7.2 DESIGN OF COUNTERMEASURES

Fundamental and general methods including design criteria to design countermeasures for road disasters are comprehensively described in Volume V "An Approach on Road Disaster Prevention" of the Stage I Study.

To avoid duplication of the description, only concrete procedures or solutions are discussed, in this chapter. Without mentioning general matters, the design of appropriate countermeasure selected based on characteristics of each disaster spot subjected in the Study is presented.

Drawings of countermeasure works designed in the Study are presented in Volume IV—"Drawings".

7.2.1 Surface Drainage

Surface drainage such as top slope ditch, berm ditch, vertical ditch and side ditch were designed in accordance with the following procedure:

—Two years was used as the design probability rainfall period.
—Run off was calculated according to the Rational Formula, as follows:

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

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

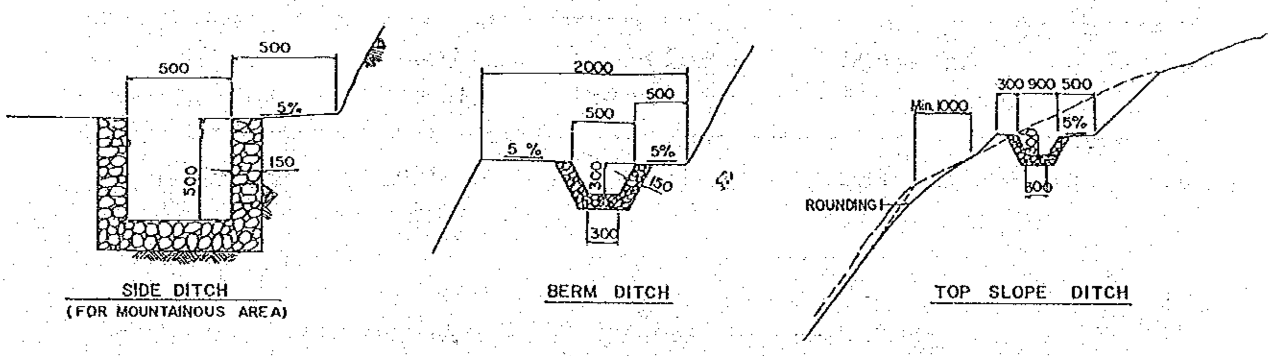


FIGURE 7.2-1 SURFACE DRAINAGE

The following values were used as coefficient of run-off in the above formula:

Paved road surface	0.80
Road shoulders, man-made slope	0.70
Hilly areas with steep gradients	0.50
Hilly areas with moderate gradients	0.30

Ten minutes was used uniformly as the average time of concentration. The cross-sections of ditches were obtained by the Manning's Formula as follows:

$V = 1/n \bullet R^{2/3}\, i^{1/2}$
V = average run-off speed (m/sec)
R = A/P: hydraulic radius (m)
A: cross-sectional area of water flow
P: length of wetted perimeter
i = hydraulic gradient
n = coefficient of roughness (sec/$m^{1/3}$)

The value 0.02 for ditches made of rough stone or wet stone masonry was used as the coefficient of roughness in the above formula.

Although top slope ditches and berm ditches are expected to be cleaned during maintenance work, their cross-sections are determined at 20 percent more than their calculated cross sections to provide some allowances in the design.

Types of ditches include earth, soil/cement, pre-cast conrete, cast-in-place concrete and wet stone masonry. Of these, earth and soil/cement ditches are thought to be temporary structures, in view of the Philippines' severe weather conditions, especially the high precipitation intensity. Pre-cast concrete ditches are not manufactured in the Philippines, therefore, they were not applied. Ditches made of wet stone masonry, which is a conventional method used in this country, were selected as the representative type of ditches applied in the Study.

7.2.2 Subsurface Drainage

1) Closed Conduit

A closed conduit was designed on the basis of flow and quantity of seepage water. In general, gravel, gabion or a porous concrete pipe was installed in the ditch excavated and vinyl sheet concrete or asphalt board was placed over the bottom of the ditch to prevent water leakage.

Closed conduits with-gabion as shown in Figure 7.2-2 were applied in the Study.

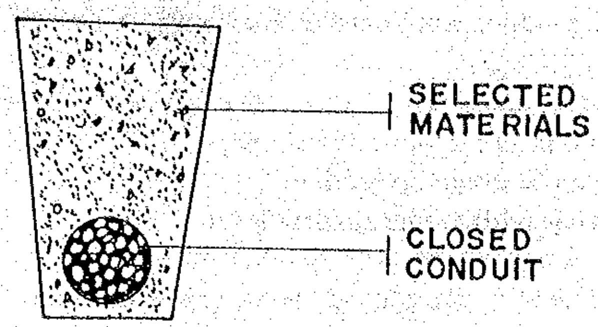


FIGURE 7.2-2 CLOSED CONDUIT

2) Horizontal Drain Hole

Horizontal drain holes with the following specifications were selected as countermeasure against debris flow at Spot No. VIII-16 in the Allen-Calbayog Section.

—The drain hole is made by 66 mm diameter boring.
—A hard polyvinyl chloride pipe is inserted into the bored hole to sustain the hole and to collect and drain water.
—Boring is made at an upward angle of 5 degrees, and intalled about 10 meters into the water-holding layer outside of the sliding plane.
—Drain holes are made at interval of 10 m ground surface.

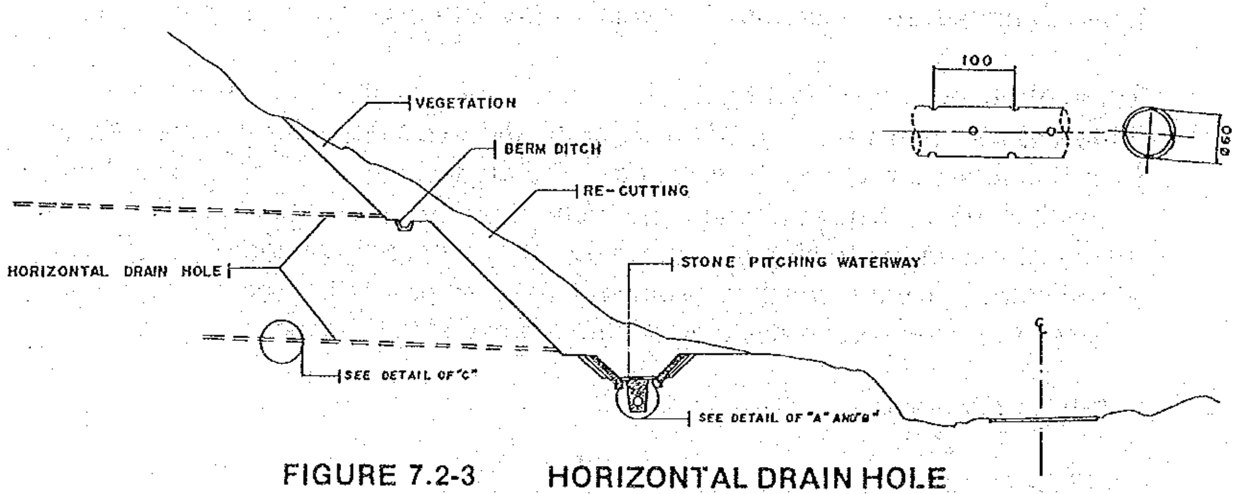


FIGURE 7.2-3 HORIZONTAL DRAIN HOLE

7.2.3 Removal

Removal work aims to remove unstable soil mass and supportless stones and boulders on slope surfaces of cut slope failure and fall. Heavy equipment cannot be used in removal work, and the work is mostly done by manual labor. Since the volume to be removed by not be so much, traffic safety can be ensured without protection facilities such as temporary fences, by regulating traffic while work is in progress.

