Blasting	Hard rock	Not applicable	Diabase, Porphyrite 1) (Km 114 - Km 135.6) Green Schist (Km 70 - Km 135.6)	———
			Spray applied Concrete	Granodiorite 2) (Km 56 - Km 70) Black Schist, Amphyborite (Km 70 - Km 135.6)	Sand stone, alternating layers of gravel and rock

Note: 1) Diabase, Porphyrite, and Green Schist are resistant to weathering.

2) Granodiorite, Black Schist, and Amphyborite are not resistant to weathering.

3) Coello Bypass

This bypass route has been studied to avoid the zone in danger of landsliding between Km71 and Km77. The existing road which this bypass would avoid runs through an area, where granodiorite, black schist, green schist and volcanic ash are found on the mountain side and the summit. The Ibague and the Perico Faults extend into this area. The surface of granodiorite is weathered to a sandy state so that the occurrence of surface collapse has become more likely. In addition, as gullies develop along faults and joints it is anticipated that there would be a danger of soil discharge. Therefore, when planning the route, it is necessary to take into account measures against slope and gully erosion. Additionally with the marked developement of a fracture zone occurres near the faults, it is especially important that measures be taken against collapse. The zone where the black schist prevails has, in general, a thick weathered surface layer. If cut for road construction, it is susceptible to surface collapse and landslide because of poor stability. On the other hand, the areas showing a distribution of green schist and amphyborite may be deemed to have a stable bedrock. The volcanic ash is cemented to a small extent, but can be easily eroded by water.

4) La Linea Bypass

For the purpose of improvement of road alignment in this section, this route is planned to pass through La Linea. The base rock is diabase, green schist, etc., on which there is a thick layer of pumice deposits, which is soft and unstable, consisting of alternating grain-size pumices and very fine ash. Landslides and gully erosion due to rainfall are found everywhere in this area. The pumice deposits are up to 15 m thick at places. Hence, excavation for road construction would encourage the occurrence of landslides and collapses.

It will be necessary to protect the slope taking earth pressures into consideration, as well as to provide drainage facilities for protection against erosion by rainwater. Should the natural balance be disturbed in geological conditions such as above, the slope would rapidly collapse. It is therefore desirable that cuts be kept to a minimum.

(3) Foundations for Proposed Bridges

1) Special Long Span Bridge Sites

There are 5 (five) sites described in Table 7-12.

Table 7-12 Proposed Long Span Bridge Sites

	Location	Bridge Length
1. Medium Scale Improvement Plan (Ibague - La Linea)		
a. Km75.5	Q. Gamboa	170m(50m+70m+50m)
b. Km97.5	Q. Los Marias	170m(15m+70m+70m+15m)
c. Km101.2	Q. Perales	130m (30m+70m+30m)
2. Large Scale Improvement Plan		
a. Girardot bypass	Rio Magdalena	260m(60m+140m+60m)
b. Ibague bypass	Rio Combeima	110m(30m+50m+30m)

i) Bridge sites of Medium Scale Improvement Plans

The base materials where all 3 bridges planned between Ibague and La Linea would be constructed consists of black schist (Refer to Drawings, Vol. 3 of report). The surface layer is relatively thin but has in parts a thick weathered layer. Although fracture zones and sliding masses are seen at many points, no special problems are anticipated for the planned positions of abutments and piers.

ii) Bridge Sites of Large Scale Improvement Plans

The river crossing at Rio Magdalena is located on bedrock composed of alternating Tertiary hard sandstone, conglomerate, shale, etc. covered by terrace deposits (sand, gravel, silt), which can be considered suitable for bridge foundation.

The crossing point at Rio Combeima in Ibague shows also no special problems for bridge foundation, as the bedrock consists mainly of granodiorite, covered by terrace deposits and a considerably thick layer of sand and gravel.

2) Other Bridge and Structure Sites

Sand and gravel layers in the Project Area are very thick. Alternatively hand rock course close to the surface, so that it should not be necessary to construct special foundation.

(4) Geology of Proposed Tunnel Locations

Five tunnels were studied as described in Table 7-13.

Table 7-13 Proposed Tunnel Sites

	Location			Length (m)
	Section	Station	Location	
1. Medium Scale Improvement Plan (Ibague - La Linea)				
a. Km71.900 to Km72.700	07	No. 39	Landslide	730
b. Km76.100 to Km77.100	10	No. 52	"	790
c. Km 85.000	13	No. 42	Highland	250
2. Large Scale Improvement Plan				
a. Coello bypass		STA 13+200	Highland	950
b. La Linea bypass		STA 3+800	"	970

For the medium scale plan seismic survey was made of the section between Km72 & Km72.7 to determine the state of the rock and fracture zones. From the results of the seismic survey was estimated. These are shown in Fig. 7-7 to 7-10. The base rock has been classified as follows (see Table 7-14).

Table 7-14 Rock Mass Classification

Classification	Velocity of seismic wave	Characteristics of Rock Mass
1	1.0 - 1.5 km/s	very poor - poor rock
2	1.5 - 2.0	poor rock
3	2.0 - 2.5	fair rock
4	2.5 - 3.0	good rock
5	3.0 - 3.5	very good rock
6	3.5 - 4.0	very good rock
7	4.0 - 5.0	very good rock

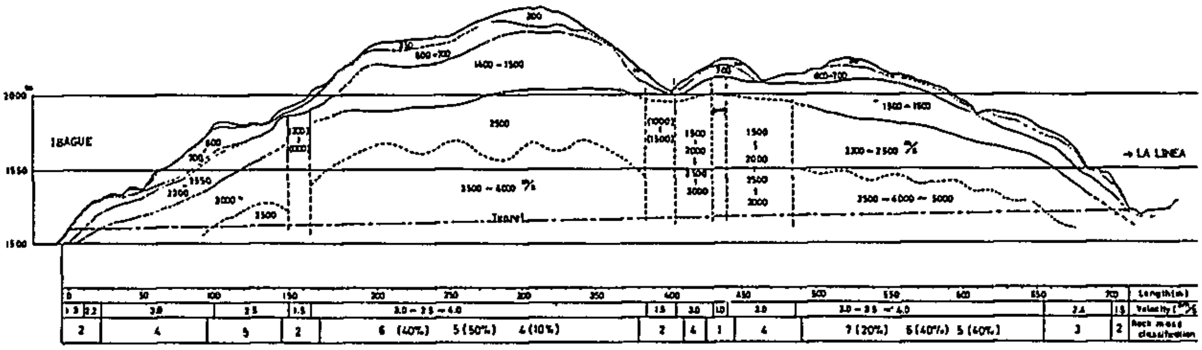


Fig. 7-6 km 71.900-72.700 Velocity Profile along the Seismic Retraction Survey Line

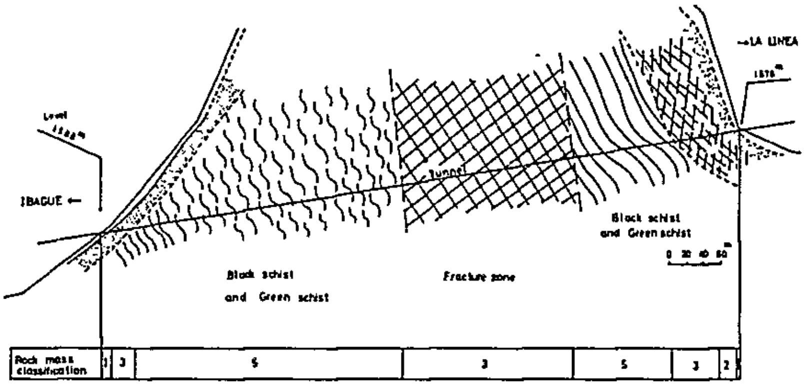


Fig 7-7 km76.100-77.100 Probable Geologic Section of the Tunnel

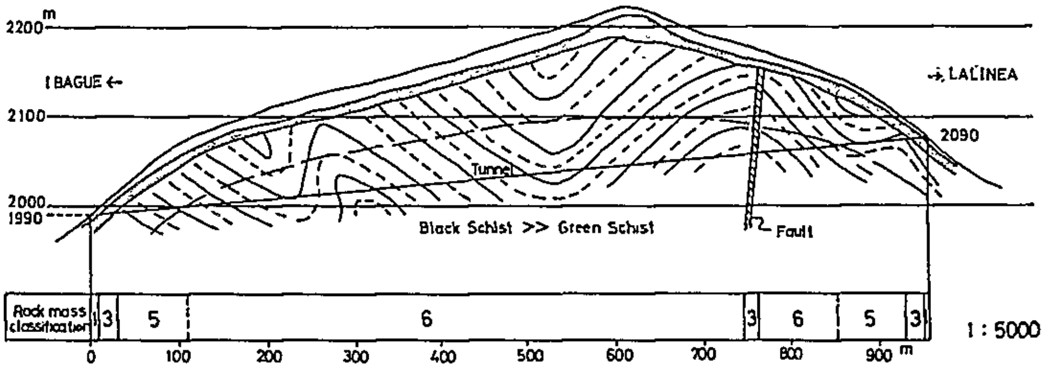


Fig 7-8 Probable Geologic Section of Coello Bypass Tunnel

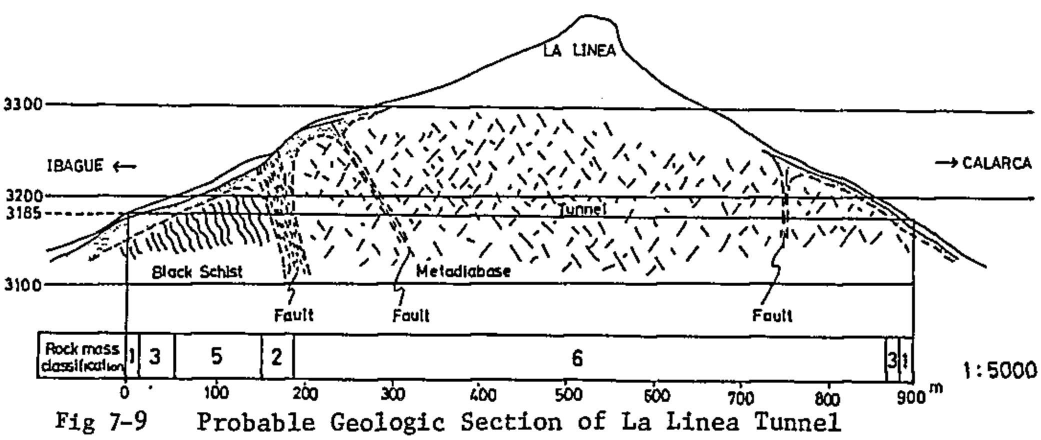


Fig 7-9 Probable Geologic Section of La Linea Tunnel

1) Tunnels in the Medium Scale Improvement Plan

i. Tunnel at Km71.9 - Km72.7

This tunnel has been studied to avoid the landslides above the existing road.

Quartz diorite, green schist, amphyborite, black schist, etc. are found on the planned tunnel route, which form a complex geological structure with many faults and fracture zones. As a result of the seismic survey, a fracture zone with faults may exist between the measuring points at 380 m and 480 m, where the base rock may be poor and a quantity of seepage water may arise in excavation works.

ii. Tunnel between Km76.1 and Km77.1

The geology of the area where this tunnel is proposed, shows an alternating green schist and black schist. It is estimated that a fracture zone of approx. 200 m width may exist on the planned route and another fracture zone of about 60 m width may be found near the tunnel end on La Linea side. Therefore, if the tunnel is to be constructed, a detailed geological survey will be required prior to tunnel construction works.

2) Tunnels in the Large Scale Improvement Plans

i. Tunnel on Coello Bypass

The geology of the planned route of this tunnel indicates rock consisting of black schist and, in part, a seam of green schist. It is thought that faults may exist there, which, however, can not be very wide. At the tunnel ends, a thick layer of poorly cemented volcanic ash covers weathered black schist.

ii. Tunnel on the La Linea Bypass

This area consists of black schist and diabase, the former is weathered to a substantial thickness, while the latter forms a hard bedrock. There may exist fracture zones with faults which may be an extension of the La Linea Fault, etc. A loose volcanic ash layer will be found at the tunnel ends.

