

REPUBLIC OF THE PHILIPPINES
MINISTRY OF PUBLIC WORKS & HIGHWAYS

**THE FEASIBILITY STUDY
OF
PHILIPPINE ROAD DISASTER PREVENTION PROJECT**

STAGE II

FINAL REPORT
EXECUTIVE SUMMARY

(VOLUME I)

JULY, 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of the Philippines, the Government of Japan decided to conduct a feasibility study on the Philippine Road Disaster Prevention Project Stage II which focused on the disaster spots along the Maharlika Highway and main national roads around Baguio City, and entrusted the study to the Japan International Cooperation Agency (JICA).

The feasibility study on Stage I was started in May 1983 and completed in June 1984 on the following three sections which claimed the highest priority, namely: i) Dalton Pass section; ii) Mahaplag – Sogod section (both along the Maharlika Highway); and iii) Kennon Road.

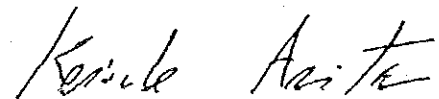
Based on the Stage I Study, the Stage II Study has placed priority on the following three sections namely: i) Lucena – Calauag section, ii) Allen – Calbayog section (both along the Maharlika Highway), and iii) Naguilian Road, and the JICA sent to the Philippines a survey team headed by Mr. Tsuneo Bekki from October 1984 to March 1985.

The Team had a series of discussions on the project with the officials concerned of the Government of the Philippines and conducted a field survey in the Philippines. After the return of the team to Japan, further studies were made and the present report has been prepared.

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

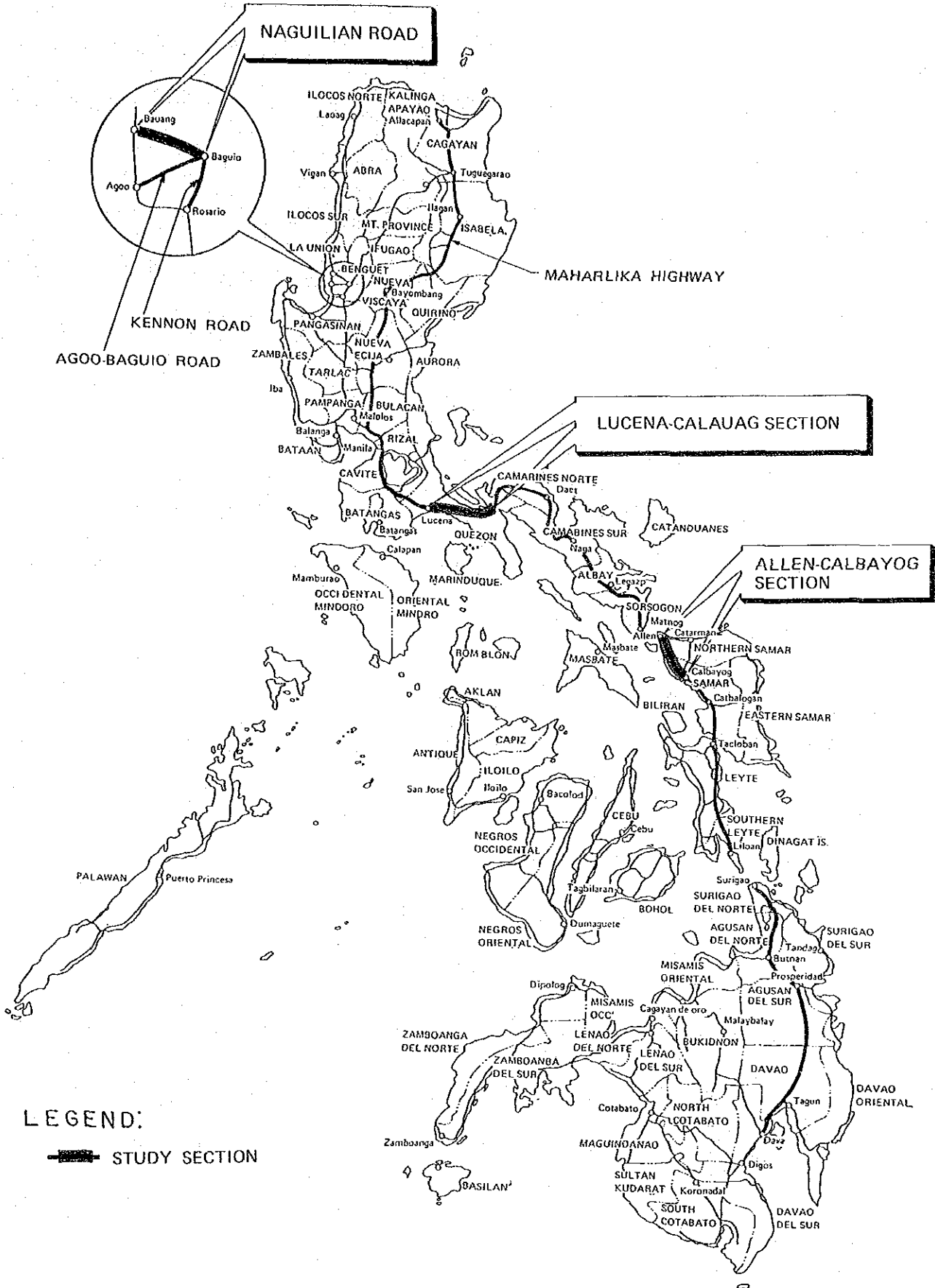
I wish to express my deep appreciation to the officials concerned of the Government of the Philippines for their close cooperation extended to the Team.

July, 1985



Keisuke Arita
President
Japan International Cooperation Agency

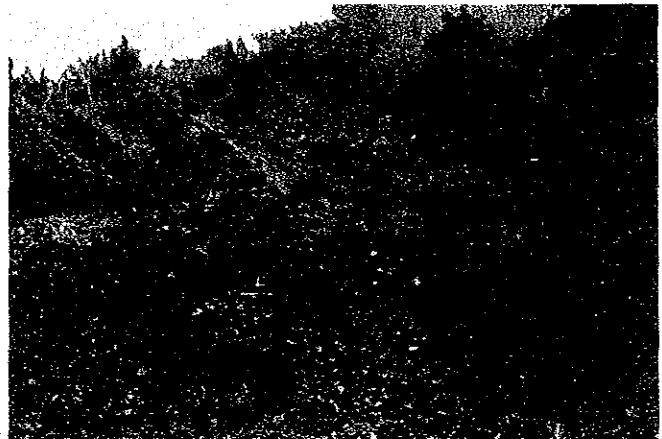
LOCATION MAP



LEGEND:
 STUDY SECTION



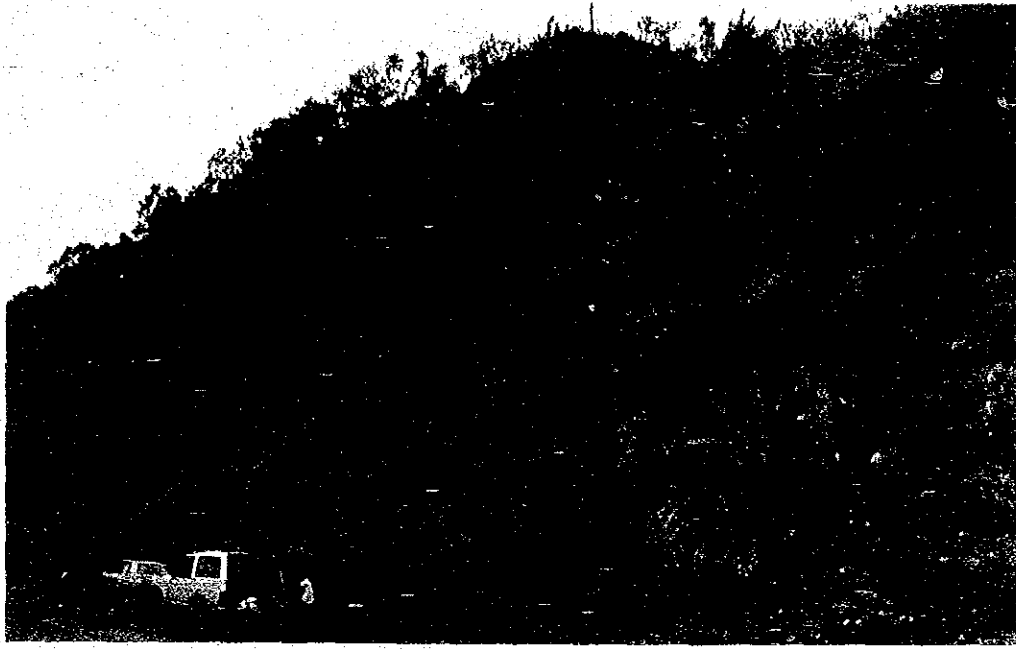
*CUT (NATURAL) SLOPE SURFACE FAILURE
NAGUILIAN ROAD
km 294 + 800*



*CUT SLOPE DEEP FAILURE
NAGUILIAN ROAD
km 281 + 500*



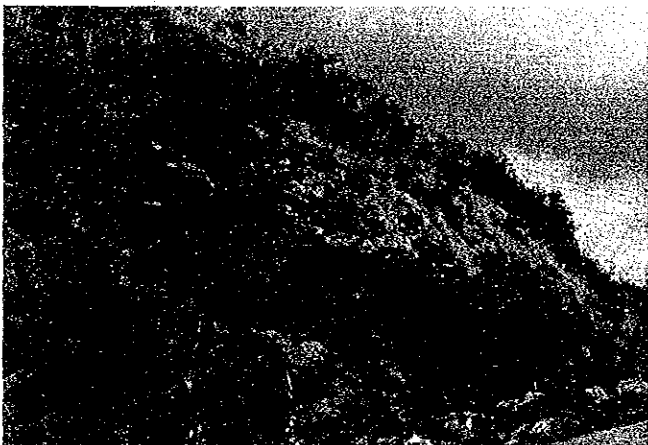
*CUT SLOPE DEEP FAILURE
LUCENA - CALAUAG SECTION
km 158 + 500*



FALLS
NAGUILIAN ROAD
km 294 + 100



FALLS
LUCENA – CALAUAG SECTION
km 153 + 900



FALLS
ALLEN – CALBAYOG SECTION
km 705 + 600



*EMBANKMENT SLOPE DEEP FAILURE
NAGUILIAN ROAD
km 286 + 600*



*LANDSLIDE
LUCENA – CALAUAG SECTION
km 160 + 800*



*DEBRIS FLOW
ALLEN – CALBAYOG SECTION
km 718 + 100*

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I INTRODUCTION

INTRODUCTION

1. BACKGROUND

The government of Republic of the Philippines (GOP) has long been emphasizing the development of trunk roads in view of their importance to the overall socio-economic development program of the country. This has been manifested by the present network which could now be considered as sufficient in extent and location. Owing to the efforts, a quantitative expansion of trunk roads has been realized. Despite the achievements made, however, some of the most important roads suffer many deficiencies including, among others, disasters due to slope failures, fall, landslide, debris flow, and the like, which impair the efficiency of the road transport system. Such disasters are eagerly desired to be resolved in order not to hamper the socio-economic activities in the country.