The quantity of removal work required was estimated as follows:

—Since the unstable soil masses and supportless stones and boulders needing removal are found, sporadically, their quantity cannot be determined by land surveys. Therefore, a rough volume was estimated based on ocular inspection.
—Estimates of the volume were classified into earth, soft rock and hard rock.

7.2.4 Re-cutting

Re-cutting work is classified into two types by the purpose of work: one is to reshape the surface of slope to provide smooth surface so that other structural protection work can be easily constructed, while the other, which is a most fundamental countermeasure, is to re-cut unstabe slope until stable gradient is obtained.

In the Study, re-cutting as a fundamental countermeasure was designed by the following standard.

Unstable slopes with steep gradients must be re-cut to achieve a stable gradient. The stable gradient of a slope is difficult to determine by stability calculation, because the characteristics of natural ground are complicated and not homogenous. It is the general practice to determine the stable gradient based on standard gradients established empirically.

Cut slopes are usually provided with berms. The purpose of berms are: a) to moderate the average gradient of the slope, thus providing greater stability and b) to reduce the speed of surface water running down the slope, thus preventing erosion and scouring. In general, berms of 1.0 to 2.0 m widths are constructed at 5.0 to 10.0 m intervals of height. Where a slope consists of different layers, it is desirable to provide berms at the borders of the different layers. However, berms are not proposed for slope composed of hard rock since erosion and scouring of hard rock are not likely to occur.

The standards adopted in the study are shown in Table 7.2-1 while typical cross section is presented in Figure 7.2-4.

TABLE 7.2-1 STANDARD OF RE-CUTTING

	Kind of Rocks		
	Soil	Soft Rock	Hard Rock
Gradient	1.0:1	0.8:1	0.5:1
Location of Berm	every 7.0^m	every 10.0^m	
Width of Berm	2.0^m	2.0^m	

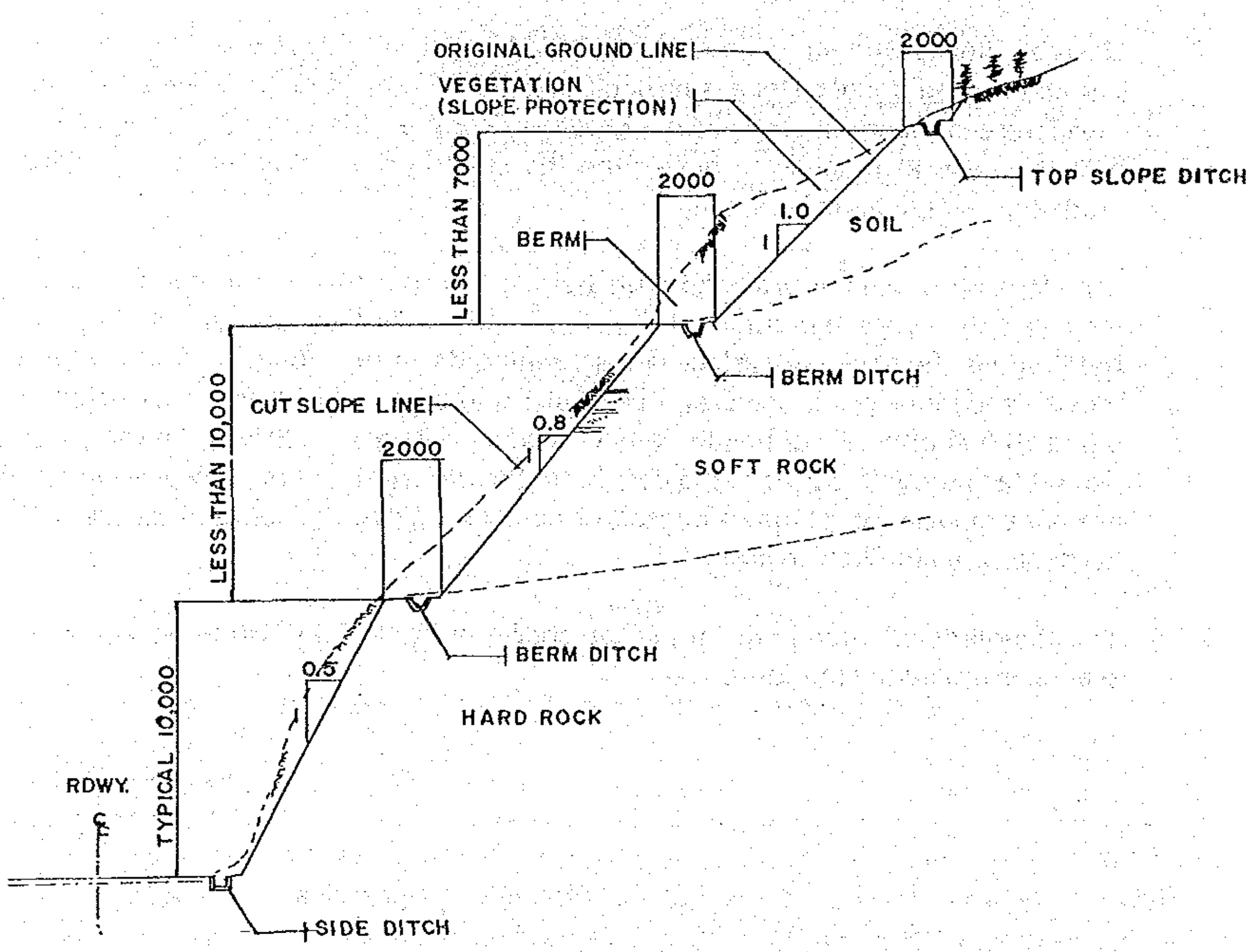


FIGURE 7.2-4 TYPICAL CROSS SECTION FOR CUT SLOPE

It is difficult to ensure continuous traffic flow during construction because of the voluminous excavated materials by re-cutting. As mentioned earlier, re-cutting was programmed to be carried out at night time with traffic conrol, since proper protection facilities are not available. Re-cutting should be done manually due to narrow working space where heavy equipment cannot be accommodated.

The quantity of re-cut material was computed based on the cross section surveys and classified into earth, soft rock and hard rock.

7.2.5 Seed Mud Spraying

Seed mud spraying is a method of spraying a mud-like mixture composed of seeds, fertilizer and soil onto the slope, using a gun with pump or air compressor. Specifications of seed mud spraying applied in the Study are as follows:

—The quantity of soil to be used is $0.01 m^3/m^2$.
—Since seed mud spraying has never been applied in the Philippines, seeds for this purpose are not produced in this country and the type of grass that is suitable is still unknown. A summer grass called weeping love grass is tentatively selected from among those used in Japan for seed mud spraying in the Study. It will be necessary in the future to determine the type of grass that suits local conditions by making trial spraying.
—Cation asphalt emulsions are used for film curing, sprayed at a ratio of $1 \ell/m^2$.