7-4-2 Slope Failure Countermeasures Not Included in the Alignment Improvement

For the sections Melgar to Ibague and Calarca to Buga, any disasters occurring can be easily repaired. Hence in this report, they will not be handled as specific problems. However, in the Ibague to Calarca section, the frequency of occurrence is high and the delays for repairs long. Moreover, there is no alternative route. Therefore it is imperative that for Ibague - Calarca section countermeasures be carried out to prevent any hindorance to traffic in the event of a disaster. The types of disasters are detailed in Chapter 6. In this part of this report, only countermeasures against landslides are discussed. The countermeasures against other disasters are detailed in Annex Table 7-2.

(1) Methods of Landslide Control Measures

According to the findings of the site survey, landslide control measures were studied after classification by type and severity of the landslide. Therefore, the measures against landslides are proposed with emphasis on control.

1) Drainage Well

A method of installing a drainage well in a landslide zone, the well forming the hub of horizontal boreholes which collect and drain ground water. (See Fig. 7-10)

2) Drainage Boring

A method of extracting ground water from within the sliding mass for the purpose of reducing the pore water pressure. (See Fig. 7-11)

3) Surface Drainage

A method of draining the surface water as quickly as possible from the landslide zone in order to minimize the permeation of water into the sliding mass. (See Fig. 7-12)

4) Excavation

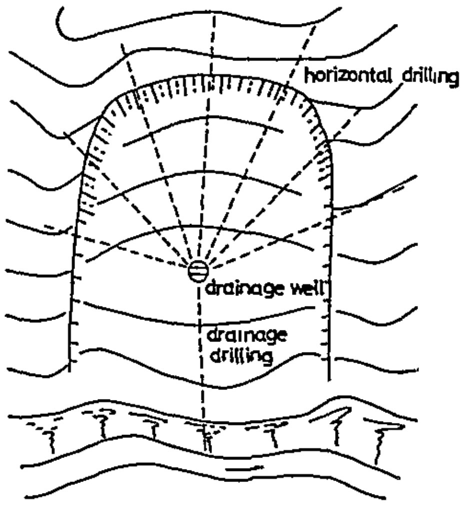
A method of removing the sliding mass on the landslide zone for the purpose of stabilizing the zone. (See Fig. 7-13)

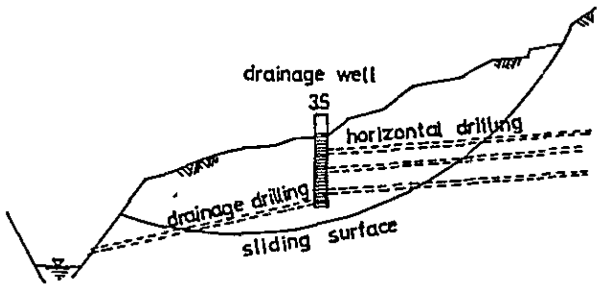
5) Retaining Wall

A method of installing a retaining wall at the toe of the mass to control the movement. (See Fig. 7-14)

6) Pile Work

A method of driving piles into the bed on which the sliding mass rests, in order to hold back the sliding mass. (See Fig. 7-15)





Section of a drainage well

Fig 7-10 Plan of drainage well

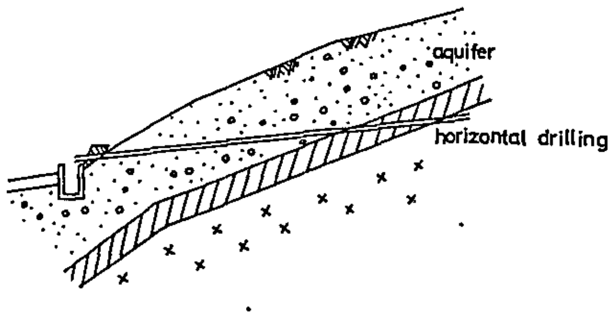


Fig 7-11 Section showing horizontal drilling

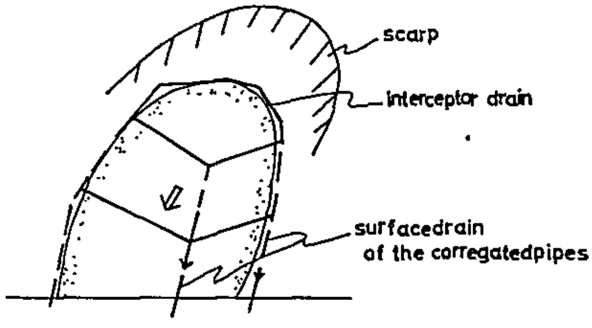


Fig 7-12 Surface drain system

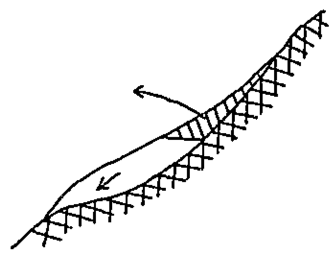


Fig 7-13 Excavation

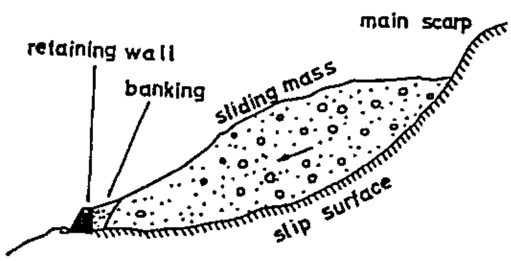
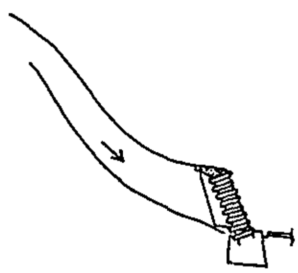


Fig 7-14 A retaining wall for counterweight fills



Crib work

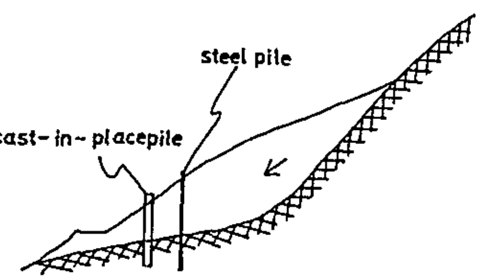


Fig 7-15 Pile work

(2) Control Works for Each Specific Landslide Zone (Refer to Table 7-15)

i) For the landslide (LS-1) (Km62.500 - Km62.680), it is necessary to remove the sliding mass and provide a surface drainage system for the purpose of stabilizing the zone.

ii) For the landslide (LS-2) (Km71.770 - Km72.240), the drainage of surface water, protection of slope, and control of the washout of soil from the gully should by combined.

iii) For the landslide (LS-3) (Km73.670 - Km73.920), it is necessary to drain surface water and ground water and at the same time to protect the slope.

iv) For the landslide (LS-4) (Km75.400 - Km75.505), it is necessary to install a surface water drainage system and at the same time to control flood erosion.

v) For the landslide (LS-5) (Km76.520 - Km76.840), it is necessary to control landslides by draining ground water.

vi) For the landslide (LS-6) (Km77.830 - Km78.080), surface water drainage and slope protection are required.

vii) For the landslide (LS-7) (Km81.430 - Km81.500), it is necessary to install a gravity wall to checking bulging out of the sliding mass.

viii) For the landslides (LS-8) (Km 82.200 - Km82.300) and (LS-9) (Km97.730 - Km97.820), surface water drainage, slope protection and flood erosion control are necessary.

ix) For the landslides (LS-10) (Km101.350 - Km101.550) and (LS-11) (Km102.860 - Km102.980), it is necessary to drain surface water and ground water and at the same time to control flood erosion.

x) For the landslides (LS-12) (Km106.200 - Km106.280), (LS-13) (Km106.470 - Km106.540), (LS-14) (Km108.570 - Km108.800), and (LS-15) (Km112.340 - Km112.520), it is necessary to install a surface water drainage system and at the same time to drive piles into the shoulder to stabilize the slope.

xi) For the Landslides (LS-16) (Km113.000 - Km113.200) it is necessary to install a surface water drainage system and to drive the horizontal piles to control the ground water.

xii) For the Landslides (LS-17) (Km119.550 - Km119.650) it is necessary to drain ground water and to install a cribwork type retaining wall to checking bulging out of the sliding mass.

Table 7-15 shows the quantity of work for the measures specified above. The types of work and the work volume given are the minimum necessary. For landslides, it is imperative that proper investigations be carried further, in order to formulate the most economical designs for countermeasures.

Tablle 7-15 List of Specific landslides and Countermeasures

Landslide No.	Location	Drainage well ϕ3.5 m	Horizontal boreholes for ground water draining	Steel pipe pile	H-beam pile	Deep foundation	Removal of overburden	Intercepting drain	Drainage ditch	Flush ground sill (places)	Well hole protection	Retaining wall, torrential control work, etc.
LS-1	Km62.5 to km62.68						Sliding mass, 30,000m^3 (excavated volume, 42,000m^3)	230m	180m			4.5m x 4.0m culvert x 2 places
LS-2	Km71.77 to Km72.24							350m	500m	30		•Crib type retaining wall (H=10m, L=330m, double type) • Embankment x 3 (H=4m, L=10m)
LS-3	Km73.67 to Km73.92		30m Long x x 12 pcs.					190m	300m	10		Gravity type retaining wall, L=240 m, H=3 m
LS-4	Km75.4 to Km75.505							150m	260m	10		Drain works, W=4m, L= 320m; flush ground sill x7, H=1.5m; Embankment x6, H=4m, L=20m
LS-5	Km76.52 to Km76.84	2 holes x 38m deep	66mmϕ borehole 40m long x 10pcs., 30m long x 10pcs.; 110mmϕ draining borehole 70m long x 2 pcs.						170m	10	2 places	
LS-6	Km 77.83 to Km 78.08							120m	200m	15		Crib type retaining wall, H=20m, L=100m, double type

Table 7-15 (Cont'd) List of Specific Landslides and Countermeasures

Landslide No.	Location	Drainage well ∅3.5 m	Horizontal boreholes for ground water draining	Steel pipe pile	H-beam pile	Deep foundation	Removal of overburden	Intercepting drain	Drainage ditch	Flush ground sill (places)	Well hole protection	Retaining wall, torrential control work, etc.
LS-7	Km 81.43 to Km 81.50											Crib retaining wall, H=20 m, L=55 m, double type
LS-8	Km 82.00 to Km 82.30							300m	740m	50		•Crib retaining wall, H=20m, L=100m, double type •Embankment, H=5m, L=20m •Slope- **Protection C** H=14m, L=100m •Rock fence, H=1.5m, L=100m
LS-9	Km 97.73 to Km 97.82							200m	220m	15		•Crib work,H=5m, L=80m •Drain channel work, W=4m, L=280m
LS-10	Km 101.35 to Km 101.55		30m long x 6 pcs.					100m	400m	30	2	•Drain channel work, W=4m, L=800m •Flush ground sill, H=1.5m, L=6m (W=4m) •Embankment, H=4m, L=15m, x 5
LS-11	Km 102.86 to Km 102.98		30m long x 6 pcs.					100m	300m	10	2	•Drain channel work, W=4m, L=150m •Embankment, H=3m, L=20m, x 2
LS-12	Km 106.20 to Km 106.28			350mm∅ x 580m 33pcs				200m	450	15		

Table 7-15 (Cont'd) List of Specific Landslides and Countermeasures

Landslide No.	Location	Drainage well ϕ3.5 m	Horizontal boreholes for gound water draining	Steel pipe pile	H-beam pile	Deep foundation	Removal of overburden	Intercepting drain	Drainage ditch	Flush ground sill (places)	Well hole protection	Retaining wall, torrential control work, etc.
LS-13	Km 106.49 to Km 106.54				200x 200x 30pcs. (532m)			170m	250	20		
LS-14	Km 108.57 to Km 108.80				175x 175x 20 pcs. (250 m)			150	400	10		
LS-15	Km 112.34 to Km 112.52					ϕ3.0m (108m)						
LS-16	Km 113.00 to Km 113.20	26m deep x 1 pc.						140	250	20	1	
LS-17	Km 119.55 to Km 119.65							100	250	20		C1.b retaining wall H=5m, L=90m

Note: 1) Flush ground sill means Stream Velocity Reduction Scheme.

7-4-3 Landslide Locations Where Urgent Measures are Necessary Including Cost Estimates

According to the present survey, it was found that the Ibague-Calarca section has seventeen major landslide prone sites and more than 500 critical locations with hillside collapse, debris flow and other forms of disaster that affect the road and traffic.

The problem sites were classified according to the frequency of occurrence (A, B, C) and as to extent of the damage (L, M, S) which may take place. For designation of these types, see Legend Annex Table 7-2. Among these sites, those denoted L and M are considered to be those where the magnitude of damage is extremely high. The sites designated A and B are those where there is high probability for the occurrence of failures in the near future.