In the recognition to the importance of road disaster prevention, GOP has planned the formulation of a long term program for which the Government of Japan (GOJ) through the Japan International Cooperation Agency (JICA) provided technical assistance in the formulation of the same under the Feasibility Study of the Philippine Road Disaster Prevention Project (Stage I), hereinafter called as the Stage I Study.

The Stage I Study which started in May 1983 and completed in June 1984, was implemented in two phases; Phase I, was focused in the identification of disaster spots and prioritization of disaster sections along four national roads namely:

i) Maharlika Highway (Luzon and Samar, Leyte section only); ii) Kennon Road; iii) Agoo-Baguio City Road; iv) Naguilian Road. On the basis of the prioritized sections, Phase II was conducted for the feasibility studies of only three specific sections under category A namely; i) Dalton Pass section; ii) Mahaplag-Sogod section (both along the Maharlika Highway); and iii) Kennon Road.

Drawn from the experience and the results and recommendations from the Stage I Study, the seriousness of the related problems have been exemplified and their immediate solutions emphasized so that further deterioration and/or eventual disaster in these sections could be avoided. On this premise, therefore, the Government of the Philippines is more than ever determined to pursue the implementation of the initial road disaster prevention program and at the same continue further in the conduct of feasibility studies for the other identified disaster potential sections along the above mentioned road network.

Thus, the GOP has requested the GOJ to provide technical assistance for the conduct of "the Philippine Road Disaster Prevention Project (Stage II)", hereinafter referred to as "the Study", which aims to undertake feasibility studies of the specific remaining sections of the above mentioned road network. In response to this request, the GOJ determined to provide technical assistance through the JICA.

The implementing arrangement for the said technical assistance was signed in August 1984 between the JICA and the GOP represented by the Ministry of Public Works and Highways (MPWH) as the implementing agency. The Study started in October 1984 and completed in June 1985.

2. OBJECTIVES OF THE STUDY

The objectives of the Study are to:

- 1) Assess the disaster potential and recommend countermeasures along the relevant project roads/sections.
- 2) Prepare a program for implementation for the disasters prevention.
- 3) Develop techniques of road disaster prevention.

3. PROJECT ROAD/SECTIONS

- 1) Lucena—Calauag Section (Region IV)
- 2) Allen—Calbayog Section (Region VIII)
- 3) Naguilian Road (Region I)

4. SCOPE OF THE STUDY

Subject to the Study are slope failures, rock falls, landslides, debris flow, scourings and other disasters on the said roads/sections. Large scale riparian and sabo works are excluded.

5. REPORTS

The following reports were prepared during the Study

INCEPTION REPORT
INTERIM REPORT
DRAFT FINAL REPORT

The Final Report was developed based on the GOP's comments on the draft final report, and presented in four (4) volumes as follows;

VOLUME I	:	EXECUTIVE SUMMARY
VOLUME II	:	TEXT
VOLUME III	:	APPENDIX
VOLUME IV	:	DRAWINGS

The Study was carried out jointly by a team composed of seven JICA experts and a group of GOP counterparts and support staff. Technical guidance in the conduct of the Study was provided thru periodic review by the Steering Committee of the Philippines and the Advisory Committee of Japan, both were especially created to oversee the overall implementation of the Study.

II FINDINGS AND RECOMMENDATIONS

II. FINDINGS AND RECOMMENDATIONS

IMPORTANCE OF ROAD DISASTER PREVENTION

The overall transport system of the country is highly dependent upon road transport which is at present catering for 97 percent of intra-island passenger and 60 percent of commodity transport demand. However, the efficiency of the system particularly with the role of the trunk roads is interfered due to road disasters, among others, causing substantial detrimental impacts upon the economic and socio activities of the nation.

The present restoration work of road damage caused by disasters is no more than a stopgap measure. If potential disaster spots are left alone without appropriate disaster prevention measures, the scope of potential disaster will be aggravated and some road sections are liable to be completely destroyed beyond economic restoration measures before long, resulting in necessitating huge government expenditures.

Measures to prevent disaster damage on trunk roads are, therefore, of a vital and urgent issue in view of the above.

PROMOTION OF ROAD DISASTER PREVENTION PROJECT

The existing trunk roads as developed have not been provided, if at all, significant protection against disasters, where these are required. Due to the susceptibility of the roads to disasters and in view of stern natural environment of the country, even the Maharlika Highway which is considered the most important trunk road has often been closed in many sections due to disasters and which have impaired the efficiency of the system during these periods.

Road disaster prevention project can secure the functions of these important roads by improving their reliability to the users. Such project will result in the ensurance against road closures with reasonable investments, which realizing the maximum effect of the huge amount of road development funds that have already been invested.

In this view, it is highly recommended that the road disaster prevention project should be positively considered and actively implemented.

1. BASIC INFORMATION

LENGTH OF STUDY SECTIONS

	Lucena-Calauag Section	Allen-Calbayog Section	Naguillian Road	Total
Section Length (km.)	95.7	72.9	47.2	215.8

NUMBER OF DESIGN DISASTER SPOTS

Type of Disaster	Lucena-Calauag Section	Allen-Calbayog Section	Naguillian Road	Total
Cut Slope Failure	1	1	5	7
Embankment Slope Failure	1	2	5	8
Fall	4	9	5	18
Landslide	1	—	—	1
Debris Flow	—	2	—	2
Total	7	14	15	36

PROJECT COSTS

Unit: Million Pesos

		Lucena-Calauag Section	Allen-Calbayog Section	Naguillian Road	Total	
November 1984 Price	Detailed Engineering	Foreign	—	—	2.97	
		Local/Tax	—	—	1.60	
		Total	—	—	4.57	
	Construction ^{1/}	Foreign	13.44	16.82	9.54	39.80
		Local/Tax	8.89	11.01	5.66	25.56
		Total	22.33	27.83	15.20	65.36
	Construction Supervision	Foreign	—	—	—	2.97
		Local/Tax	—	—	—	1.60
		Total	—	—	—	4.57
	Total	Foreign	—	—	—	45.74
		Local/Tax	—	—	—	28.76
		Total	—	—	—	74.50
Current Price ^{2/}	Detailed Engineering	Foreign	—	—	3.98	
		Local/Tax	—	—	2.97	
		Total	—	—	6.95	
	Construction	Foreign	19.98	25.01	14.19	59.17
		Local/Tax	18.53	22.95	11.79	53.27
		Total	38.51	47.96	25.98	112.45
	Construction Supervision	Foreign	—	—	—	3.98
		Local/Tax	—	—	—	2.97
		Total	—	—	—	6.95
	Total	Foreign	—	—	—	67.59
		Local/Tax	—	—	—	59.58
		Total	—	—	—	127.17

^{1/}Includes 10% physical contingency.

^{2/}1984 prices are escalated.

INTERNAL RATE OF RETURN

	Lucena-Calauag Section	Allen-Calbayog Section	Naguillian Road
IRR (%)	16.0	14.4	15.4

2. RECOMMENDATION

The evaluation for the three study sections have proven that the projects are technically, economically and financially feasible. The project evaluation result is summarized in Table-A.

It is, therefore, recommended that disaster prevention project on the three study sections be implemented in the earliest possible time. Any delay in the project implementation will just increase the disaster potential and will compound the seriousness of the existing condition which inevitably may result in more expensive restoration works and longer traffic shutdown, thereby, further incurring greater costs to the economy.

TABLE-A PROJECT EVALUATION

	Technical Evaluation	Economic Evaluation	Financial Evaluation
Lucena-Calauag Section	<ul style="list-style-type: none"> • 7 spots with high disaster potentials. • Fast aggravation of disaster condition because of limestone. • 8 days of traffic interruption a year. • Necessity of immediate restoration work. • Practically no detour road. 	<ul style="list-style-type: none"> • IRR = 16.0%. • Provided the only access to the Bicol Region. • Vitally supports socio-economic activities and development of Quezon Province and Bicol Region. 	<ul style="list-style-type: none"> • 3-year implementation period (mid 1988-mid 1991) assumed. • 1.5-year construction period 1990-mid 1991) assumed.
Allen-Calbaying Section	<ul style="list-style-type: none"> • 14 spots with high disaster potentials • Fast aggravation of disaster condition because of alternative layer of rocks. • 9 days of traffic interruption a year. • Necessity of chronic maintenance and restoration work. • No reliable detour road. 	<ul style="list-style-type: none"> • IRR = 14.4%. • The only trunk road in Samar Island. • Daily life of Northern Samar's citizens relied on. • Efficient operation of ferry service between Luzon and Samar depended upon. 	<ul style="list-style-type: none"> • Maximum annual financial requirement be 70.3 million pesos in 1990. • Maximum annual financial requirement of local portion estimated at 33.0 million pesos is within the Government funding capability.
Naguilian Road	<ul style="list-style-type: none"> • 15 spots with high disaster potentials. • Entire cut of road. • 4 days of traffic interruption a year. • Urgency of restoration work. • No access for inhabitants along road. 	<ul style="list-style-type: none"> • IRR = 15.4%. • Transportation of daily consumption goods in Baguio relied on. • Commuting of more than 3,400 workers and students depended upon. 	<ul style="list-style-type: none"> • Foreign funds for foreign cost component recommended.

3. PROJECT IMPLEMENTATION

Successive implementation of the Stage I Sections and the Stage II Sections is recommended. As construction work of Stage I Sections was targeted to be completed in 1990, it is recommended that construction work of the Stage II Sections be started in 1990. Recommended implementation schedule and annual financial investment program are shown in Table-B.

TABLE B IMPLEMENTATION SCHEDULE

		1985	1986	1987	1988	1989	1990	1991
Construction of Stage - I Sections								
Feasibility Study (This Study)								
Financial Arrangement for Implementation								
Detailed Engineering Study (10 months)								
Tender (6 months)								
Construction (20 months)								
Construction Supervision (20 months)								
Financial Requirement - November 1984 Price - (Unit : Million ¥)	Foreign Component				1.19 (1.54)	1.78 (2.44)	25.66 (37.27)	17.11 (26.34)
	Local/Tax Component				0.64 (1.14)	0.96 (1.83)	16.29 (33.03)	10.87 (23.58)
	T o t a l				1.83 (2.68)	2.74 (4.27)	41.95 (70.30)	27.98 (49.92)

Note: Figure in () shows financial requirement in current price.

Annual escalation rate (%)

Year	1985	1986	1987	1988	1989~1991
Foreign Component	7.5	7.0	6.0	6.0	6.0
Local Component	25.0	15.0	12.0	10.0	7.0

III SUMMARY

1. STUDY SECTIONS

For general location of the study sections, please see Figure 1.1 which also indicate basic information along the respective influence areas.