An illustration of seed mud spraying is shown in Figure 7.2-5.

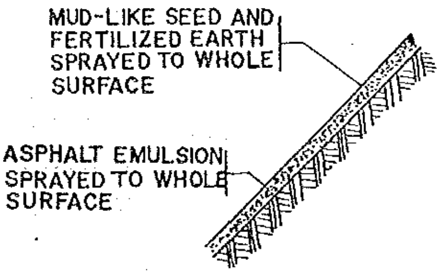


FIGURE 7.2-5 SEED MUD SPRAYING

7.2.6 Concrete Spraying

In concrete spraying, concrete is sprayed onto slopes of highly weathered or easily weathered rock using spray guns, in order to prevent further weathering, erosion and scouring of slope surface due to surface water flow. In general, the method is not applied to slopes to earth or slopes with spring water because adhesion with slope surface is poor and separation may occur.

The thickness of concrete spraying is determined depending on the slope gradient, degree of weathering, crack condition, etc.. However, the standard thickness is 10 to 15 cm. Specifications for concrete sprayings applied in the Study are as follows:

—The concrete mixture is 1:3:2 (cement, sand and gravel), and the ratio of water to cement is 45 percent.

—Concrete spraying of 15cm thickness with reinforced steel net is applied to slopes of drastically weathered rock, slopes with loose rock masses of fairly large sizes, and slopes which are expected to have large volumes of surface water flow. At other slopes, concrete spraying of 10 cm thickness with wire net is applied.

—Weep holes are provided every 2 square meters, which is the maximum standard interval.

Forming work was always executed to remove unstable material from slope where concrete spray was planned. Prior to concrete spraying, spalls and dust on the face of slope to be sprayed should be removed with high pressure water spray or compressed air.

An illustration of concrete spraying is shown in Figure 7.2-6.

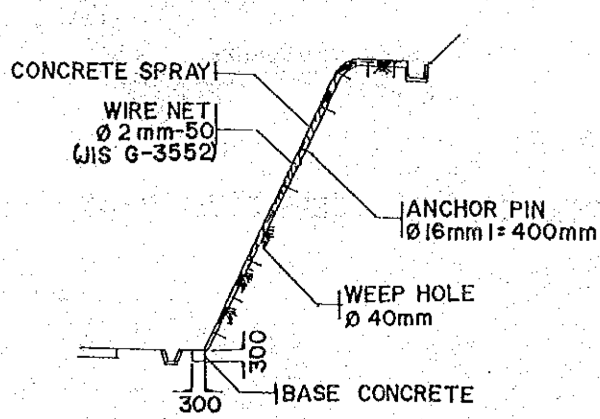


FIGURE 7.2-6 CONCRETE SPRAYING

7.2.7 Retaining Wall

The types of retaining wall adopted in this study are stone masonry and the gravity type. They are illustrated in Figure 7.2-7. Gabion was applied to prevent scouring of foundation of the retaining wall.

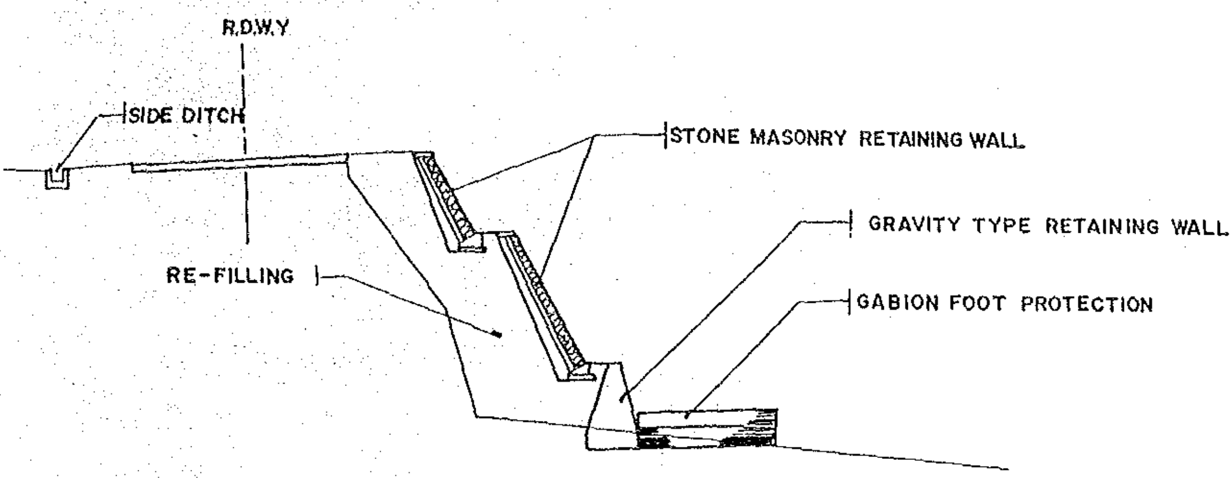


FIGURE 7.2-7 RETAINING WALLS

Stone masonry retaining wall is commonly used in the Philippines known as rip-rap. This was modified and developed based on Japanese experience as shown in Volume IV: Drawings.

The structural dimensions shown in this drawing were determined in accordance with height of wall based on the past experiences in Japan.

For gravity type retaining wall, typical drawings were also prepared with design condition as shown in Table 7.2-2.

TABLE 7.2-2 DESIGN CONDITION

	Normal Case	Earthquake Case
Safety Factor for sliding	>1.5	>1.5
Stability for Overturning	$e \leqq B/6$	$e \leqq B/3$
Safety Factor for Bearing Capacity	>3.0	>2.0

e = eccentric distance
B = width of retaining wall

7.2.8 Anchoring

Anchoring aims to directly fix unstable materials to prevent fall or detachment of bed rocks on slopes with many joints and cracks. An example is shown in Figure 7.2-8. In this figure anchoring directly fixes unstable materials to prevent fall.

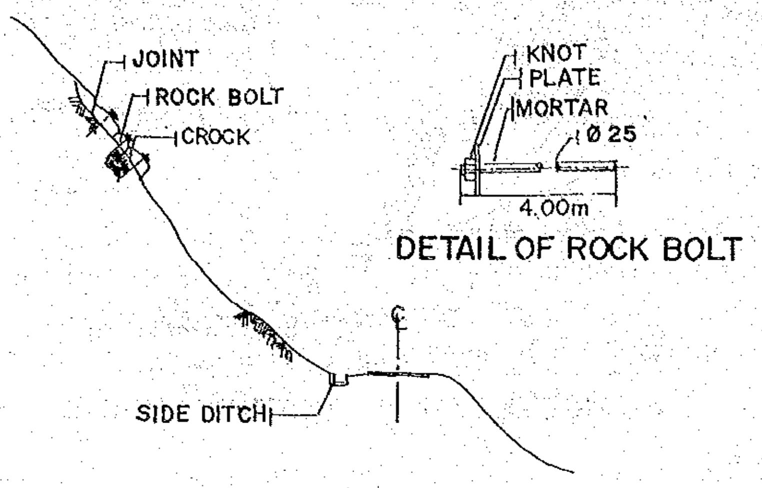


FIGURE 7.2-8 ANCHORING

Design was done as follows.