Once failure has occurred, traffic interruption and repair work will follow.

Comparing the total costs required for the corrective work at such sites LA, MA, LB and MB, and the total costs for the preventive work against the same failures at such sites, it was found their costs of repair were higher than those for preventive measures. (See Table 7-16)

This implies that the preventive work at the above sites should be undertaken at the earliest convenience from the economic view-points. For estimating the quantities for preventive and corrective works, see Annex Table 7-3.

As shown in Annex Table 7-4, the preventive work is considerably cheaper than the corrective work at 19 out of the 30 sites designated type LA.

If a disaster should occur, the road will be closed and traffic will be interrupted until repairs are done. Traffic will take an alternate route. In such a case, corrective work costs and traffic costs for detouring and waiting become necessary to evaluate.
At present it is not possible to quantify the frequency of occurrence and pinpoint the places where there is a range of occurrence of disaster. Hence, it has been decided to group the occurrences as follows: "A", once in 20 years, and "B", once in 40 years. With these probabilities comparison of costs between implementation and non-implementation of countermeasures was made. (See Annex 7-5)

Using the above assumptions, derivations were made for Type A & Type B occurrences, from which Table 7-17 was prepared. It is shown clearly that preventive works were more economical than the corrective works in the long run. Table 7-18 is the economic cost of the preventive work which is stated in Table 7-17.

Table 7-16 Preventive and Corrective Work Cost

(UNIT: $,000)

	Classification	Number	Preventive Works	Corrective Works	Remarks
LA 1) 2)	Land slide	14	151,871	152,955	
	Fall	4	5,053	16,062	
	Failure of valley side	6	57,830	48,937	
	Debris flow	6	8,758	34,881	
	Total	30	223,512	252,835	(-) 29,323
MA 1) 2)	Land slide	2	7,359	2,986	
	Fall	37	55,551	34,835	
	Failure of valley side	24	74,390	96,352	
	Debris flow	17	17,942	99,065	
	Total	80	155,242	232,238	(-) 76,996
LB 1) 2)	Land slide	2	10,047	30,300	
	Fall	2	8,147	6,754	
	Failure of valley side	5	28,814	39,207	
	Debris flow	7	8,735	13,300	
	Total	16	55,743	89,561	(-) 33,818
MB 1) 2)	Land slide	6	32,865	18,856	
	Fall	32	23,479	27,503	
	Failure of valley side	38	114,350	169,047	
	Debris flow	8	5,335	41,145	
	Total	84	176,029	256,551	(-) 80,522
3)	Total	210	610,526	831,185	(-) 220,659

NOTE: 1) Extent of disaster classified as L.M.S.

2) Urgency of countermeasures classified as A.B.C. (See. Legend in Annex Table 7-2.)

3) The S and C' classification are considered to be covered by routine maintenance exclude in this table.

4) Preventive work is not considered at the places, No. 171, 172, 174, 343, 341 of LA, No. 173, 340, 342 of MA and 344 of MB, where the alignment is improved in accordance with the feasible solution.

Legend: The cost is shown by the direct economic cost with the additional 25% of overhead cost and profit.

Table 7-17

Result of Comparative Cost Analysis (UNIT: $'000)

	Type A	Type B
P.W. Cost With Preventive Work	350.222	214.312
" " Without "	539.521	232.698
P.W. Balance	189.299	18.377

Note P.W. means the present worth discounted by 12%.
Cost without preventive work is the total cost of corrective work and traffic cost due to road closure during the 20 years.

Table 7-18

Preventive Work Economic Cost in 1980 Prices (UNIT: $'000)

ITEM	FC	LC	TAX	TOTAL
1) Total Direct Cost	214,190	274,230	27,486	515,906
2) w/Overhead and Profit 1)x1.25	305,770	304,756	34,357	644,883
3) Supervision 2)x0.05	24,506	6,126	1,612	32,244
4) Contingency 2)x0.05	33,027	31,088	3,597	67,713
5) G. Total	363,304	341,970	39,566	744,840
6) Detailed Eng. w/Contingency 3)x1.10	26,957	6,738	1,773	35,468
Total	390,261	348,708	41,339	780,308
ECONOMIC COST	390,261	348,708	-	738,969

CHAPTER - 8

COST
OF
THE IMPROVEMENT PLAN

Chapter 8. Cost of the Improvement Plans

8-1 Cost Estimate Method

In this survey the unit costs of construction items for payment, have been determined from the basic cost elements of materials, labour, machinery. These costs considered the Colombian market conditions prevailing in mid-1980. The cost factors were obtained from MOPT, its local offices and local consultants.

Unit construction costs are made up from the cost of imported machinery and materials, and the cost of domestic machinery and materials. The domestic and foreign currency components of each unit construction cost were calculated according to the classification of basic cost factors given below.

The foreign currency component is composed of the following costs.

- Imported machinery (depreciation cost), supplies and raw materials.
- Materials imported and processed in Colombia.
- Wages and salaries for foreign residents, and overhead costs and Profits for the foreign corporations.

The domestic currency component is composed of the following costs.

- Domestic machinery and materials, and raw materials originating in Colombia.
- Wages of domestic residents.
- Overhead costs and profits for domestic corporations, customs duties and taxes.

The foreign exchange rate of Colombian peso in mid-1980 was as follows.

$49.00 = US$1.00 = Yen 220.00

8-2 Construction Quantities

The quantities for all construction items estimated for cost purposes in this study were calculated on the basis of the original designs and drawings, and may fluctuate by as much as 10%.

8-3 Unit Price Analysis

For the purpose of evaluating construction costs, each pay item was calculated using the basic cost factors determined from the available data.

The unit construction costs are given in Table 8-1. Costing was made in the form of a cost estimate sheet and work sheet which appear in detail in Annex Table 8-1. The hourly costs [1] of the machinery and facilities expected to be used in the construction work are given in Table 8-2. For details, refer to Annex Table 8-2.

The wages for local labour are shown in Table 8-3.

Costs of main materials and supplies expected to be used in the project under study are shown in Table 8-4.

8-4 Land Acquisition Costs [2]

For the Ibague-La Linea section, the right-of-way cost will not be of great significance, because the improvement is limited to a minor widening of roadway and the construction of a small-scale bypass. Following are the prices used for land acquisition.

(1) Calarca-Uribe section

Pasture	\$110,000/ha
Coffee plantation	\$300,000/ha

(2) Uribe-Buga section

-Within 200 m from either side of the existing road:

\$110-\$150/m^2

Beyond 200 m : \$600,000/ha

- Large-scale land acquisition

Flat terrain (uncultivated land)	:	\$250,000/ha
Hilly terrain	:	\$150,000/ha

8-5 Construction Cost

As for the Project Road upgrading costs, alternative proposals for various construction costs have been prepared. The costs for the chosen upgrading scheme are shown in Table 8-5-1. The implementation schedule from 1983 to 1987 is shown in Fig.8-1. In addition cost details for the various alternatives are shown in Annex Table 8-3. For the construction costs of Girardot and Ibague Bypasses are shown in Table 8-5-2 and Table 8-5-3.

Source: 1/ACIC (Asociacion Colombiana de Ingenieros Constructores), "Distribuidores de Equipos para Construccion, "Enero 1980.

2/INESCO - Consultant, Cali and MOPT Calarca Distorito.

The implementation schedules are shown in Fig. 8-2, Fig.8-3 respectively.

Annex Table 8-4 presents the quantities of materials to be procured, and Annex Table 8-5 shows the quantity of equipment to be used for construction.

8-6 Road Maintenance Cost

The maintenance work necessary to keep the roads in good condition is classified into two types-routine maintenance and periodic maintenance.

8-6-1 Routine Maintenance

-Patching repairs of furrows and potholes
-Cleaning of stormwater sewers and culverts, and vegetation control.
-Removal of washout debris.
-Repairs of road surface markings.
-Other traffic services.

8-6-2 Periodic Maintenance

-Partial replacement of pavement
-Overlaying of pavement
-Painting and repairs of bridges and structures
-Others

The annual maintenance costs per Km are as estimated in Table 8-6. For details, refer to Annex 8-1.

Table 8-6 Road Maintenance Cost (pesos/Km)

	Routine Maintenance	Periodic Maintenance
ADT $>$ 2,000	113,808.00	1,878,640.00

Table 8-1 Unit Construction Cost (UNIT: $)

ITEM	UNIT	FC	LC	TAX	TOTAL
General Work					
1. Clearing and Grubbing	M2	1.22	0.55	0.22	1.99
2. Stripping	M2	2.55	0.97	0.46	3.98
3. Removal of Old Pavement	M2	74.48	50.52	19.08	144.08
4. Excavation Common A (Borrow)	M3	18.93	9.02	3.45	31.40
5. Excavation Common B (100m - 500m)	M3	75.24	28.73	13.87	117.84
6. Excavation Common M (Manpower)	M3	17.62	78.79	2.91	99.32
7. Excavation Hard Rock	M3	304.56	203.12	80.80	588.48
8. Excavation Soft Rock	M3	121.71	75.43	29.10	226.24
9. Embankment	M3	57.59	34.20	12.50	104.31
10. Transportation of Const. Material	M3-Km	9.12	9.81	3.68	22.61
11. Loading of Material	M3	18.78	9.26	3.40	31.44
12. Crushed Stone	M3	155.04	81.04	57.92	294.00
13. Concrete A (210 kg/cm^2)	M3	1,117,17	1,228.91	93.22	2,439.30
14. Concrete B (180 kg/cm^2)	M3	981.15	1,016.63	70.54	2,068.32
15. Concrete C (140 kg/cm^2)	M3	941.97	955.05	62.98	1,960.00
16. Concrete B mixed Stone	M3	827.02	1,182.88	94.55	2,104.45
17. Concrete C mixed Stone	M3	851.70	1,222.60	99.32	2,173.62
18. Concrete Placing H	M3	405.06	410.02	83.62	898.70
19. Concrete Placing L	M3	166.19	130.66	36.80	333.65
20. Form work	M2	74.35	358.87	19.97	453.19
21. Scaffolding	M3	21.30	111.96	5.27	138.53
22. Cement Mortar	M3	1,203.60	2,444.94	131.04	3,779.58
23. Reinforcing Steel, fabricated	KG	19.71	33.10	3.52	56.33
Pavement work					
1. Subgrade Preparation	M2	3.09	2.11	0.68	5.88
2. Subbase Course, natural	M3	205.49	180.34	65.37	451.20
3. Subbase Course, semi-crushed	M3	332.15	264.06	92.73	688.94
4. Base Course	M3	509.13	339.73	108.60	957.46
5. Asphalt Tack Coat	M2	9.12	5.92	1.00	16.04
6. Asphalt Prime Coat	M2	11.82	8.69	1.16	21.67

Table 8-1 (Cont'd)

(UNIT: $)

ITEM	UNIT	FC	LC	TAX	TOTAL
7. Asphalt Seal Coat	M2	20.35	13.73	2.97	37.05
8. Asphalt Cement	T	5,233.50	3,063.20	563.17	8,859.87
9. Asphalt Concrete Pabement	T	906.51	580.26	133.87	1,620.64
10. Road Marking	M2	19.12	91.34	6.82	117.28
Bridge and Structure					
1. R.C. Box Culvert 4.5m x 4.0m	M	34,840.92	51,342.55	5,142.15	91,325.62
2. Concrete Gravity Wall H = 3.0m	M	3,998.80	5,553.94	576.98	10,129.72
3. Retaining Wall H=5.0m	M	10,187.19	17,259.11	1,594.41	29,040.71
4. Retaining Wall H=7.0m	M	19,161.70	31,382.66	2,983.17	53,527.53
5. Retaining Wall H=10.0m (Crib Wall)	M	29,162.55	36,238.64	2,830.87	68,232.06
6. R.C.Half Bridge	M	26,478.44	47,787.70	4,065.46	78,331.60
7. R.C.Bridge L=5.0m	U	293,014.00	459,890.00	43,517.00	796,421.00
8. R.C.Bridge L=10.0m	U	580,457.00	930,428.00	91,377.00	1,602,262.00
9. P.C.T-Bridge L=20.0m	U	2,393,632.00	2,940,588.00	572,892.00	5,907,112.00
10. P.C.T-Bridge L=30.0m	U	3,862,716.00	4,466,917.00	936,769.00	9,266,402.00
11. P.C.T-Bridge L=40.0m	U	5,208,537.00	5,756,870.00	1,267,777.00	1,223,184.00
12. Formwork for Bridge	M2	97.46	465.62	26.09	589.17
13. Formwork for Foundation A	M2	662.75	262.74	131.83	1,057.32
14. Pile Foundation ϕ2.0m	M	12,614.00	12,843.98	2,047.73	27,505.71
15. Structural Concrete (400 kg/cm^2)	M3	1,244.19	1,426.81	187.24	2,858.24
16. Structural Concrete (300 kg/cm^2)	M3	1,160.19	1,313.41	174.64	2,648.24
17. Excavation for Foundation	M3	64.33	47.13	11.39	122.85
18. Grouting of P.C.Cable	M	23.37	92.90	3.73	120.00
19. Setting of Guard Rail	M	992.55	1,463.27	126.32	2,582.14
20. R.C.Box Culvert 1.2m x 1.0m	M	5,727.14	8,872.20	827.45	15,426.79