Lucena—Calauag Section

The Bicol Region in the southern most part of Luzon is connected by land transport with Metro Manila and the rest of the island only thru the Maharlika Highway. The project section, Lucena—Calauag Section is located at the gateway of the Bicol Region. Although there are other transport modes such as rail, sea and air, none of these pose any significant competition with road transport, despite the fact that there is only one road access to the region.

In actuality, the whole section is located in the province of Quezon within the Southern Tagalog Region. It starts from the southern end of South Sierra Madre Range in Lucena and extends up to the northern part of the Bondoc Peninsula in Calauag. The whole section is approximately 96 km. The Philippine Fault runs on the east of the Bondoc Peninsula and by Calauag. The section between Pagbilao—Atimonan runs through a rolling or mountainous terrain for about 30 kilometers. The spots with high disaster potential are concentrated in this mountainous section. Other than this mountainous section the topography of the section is generally flat.

The geology of this section is generally made up of the rocks formed during the Oligocene era, when land upheavals and submergences formed the present shape of the Philippines. They are chiefly sandstone and limestone and occasionally andesite and mudstone.

The broad influence area considered for this section covers about 650 kilometers from Metro Manila to the southern end of Bicol Region.

This section is functioning as a major inter-regional trunk road with heavy passenger and commodity movements serving long distance trips.

Allen—Calbayog Section

This section is located in the Samar Island along the existing coastal alignment starting from Allen to the outskirts of Calbayog City, extending about 73 km. The Samar Island generally consists of hills at an elevation of about 800 meters above sea level without any obvious range and a developed coastal terrace.

The geology of this section is mainly sandstone, with some limestone, andesite and shale. Sandstone is of an old origin, dating back to the Mesozoic Cretaceous to the Palaeogene, and is therefore hard but has developed cracks caused by the diastrophism which continued for a long time. Thus, the sandstone is prone to fall in large pieces.

Again, the Maharlika Highway which includes the Allen—Calbayog Section is the trunk road in Samar Island which also serves as the main route linking the Island with Luzon and Leyte Islands. The influence area considered in the assessment of the section has been limited to Northern Samar, Western Samar and Northern Leyte areas only.

At present, the section is functioning as a secondary trunk road. However, when the development efforts currently pursued by the Government for depressed areas of Samar and Leyte would have been realized, the interlinkages between these islands with the rest of the country and that of Metro Manila will certainly become more important and thus the section will consequently function as a major inter-regional trunk road in the network.

Naguillian Road

The Naguillian Road is situated in the northern part of Luzon Island. It is one of the three roads leading to Baguio City, the summer resort of the country. It starts in Bauang, La Union and runs through a rolling terrain for about 16 kilometers and from there on to Baguio City it runs through a mountainous area for about 31 kilometers with difference in elevation of about 1400 meters. With the torrential rains peculiar to Baguio area, moreover, slope failures have been experienced as the road was constructed mostly on the steep mountain slopes.

The geology of this section is chiefly tuff, tuff breccia, conglomerate, limestone and sandstone.

Although this road can be classified only as a secondary trunk road due to predominant medium distance traffic which is mainly between Baguio City and San Fernando, La Union, this road, nevertheless, has a very important role to the overall transport demand of the areas served. It is this road that is mainly used for the transport of bulk cargoes to and from Baguio City. Furthermore, of the three roads leading to Baguio City, namely the Kennon Road, the Agoo-Baguio Road and the Naguillian Road, the Naguillian Road offers better geometrical standard and at present the most stable route in terms of road disasters.

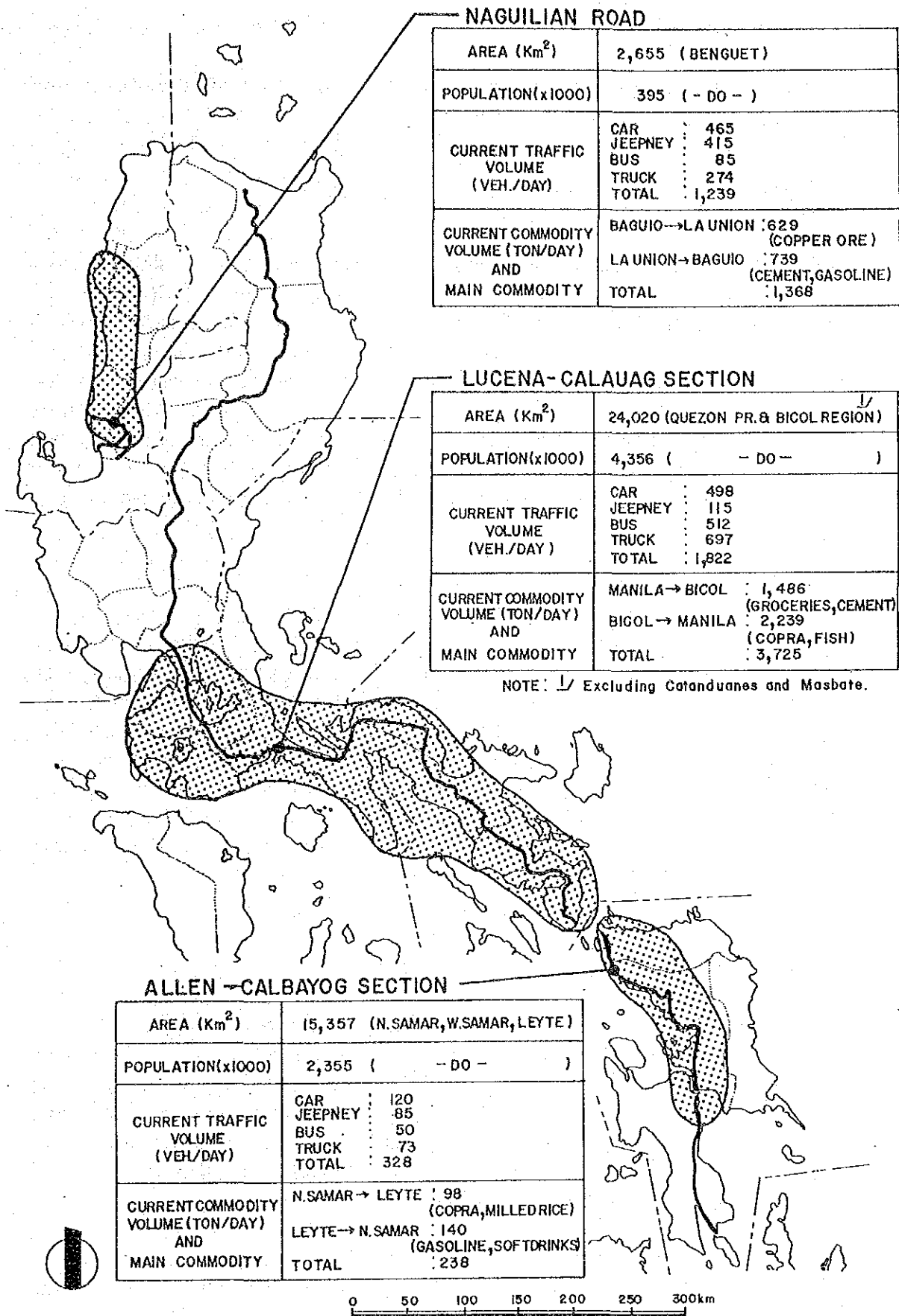


FIGURE 1-1 INFLUENCE AREA OF STUDY SECTION

2. FUTURE TRAFFIC

Figure 2-1 presents in graphical form the estimated present and future traffic and commodity volume along the study sections.

Lucena—Calauag Section

The current traffic through the Pagbilao—Atimonan Sub-section is 1,822 vehicles/day. This traffic is estimated to increase at an average annual growth rate of 4.8 percent during the period of 1984—2015. Traffic volume will therefore, reach about 7,700 vehicles/day in the year 2015. Growth of traffic during the 1990s and thereafter is expected to be slightly higher than in the 1980s. This based on the assumptions that the overall trend of the Philippine economy in the 1980s will be the decade for transition period for economic recovery and the economy will remain stable after 1990. The present volume of commodity transported is about 3,725 tons/day. This is estimated to increase to 16,807 tons/day in the year 2015.

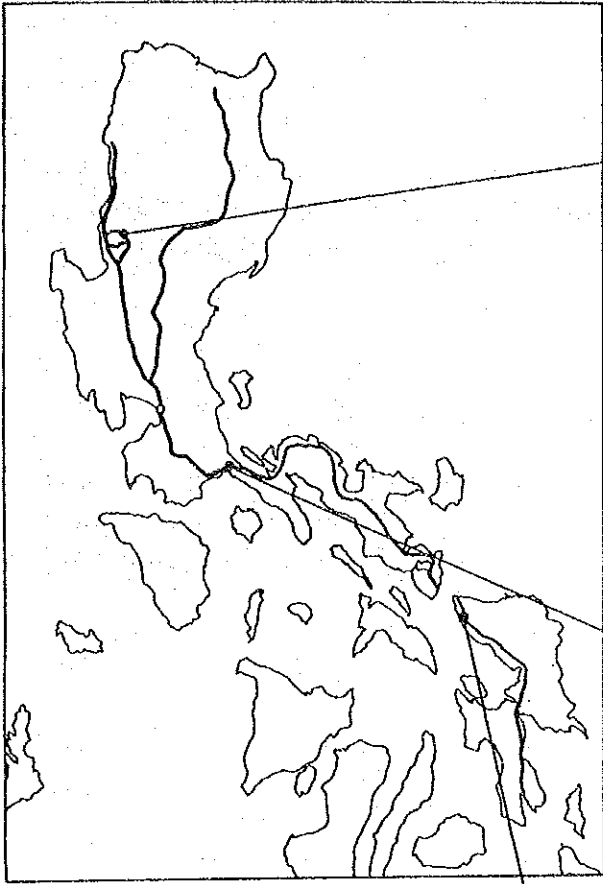
Allen—Calbayog Section

The present traffic passing thru the Allen—Calbayog Section is relatively low at about 328 vehicles/day. It is however expected to increase at an average annual growth rate at 5.3 percent up to year 2015 when the traffic at that time is estimated to be about 1,600 vehicles/day. Although the growth of passenger car traffic is higher than that of other vehicles types, over 80 percent of passenger transport on this section will still rely on the public transportation up to year 2015. Commodity flow through this section is currently about 238 tons/day. This is expected to increase at 5.5 percent average annual growth rate up to year 2015 when the volume of commodity transported would then be about 1,245 tons/day.