—The force against the anchor was estimated based on the sliding force along the sliding plane.

—Ultimate tensile resistance force of the bonding portion between anchor and ground was calculated from the following:

$$T = \pi D (L - L_f) \tau$$

Where:

T : Ultimate tensile resistance force of anchor

D : Diameter of main portion of anchor (cm)

L : Total length of anchor (cm)

Lf : Length of unanchored portion (cm)

t : Pull-out shearing resistance between ground and main portion of anchor (kg/cm²)

—The value 20 kg/cm² for hard rocks and 10 kg/cm² for weathered rocks were used as τ.

—Factor of safety Fs was determined as 3 and the length of anchor was determined from the following equation.

$$L - Lf = \frac{F_S T}{\pi D \tau}$$

Rock bolts used in the Study is the glued-type.

7.2.9 Re-filling

Re-filling is classified into two types by the purpose of the work: one, which is a basic countermeasure, is to form stable embankment slope by re-filling with earth and the other is back-filling for structural protection work such as a retaining wall.

In the Study, re-filling as a basic countermeasure was proposed based on the following standards.

Re-filling is planned for embankment slopes with steep gradients which have slope failures. The stable gradient of an embankment can be determined by stability calculation, contrary to the case of cut slopes. The general practice is to apply standard gradients determiend empirically, such as those given in Table 7.2-3.

TABLE 7.2-3 STANDARD GRADIENT OF EMBANKMENT SLOPES

Filling Materials	Height of Fill (m)	Gradient
Sand with well grading, gravel and sand mixed with gravel	Less than 5 m.	1.5:1 to 1.8:1
	5 to 15 m.	1.8:1 to 2.0:1
Sand with poor grading	Less than 10 m.	1.8:1 to 2.0:1
Rock masses (including muck)	Less than 10 m.	1.5:1 to 1.8:1
	10 to 20 m.	1.8:1 to 2.0:1
Sandy oil, hard clayey soil, hard clay (hard clayey soils and clay of alluvium)	Less than 5 m.	1.5:1to 1.8:1
	5 to 10 m.	1.8:1 to 2.0:1
Soft clayey soil	Less than 5 m.	1.8:1 to 2.0:1

Berms are provided not only on cut slopes but also on embankment slopes. Their purposes are previously discussed in Section 7.2.4. Berms on embankment slopes are usually 1.0 to 2.0 m in width and placed at 5 to 7 meter intervals of height.

However, this method was not applied in the Study, because, the gradients of embankment slopes were steep. Instead, re-filling as backfill of stone masonry retaining wall was adopted. An example of backfill is shown in Figure 7.2-9.

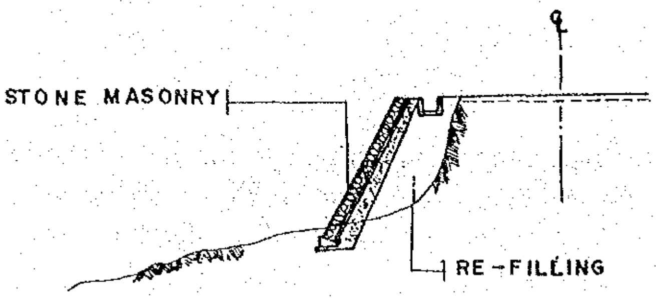


FIGURE 7.2-9 RE-FILLING

7.2.10 Catch Fence

Catch fence aims to prevent roads from damage due to rock fall. This fence consists of several types available in the market and can be selected depending on a bouncing height and kinetic energy of the falling rock. The typical drawing is shown in Volume IV "Drawings".

Fall at the spot where catch fence was applied was expected to have a bouncing height of 2.5 m or more. The tallest fence of 3.0 m sold on the market was selected. An illustration of catch fence is shown in Figure 7.2-10.

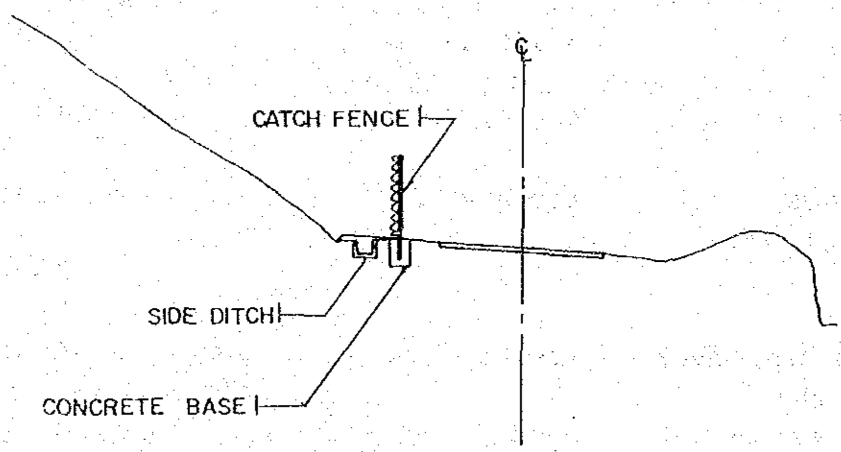


FIGURE 7.2-10 CATCH FENCE

7.2.11 Anchor Wire Net

Anchor wire net aims to provide resisting force to fall directly by covering the slope with net. There are two kinds of net: one is made of chemical fiber and the other is the metal net. The chemical fiber net is used for small-scale fall or rock weighing less than 60 kg. Its durability is uncertain especially when exposed to sunlight. Due to these conditions, the metal net was adopted in the Study. This metal type wire net is also available in the market and the typical standard design is shown in Volume IV. Considering the volume of rock fall, galvanized net which resists fall weight of 1500 kg. was adopted in this study.

An illustration of anchor wire net is shown in Figure 7.2-11

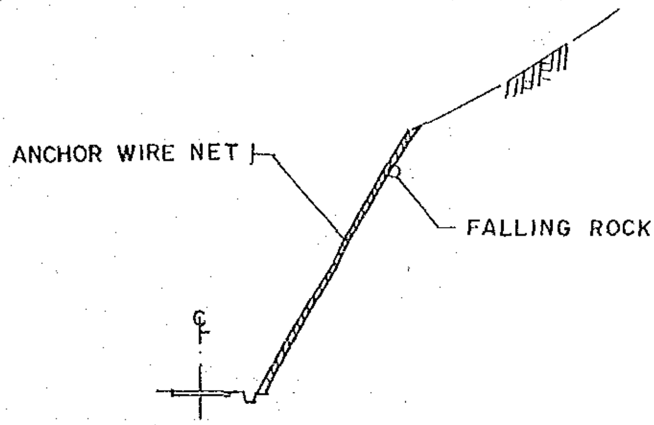


FIGURE 7.2-11 ANCHOR WIRE NET

7.2.12 Earth removal for Landslide

The amount of earth to be removed was decided by the following procedure:

—sliding plane is assumed based on result of boring and seismic survey.
—assuming the safety factor to be 1.0 in the present condition, a linear equation retaining to cohesion (c) and angle of internal friction (ϕ) was estimated using the following equation.