Table 8-1 (Cont'd)

(UNIT: $)

ITEM	UNIT	FC	LC	TAX	TOTAL
Drainage and Side Ditch					
1. Concrete Pipe ϕ0.3m	M	3.09	2.11	0.68	5.88
2. Concrete Pipe ϕ0.6m	M	1,053.28	1,266.61	118.91	2,438.80
3. Concrete Pipe ϕ0.9m	M	1,563.42	1,890.13	186.56	3,640.11
4. Side Ditch	M	467.72	734.16	87.33	1,289.21
5. R.C. Catch Basin	U	1,988.31	6,242.96	285.96	8,517.23
Preventive Work					
1. Slope Protection A (Blok Type)	M2	3,841.07	4,915.22	402.83	9,159.12
2. Slope Protection B (Leaning Type)	M	7,471.31	8,605.95	746.55	16,823.81
3. Slope Protection C (Frame Type)	M2	414.76	590.54	42.89	1,048.19
4. Rock Net	M2	151.80	197.27	51.22	406.29
5. Rock Fence	M	2,000.74	1,961.37	507.40	4,469.51
6. Concrete Spraying	M2	54.20	53.77	14.52	122.49
7. Seed Spraying	M2	16.07	23.35	4.29	43.71
8. Corrugate Pipe ϕ4.5m	M	56,165.68	8,273.48	11,235.51	75,674.67
9. Concrete Gravity Dam H=4.0m	M	8,230.46	10,979.61	1,170.82	20,380.89
10. Channel width 4.0m	M	6,149.94	7,587.05	570.25	14,307.24
11. Gabion ϕ0.6m	M2	148.32	595.77	21.06	765.15
12. Driving Sheet Pile	M	2,673.06	985.89	944.53	4,603.48
13. Driving Steel Pipe Pile ϕ0.35m	M	3,873.25	1,445.49	1,317.49	6,636.23
14. Sinking Well ϕ3.5m	M	17,009.38	33,995.52	3,385.03	54,389.93
15. Form work for Foundation B	M2	761.96	231.94	151.92	1,145.82
16. Pile Foundation ϕ3.0m	M	24,652.14	23,167.91	3,888.35	51,708.40
17. Collecting Drain	M	522.62	971.37	58.38	1,552.37
18. Drilling	M	464.27	1,179.46	83.96	1,727.69
19. Driving Steel Pile H-200x200	M	1,943.35	748.73	655.33	3,347.41

Legend

FC: Foreign component expressed in Colombian Pesos
LC: Local component expressed in Colombian Pesos
Total: Total unit cost expressed in Colombian Pesos
KG: Kilogram, M2: square meter, M3: Cubic meter, M: meter
U: Total unit or lump sum, T: metric ton = 1000 kg

Prices given are for direct costs with no overhead, fringe and profit.
Prices are calculated for mid-1980.

Table 8-2 Hourly Cost of Construction Equipment

UNIT: $

EQUIPMENT	FC	LC	TAX	TOTAL
1. Bulldozer D6D	1,762.10	456.84	291.18	2,510.12
2. Bulldozer D7G	2,401.50	622.60	396.83	3,402.93
3. Bulldozer D8K	3,348.24	868.07	553.27	4,769.58
4. Bulldozer D8K w/Ripper	3,756.48	973.90	620.73	5,351.11
5. Bulldozer D6DL	2,233.17	578.97	369.01	3,181.15
6. Tractor Shovel 955L	1,621.32	423.26	268.29	2,312.87
7. Tractor Shovel 977L	2,604.52	679.93	430.99	3,715.44
8. Wheel Loader 950	1,933.40	498.50	322.23	2,754.13
9. Wheel Loader 930	1,348.27	347.63	224.71	1,920.61
10. Excavator 215	1,912.40	495.81	316.01	2,724.22
11. Excavator 225	2,377.47	616.38	392.86	3,386.71
12. Motor Grader G12	1,769.38	458.73	292.38	2,502.49
13. Motor Grader GD600R-1	984.34	255.20	162.66	1,402.20
14. Motor Scraper 621B	3,533.46	911.05	588.91	5,033.42
15. Road Roller, Macadam KD7610	399.67	105.62	65.66	570.95
16. Road Roller, Tire TS7409	580.22	153.34	95.32	828.89
17. Vibration Roller SV90	873.80	230.94	143.55	1,248.29
18. Asphalt Plant BA1000	3,384.85	932.64	566.42	4,882.91
19. Asphalt Finisher SA35	639.77	168.17	106.02	913.96
20. Asphalt Finisher PT280	557.54	146.55	92.39	796.48
21. Asphalt Distributor D8-50EA	346.20	92.25	57.53	495.98
22. Motor Generator EG55	235.95	60.75	38.93	335.63
23. Motor Generator EG200	549.79	141.55	90.72	782.06
24. Motor Generator EG300	895.93	230.67	147.84	1,274.44
25. Air Compressor 10.5 m^3/min.	310.23	110.84	234.81	655.88
26. Air Compressor 17.0 m^3/min.	487.51	174.18	368.98	1,030.67
27. Crawler Drill PCR200	565.14	144.70	94.06	803.90
28. Leg Hammer 322D	23.52	6.02	3.91	33.45
29. Pick Hammer CA7A	4.01	1.03	0.66	5.70
30. Batching Plant	3,295.71	907.03	546.12	4,748.86
31. Concrete Mixer	365.46	94.23	60.91	520.60

Note: 1) The hourly cost is applicable where equipment operation is for less than 8 hours.

2) When the equipment is used for one day, the daily cost is calculated by <u>0.9</u> x (8 hours) x (hourly cost).

3) When the equipment is used for more than a week, the weekly cost is calculated by <u>0.8</u> x (8 hours) x (hourly cost) x (6 days).

Table 8-2 (Cont'd.)

(Unit: $)

EQUIPMENT	FC	LC	TAX	TOTAL
32. Truck Crane 10 Ton	1,013.87	266.50	168.01	1,448.38
33. Truck Crane 20 on	1,768.14	464.77	293.01	2,525.92
34. Crawler Crane 23 on	1,857.26	488.20	307.77	2,653.23
35. Pile Driver IDH-25	609.98	158.14	100.80	688.92
36. Pile Driver IDH-35	772.67	200.32	127.68	1,100.67
37. Crushing Plant 60 T/Hr	3,567.12	1,152.16	1,790.07	6,509.35
38. Underwater Pump 10m3/min.	300.59	80.10	49.96	430.65
39. Underwater Pump 4.5m3/min.	192.36	51.26	31.97	275.59
40. Blower 150m3/min.	328.24	86.28	54.39	468.91
41. Concrete Pump car 60m3/Hr	1,618.80	411.60	269.03	2,299.43
42. Truck Mixer 3.5m3	623.38	170.42	103.15	896.95
43. Grout Pump 45 1/min.	119.50	31.41	19.80	170.71
44. Concrete Vibrator ∅ 38mm	13.35	3.61	2.22	19.18
45. Dump Truck D600 7 Ton	166.07	269.86	83.03	518.96
46. Flatbed Truck 6 Ton	141.58	230.07	70.79	442.44
47. Water Tanker 2000 Gallon	154.50	251.05	77.25	482.80
48. Line Marker	187.99	49.41	31.16	268.56
49. Belt Conveyor	25.54	6.71	4.23	36.48
50. Concrete Blow up Apparatus	243.52	64.01	40.35	347.88
51. Seed Blow up Apparatus	196.63	51.69	32.58	280.90
52. Drilling Machine ∅ 66 mm	214.67	56.43	35.57	306.67
53. Air Compressor 5 m3/min.	279.37	73.44	46.29	399.10
54. Hand Hammer	19.78	5.20	3.27	28.25

See Legend under Table 8-1.

Table 8-3 Hourly Wages

(Unit: $)

Classification	Daily Rate	Hourly	Hourly x Factor
Operator, Bulldozer	400.00	50.00	116.70
Operator, Excavator	400.00	50.00	116.70
Operator, Loader	400.00	50.00	116.70
Operator, Grader	400.00	50.00	116.70
Operator, Crane	400.00	50.00	116.70
Operator, Scraper	500.00	62.50	145.80
Operator, Roller	300.00	37.50	87.53
Operator, Compressor	300.00	37.50	87.53
Operator, Generator	300.00	37.50	87.53
Operator, Batching Plant	500.00	62.50	145.88
Operator, Concrete Mixer	280.00	35.00	81.69
Operator, Asphalt Plant	500.00	62.50	145.88
Operator, Asphalt Finisher	500.00	62.50	145.88
Operator, Crushing Plant	400.00	50.00	116.70
Operator, Driver	250.00	31.25	72.94
Assistant Operator	250.00	31.25	72.94
Foreman	400.00	50.00	104.55
Carpenter	350.00	43.75	91.48
Electrician	400.00	50.00	104.55
Ironworker	300.00	37.50	78.41
Mason	250.00	31.25	65.34
Mechanic	400.00	50.00	104.55
Welder	400.00	50.00	104.55
Technician	400.00	50.00	104.55
Common Laborer	200.00	25.00	52.28

SOURCE: MOPT

Table 8-4 Cost of Main Materials (UNIT : $)

Classification	UNIT	FC	LC	TAX	TOTAL
Portland Cement	T	1,600.00	2,160.00	240.00	4,000.00
Reinforcing Steel, round	KG	14.00	19.00	2.00	35.00
Reinforcing Steel, deformed	KG	18.00	24.00	3.00	45.00
Structural Steel,fabricated	T	38,700.00	13,400.00	13,900.00	66,000.00
Sheet Pile	T	34,000.00	11,800.00	12,200.00	58,000.00
Corrugated Pipe	T	73,890.00	7,820.00	14,780.00	96,490.00
P.C. Cable (Wire)	KG	76.70	26.63	27.52	130.85
Wire Pope	KG	18.00	24.00	3.00	45.00
Steel Wire	KG	20.00	27.00	3.00	50.00
Asphalt Cement	T	5,040.00	2,860.00	500.00	8,400.00
Asphalt Liquid, MC-70	T	7,920.00	4,480.00	800.00	13,200.00
Asphalt Liquid, RC-250	T	7,920.00	4,480.00	800.00	13,200.00
Diesel	Gal	28.60	10.70	8.50	47.80
Gasoline	Gal	28.60	10.70	8.50	47.80
Kerosene	Gal	29.60	11.00	8.80	49.40
Motor Oil	Gal	170.20	63.00	50.40	283.60
Transmission Oil	Gal	156.00	57.80	46.20	260.00
Hydraulic Oil	Gal	141.80	52.60	42.00	236.40
Grease	Lb	19.50	11.60	1.40	32.50
Plank, Lumber	M3	1,170.00	4,340.00	350.00	5,860.00
Log	M3	720.00	2,670.00	210.00	3,600.00
Aggregate	M3	360.00	240.00	-	600.00
Sand	M3	300.00	200.00	-	500.00
Crushed Stone	M3	343.70	223.70	73.60	641.00
Brick	U	-	4.00	-	4.00
R.C. Pipe 900 dia.	M	910.00	335.00	55.00	1,300.00
R.C. Pipe 600 dia.	M	630.00	232.00	38.00	900.00
R.C. Pipe 300 dia.	M	350.00	129.00	21.00	500.00

SOURCE: MOPT and JAPAN Supplies.