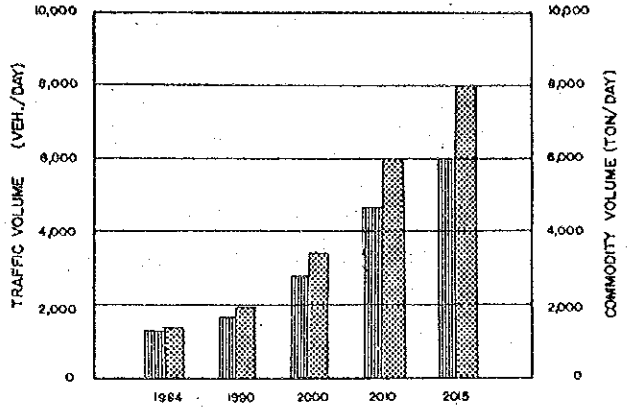
Naguilian Road

The current traffic on the Naguilian Road is about 1,239 vehicles/day which is increasing at an average annual growth rate of 5.2 percent up to the year 2015. This will mean that by year 2015 an average 6,000 vehicles/day would be travelling along the project section. The traffic capacity of the Naguilian Road is rather small compared to the ordinary two-lane roads due to its narrow roadway width and steep vertical gradient. Traffic volume of 6,000 vehicles/day in 2015 will be closed to the maximum traffic the road would be able to accommodate.

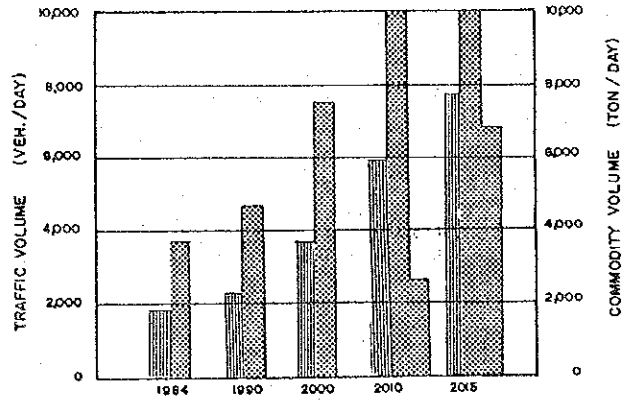
The current commodity flow of 1,368 tons/day will increase to 7,935 tons/day in the year 2015. Average annual growth rate of 5.8 percent will be the highest among three Study Sections.



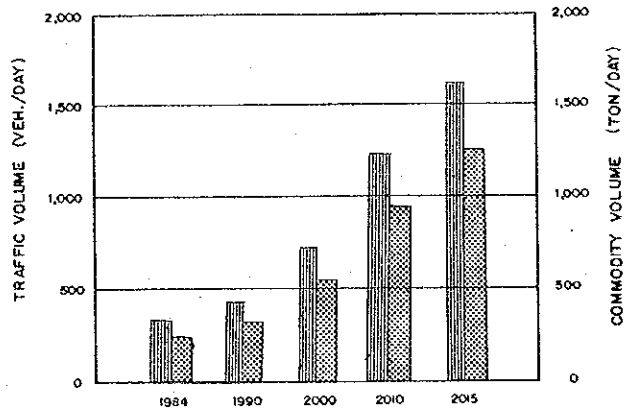
NAGUILIAN ROAD



LUCENA - CALAUAG SECTION



ALLEN - CALBAYOG SECTION



LEGEND :
 COMMODITY VOLUME (stippled pattern)
 TRAFFIC VOLUME (vertical lines pattern)

FIGURE 2-1 FUTURE TRAFFIC/COMMODITY VOLUME

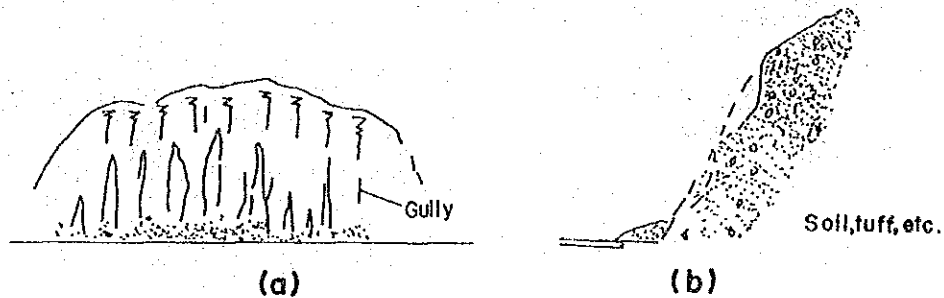
3. IDENTIFICATION OF ROAD DISASTERS

3.1 TYPES OF ROAD DISASTERS

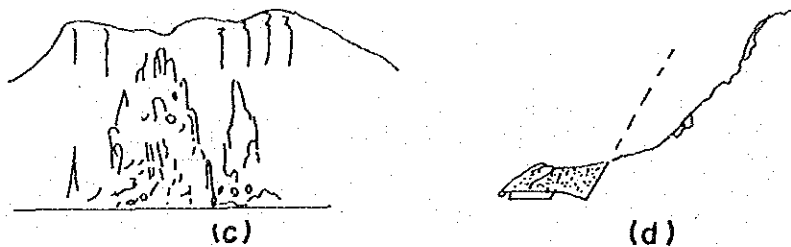
Road disaster were classified into five types based generally on the shapes of failures which were assessed through visual inspection and land and geo-technical surveys.

Cut Slope Failure

This type is sub-classified into surface and deep failures. Surface failures are generally caused by erosion, weathering and structural weakness while deep failures are caused by scouring, rotational and translation failures. See Figure 3-1.



Surface Failure due to erosion



Deep Failure due to scouring

FIGURE 3-1 CUT SLOPE FAILURE

Embankment Slope Failure

This type is sub-classified into surface failure due to erosion and deep failure due to scouring and saturation. See Figure 3-2.

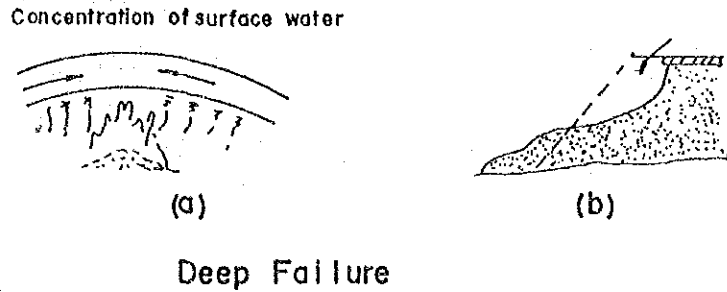


FIGURE 3-2 EMBANKMENT SLOPE FAILURE

Fall

This type is sub-classified into rock and debris falls. The former is free fall of rocks detached from bedrocks, while the latter is that of unsupported pebbles, cobbles, and boulders on a slope. See Figure 3-3.

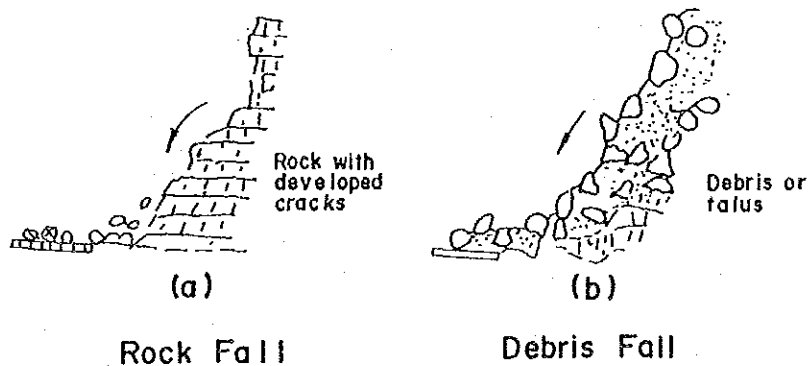


FIGURE 3-3 FALL

Landslide

Landslide is caused by loss of balance between shear strength of materials and movement force along a specific slide plane. This type is sub-classified into rock and soil landslides. See Figure 3-4.

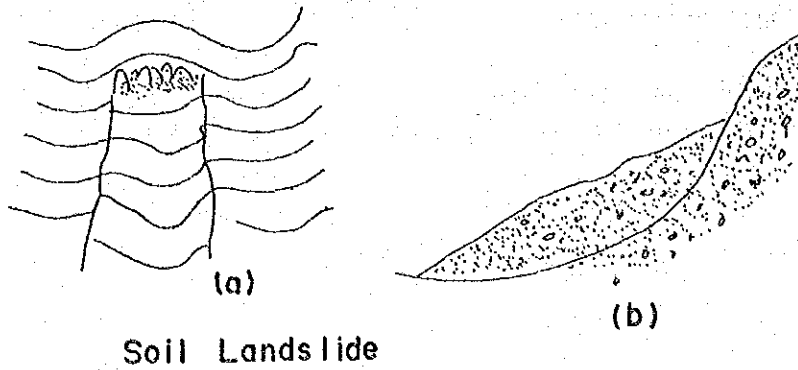


FIGURE 3-4 LANDSLIDE

Debris Flow

Debris flow is induced by a force of flow caused by floods where there exist deposits on torrent or riverbed. This type is sub-classified into debris and mud flows. See Figure 3-5.

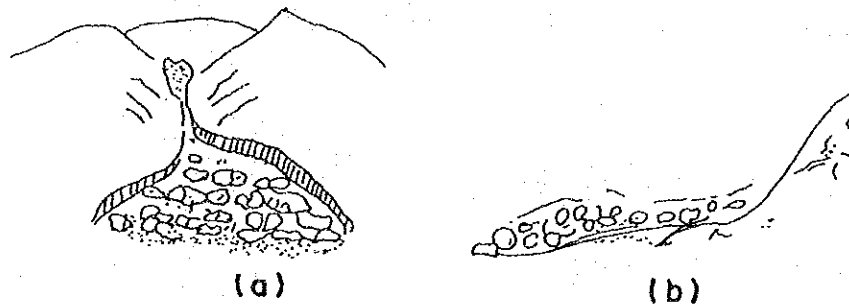


FIGURE 3-5 DEBRIS FLOW

3.2 DISASTER POTENTIAL

Each spot identified was ranked into three categories. Category A (Heavy), Category B (Medium) and Category C (Small) giving emphasis on the impact of the disaster on traffic. The criteria adopted in determining the disaster potential are shown in Table 3-1.

TABLE 3-1 CRITERIA FOR DISASTER POTENTIAL

IMPACT	Type of Disaster		
	Cut Slope Failure, Landslide, Debris Flow, etc.	Rock Fall	Embankment Slope Failure
Category A (Heavy) (Urgent countermeasure is required)	<ul style="list-style-type: none"> Failure or moved material may cover full lanes of pavement. Expected to be closed to traffic. 	<ul style="list-style-type: none"> Fallen materials may cover full lanes or large sized rocks (more than 50cm) may fall to part of carriageway. 	<ul style="list-style-type: none"> Pavement structure may collapse.
Category B (Medium) (Urgent countermeasure is required)	<ul style="list-style-type: none"> Failure or moved materials may cover about one lane. 	<ul style="list-style-type: none"> Fallen materials with size of less than 50cm may cover about one lane. 	<ul style="list-style-type: none"> Shoulder may fully collapse.
Category C (Small) (No urgent countermeasure is required.)	<ul style="list-style-type: none"> Failure or moved materials may not extend to carriageway. 	<ul style="list-style-type: none"> Fallen materials may not extend to carriageway 	<ul style="list-style-type: none"> Shoulder may partially collapse.