$$Fs = \frac{\Sigma \{c \cdot \ell + (W\cos\phi - u)\tan\phi\}}{W\sin\phi}$$

Fs = Safety factor (assuming to be 1.0)
W = Weight of a slice (t/m)
ℓ = Length of arc of sliding surface cut by equation each slide (m)
C = Cohesion (t/m^2)
ϕ = Angle of internal friction (°)
u = Pore water pressure (t/m^2)

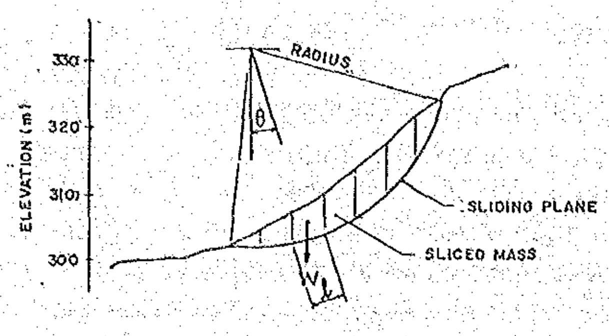


FIGURE 7.2-12 STABILITY CALCULATION (CIRCULAR RAPTURE PLANE)

Based on the linear equation pertaining to C and ø obtained as shown in *Figure* 7.2-13 the value of C was determined by referring to the empirical figures given *in* Table 7.24 and then the value ø was obtained.

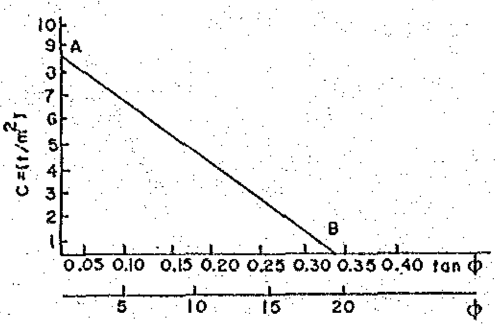


FIGURE 7.2-13 LINEAR EQUATION PERTAINING TO C AND ø

TABLE 7.2–4 RELATIONSHIP BETWEEN THICKNESS OF SLIDING MASS AND COHESION

Thickness of Sliding Mass (m)	Cohesion (t/m²)
5	0.5
10	1.0
15	1.5
20	2.0
25	2.5

—Planned factor of safety was 1.1. The volume of earth to be removed was decided using the above formula, while C and o was estimated based on procedures mentioned earlier.

Cutting and removal work is done by bulldozer, and the removed earth is disposed of somewhere outside the landslide area. The slope that results from the removal work is shaped so that drainage is facilitated, and vegetation is used for slope protection.

7.2.13 Water Way

Water ways were applied as main countermeasure for debris flow. Assuming two years as the design probable rainfall period, the flow and the cross-section of water way were calculated according to the same procedure given in 7.2.1 for surface drainage. Stone pitching was used for water ways, as shown in Figure 7.2-14.

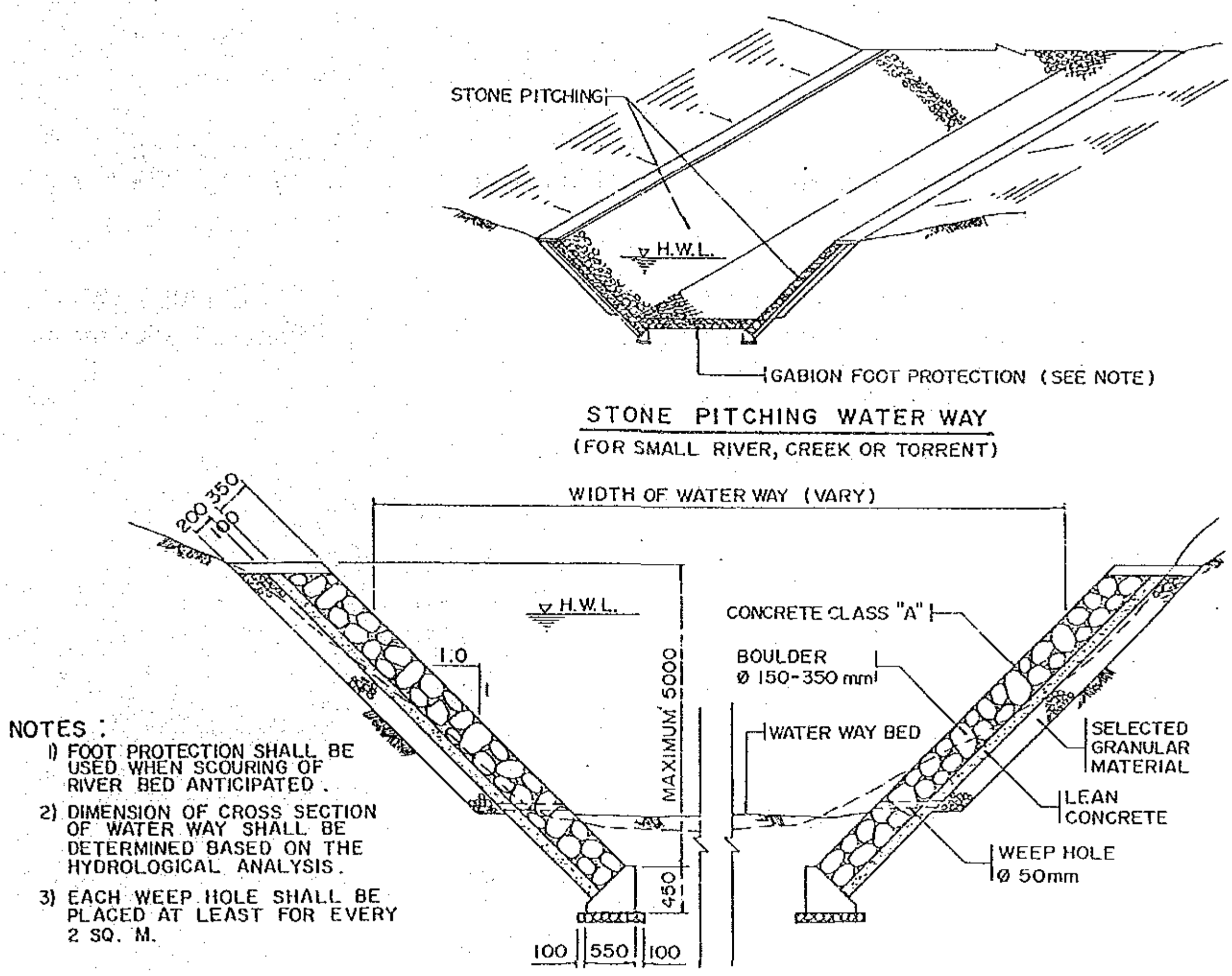


FIGURE 7.2-14 STONE PITCHING WATER WAY

7.2.14 Pipe Culverts

Pipe culvert was planned at spots where insufficient or destroyed drainage facilities were thought to have caused road disasters. The cross-section of pipe culvert was determined in accordance with the procedure given in 7.2.1 for surface drainage, assuming that the probable rainfall period for pipe culverts is 10 years. Considering maintenance works, the diameter of pipe culverts should not be less than 1.0 meter.

Where outlet of existing culvert was scoured, protection of outlet was planned. Stone pitching was mainly adopted for protection of water way bank.