Table - 8-4 (Cont'd) Cost of Main Materials (UNIT : $)

Classification	UNIT	FC	LC	TAX	TABLE
R.C. Pipe 200 dia.	M	40.00	85.00	5.00	130.00
P.V.C. Pipe 50 dia.	M	15.00	32.00	3.00	50.00
Wire Net	M2	128.96	44.76	46.28	220.00
Nail	KG	24.00	33.00	3.00	60.00
Paint	LIT	40.00	140.00	10.00	190.00
Beeds	KG	-	61.00	4.00	65.00
Filler	T	320.00	430.00	50.00	800.00
Explosive	KG	-	104.00	6.00	110.00
Cap Electric	U	10.00	21.00	2.00	33.00
Electric Cord	M	10.00	18.00	2.00	30.00
Form Oil	LIT	40.00	148.00	12.00	200.00
Seel	KG	-	130.00	-	130.00
Guard Rail	M	960.00	1,320.00	120.00	2,400.00
Concrete Block	U	55.00	60.00	5.00	120.00
Sheath 62 dia.	U	77.50	26.90	27.80	132.00
Sheath 45 dia.	U	48.89	16.97	17.54	83.40
Sheath 32 dia.	U	35.52	12.33	12.75	60.60
Concrete Frame	M	440.00	480.00	50.00	970.00
Bentonite	KG	3.00	6.00	1.00	10.00
Steel Pipe 200 dia.	M	440.00	590.00	70.00	1,100.00
Air Hose 20 dia.	M	30.00	54.00	6.00	90.00

See Legend under Table 8-1.

Table 8-5-1 Improvement Plans Selected (Ibague-Calaca Section)

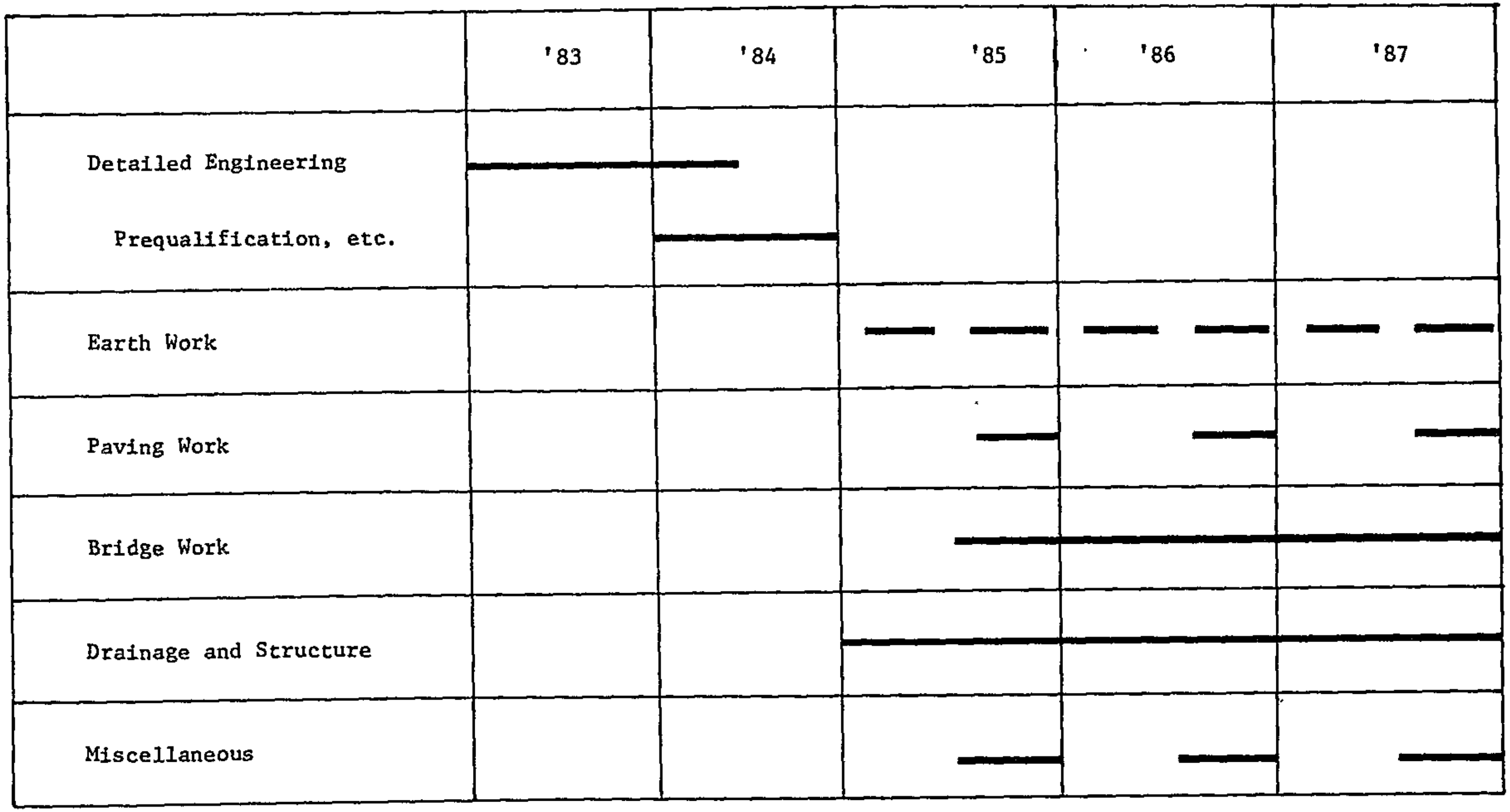
Economic Cost in 1980 Prices

(UNIT: $'000)

ITEM	FC	LC	TAX	TOTAL
1) Earthwork	75,858	59,010	18,054	152,922
2) Pavement	34,279	23,506	6,651	64,436
3) Bridge	66,415	66,757	14,384	147,556
4) Structure	37,392	58,109	4,652	100,153
5) Total	213,944	207,382	43,741	465,067
6) w/Overhead and Profit 5) x 1.25	296,784	234,996	49,554	581,334
7) Supervision 6) x 0.05	22,091	5,523	1,453	29,067
8) Contingency 6)+7) x 0.10	31,887	24,052	5,101	61,040
9) G. Total	350,762	264,571	56,108	671,441
10) Detailed Eng. w/Cont. 7 x 1.10	24,301	6,075	1,598	31,974
Total	375,063	270,646	57,706	703,415
Economic Cost	375,063	270,646	-	645,709

See Legend under Table 8-1.

Fig. 8-1 Implementation Schedule [1)]



Notes: 1) The feasible plans are shown in Table 9-6

Table 8-5-2 Girardot Bypas A1-B1 Route

Economic Cost in 1980 Prices

(UNIT: $'000)

ITEM	FC	LC	TAX	TOTAL
1) Earth Work	15,868	9,061	2,779	27,708
2) Pavement	116,977	83,941	25,676	226,594
3) Bridge	137,875	97,603	20,787	256,265
4) Structure	14,814	22,890	2,127	39,831
5) Total	285,534	213,495	51,369	550,398
6) w/Overhead and Profit 5) x 1.25	383,574	246,175	58,249	687,998
7) Supervision 6) x 0.05	26,144	6,536	1,720	34,400
8) Contingency 6) + 7) x 0.10	40,972	25,271	5,997	72,240
9) G. Total	450,690	277,982	65,966	794,638
10) Detailed Eng. w/Cont. 7) x 1.10	28,758	7,190	1,892	37,840
Total	479,448	285,172	67,858	832,478
Economic Cost	479,448	285,172	-	764,620

Note: Land acquisition cost is estimated separately as 49 million pesos.

Fig. 8-2

Implementation Schedule: Girardot Bypass

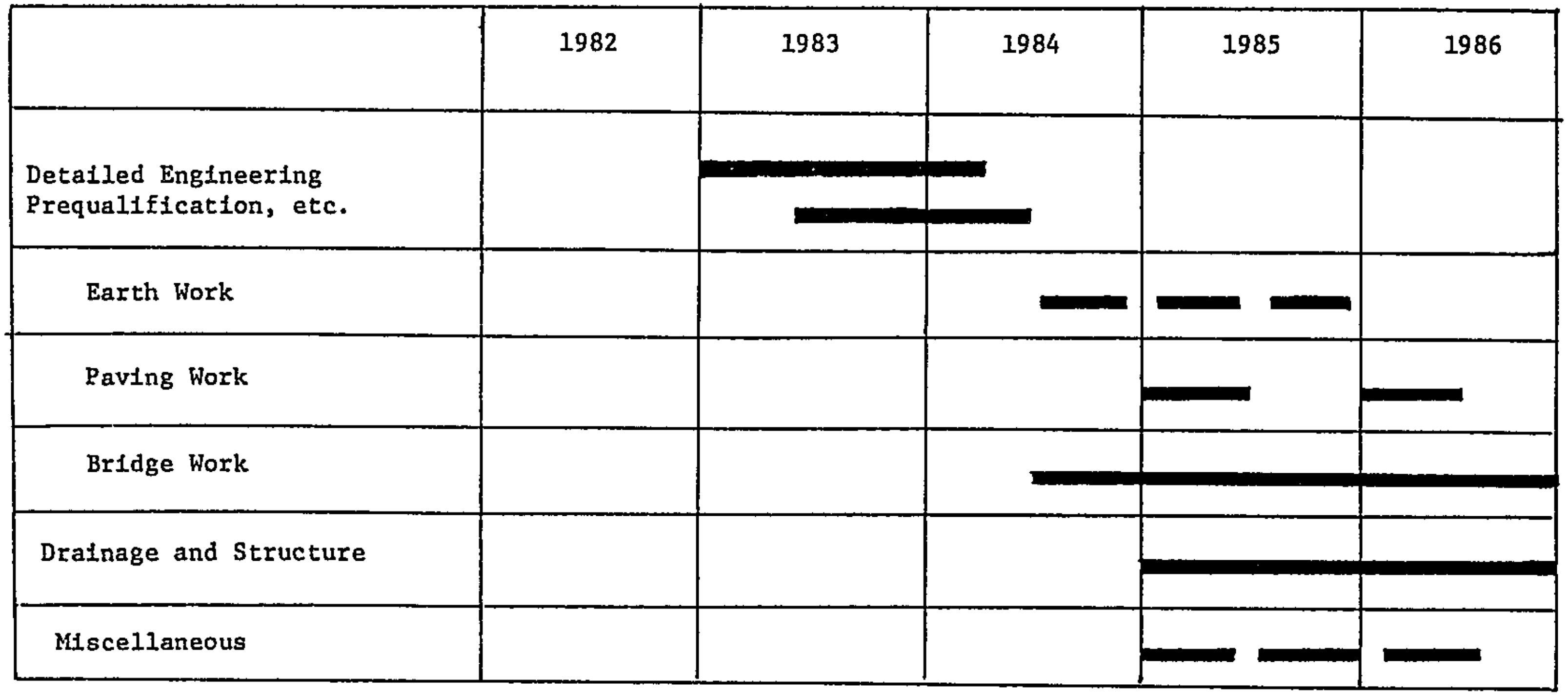


Table 8-5-3 Ibague Bypass A Route

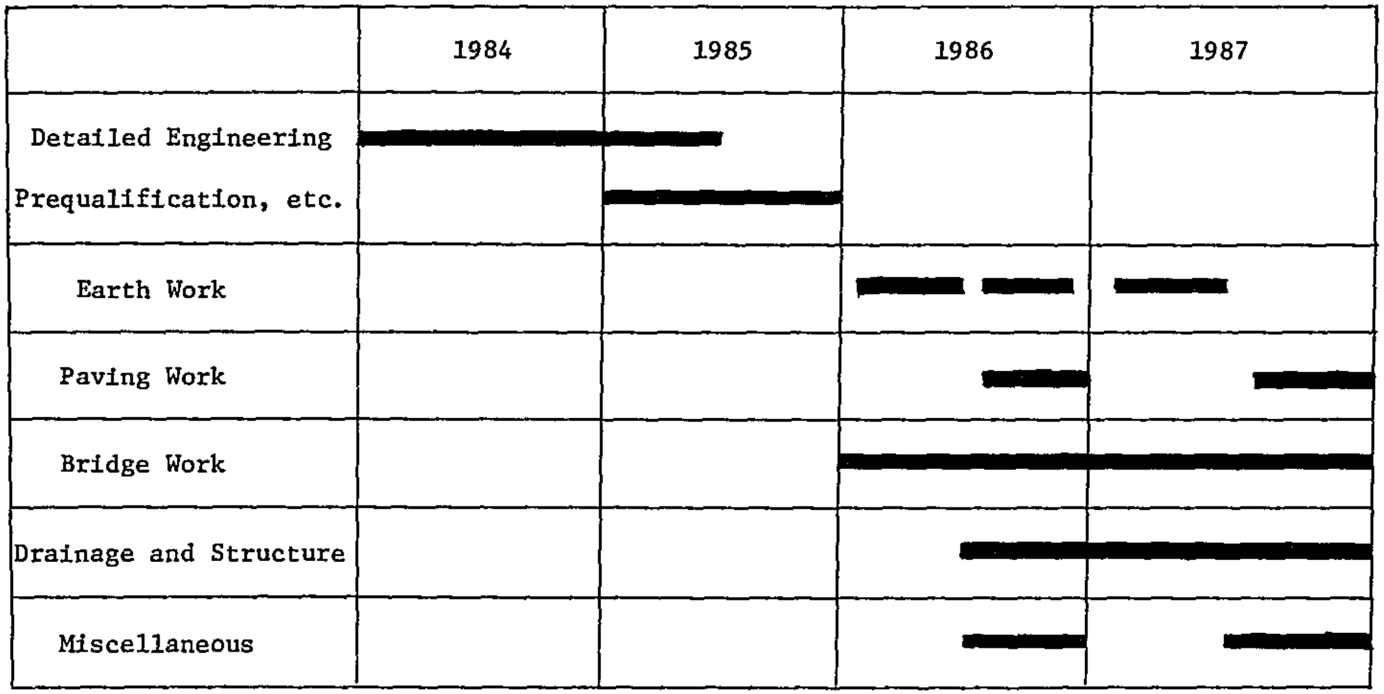
Economic Cost in 1980 Prices

(UIT: $'000)