3.3 DISASTER SPOTS IDENTIFIED

Disaster potential spots were identified thru actual field investigation considering the following items.

- Height and gradient of slope
- Types of rocks
- Conditions of weathering, cracks, joints and faults
- Thickness and compactness of topsoil
- Degree of water saturation of slope
- Existence of seepage water
- Influence of force of waves from sea or stream
- Evidence and scale of past disaster

A total of 123 disaster potential spots, 38 along the Lucena—Calauag Section, 41 along the Allen—Calbayog Section and 44 along Naguilian Road were identified as shown in Table 3-2.

**TABLE 3-2 SUMMARY OF DISASTER SPOTS
BY TYPES OF DISASTER AND DISASTER POTENTIAL**

	Disaster Potential	C-S.F. D.F.	F-S.F.D.F.	C-F	L.S.	D.F	Others	Total
Lucena-Calauag Section	H	1	—	2	—	—	—	3
	M	—	2	2	1	—	—	5
	S	16	4	10	—	—	—	30
	Total	17	6	14	1	—	—	38
Allen-Calbayog Section	H	—	2	2	—	—	—	4
	M	1	3	7	—	2	—	13
	S	3	2	19	—	—	—	24
	Total	4	7	28	—	2	—	41
Nagullian Road	H	2	—	1	—	—	—	3
	M	3	8	4	—	—	—	15
	S	13	6	7	—	—	—	26
	Total	18	14	12	—	—	—	44
Grand Total	H	3	2	5	—	—	—	10
	M	4	13	13	1	2	—	33
	S	32	12	36	—	—	—	80
	Grand Total	39	27	54	—	2	—	123

Type of Disaster

(1) Cut Slope Failure
C-S.F. = Surface Failure
C-D.F. = Deep Failure

(2) Embankment Slope Failure
E - S.F. = Surface Failure
E - D. F = Deep Failure

(3) Fall
C-F
(4) Landslide
L.S
(5) Debris Flow
D.F.
(6) Others

Disaster Potential

H : Heavy
M : Medium
S : Light

Shown in Figure 3-6 is the number of cut slope failures and falls with the disaster potential of Heavy and Medium in relation to kinds of rocks. This number do not tally with the number of disaster spots because slope is often composed of more than two kinds of rocks.

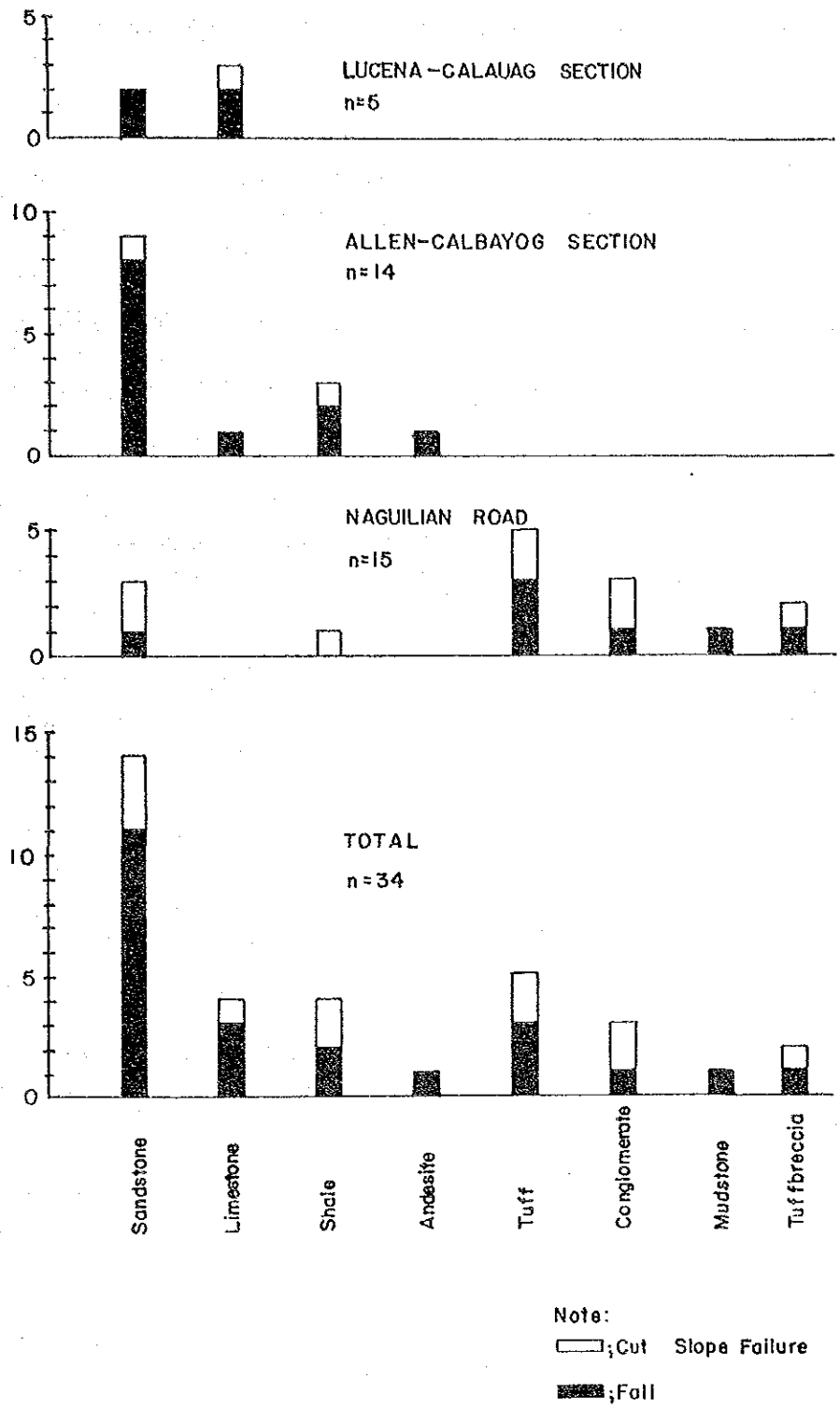


FIGURE 3-6 NUMBER OF CUT SLOPE FAILURES AND FALLS AND KINDS OF ROCKS

4. EXISTING CONDITIONS AND CAUSES OF ROAD DISASTERS

4.1 EXISTING CONDITIONS OF ROAD DISASTERS

Lucena—Calauag Section

Since the opening of the Pagbilao—Atimonan sub-section in the section in 1979, substantial damages on the section were attributed not only to pavement deterioration but failures of cut and embankment slopes and falls of severely weathered limestones. The number traffic interruptions is reported to be an average of about 8 days a year.

The topography of this section is generally flat with exception of rolling or mountainous terrain from Pagbilao to Atimonan. The geologic formation is of sandstone and limestone and occasionally andesite and mudstone. These bedrocks, especially limestone are severely weathered and feared to collapse in the future.

Most of 38 disaster spots identified in this section are located in the Pagbilao—Atimonan sub-section (about 30 kilometers). The disaster spots density in this sub-section (the number of disaster spots per kilometer) is 1.13 spots per kilometer.

Moreover, of 38 disaster spots, eight spots are considered of the Heavy (H) and Medium (M) category requiring urgent implementation of countermeasures. These type of spots are concentrated within the old zigzag road section which extends only for about 9.6 kilometers. The disaster density of H and M in this particular sub-section is 0.83 spots per kilometer.

Of the eight disaster spots mentioned, fall is dominant in four spots, followed by embankment slope failures in two spots and cut slope failure and landslide in one spot each.

Occurrence of a large number of fall is mainly due to severely weathered limestone with developed cracks. The sizes of fallen rocks are 1.5 to 2.5 meters. More of these failures are feared to occur in the future.

The embankment slope failures are mainly caused by scouring due to the concentration of surface water, particularly at inner curves of roads with steep vertical gradients. Side ditches are recommended to be adequately constructed.

Allen—Calbayog Section

After the improvement of the section in 1978, the section was exposed to the danger of rock falls. This type of disaster has often caused the interruption of traffic flow at an average of 9 days a year specially after heavy rains and typhoons. The majority of slopes still seem to be unstable.

This section can be divided into the moderately hill segment that passes through the foot of Samar's central range and the flat coastal terrace segment passing along the coast. The geology is of sandstone, shale, andesite and limestone with folds and faults. These rocks have many developed cracks and are highly weathered. The sandstone is prone to fall in large sizes.

The 41 disaster spots identified along the section are almost equally scattered between San Isidro (km. 686 + 500) and Tinambacan (km. 723 + 300) with disaster spot density of 1.11 spots per kilometer.

Of the total number, 17 spots were evaluated of the Heavy and Medium category which require the immediate application of countermeasures.

By type of disaster belonging to the H and M spots, fall is predominant in nine spots, followed by embankment slope failure, debris flow and cut slope failure with 5, 2 and 1 spots, respectively.

The majority of fall occurred on cut slopes of highly weathered sandstone with developed cracks. Most of fallen rocks are 30 to 50 centimeters in size but occasionally over 3 meters. These falls may continue if no countermeasures are applied.

Almost all embankment slope failures observed along the coastline are caused by scouring due to sea waves and flood water.

Naguilian Road

Disasters along this road must have occurred many times during the last 64 years since its completion in 1919. Although no accurate records are available, it is predicted that disasters occurred at an average of two times a year causing traffic interruption for 4 days.

The road runs in rolling areas for about 17 kilometers from the town of Bauang and the rest of the section as it proceeds towards Baguio City through steep mountainous terrain. The geology of this road is chiefly tuff, tuff breccia, conglomerate limestone and sandstone.

Of the total of 44 disaster spots recorded, there are only four disaster spots in the rolling area, while 40 spots are in the remaining mountainous section with approximately 30 kilometers. The disaster density is 0.24 in the former and 1.33 in the latter.

A total of 18 disaster spots are classified of the Heavy and Medium category. Embankment failures are dominant amounting in eight spots, followed by five spots each respectively of cut slope failure and fall.

In this road, embankment slope failures means the collapse of stone masonry applied to embankment slopes at the valley side. These failures were observed widely in several spots and are feared increase along the road in the future.

Cut slope failures and falls were observed on slopes composed of hard rocks such as tuff, tuff breccia and conglomerate.

4.2 CAUSES OF ROAD DISASTERS

Cut Slope Failure

Cut slope failures were observed in all the mountainous sections of the three Study sections, especially in the Lucena—Calauag section and Naguilian Road. These sections have many high cut slopes with the rocks highly weathered and fractured due to faults.

This type of failure has been observed to be predominant on slopes of soil and rock such as diabase, andesite, limestone, sandstone, mustone, tuff, tuff breccia, conglomerate, etc. Nearly all of cut slope failures observed were due to the effect of unabated water flow. Many were caused by erosion or scouring resulting from the flow of surface water during rainfalls, and some by groundwater seepage.

As noted, the failures could not have been prevented because of the following deficiencies.