7.2.15 Re-alignment

Re-alignment means shifting the route to avoid damages due to disaster. Re-alignment was positively adopted from the economical point of view, whenever it was applicable.

Re-alignment was applied for 8 spots, three spots at the Lucena-Calauag Section, and 5 spots at the Allen-Calbayog Section. By the type of disaster, 1 spot for cut slope failure, and 7 spots for fall.

Typical cross section of re-alignment is shown in Figure 7.2-14.

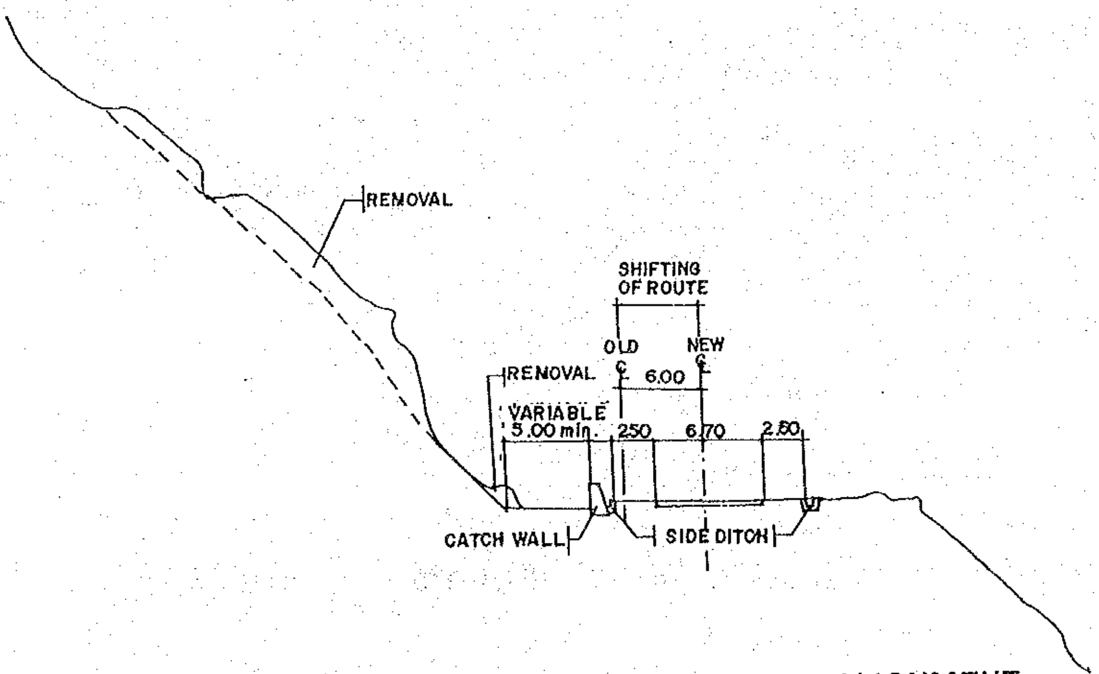


FIGURE 7.2-15 TYPICAL CROSS SECTION OF RE-ALIGNMENT

In the study, a minimum of 5 meters for the space of deposit for fallen rocks was adopted taking into consideration the following factors:

—Volume of unstable material and fallen rocks which will fall down in the future.
—Space enough to absorb an energy of falling rock.
—Space for maintenance work.
—Provision for a sight distance for driving.

On the other hand, the height of a catch wall was designed based on experiments on rocks trajectory as mentioned hereafter.

The jumping height of falling rock during jumping motion is greatly affected by the concavities and convexities on a slope and the conditions of exposed rocks and the size of trees. Therefore, the jumping height should be assumed taking into full account these conditions.

In general, rock trajectory is assumed as shown inFigure 7.2-15.

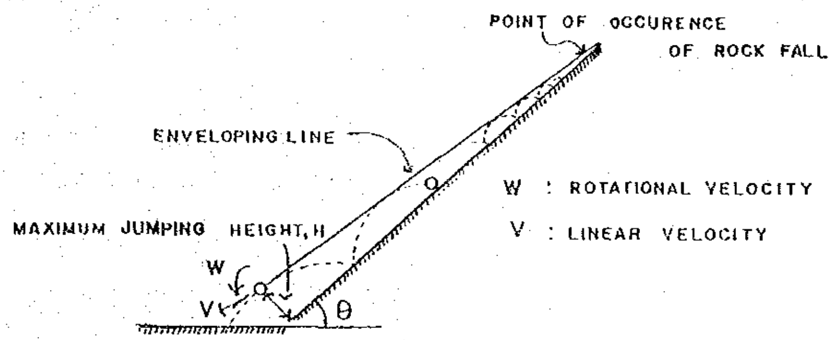


FIGURE 7.2-16 CONCEPTIONAL DIAGRAM OF ROCK TRAJECTORY

From the results of experiments, the jumping height of the falling rock increases as the falling height becomes higher, but does not exceed 2.0 meters for ordinary slopes. However, it should be noted that the jumping height may occasionally exceed 2.0 meters if there is a partial protection on the slope, bedrock is exposed, or on a very irregular slope. Nevertheless, on ordinary slopes, a jumping height of 2.0 meters is often used as the acting position of the design external force for the rock fall protection works.

Depending on the location of catch wall, the height is designed using the following formula, considering that falling stones should not jump over a wall.

(1) Without flat area

$h > h_1 \sec\theta$

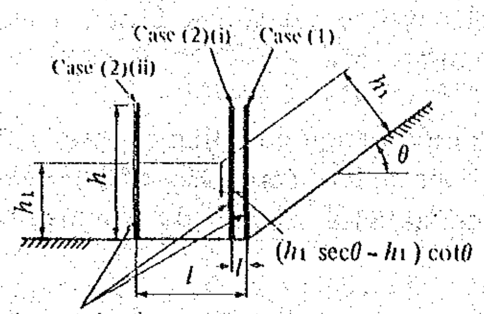
(2) With flat area

i) When $0 < \ell < (h_1 \sec\theta - h_1) \cot\theta$

$h > (h1 \sec\theta - \ell \tan\theta)$

ii) When $\ell > (h_1 \sec\theta - h_1) \cot\theta$

$h > h_1$



h_1 : Jumping height of falling stone (2m if there is no concave or convex which may cause the falling stone to jump).

ℓ : Width of flat area.

θ : Gradient of slope.

FIGURE 7.2-17 HEIGHT OF CATCH WALL

According to this formula, the height of catch wall should be more than 2 meters, even though wall is placed far from a toe of slope.

However, the height of 1.7 meters above the ground level was proposed in the study because of the space of deposit of 5 meters which is considered enough for rocks to stop their motion.

Details of a catch wall and deposit space is shown in Figure 7.2-18.