ITEM	PC	LC	TAX	TOTAL
1) Earth Work	32,408	24,319	6,778	63,505
2) Pavement	16,826	11,434	3,130	31,390
3) Bridge	54,605	52,253	11,884	118,742
4) Structure	27,507	41,829	3,382	72,718
5) Total	131,346	129,835	25,174	286,355
6) w/Overhead and Profit 5) x 1.25	182,353	146,837	28,754	357,944
7) Supervision 6) x 0.05	13,602	3,400	895	17,897
8) Contingency 6) + 7) x 0.10	19,595	15,024	2,965	37,584
9) G. Total	215,550	165,261	32,614	413,425
10) Detailed Eng. w/Cont. 7) x 1.10	14,962	3,740	985	19,687
Total	230,512	169,001	33,599	433,112
Economic Cost	230,512	169,001	-	399,513

Note: Land acquisition cost is estimated separately as 12 million pesos.

Fig. 8-3 Implementation Schedule : Ibague Bypass



CHAPTER - 9

ECONOMIC EVALUATION

Chapter 9 Economic Evaluation

9-1 General

9-1-1 Subjects for Economic Study

The economic evaluation was conducted to determine the most feasible solution in planning the improvement program of the existing road considering traffic demand until 2005. The determination was made by comparing alternative improvement programs through benefit/cost figures.

9-1-2 Influence of Other Road Projects and the Extent of this Study

The Bogota-Medellin road is expected to be completed in 1983, and the road between Armenia and La Paila (Zarzal) will be improved with new surfacing in 1983. The Traffic diverted to these routes has been estimated and deducted from the forecasted traffic on the Project Road (See Chapter 4).

The ongoing rehabilitation work from Ibague to Calarca and other sections will be completed within a few years. The users will benefit from these investment programs for years to come. This study will therefore explore the opportunities of additional works to be done, above and beyond the current rehabilitation work, carried out by others, and will not therefore explore its adequacy.

Three levels of improvement plans have been considered for this project, namely minimum scale (P-2), medium scale (P-3), and large scale (P-4). These plans have been the subject of economic evaluation. A critical curve improvement plan(P-1) has been studied, however, it is not being considered as a separate improvement program, but rather it has been included in the other higher improvement plans. Also it was realized that the project with P-1 level of improvement would be too small for consideration as a project with a magnitude which would require foreign financing. Following is the classification of the three improvement plans:

(1) The minimum scale improvement plan (P-2) aims at a betterment work wherein all vehicles, including the meeting of tractor trailers (tractomulas) travelling in opposite direction, can pass-by without stopping or slow down. The minimum scale improvement plan initially considered the construction of a passing lane for some subsections, however, the passing lane has been eliminated from this plan. One of the reasons is that it is considered for the coming ten years or so the traffic would be substantially lower than the level at which queuing vehicles are able to pass-over only on the passing lane. It is quite common that vehicles maneuver to pass over on any segment of the road by using the opposite lane. The another reason is that the cost of constructing the passing lane in the mountainous terrain would be very high compared to the savings in VOC to be realized by that construction.

(2) The medium scale improvement plan (P-3) will result in widening by increasing the horizontal curves radii, a reduction of the grades to less than 8% and shortening of the road length, with complete freedom of vehicular movement without stopping at curves.

(3) The large scale improvement plans (P-4) involve bypasses of some parts of the existing road. In most of the major sections in Table 9-1 the traffic volume has not yet reached the level which would require the immediate construction of additional lanes or new bypasses. Consequently, such plans were not studied except for the four bypass plans at Girardot, Ibague, Coello, and La Linea which are defined as the large scale improvement plan. Since the subsections for large scale improvement plan are different from those defined for the minimum and medium scale improvement plans, the evaluation is presented separately in 9-5 of this chapter.

9-1-3 Unquantified Benefits and Costs

The benefits and costs in the economic evaluation are described elsewhere in this chapter (See Paragraph 9-2 and 9-3). There are, however, elements in costs and benefits which cannot be measured. Some elements are difficult to measure in terms of monetary costs whereas others cannot be measured due to lack of supporting information. Since the records of slope failure in the past are not available, and the studies on geological and soil features are only preliminary in nature, no statistical inference was conducted to forecast the possibility of road closure and traffic interruption. Instead, a simple assumption was used to quantify the cost and the benefit of road protection scheme which would minimize or prevent slope failures. (Chapter 7)

9-1-4 Repair Works for Bridges and Structures

The inventory study has found that there are some deficiencies in the bridges and other structures. These are described in Paragraph 6-4. It is recommended that these deficiencies be repaired at the earliest opportunity. Since the magnitude and costs associated with repairs and rehabilitation and their influence on the traffic cost are hard to measure, they are not included in the economic evaluation of improvement plans. They should be treated in the year to year maintenance work.

9-1-5 Alternative Plans of Improvement

The existing road between Melgar and Buga is divided into nine major sections as shown in Table 9-1. Among them the mountainous section between Ibague and Calarca which has been divided into 18 subsections each falling under one or two improvement plans. They are shown in Table 9-2. The improvement plans have been geared to facilitate the passing of vehicles on sharp curves and to flatten steep grades. Accordingly, curves and segments in each of the subsections are treated as a group in lieu of individual betterment of each curve or each segment.

Table 9-1 Improvement Plans and Traffic Volume: Melgar to Buga

No. Section	Length in Km Existing road	Number of curves scheduled for betterment under the minimum scale improvement plan	Length of road in Km scheduled for betterment under the medium scale improvement plan 5)	Length of road in Km scheduled for betterment under the large scale improvement plan 6)	AADT in 1985	AADT in 1995
1. Melgar-Girardot -Espinal	44.1	-	-	27.1 (40.3)	6500	12000
2. Espinal -Mirolindo	48.0	-	-	-	5200	9200
3. Mirolindo -Ibague	7.4	-	-	6.6 (8.2)	10000	17000
4. Ibague -Coello 1)	9.0	4	(1) 1.0	-	2400	4100
5. Coello -Cajamarca 2)	24.7	35	(5) 16.8	24.1 (18.0)	"	"
6. Cajamarca -KM 110.0 3)	20.0	17	(2) 1.0	-	"	"
7. KM 110.0 -Calarca -La Espanola 4)	35.0	46	-	29.9 (25.2)	"	"
8. La Espanola -Uribe	57.2	-	-	-	1900	3600
9. Uribe -Buga	43.6	-	-		8400	17100
Total	307.0	102	18.8		-	-

Notes: 1) - 4) See Table 9-2 for the detailed improvement plan.
5) The figures in ( ) indicate the number of subsections which are scheduled for betterment under the medium scale improvement plan.
6) The indicated figures show the length of the new bypass. The figures in ( ) show the actual length of existing road.

Table 9-2 Improvement Plans by Sub-section: Ibague-Calarca

No. Sub-sect.	Length of existing road in Km classified by road grade: 1%	3%	5%	7%	9%	Total	Number of Critical Curves 1): A	B	C	Total	No. of Curves for Min. Imp.pl.	Medium Scale Improve.Plan Length in Km by grade: 1%	3%	5%	7%	Total	No. of the location with possibility of slope failures: MLA 2)	MLB 3)	Total
Ibague-Coello																			
1				0.5		0.5		1		1	2						1	2	3
2			0.2	0.9		1.1			2	2	2	1.0				1.0	3	0	3
Coello-Cajamarca																			
3	0.3	0.3	0.7	0.9	0.3	2.5	1	2	2	5	7		0.6	0.5	1.5	2.6	12	8	20
4			0.4	0.4		0.8	1	4		5	5				0.7	0.7	1	4	5
5			0.1	0.8		0.9		1	1	2	2						2	2	4
6			0.5	0.6	0.1	1.2		2		2		0.3		0.2	0.6	1.1	1	0	1
7	0.4	0.2	0.3	0.6	0.1	1.6						0.7		0.5	0.1	1.3	5	4	9
8		0.3	0.8	0.7		1.8						0.9		0.5	0.2	1.6	2	0	2
9	0.1		0.3	0.1		0.5			1	1				0.3		0.3	4	0	4
10	0.5	1.4	1.0	2.4	0.1	5.4		2	1	3		1.5	1.6	1.1	0.6	4.8	11	9	20
11		0.3		0.2		0.5		1		1		0.2			0.1	0.3	4	0	4
12	0.6	0.4	0.8		0.1	1.9		1		1	1						3	1	4
13	0.5	0.7	0.4	1.3	1.9	4.8		1		1	7	0.3	0.5	3.3		4.1	9	12	21
Cajamarca-Calarca																			
14	0.5	0.2	0.1	1.9	0.6	3.3		2		2	5						13	19	32
15	0.2	0.2		0.2		0.6					1	0.3				0.3	3	0	3
16	0.1		0.4	0.6	1.4	2.5					1						5	2	7
17		0.5	0.9			1.4	1	1		2	2	0.7				0.7	4	1	5
18	0.6	2.7	1.9	6.9	20.9	33.0	5	15	4	24	54						35	37	72
Total	3.8	7.2	8.8	19.0	25.5	64.3	8	33	11	52	89	5.9	2.7	6.4	3.8	17.8	118	101	219

Notes: 1) The classification of the curves A, B and C is described in the notes of Table 9-4.
2) MLA means medium and large scale slope failures with high likelihood of occurrence in near future.
3) MLB means medium and large scale slope failures with less likelihood of occurrence in near future.

9-2 Benefits

9-2-1 Traffic Cost

(1) Vehicle Operating Cost

The vehicle operating cost (VOC) has been calculated for the traffic level of 1980 and for the year 1995. It is composed of the cost of the fuel, oil, tyres, maintenance, depreciation, and overhead cost including driver's wages converted to a cost per km. The total is shown in Table 9-3. The procedure for estimating the cost is based on the MOPT system with the details shown in Annex 9-1. The results indicate that the increases in vehicle operating costs (VOC) from 1980 to 1995 are relatively modest.

In the economic assessment of the improvement project, the above VOC will be modified to take into account the realistic feasures of the road which would affect costs, namely, the cost of encounters at sharp curves as described below.

(2) Traffic Cost at Sharp Curves

In order to represent the additional cost arising out of encounters by traffic and resulting in stoppages at sharp curves of the existing road, the traffic movement is analyzed as follows:

1) The traffic in one lane stops and waits for the oncoming vehicle which slows down to half of its speed.

2) The frequency of encounters at curves are calculated as stated in Chapter 5.

3) The sharp curves at which the stopping occurs are identified in the engineering inventory study, Chapter 6. The curves according to the degree of difficulty of passing-by in two directions are classified in the order of their severity starting with the most difficult case. The classification is shown in Table 9-4.

If a vehicle stops and returns to the original speed, additional cost should be added to that of the running under normal road conditions. It is determined that a vehicle in one lane registers one "stop and go" when it encounters another vehicle at the curve. The unit cost of "stop and go" is determined as stated in Annex 9-2. The result is shown p-179.