- No drainage facilities to prevent erosion and scouring due to heavy rain.
- No berms on high slopes to ease velocity of surface water.
- No slope protections by vegetation and the like.

Embankment Slope Failure

This type of failure was also observed widely along the project roads, especially at the spots with the following topographical conditions: i) spots inside the curve with the steep gradient, ii) sections along sea coast and river and iii) approach sections of bridges.

Embankment failures were generally attributed to scouring and, therefore, the failures frequently occur due to the following reasons:

- Inadequate drainage facilities in terms of number and capacity
- Inadequate connections and protections at the outlet of cross drain facilities
- No or inefficient protections of slopes.

Fall

The predominant type of disaster observed along the project section is fall. Falls are categorized into debris falls and rock falls, but all falls in the study sections are rock falls. Falls mainly occur in the slopes composed of debris or diorite, andesite, sandstone, conglomerates, limestone, etc. Slopes of highly weathered or fractured rocks usually produced cut slope failure, while falls mainly occur on slopes of hard rock with developed open cracks or on slopes with (alternative of) different rocks layers.

Most of the fallen rocks were 30 to 50 centimeters in size, but occasionally over 3.0 meters were seen on the Allen-Calbayog section and the Lucena-Calauag section. The deficiencies which may have caused the failure are similar to those mentioned in cut slope failure.

Landslide

Landslides are classified into soil and rock landslides, but only soil landslide at one spot in the Lucena-Calauag section was noted among the Study sections. The landslide at this spot is a movement of a thick layer of soil covering over the bedrock. Judging from the land formation in which surface water easily concentrates, the landslide is due to the affect of uncontrolled surface water flow.

Debris Flow

Debris flows are classified into debris flow and mud flows. There are only two spots of debris flows identified along the Study sections and both are debris flow types. These are located in the Allen-Calbayog section.

At a spot, a large quantity of spring water was observed at the toe of the slope and, therefore, the debris flow is likely to have been caused by the high level of groundwater. Debris flow at the another spot is caused by torrent due to the absence of countermeasures such as cross drains, water ways, small scale sabo dam etc.

5. RECOMMENDED COUNTERMEASURES

5.1 Design Spots

The disaster spots requiring urgent countermeasure work and where the design of the proposed countermeasures were prepared are shown in Table 5-1.

Some spots where countermeasures are being implemented or require large scale riparian were excluded from design.

TABLE 5-1 DESIGN SPOTS

Type of Disaster	Lucena-Calauag Section	Allen-Calbayog Section	Naguilian Road	Total
Cut Slope Failure	1	1	5	7
Embankment Slope Failure	1	2	5	8
Fall	4	9	5	18
Landslide	1	—	—	1
Debris Flow	—	2	—	2
Total	7	14	15	36

5.2 Policies for Countermeasure Selection

Various countermeasures commonly adopted in other countries have been studied in accordance with the types and the causes of disasters. These were closely examined with regard to effectiveness and practicability in this country.

The proposed countermeasures were selected in due consideration of geology, topography, surface water, groundwater and other condition of each disaster spot. In addition to these local conditions, the following policy considerations were also taken in the selection of countermeasure:

- Introduction of new technology on disaster prevention
- Minimal traffic obstruction during construction
- Harmony with the environment
- Minimal maintenance work

5.3 TYPES OF APPLIED COUNTERMEASURES

Table 5-2 shows the number of countermeasures by section and type of disaster in relation with type of countermeasures adopted in the study.

TABLE 5-2 NUMBER OF APPLIED COUNTERMEASURES

SECTION	DISASTER		APPLIED COUNTERMEASURES													TOTAL	
	TYPE	SPOT NUMBER	EARTH WORK		DRAINAGE WORK		PROTECTION WORK		CATCH WORK		STRUCTURE WORK			TORRENT WORK			AVOIDING WORK
			REMOVAL/RE-CUTTING	RE-FILLING	SURFACE DRAIN	SUB-SURFACE DRAIN	VEGETATION	CONCRETE SPRAYING	ANCHOR WIRE NET	CATCH WALL	STONE MASONRY R.W.	GRAVITY TYPE R.W.	ANCHORING	STONE PITCHING WATER WAY	GABION F.P.		RE-ALIGNMENT
LUCENA-CALAUAG SECTION	C-SF, DF	1	1	-	1	-	-	-	-	1	-	-	-	-	-	1	4
	E-SF, DF	1	-	1	1	-	-	-	-	-	1	-	-	-	-	-	3
	C-F	4	4	-	4	-	-	2	-	2	-	-	1	-	-	2	15
	L.S	1	1	-	1	-	1	-	-	-	-	-	-	1	-	-	4
	D.F	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	SUB-TOTAL	7	6	1	7	0	1	2	0	3	1	0	1	1	0	3	26
ALLEN-CALBAYOG SECTION	C-SF, DF	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	2
	E-SF, DF	2	-	2	-	-	-	-	-	2	1	-	-	1	-	-	6
	C-F	9	9	-	9	-	-	3	1	7	-	-	-	-	-	5	34
	L.S	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	D.F	2	2	-	2	1	1	-	-	1	-	-	-	2	-	-	9
	SUB-TOTAL	14	12	2	12	1	1	3	1	8	2	1	-	2	1	5	51
NAGUILIAN ROAD	C-SF, DF	5	4	1	5	-	2	-	2	1	1	1	1	1	-	-	19
	E-SF, DF	5	-	5	5	-	-	-	-	-	5	1	-	-	-	-	16
	C-F	5	5	-	5	-	-	1	3	-	-	-	1	-	-	-	15
	L.S	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	D.F	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	SUB-TOTAL	15	9	6	15	0	2	1	5	1	6	2	2	1	0	0	50
TOTAL	C-SF, DF	7	6	1	7	-	2	-	2	2	1	1	1	1	-	1	25
	E-SF, DF	8	-	8	6	-	-	-	-	-	8	2	-	-	1	-	25
	C-F	18	10	-	18	-	-	6	4	9	-	-	2	-	-	7	64
	L.S	1	1	-	1	-	1	-	-	-	-	-	-	1	-	-	4
	D.F	2	2	-	2	1	1	-	-	1	-	-	-	2	-	-	9
	TOTAL	36	27	9	34	1	4	6	6	12	9	3	3	4	1	8	127

NOTE :

TYPE
OF
DISASTER

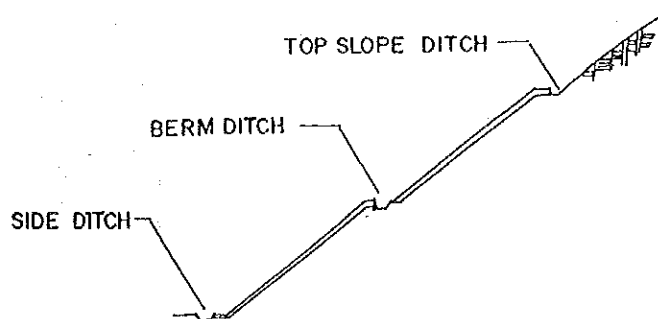
C-S.F, D.F Cut slope surface failure, deep failure
 E-S.F, D.F Embankment slope surface failure, deep failure
 C-F Cut slope rock fall
 L.S Landslide
 D.F Debris flow
 R.W RETAINING WALL
 F.P FOOT PROTECTION

5.4 TYPICAL COUNTERMEASURES

The following are typical countermeasures adopted in the Study.

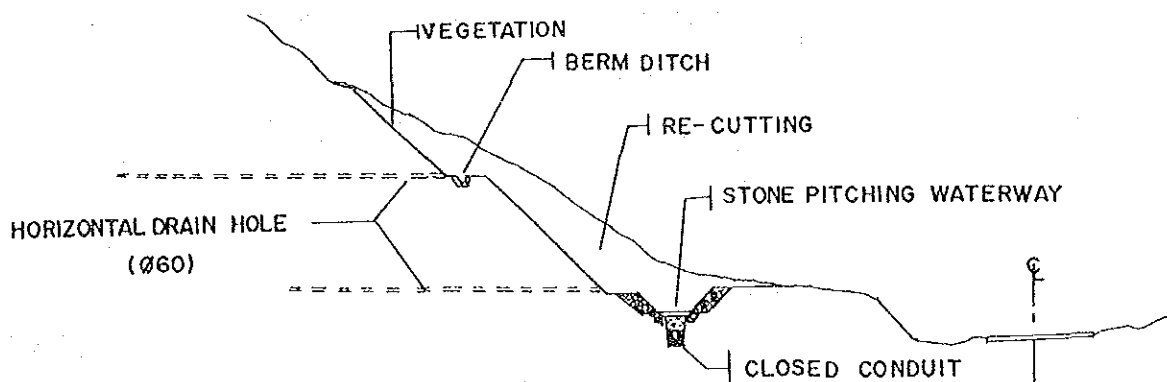
Surface Drain

The main cause of cut slope and embankment slope failures is surface water. Various kinds of ditches were applied in many sections. Top slope ditches were placed where running water from adjacent hinterland area was expected and berm ditches adopted everytime berms were proposed. Side ditches were applied as a prerequisite in all disaster spots because of the non-existence of drainage facilities.



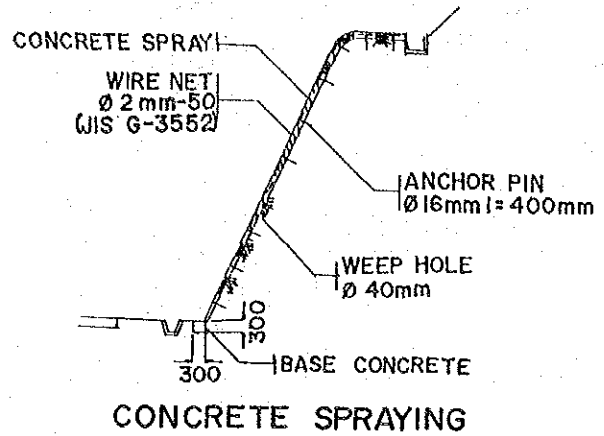
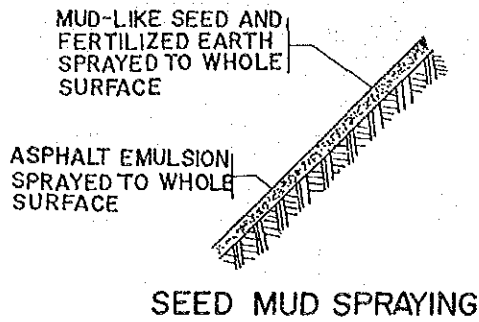
Subsurface Drain

Horizontal drain hole and closed conduit were applied to check debris flow where the level of groundwater seems to be high and seepage water was observed.