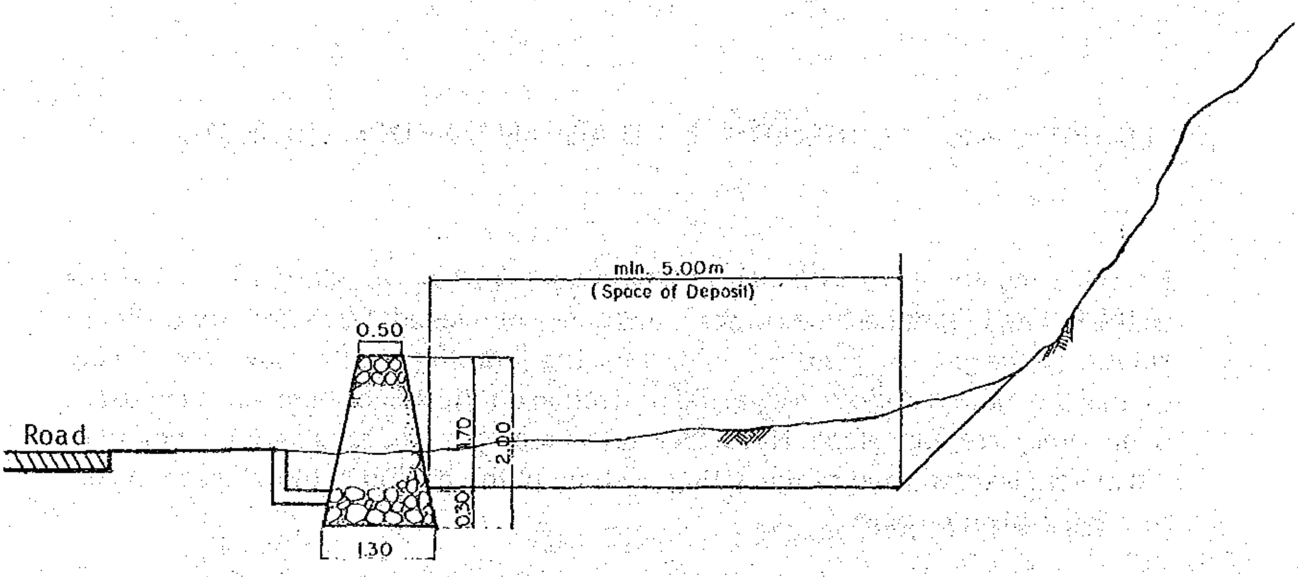


FIGURE 7.2-18 DETAIL OF CATCH WALL AND DEPOSIT SPACE

CHAPTER 8 PROJECT COST

PAGE

CHAPTER 8
PROJECT COST

8.1 GENERAL

The project cost consists of detailed engineering, land acquisition, construction and construction supervision costs. The project cost was estimated in November 1984 prices broken down into the foreign currency, local currency and tax components. The foreign component includes cost of imported equipment and spare parts, the foreign currency portion of locally purchased goods and services, wages of expatriate personnel and foreign overheads and profits. The local components includes cost of locally produced equipment, materials and supplies, local wages, local supervision, local transport and freight and local overheads and profits. The following conversion rates are applied to foreign components:

₱20.00 = US$ 1.00 = ¥246.4

The economic cost consists of local and foreign components, excluding taxes. The financial cost consists of economic cost and taxes.

8.2 CONSTRUCTION COST

A market price survey was intensively conducted to get pertinent information on market prices of construction materials and equipment. Market prices were fluctuating due to unstable foreign currency exchange rates and a high rate of inflation (1984 inflation rate was estimated to be 50.3%). In the unit cost analysis, average market prices were used. The unit cost of each construction item was estimated based on the market price survey findings, information from contractors and latest unit costs from other projects. Unit costs of major construction items are presented in Table 8.2-1. The unit cost of major cosntruction equipment, materials and laborers which were used in the unit cost analysis are enumerated in Table 8.2-2 to 4. The analysis of unit costs of major items is explained in Appendix 8.2-1.

8

Total construction cost, in November 1984 prices, was estimated at 65.36 million pesos, of which 22.33 million pesos (34%) is for the Lucena-Calauag Section, 27.38 million pesos (43%) is for the Allen-Calbayog Section and 15.20 million pesos (23%) is for the Naguilian Road (See Table 8.2-5, also refer to Appendix 8.2-2).

TABLE 8.2-1 SCHEDULE OF UNIT COST

Item No.	Description	Unit	Unit Cost (Pesos)	Component (%) F	L	T	Subsidiary Work Item Included in Unit Cost
	MAIN WORK ITEM						
100	Earth Work						
101.2	Removal of Soft Rock	Cu.M.	240.31	62	24	14	
102.2	Re-cutting of Soft Rock	Cu.M.	356.00	64	21	15	
102.3	Re-cutting of Hard Rock	Cu.M.	425.00	65	21	14	
105	Re-filling of Common Material	Cu.M.	92.30	56	31	13	
200	Drainage Work						
201	Top Slope Ditch	Li.M.	418.00	55	32	13	. Structural excavation . Rubble concrete
207.1	Concrete Pipe Culvert (Ø1070 mm)	Li.M.	2,862.00	56	31	13	
300	Slope Protection Work						
302.2	Concrete Spraying (t = 15^{cm})	Sq.M.	822.00	59	28	13	
304.1	Stone Pitching (H = 2.0 m)	Li.M.	1,300.00	54	33	13	. Boulder concrete . Lean concrete . Structural excavation etc.
400	Catch Work						
401	Anchor Wire Net	Sq.M.	475.90	67	19	14	
402	Catch Wall	Li.M.	1,215.00	54	33	13	
500	Structural Work						
501.3	Stone Masonry Retaining Wall (H = 5.0 m)	Li.M.	3,086.00	53	34	13	. Boulder concrete . Lean concrete . Structural excavation etc.
502	Gravity Type Retaining Wall (H = 3.0 m)	Li.M.	8,490.00	55	33	12	. Concrete Class "A" . Structural excavation etc.
	SUBSIDIARY WORK ITEM						
Sub. 1	Structural Excavation in Common Material	Cu.M.	37.74	63	22	15	
Sub. 2	Structural Excavation in Rock Material	Cu.M.	236.64	65	20	15	
Sub. 3	Backfill Material (Selected Material)	Cu.M.	316.37	64	23	13	
Sub. 4	Lean Concrete	Cu.M.	1,188.50	54	29	17	
Sub. 5	Concrete Class "A"	Cu.M.	2,371.30	52	34	14	
Sub. 6	Rubble Concrete	Cu.M.	637.72	65	22	13	
Sub. 7	Boulder Concrete	Cu.M.	444.14	65	22	13	
Sub. 8	Steel Reinforcement	kg	14.08	62	24	14	

TABLE 8.2-2 HOURLY COST OF CONSTRUCTION EQUIPMENT

Unit : Pesos at Nov. 1984 Prices

\$ 1 = ₱ 20

Construction Equipment	Hourly Cost	Component (%)		
		F	L	T
Bulldozer 75 HP	639.25	67	19	14
Bulldozer 125 HP	998.60	67	19	14
Bulldozer 230 HP	1,955.76	67	19	14
Crawler Loader 110 HP	696.59	67	19	14
Crawler Excavator 135 HP	868.18	67	19	14
Tandem Roller	422.32	67	19	14
Explosion Rammer	21.19	64	19	17
Concrete Batching Plant 80 HP	773.03	60	18	22
Concrete Mixer 75 HP	74.80	60	19	21
Concrete Mixer 30 HP	101.08	60	19	21
Screening Plant 25 HP	1,056.78	60	18	22
Crushing Plant 45～65t/h	1,373.76	60	18	22
Dump Truck 10 ton	421.17	60	20	20
Concrete Spraying Machine 0.8～1.2 m^3/Hour	384.00	67	19	14
Air Compressor 10.5 m^3	637.21	67	19	14
Hard Hammer 15 kg	12.00	67	20	13
Water Pump Ø 50 mm	36.78	66	19	15
Belt Conveyor 7 (m)	28.00	67	20	13
Motor Generator 7.5 KVA	38.00	67	20	13
Truck Crane 20～22 ton	1,430.23	67	19	14
Winch 1.0 ton 10 PS	54.00	40	48	12
Wheel Loader 134 HP	1,007.68	67	20	13
Motor Grader 125 HP	995.82	67	20	13
Water Tank Truck 140 HP	336.30	65	20	15