Table 9-3 Vehicle Operating Economic Cost $/Km

(In 1980 prices of the Colombian Pesos)

	Vehicle	Road Grade 1%	3%	5%	7%	9%
For the traffic in 1980	Auto	11.000	12.049	12.709	13.239	13.822
	Bus	21.977	23.991	26.310	28.872	31.564
	Truck	23.882	26.036	28.549	31.186	34.026
	Tractomula	45.198	48.392	53.423	59.043	65.218
For the traffic in 1995	Auto	11.083	12.292	13.115	13.811	14.758
	Bus	21.860	24.263	26.739	29.482	32.032
	Truck	23.720	26.277	28.762	31.631	34.567
	Tractomula	44.906	48.753	53.912	59.900	66.144

Source: Annex 9-1. Assuming a well surfaced road.

Table 9-4 Sharp Turning Curves, Existing Status and Impromements

Outside lane / Inside lane		Existing Curve		Improvement Plans P-2 and P-3	
		Truck	Tmula	Truck	Tmula
A	Truck	Slow down / Stop	Slow down / Stop		
	Tmula	Slow down / Stop	Slow down / Stop		
B	Truck		Slow down / Stop		
	Tmula	Slow down / Stop	Slow down / Stop		
C	Truck				
	Tmula	Slow down / Stop	Slow down / Stop		
D	Truck				
	Tmula		Slow down / Stop		

Notes: A. A truck, or a bus or a tractomula on the inside lane vs a truck or a bus or a tractomula on the outside lane.
Traffic on the inside lane must stop and wait, then proceed one at a time. Traffic on the outside lane slows down to half speed.

B. A truck or a bus on the inside lane vs a tractomula on the outside lane, or a tractomula on the inside lane vs a truck or a bus or a tractomula on the outside lane. Traffic on the inside lane must stop and wait, then proceed one at a time. Traffic on the outside lane slows down to half speed.

A truck or a bus on the inside lane vs a truck or a bus on the outside lane can proceed in both directions without stopping

Note: (Cont'd.)

nor waiting.

C. A tractomula on the inside lane vs a truck or a bus or a tractomula on the outside lane. Traffic on the inside lane must stop and wait, then proceed one at a time. Traffic on the outside lane slows down to half speed.

A truck or a bus on the inside lane vs a truck or a bus on the outside lane can proceed in both directions without stopping nor waiting.

D. A tractomula vs a tractomula. Traffic on the inside lane must stop and wait, then proceed one at a time. Traffic on the outside lane slows down to half speed.

Traffic in other combinations can proceed with no stopping. Above "A" corresponds to "a" in Annex Table 9-23, above "B" and "c" in Annex Table 9-23.

Improvement plans of P-2 and P-3 will eliminate all of the "stop and go" and "slow down" at the existing curve.

	Ratio of a "stop and go" cost to the running cost per 1 km.
Passenger Car	0.348
Bus	0.411
Truck	0.417
Tmula	0.435

Example

In the case of a passenger car travelling on a 10 km section of road with 2 "stop and go" curves, with 3% grade in 1980.

From Table 9-3, VOC is 12.049

* Cost of travel is 12.049 x 10 km + 2 x 0.348 x 12.049
= 120.49 + 8.39 = 128.88

It is also assumed that the vehicles in one lane will slow down when they encounter those which stop in the other lane. The slow down is assumed to cause a speed reduction equal to one half the initial speed. The cost of a "slow down" is estimated at 60% of the cost of a "stop and go", according to the same source referred to in Annex 9-2.

The cost is relatively high due to the steep grades at the curves. If the curve is improved this cost would be saved since the stop-go and slow down phenomenon will be eliminated. The frequency of encounters at the curves are studied in Chapter 5 with the results summarized in Annex Table 9-26.

(3) Estimate of Traffic Cost

The traffic cost on a subsection is the total of vehicle operating cost (VOC) on the subsection and the excess cost of stop and go and slow down at the curves within that subsection.

Savings (benefits) in VOC are obtained by finding the difference of the traffic cost between the case without the improvement plan and that with the plan. They are shown in Table 9-5. Annex 9-3 presents an example of the estimate of total traffic cost in 1983 for subsection No.4.

9-2-2 Benefits

The benefits of the project in this study are measured by the savings in the traffic cost. The traffic cost is determined as in the previous sections for 1983 and 1995. Table 9-5 presents the

Table 9-5 Savings in VOC by Selected Year, by Subsection and by Plan

($'000 in the economic cost of 1980)

Year	Sub-section	P-2	P-3	Sub-section	P-2	P-3
1983	1	639		11	181	4,962
1995		2,716			679	9,591
2000		4,964			1,178	12,623
2005		4,964			1,178	12,623
1983	2	316	2,343	12	391	
1995		1,297	4,990		1,519	
2000		2,336	6,856		2,662	
2005		2,336	6,856		2,662	
1983	3	1,636	- 1,016	13	376	25,324
1995		6,093	1,041		1,592	48,671
2000		10,537			2,905	63,892
2005		10,537			2,905	63,892
1983	4	1,371	3,001	14	1,339	
1995		5,354	8,268		5,797	
2000		9,445	12,610		10,676	
2005		9,445	12,610		10,676	
1983	5	481		15	105	7,150
1995		2,030			487	13,549
2000		3,699			923	17,682
2005		3,699			923	17,682
1983	6	369	4,048	16	45	
1995		1,443	8,429		198	
2000		2,547	11,444		367	
2005		2,547	11,444		367	
1983	8	75	8,074	17	497	17,565
1995		335	15,679		1,932	33,722
2000		625	20,669		3,401	44,246
2005		625	20,669		3,401	44,246
1983	9	158	4,462	18	9,381	
1995		656	8,548		38,996	
2000		1,187	11,209		71,027	
2005		1,187	11,209		71,027	
1983	10	541	23,945			
1995		1,837	46.056			
2000		3,057	60,485			
2005		3,057	60,485			

Notes: P-2 and P-3 indicate the savings in VOC from the application of improvement plan P-2 and P-3 respectively.

savings (benefits) for the alternative plans by subsection in 1983 and in 1995. It is found that the traffic costs increase at a higher rate than the growth of traffic volume because the number of encounters at sharp curves will increase at a higher rate than the traffic growth. The savings in VOC realized from improvements have been calculated on the basis of compounding over the period 1985 or 1986 to 2005.

Savings in road maintenance costs are assumed to be equal among the alternatives except in the case where a reduction in the road length has been attained. Road maintenance work associated with clearing of slides would generate a high benefit especially in the case where slope protection work is used. However, this kind of saving has not been incorporated in the study because of lack of information. A rough approach was conducted in Annex 7-4.

Development benefits are not taken into account since the improvement plans of the existing road will not generate this type of benefit. Reductions in the accident cost are also not considered due to lack of information. There are savings in time of travel when these plans are completed, however, it is questionable and difficult to measure economic value of the time saved in the study of this kind of road project. The time value is not considered in the economic analysis.

9-3 Cost

Economic cost is studied in terms of the prices in June/July 1980. Costs are summarized for each improvement level by subsection. They are presented in Tables 8-3-2 and 8-3-3 of Annex 8-3. Details of the cost study are presented in Chapter 8. The work schedule is developed by considering the total quantities for each level of improvement for the whole section of Ibague-Calarca. Generally, the subsections closer to Ibague and Calarca are supposed to be completed earlier followed by those near La Linea. The detailed engineering study is scheduled for 1983 and the construction is due for completion in 1987 at the latest.

9-4 Benefit/Cost Calculations

The benefit-cost calculations are conducted primarily to evaluate the overall viability of Improvement Plan P-2 for all the subsections. The resultant figures are shown below.

PW Cost (i=12%)	$326 million
PW Benefit (i=12%)	$336.7 million
PW B-C (i=12%)	$10.7 million
B/C (i=12%)	1.03
IRR	12.4 %

The above results of the economic evaluation indicate that on the road between Ibague and Calarca all the curves which have been identified to be improved should be improved to the P-2 level which has been referred to as Minimum Scale Improvement Plan.

This study has developed a P-3 improvement plan for some subsections as stated in Chapter 7. P-3 is the medium scale improvement plan which incorporates the betterment of curves, horizontal alignment, and vertical grade. The comparative study of P-2 and P-3 is conducted for each subsection which is being considered for the P-3 plan. The results indicate that the subsections 02, 04, 11 and 17 have higher benefit/cost figures with P-3 than with P-2.

Accordingly, out of a total of 18 subsections, P-2 should be implemented for 13 subsections and P-3 for four subsections. Subsection No.7 is left as it is since none of its curves need improvement under the P-2 level. The subsections, each with its economic cost are shown in Table 9-6 and the breakdown of the total cost of646 million pesos in the economic cost is shown in Table 8-5. The resulting benefit/cost figures for each subsection are shown in Annex Table 9-27. The combination of P-2 and P-3 is recommended since the overall benefit/cost figure of the combination of P-2 and P-3 is higher than the case with only P-2 improvement plan.

PW Cost (i=12%)	$462.1 millinn
PW Benefit (i=12%)	$544.5 million
PW B-C (i=12%)	$82.4 million
B/C	1.178
IRR	14.1%

It is to be noted that the above recommendation also includes two other subsections, namely, (03 and 10) for which P-2 is economically not feasible. (Refer to Annex Table 9-24) However, they are recommended for simultaneous implementation, since their inclusion would involve not more than 15 percent of the total economic cost. The separate implementation of the above two subsections in later years would result in higher cost, compared with the cost of implementation at the present time.

9-5 Large Scale Improvement Plan

In the course of field studies and meetings with the staff of MOPT, it was agreed that the following four bypass plans, namely the Large Scale Improvement Plans, were to be included in this project study. The objectives of the Bypass plans are to detour the congested urban area, to shorten the road length, to have a road with better geometric criteria, etc. In any case the plan will result in the savings in the transportation cost. The four plans together with the assessment are stated below:-

(1) Girardot - Espinal Bypass

The economic consequence of the bypass route alternatives is studied as in Annex 9-4. It is found that the route which realizes the largest reduction in road distance will be the most feasible plan in the Girardot-Espinal area. While the bypass detours the urban areas of Girardot and Espinal respectively, the savings in the traffic cost for intra-urban traffic are quite modest. The study in Annex 9-4 indicates that the bypass plan which reduces the road distance by more than 32% from the existing road of 40 km will be economically viable although the traffic on the existing road is below the saturation level of the capacity yet.

Based on the findings in Annex 9-4, the engineering study and the cost estimate were refined. The engineering study is presented in Paragraph 7-2 of Chapter 7. The cost is summarized in Table 8-3-4. Savings in traffic cost are same as stated in Annex 9-4. Estimated benefit-cost figures for the recommended route are shown below:

1) Economic project cost: 764 million pesos

2) Detailed engineering study and construction: 1983-87

3) B/C, i=12% = 4.29

4) PW, i=12% = 1,834 million pesos

5) IRR = 36.5%

The bypass plan is economically viable since the new bypass will reduce the road distance by 32%, resulting in substantial savings in transport cost of the Colombia. There is no difficulty in the construction of it because it passes mostly through the plain cultivated area.

(2) Ibague Bypass

Alternative plans for Ibague Bypass were studied in Annex 9-5. The most viable route among the alternatives presents the benefit-cost figures as follows:

1) Economic project cost (Plan A) 399 million pesos

2) Detailed engineering study and construction: 1984-87

3) B/C, i=12% = 1.37

4) PW, i=12% = 115.5 million pesos

5) IRR = 16.5%

The above figures indicate that the construction of the plan A is feasible. Toward the realization of the bypass construction, more detailed investigation should be made because of the following reasons.

-1. Urban development master plan is not formulated yet in Ibague. Accordingly there remains a possibility that another bypass plan is favourable from the viewpoint of new urban development planning. Any bypass plan should be studied together with a comprehensive master plan of Ibague.

-2. Also, urban traffic study in Ibague has not been conducted yet. The study, including vehicle owner OD interviewing survey and bus passenger survey is necessary for forecasting the future traffic flows in the urban area.

-3. The traffic diversion in 1988 is estimated at 1846 ADT, while the cost of a new bypass is high because of the difficult terrain along the Rio Combeima.

(3) Coello Bypass

The bypass plan of 24.0 km from Km 64.8 to Km 82.8 was proposed to have better geometric criteria. However, it was found that the length of the bypass had to be longer than the existing road due to the given criteria and that the cost of the Bypass of 24 Km in the steep mountain range was extremely high, while the traffic between Ibague and Calarca was estimated at 2477 ADT in 1985 by Annex Table 4-5. The plan will not result in the savings in traffic cost. Consequently the bypass plan is found not economically feasible.