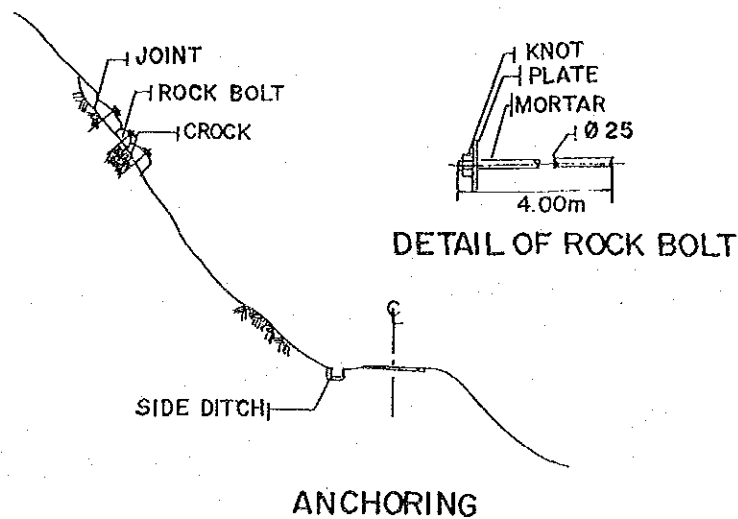
Slope Protection

Except on slopes composed of hard rock not susceptible to erosion and scouring, protection works were generally applied for all kinds of slope. Slope protection with vegetation was applied for the slopes with soil and weathered rocks where vegetation can grow. For other slopes, concrete spraying was applied.



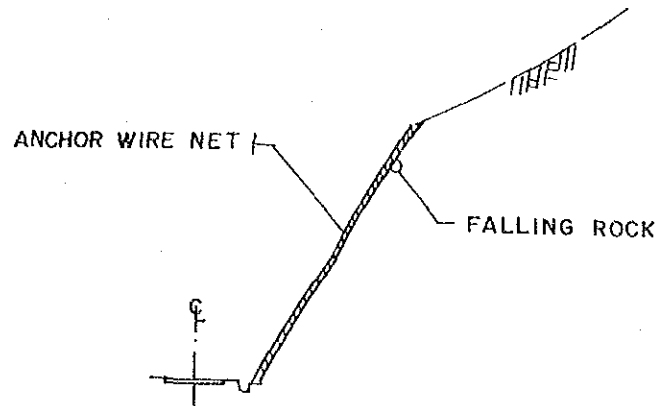
Anchoring

Unstable rocks susceptible to fall on slopes were proposed fixed to the bedrocks by anchoring with rockbolts. This measure was applied on slopes where big size but few number of rocks exist.



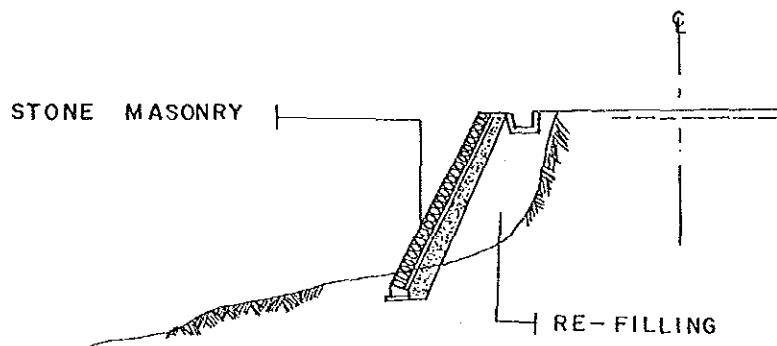
Anchor Wire Net

For slopes where small size but many unstable materials exist, anchor wire net was applied. Since this type cannot provide a completed protection for the prevention of erosion and scouring of slope surface, this was adopted mainly on slopes composed of hard rocks.



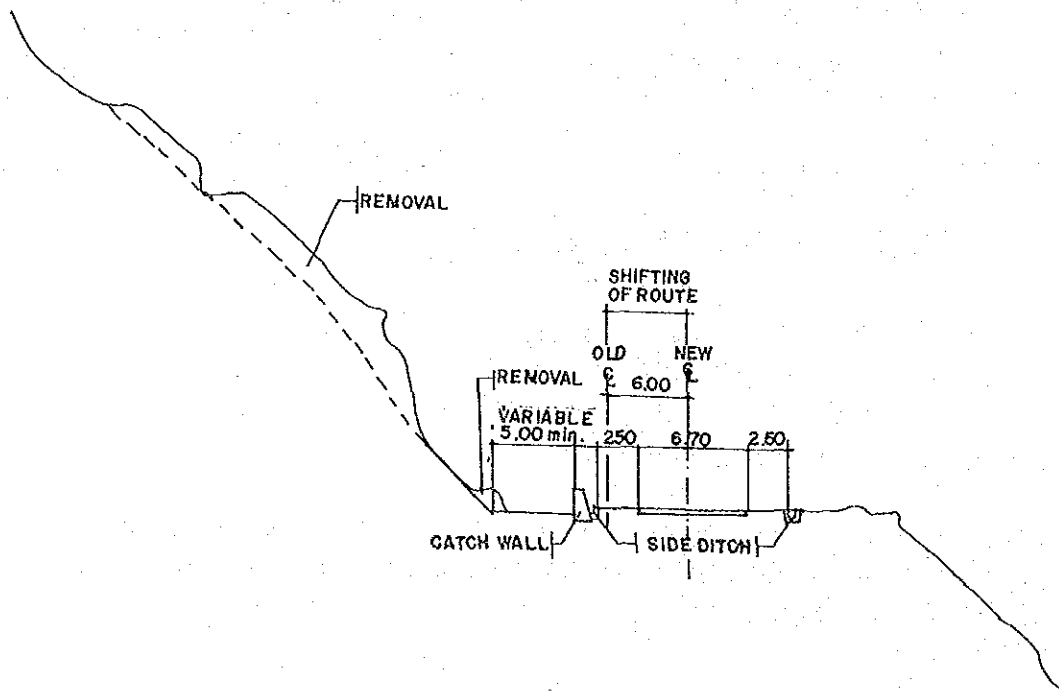
Stone Masonry Retaining Wall

For steep embankment slopes where the slope gradient cannot be improved, stone masonry retaining wall with re-filling was applied. It should be noted that side ditches were invariably provided at these spots.



Re-alignment with Catch Wall

Re-alignment was positively applied at the spots where there is enough flat space to allow shifting of the existing road. This is almost always more economical than the slope protections applied directly on slope. The maximum shift adopted in the study was six meters. Catch walls were always used to prevent spreading of damage due to falling rocks.



6. PROJECT COST

The project costs were estimated based on a unit cost analysis in November 1984 prices. The aggregate total cost of the three sections was estimated at 74.50 million pesos; of which foreign currency component amounts to 45.74 million pesos (61%) and local currency component including taxes to 28.76 million pesos (39%).

Construction cost of the countermeasures along Lucena-Calauag section was estimated at 22.33 million pesos; the Allen-Calbayog section at 27.83 million pesos; and the Naguillian Road at 15.20 million pesos. Major countermeasures applied were re-alignment method and concrete spraying both for the Lucena-Calauag section and the Allen-Calbayog section, and stone masonry retaining wall and anchor wire net for the Naguillian Road.

The cost for detailed engineering and construction supervision services were estimated respectively at 7% of the construction cost.

TABLE 6-1 PROJECT COST

Unit: Million Pesos

	November 1984 Price			Current Price ^{2/}		
	Foreign	Local/Tax	Total	Foreign	Local/Tax	Total
Detailed Engineering Construction ^{1/}	2.97	1.60	4.57	3.98	2.97	6.95
• Lucena-Calauag	13.44	8.89	22.33	19.98	18.53	38.51
• Allen-Calbayog	16.82	11.01	27.83	25.01	22.95	47.96
• Naguillian	9.54	5.66	15.20	14.19	11.79	25.98
• Sub-Total	39.80	25.56	65.36	59.17	53.27	112.45
Construction Supervision	2.97	1.60	4.57	4.43	3.34	7.77
Total	45.74	28.76	74.50	67.59	59.58	127.17

^{1/}Includes 10% physical contingency.

^{2/}1984 prices are escalated. For escalation rate, See Figure 8-1.

7. PROJECT EVALUATION

The feasibility of the projects was evaluated mainly from the viewpoints of technical, economic and financial viability but considering as well in the final analysis the various socio-economic impacts contributed by the project.

7.1 Technical Evaluation

Lucena—Calauag Section

- Of the total of 38 disaster spots, 8 are with high disaster potential.
- Limestone, the predominant type of a rock in this Section, is easily weathered, therefore, slope conditions will be quickly aggravated.
- An average number of traffic interruption is estimated to be eight days per year.
- The detour route of this Section is very substandard with many hairpin curves, steep gradients of nearly 10% and narrow roadway width of 5.0 to 6.0 meters.

Allen—Calbayog Section

- Of the total of 41 disaster spots, 17 are with high disaster potential.
- The formation of most of slope bedrocks sandwiches weak strata between sandstone layers, thus slope condition will likely to become worse year by year.
- An average number of traffic interruption is estimated to be nine days per year.
- The 21 temporary bridges along the detour route cannot allow heavy vehicles (buses and trucks) to pass.

Naguilian Road

- Of the total of 44 disaster spots, 18 are with high disaster potential.
- Due to the narrow roadway and shoulders, even a small scale road disaster greatly affects traffic flow. Road users are always exposed to danger of being hit by falling rocks and the like.
- An average number of traffic interruption is estimated to be four days per year.

- The capacity of the Kennon Road which functions as a detour road, will not be sufficient enough to accommodated detour traffic from the Naguillian Road after year 2000.

7.2 Economic Evaluation

Quantifiable benefits were mainly derived from savings on reduced vehicle operation costs, traffic efficiency and from restoration maintenance related costs savings, as mentioned below. The assessment of the unquantifiable benefits from the projects is discussed under the Socio-economic Impact Evaluation.

Project Contribution	Quantified Benefits
<ul style="list-style-type: none"> • No traffic interruption • Improved vehicle running condition • No restoration work 	<ul style="list-style-type: none"> • Savings in detour Cost • Savings in commodity opportunity Cost • Savings in traffic accident cost • Savings in travel time cost • Savings in restoration cost

- **Savings in Detour Cost**

Savings in detour cost were estimated based on assessments of the kinds of detour trips, detour lengths, duration of traffic interruption, future traffic volume and basic vehicle operation costs.

- **Savings in Commodity Opportunity Cost**

When cargo truck trips are stopped or delayed due to road disasters, commodities will not be used as scheduled which means they lose opportunity cost. The implementation of this project will eliminate such situations.

Savings in commodity opportunity cost of the Study section were considered negligible. The additional time due to detour is not considerable for both the Lucena-Calauag section and the Naguillian Road. Similarly the small commodity volume on the Allen-Calbayog section is negligible.

- **Savings in Traffic Accident Cost**

The implementation of this Project will reduce the number of traffic accidents caused by road disasters. This benefit can be quantified according to the traffic accident records. However, there are very a few traffic accident records on the Study Section caused by road disaster. Therefore, this benefit was considered negligible.

- **Savings in Travel Time Cost**

Savings in travel time cost is quantified from the amount of reduced travel time as a result of the project. The travel speed of vehicles is suppressed due to the insecurity of the environment. Delays are also encountered during restoration works of damaged sections are carried out. With the project which will not only secure physically the environment will also give the drivers more confidence while negotiating the route, thus, will result in faster travel speeds.

- **Savings in Restoration Cost**

Based on estimated scale of damage by a typhoon attack pattern, average annual cost for restoration work was calculated. Estimated costs were compared with previous Government expenditures on restoration works in similar situations.

A 20-year project life was assumed in the analysis. The results of the cost benefit analysis and sensitivity are presented in Table 7-1.

TABLE 7-1 RESULTS OF ECONOMIC ANALYSIS
Internal Rate of Return

		%		
		Lucena- Calauag Section	Allen- Calbayog Section	Naguillian Road
Best Estimate Case		16.04	14.37	15.43
	Case-1 (Cost -20%)	20.02	18.21	19.16
	Case-2 (Cost + 20%)	13.18	11.60	12.73
	Case-3 (Benefit + 20%)	19.25	17.44	18.44
Sensitivity Tests	Case-4 (Benefit -20%)	12.55	10.99	12.20
	Case-5 (Cost -20% Benefit + 20%)	23.75	21.78	22.63
	Case-6 (Cost + 20% Benefit -20%)	10.04	8.56	9.81

7.3 Financial Evaluation

The maximum budget allocation for the local cost component in a single foreign assisted highway project was 253 million pesos in 1983 and 144 million pesos in 1984, which was equivalent to about 1/12 and 1/15 of the total budget for construction and improvement of major road, respectively.

The ratio of the possible allocation for the local cost component in a single project to the total yearly budget for major roads is estimated at 1/18, 1/30 and 1/50 for high, medium and low assumptions, respectively. The medium assumption of 1/30 is taken as the most realistic.

The total yearly budget for major roads was based on the MPWH Medium Term Infrastructure Program (1984-1992).

The maximum local fund requirement of the Project with the four-year implementation period (1988-1991) is estimated to occur in 1990 at 33 million pesos in current prices which is within the estimated possible amount of local budget allocation under the medium assumption. The project is affordable within the resources of GOP and, therefore, financially feasible.

7.4 Project Impact

Lucena-Calauag Section

- The total population in the influence area which covers the Quezon Province and the Bicol Region is estimated about 4.4 million in 1984 and 7.2 million in 2010. Without the project, traffic interruptions on this section will directly affect the day-to-day socio-economic activities of these two areas. Particularly with the Bicol Region which is largely dependent of its supplies in Metro Manila. Traffic flows of 1,800 vehicles and 13,000 passengers per day (both in 1984 volume) will be greatly disturbed.
- The old zigzag road, considered as the detour route of the Pagbilao-Atimonan Sub-section, is a very substandard road with many hairpin curves, steep gradients of nearly 10% and narrow roadway width of 5.0 to 6.0 meters. Due to the substandard geometrics, large vehicles (buses and trucks) have great difficulty in negotiating the route resulting in substandard travel time and vehicle operation costs.
- In the year 2000, traffic volume will exceed the traffic capacity of the old zigzag road.

- About 3,700 tons of commodities transported daily (in 1984) will be directly affected. Perishable commodities and foodstuff such as fish and other marine products which are major commodities from Bicol to Metro Manila will lose, to some extent, commercial value without the project.

Allen-Calbayog Section

- The influence area of this section covers Northern Samar, Western Samar and Northern Leyte. About 2.4 million people in 1984 and 3.6 million people in 2010 in the influence area will be directly or indirectly affected.
- Daily traffic of 328 vehicles in 1984 which is estimated to increase to 1,230 vehicles by 2010 will be directly affected.
- The detour route is composed of the Calbayog North Road (from Calbayog to Catarman) and the Catarman—Allen Road. Along this route are many temporary bridges with narrow timber floor and low loading capacity. In the Calbayog North Road, heavy vehicles (buses and trucks) can not pass due to substandard of the road as well as the limited capacity of the bridges. Therefore, when the section is closed to traffic due to road disasters, buses and trucks will be stranded.
- Commodity flow of about 240 tons per day (in 1984) will be stopped, which means supply of daily consumption commodities to Northern Samar will be suspended, thus daily life of people in the area will be seriously affected.
- Operation of the ferry service between Luzon and Samar will be suspended. Economic return from the investment on the ferry service project will be hampered.

Naguillian Road

- The direct influence area is the whole of Benguet Province. Population of 395,000 in 1984 and 661,000 in 2010 will be directly or indirectly affected.
- The alternative route is the Kennon Road via the Manila North Road. Additional travel time of one (1) hour and travel cost of 95 pesos per vehicle will be incurred for an additional route length of about 37 kms.
- Future traffic on the Naguillian Road will reach 4,600 veh./day in 2010, while that on the Kennon Road will be 8,050 veh./day. When traffic on the Naguillian Road is detoured to the Kennon Road, severe traffic congestion on the Kennon Road will be observed.

- About 1,400 tons of commodities in 1984 which will increase to about 6,000 tons in 2010, will be directly affected. Since fuel consumed in Baguio is mostly transported through the Naguillian Road, stable supply of fuel will be seriously disturbed.
- About 10,000 of passengers per day in 1984 will be directly affected.

7.5 Overall Evaluation

Lucena-Calauag Section

- The best estimate of the Internal Rate of Return (IRR) of the Project in the Lucena-Calauag Section is 16.0%. Results of the sensitivity test shown that *except in the worst case (cost +20%, benefit -20%), the IRRs exceed 12% in all cases.*
- Due to substandard geometrics of the detour road of this section, transport efficiency of the Section will be greatly lowered, thus seriously affecting socio-economic as well as developmental activities within the influence areas, particularly Quezon Province and the Bicol Region.
- Limestone, the predominant type of a rock in this Section, is easily weathered, therefore, slope conditions will be quickly aggravated, unless proper counter-measures are taken immediately.

Implementation of disaster prevention work of this Section is feasible as indicated by its economic rate of return as well as by the engineering aspects and favorable socio-economic impacts produced by the project.

Allen-Calbayog Section

- The best estimated of the IRR is 14.4%.
- Due to low loading capacity of many temporary bridges on the detour road, large vehicles (buses and trucks) will have to terminate their trips when the Section is closed to traffic. Citizen's daily lives in Northern Samar where supply of daily needs depends on this section will be seriously affected.
- Operation of the ferry service between Luzon and Samar will be suspended when traffic on this Section is interrupted, thus economic return from the investment on the ferry service project will be hampered.
- As the formation of most of slope bedrocks sandwiches weak strata between sandstone layers, slope condition will become worse year by year, if the project is not implemented.

Despite the marginal economic feasibility of the project in this section, it is nevertheless, a project worthwhile undertaking considering its important role in the overall highway system of the country and its related socio-economic impacts upon the direct influence area.

Naguillian Road

- The best estimated of IRR of the Project is 15.4%.
- Daily consumption such as fuel, seafoods, etc. for Baguio City and copper ore, the major products of Benguet Province are transported through this road, therefore, it is functioning as a life line of Baguio City and its adjacent areas. Traffic interruption of this road will create serious socio-economic problems within the direct influence area.
- Due to narrow roadway and shoulders, even a small scale road disaster greatly affects traffic flow on the road. Road users are always exposed to danger of being hit by falling rocks and the like.

The project is feasible in terms of its economic rate of return and various favorable impacts to the socio-economic activities in the direct influence area.

IV SPECIAL PROPOSITIONS

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In view of the urgency of the Project and on the basis of the findings of the Study, special propositions are prepared for the development of sound engineering practices and methods on road disaster prevention in the country.

Realizing the fact that road disasters are potential and likely to be grave and severe if no countermeasures are adopted, it is recommended to develop and work out ways not only in the search of immediate solutions, but in the longer term, a more systematic approach in considering the solutions to the problems.

1 SHORT TERM MEASURES

1.1 Recording of Road Disasters

The recording of disaster should be comprehensive and systematically compiled. The information to be covered should include topography, geology, type, size and causes of road disaster, precipitation and influence of water.

These records can provide the basic engineering data to be analyzed for the identification of disaster spots, the frequency of the occurrence of disaster and even the selection of the appropriate countermeasures.

1.2 Identification of Disaster Potential Spots

All spots where failures are likely to occur should be investigated and recorded by the agency concerned. The types, size and damage of roads due to failures should be identified and the potential disaster intensity of each spot should be assessed.

The availability of data will enable to prepare and install appropriate warning signs at strategic locations for the information of the road users, well ahead of the disaster potential areas. Moreover, with the availability of such records, the engineering approach to the solution of the problem can be developed and corresponding preventive measures can be formulated.

1.3 Provisional Remedial Measures

It can be safely concluded through the Study that the main cause of road disaster, without exception, is the effect of water, and therefore, the provisional remedial measures recommended to control water include;

—Provision of side and cross drainage pipe

—Vegetable on slopes

—Utilization of gabion, whenever applicable

—Provision of closed conduits for groundwater and spring water

2 LONG TERM MEASURES

2.1 Development of Techniques of Road Disaster Prevention

The Study has been carried out mainly based on techniques of road disaster prevention experienced in Japan. Time constraint and limited study area coverage of the trunk road has not permitted to allow the Study to generalize the findings on the projects which can be adopted on a nationwide scale. So much so that road disaster prevention in this country must be carried out in a stern environment. In most parts of the country, the topography is mountainous with rugged terrain and the geology is generally of a fragile structure of the tertiary period. Furthermore, the geographical location of the country lies in the South Pacific typhoon belt where typhoon-bearing heavy rains passes the country's area of responsibility nineteen times or more each year on the average.

In view of the fact that such natural conditions in the Philippines are generally more stern than that in Japan, it is recommended that a disaster prevention system and technology suitable and adaptable to environmental characteristics of the country should be developed.

2.2 Road Planning

The Philippines' Fault Line traverses the archipelago from north to south. Secondary faults and folds resulting from this major fault are observed in all region. Where road run parallel to those faults, large scale slope failures are likely to occur. The typical example is the failure of some sections on the Maharlika Highway which runs along the Philippines Fault.

In the planning of new road alignment, therefore, a more comprehensive route study is suggested to avoid such cases. Alternative routes should be evaluated taking into full consideration the extent of disaster control works as well as road functions and costs.

2.3 Road Design and Construction

In designing new roads, a completed and detailed investigations related to road disasters should be carried out. A general policy to include the design of slope protection works and countermeasures for road disasters, is suggested whenever any road improvement is planned.

In which cases, a thorough study for selection of proper countermeasures should be made taking into account the class of road, traffic demand, future development of the area and the like.

2.4 Disaster Beyond the Scope of Highway Works

There exists a considerable number of spots which were seriously damaged due to scouring by sea wave, meandering of river, and the like. Countermeasures to solve these types of problems normally involve large scale riparian works which are all beyond scope of highway works.

In such cases, it is recommended that coordination with various sectors and/or agencies concerned be initiated to prevent further damage on the road sections.

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