(4) La Linea Bypass

The bypass plan from Km 110.0 to Km 135.6 was proposed to have better geometric criteria. However, the bypass plan is found not economically feasible. The reasons are same to the case of (3) Coello Bypass. Annex Table 9-27 presents the summary of the economic cost of the four bypass plans.

Table 9-6 Recommended Improvement Plands

(Ibague-Calarca Section)

Section		Improvement Plans	Economic Cost ($1,000 in 1980 price)
1.	K61.3 - K62.8	P-2	5,539.-
2.	K62.8 - K63.9	P-3	29,742.-
3.	K63.9 - K68.4	P-2	60,317.-
4.	K68.4 - K69.2	P-3	52,165.-
5.	K69.2 - K70.1	P-2	9,292.-
6.	K70.1 - K71.3	P-2	3,532.-
7.	K71.3 - K73.4	-	
8.	K73.4 - K75.2	P-2	1,320.-
9.	K75.2 - K75.7	P-2	3,207.-
10.	K75.7 - K81.1	P-2	24,909.-
11.	K81.1 - K81.6	P-3	31,368.-
12.	K81.6 - K83.5	P-2	6,282.-
13.	K83.5 - K88.7	P-2	8,317.-
14.	K88.7 - K97.6	P-2	10,092.-
15.	K97.6 - K98.2	P-2	1,158.-
16.	K98.2 - K100.7	P-2	902.-
17.	K100.7 - K102.1	P-3	178,623.-
18.	K102.1 - K135.6	P-2	218.947.-
Total			645,709.-

Notes: Refer to Annex Table 8-3-1.

Table 9-7 Implementation Program of the Selected Plans

(UNIT: $'000)

Improvement of Existing Road

	1983	1984	1985	1986	1987	Total
Economic Cost	20,544	8,805	157,540	308,470	150,350	645,709
FC	11,933	5,117	96,896	175,177	85,940	375,063
LC	8,611	3,690	64,397	130,507	63,441	270,646
(In prices of 1980)						
Financial Cost	22,368	9,566	171,633	336,021	163,827	703,415
FC	11,933	5,117	96,896	175,177	85,940	375,063
LC	8,611	3,690	64,397	130,507	63,441	270,646
Tax	1,824	761	14,093	27,551	13,477	57,706
(In prices of 1980)						
Financial Cost	34,018	16,731	345,216	777,238	435,780	1,608,983
FC	18,194	8,971	195,377	406,202	229,171	857,915
LC	13,083	6,447	129,393	301,566	168,583	619,072
Tax	2,775	1,336	28,336	63,722	35,827	131,996
LC Total (Current Prices)	15,858	7,783	157,729	365,288	204,410	751,068

(In prices of the current prices. Price level is assumed to rise 15% p.a. up to 1987.)

Table 9-8 Implementation Program of Girardot Bypass

(UNIT: $'000)

	1983	1984	1985	1986	Total
Economic Cost	23,170	98,501	336,946	306,003	764,620
FC	14,529	67,786	212,111	185,022	479,448
LC	8,641	30,715	124,835	120,981	285,172
(In prices of 1980)					
Financial Cost	74,006	106,057	367,057	334,138	881,258
FC	14,529	67,786	212,111	185,022	479,448
LC	57,421	30,715	124,835	120,981	333,952
Tax	2,056	7,556	30,112	28,134	67,858
(In prices of 1980)					
Financial Cost	112,554	185,494	738,283	772,881	1,809,212
FC	22,097	118,558	426,631	427,967	995,253
LC	87,330	53,721	251,088	279,836	671,975
Tax	3,127	13,215	60,564	65,078	141,984
LC Total (Current Prices)	90,457	66,936	311,652	344,914	813,959

(In prices of the crrent prices. Price level is assumed to rise 15% p.a. up to 1986)

Table 9-9 Implementation Program of Ibague Bypass

(UNIT: $'000)

	1984	1985	1986	1987	Total
Economic Cost	12,106	6,054	192,990	188,363	399,513
FC	6,984	3,493	119,647	100,388	230,512
LC	5,122	2,561	73,343	87,975	169,001
(In prices of 1980)					
Financial Cost	24,914	6,563	209,494	203,931	444,902
FC	6,984	3,493	119,647	100,388	230,512
LC	16,912	2,561	73,343	87,975	180,791
Tax	1,018	509	16,504	15,568	33,599
(In prices of 1980)					
Financial Cost	43,574	13,515	484,560	542,457	1,084,106
FC	12,215	7,026	276,744	267,032	563,017
LC	29,579	5,413	169,642	234,014	438,648
Tax	1,780	1,076	38,174	41,411	82,441
LC Total (Current Prices)	31,359	6,489	207,816	275,425	521,089

(In prices of the current prices. Price level is assumed to rise 15% p.a. up to 1987.)

9-6 Conclusion

9-6-1 Road Improvement

The section between Ibague and Calarca is divided into 18 subsections which are defined in the study. Each subsection has one or two alternative plans for which economic assessment was carried out. Table 9-6 presents the plan for each subsections which has been found to be economically feasible. The total economic cost is$646 million in terms of 1980 prices.

A work program for the section Ibague-Calarca is established by considering only these feasible plans. It is shown in Fig. 8-1. The economic cost is summarized in Table 8-5-1 and the BC figures for the improvement plans in each subsection are shown in Annex Table 9-24 and summarized below.

PW (i=12%)	$82.4 million
B/C (i=12%)	1.178
IRR	14.1 %

The implementation programs in terms of the economic cost and the financial cost with the constant prices in 1980 are shown in Table 9-7. The table also presents the disbursement plan with the assumed inflation ratio of 15% p.a.

Of the 703.4 million pesos in terms of the financial cost in 1980 prices, the foreign component will be$375.1 million(53.3%), local component $270.6 million (38.5%),and tax elements $57.7 million (8.2%).

9-6-2 Bypass Plan of Girardot-Espinal and Ibague

Bypass plans are studied for detouring Girardot and Espinal areas. The bypass will reduce the road distance substantially and avoid the urbanized established areas. The study indicates that the savings in traffic cost, resulted from the reduced road length of approximately 13 Km from the existing road of 40 Km, is substantially high, while the traffic diverted on the bypass is estimated at 3000 ADT in 1988 for the Espinal section and 3400 ADT in 1988 for the Girardot section. The followings are the benefit-cost figures of the selected bypass plan:

PW (i=12%)	$1,966.5 million
B/C (i=12%)	4.37
IRR	39.0%

It is recommended that the bypass plan as studied in Chapter 7 be constructed with the schedule shown in Fig. 8-2 . The total financial cost is 832.5 million pesos in 1980 prices of which the foreign cost component is 479.4 million (57.6%), the local cost component 285.2 million (34.3%) and the tax element 67.9 million (8.1%).

Ibague bypass plan will reduce the road distance and avoid the urbanized areas. The road length reduction is about 20% (1.6 Km of 8.2 Km existing length). The traffic volume diverted on the bypass is estimated 1846 ADT in 1988.

The followings are the benefit-cost figures.

PW	(i=12%)	$115.5 million
B/C	(i=12%)	1.37
IRR		16.5%

It is recommended that the plan as studied in Chapter 7 be constructed with the schedule shown in Fig. 8-3 . The total project cost is 433.1 million pesos in 1980 prices.

Foreign component	$230.5 million	(53.2%)
Local component	$169.0 million	(39.0%)
Tax component	$ 33.6 million	(7.8%)

9-6-3 Protective Work against the Slope Failures

It is commonly known that there will be a number of occasions when slope failures may occur, some of these failures could result in the closing of the road for several days. However, no systematic investigation has been conducted to protect the road from this kind of occurrence.

The study team explored the nature of soils and slopes by making borings and testing soils at some selected points. The studies which were conducted in August - October, 1980 were not oriented towards producing data with which to carry out the economic analysis of such protective works. The investigation was at the preliminary stage.

It is recommended that MOPT keep records of slope failures along the road, conduct further soil investigation and study the responses of the people, vehicles, and economy when they encounter these accidents. MOPT should also collect cost data on any corrective measures they are forced to implement on an emergency basis and separate such costs from normal maintenance costs. This effort will require many months to complete.

Whether or not an extensive study of slope failure is conducted, it is sure that occasional falls and road closure would occur on the existing road. Preventive work should be conducted immediately at selected locations which are found to be extremely dangerous regardless of the economic justification. The recommendation of preventive work is stated in Annex 7-4, which presents a rough approach in economic evaluation.

The project cost for the preventive work in terms of 1980 prices will be 390.3 million pesos (50%) for the foreign currency component, 348.7 million (44.7%)for the local currency component and 41.7 million (5.3%)for the tax element, totaling 780.3 million pesos.

MEMBER LIST CONCERNED OF THE STUDY

Member of Advisory Committee

Mr. Hiroaki Tamamitsu	Director of the International Affairs Division, Ministry of Construction
	Director of the Flood Control Division Ministry of Construction (Active)
Mr. Shoichiro Magasaki	Head of the Third Technical Section, Tokyo First Construction Bureau, Japan Highway Public Corporation
	Head of the Hitachi Construction Office, JHPC (Active)
Mr. Fumiaki Utsunomiya	Deputy Head of the Maintenance Section, JHPC
	Head of the Third Technical Section, Hiroshima Construction Bureau, JHPC (Active)
Mr. Eiji Sakai	Deputy Director of the Highway Economic Research Section, Ministry of Construction
	Deputy Director of the Housing Policy Division, Ministry of Construction (Active)
Mr. Tadao Hoya	International Engineering Consultant Association
	Chief Professor, Construction College, Ministry of Construction (Active)
Mr. Toshiyuki Kasai	Social Development Cooperation Department, Japan International Cooperation Agency
	Deputy Head of the First Training Division, Training Affairs Department, JICA (Active)
Mr. JUnichi Inoue	Social Development Cooperation Department, JICA
	Traffic Technology Section, Engineering Section JHPC (Active)
Mr. Go Nishibe	Social Development Cooperation Department

Japanese Staff of The Study Team

1.	Mr. Kanenari Ijuin	Project Manager
2.	Mr. Teruhiko Horie	Economist
3.	Mr. Toshisada Katsurada	Transport Planner
4.	Mr. Toshio Moori	Regional Planner
5.	Mr. Takesi Tomiyasu	Road Engineer
6.	Mr. Takeo Sato	Structural Engineer
7.	Mr. Junji Yasui	Structural Engineer (Bridge)
8.	Mr. Kunio Taniguchi	Cost Estimator (Construction Planning, Tunnel)
9.	Mr. Shoichi Ohmori	Geologist
10.	Mr. Kunio Fujiwara	Geologist
11.	Mr. Denichi Sasaki	Geologist
12.	Mr. Seizo Kakishita	Director of Aerial Survey
13.	Mr. Eiji Matsufuji	Chief of Aerial Survey
14.	Mr. Koji Jyobu	Surveyor
15.	Mr Masashi Suzuki	Surveyor
16.	Mr. Keisuke Ito	Surveyor
17.	Mr. Takayuki Kidokoro	Surveyor
18.	Mr. Yoichi Kimura	Surveyor
19.	Mr. Hiroshi Tamaki	Coordinator

Colombian Counterparts of the Study

Ministry of the public Works and Transportation

Dr. Guillermo Ramos R.	Chief of Planning Office
Dr. Alfonso Corredor R.	Chief of Planning Office
Dr. Hernando Rueda P.	Asesor Ministro
Dr. Eduardo Montero	Chief of Topography and Photogrametry Section
Dr. Carlos Alba	MOPT Branch at Ibague
Dr. Juan Montero	Chief of Geological Section
Dr. Francisco Ceron A.	Traffic Economist
Dr. Ruben Cheng	Geologist
Dr. Reynaldo Uribe	Traffic Economist
Dr. Thomas Leon	Structural Engineer
Dr. Hector Garzon	Traffic Engineer
Dr. Jorge Posada	Chief of Drainage Section

Office of National Planning

Dr. German Ospina O.	Chief of Transport Division
Dra. Nohra Bateman Duran	Chief
Dr. Guillermo Uruburu V.	Assistant of Transport Division

Institute of Geography " Augustin Codazzi " Colombia

Dr. Rodolfo Llenas	Sub-Director of Cartography Department
Dr. Abraham Gutierrez	Surveyor

JICA