TABLE 8.2-3 COST OF MAIN MATERIALS

Unit : Pesos

Main Material	Unit	Unit Price	Component (%) F	L	T
Market Price of Purchase Materials					
Portland Cement	Ton	1,200.00	50	35	15
	(Bag)	48.00	50	35	15
Steel Reinforcement	kg	9.45	70	12	18
Diesel Fuel	Liter	7.26	60	20	20
Gasoline (Regular)	Liter	8.86	60	20	20
P.V.C Pipe Ø 50mm	Li.M	54.00	73	10	17
Wire Net Ø 2.0mm - 50 x 50 (JIS 3552)	Sq.M	32.00	73	10	17
Wire Net Ø 4.0mm - 50 x 50 (JIS 3552)	Sq.M	174.00	73	10	17
Wire Rope Ø 12 (JIS 3525)	Li.M	32.00	73	10	17
Wire Rope Ø 16 (JIS 3552)	Li.M	48.00	73	10	17
Rock Anchor Ø 25mm L = 1.0m	EA	692.00	73	10	17
Anchor Bar Ø 16mm L = 40cm	EA	10.54	73	10	17
Anchor Bar Ø 16mm L = 75cm	EA	20.03	73	10	17
Lumber, Yacal/Guijo	bd.ft.	9.00	55	40	5
. Processed Materials					
. Coarse Aggregate for Cement Concrete	ton	131.35	60	22	18
. Fine Aggregate for Cement Concrete	ton	85.44	60	23	17
. Coarse Aggregate for base-coarse	ton	123.31	61	22	17
. Coarse Aggregate for sub-base coarse	ton	111.53	61	22	17
. Concrete Class "A"	Cu.M	1,261.53	56	30	14
. Lean Concrete	Cu.M	914.19	54	29	17
. Standard Strength Reinforced Concrete Pipe					
Ø 1020	Li.M	1,025.80	55	31	14
Ø 1220	Li.M	1,463.06	55	31	14

TABLE 8.2-4 LABOR COST

Unit : Pesos

Labor Category	Hourly Rate	Daily Rate
Foreman	11.15	89.10
Assistant Foreman	10.85	86.90
Heavy Equipment Operator	8.90	71.26
Light Equipment Operator	8.35	66.80
Driver	8.35	66.80
Skilled Labor	7.50	60.10
Unskilled Labor	6.70	53.70
Technical Expert		1,500.00

TABLE 8.2-5 CONSTRUCTION COST—NOVEMBER 1985 PRICES

Unit: Million Pesos

Section	Foreign	Local	Tax	Total	
Lucena-Calauag	13.44	5.81	3.08	22.33	(34%)
Allen-Calabayog	16.82	7.22	3.79	27.83	(43%)
Naguilian Road	9.54	3.58	2.08	15.20	(23%)
Total	39.80	16.61	8.95	65.36	(100%)
	(60.9%)	(25.4%)	(13.7%)	(100%)	

The Construction Cost of Countermeasures applied for each disaster spot was estimated based on quantities calculation required for the construction. The cost for each spot is shown in Table 8.2-6, 8.2-7 and 8.2-8.

TABLE 8.2-6 CONSTRUCTION COST OF DISASTER SPOTS

Lucena-Calauag Section

November 1984 Price
Unit; Million Pesos

No.	Spot No.	Type of Disaster	Construction Cost	Main Countermeasures
1	IVA-6	C-F	0.91	Anchor Wire Net
2	IVA-7	C-F	1.49	Concrete Spraying
3	IVA-8	E-D.F	0.14	Stone Masonry
4	IVA-15	C-F	4.26	Re-alignment, Catch Wall
5	IVA-17	C-D.F	2.01	Re-alignment, Catch Wall
6	IVA-18	C-F	9.56	Re-alignment, Concrete Spraying
7	IVA-20	L.S.	1.93	Earth Removal, Stone Pitching
	Total		20.30	
	10% Physical Contigency		2.03	
	Gross Total		22.33	

TABLE 8.2-7 CONSTRUCTION COST OF DISASTER SPOTS

Allen-Calbayog Section

November 1984 Price
Unit; Million Pesos

No.	Spot No.	Type of Disaster	Construction Cost	Main Countermeasures
1	VIII-6	C-F	1.97	Concrete Spraying, Anchor Wire Net
2	VIII-13-1	E-D.F	0.26	Stone Masonry
3	VIII-16	D.F	3.66	Stone Pitching, Drain Hole
4	VIII-18	E-D.F	0.96	Stone Masonry
5	VIII-21	C-F	3.57	Concrete Spraying
6	VIII-27	C-F	3.11	Re-alignment, Catch Wall
7	VIII-29	C-F	1.61	Re-alignment, Catch Wall
8	VIII-29	C-F	1,54	Re-alignment, Catch Wall
9	VIII-30	C-F	2.73	Concrete Spraying
10	VIII-31	C-F	1.05	Re-cutting
11	VIII-32	C-F	0.79	Re-alignment, Catch Wall
12	VIII-33	C-S.F	1.64	Re-cutting
13	VIII-36	D.F	0.69	Stone Pitching, Water Way
14	VIII-37	C-F	1.72	Re-alignment, Catch Wall
	Total		25.30	
	10% Physical Contingency		2.53	
	Gross Total		27.83	

TABLE 8.2-8 CONSTRUCTION COST OF DISASTER SPOTS

Naguilian Road

November 1984 Price
Unit; Million Pesos

No.	Spot No.	Type of Disaster	Construction Cost	Main Countermeasures
1	IN-3-2	E-D.F	0.23	Stone Masonry
2	4-1	C-D.F	0.38	Vegetation, Re-cutting
3	4-4	E-D.F	0.30	Stone Masonry
4	4-5	E-D.F	0.05	Stone Masonry
5	5	C-F	3.42	Concrete Spraying
6	7	C-F	1.34	Re-cutting
7	8-4	C-S.F	1.00	Stone Masonry, Gravity R.W.
8	9-5	E-D.F	0.14	Stone Masonry
9	10	C-F	1.06	Anchor Wire Net, Rock Bolt
10	12	C-F	1.07	Anchor Wire Net
11	13	C-S.F	0.83	Anchor Wire Net
12	14	E-D.F.	0.73	Stone Masonry
13	15	C-F	1.51	Anchor Wire Net
14	5-1	C-S.F	0.94	Anchor Wire Net, Rock Bolt
15	16	C-S.F	0.82	Re-cutting
	Total		13.82	
10% Physical Contingency			1.38	
	Gross Total		15.20	

As for the construction cost for one disaster spot, the biggest was estimated to be 9.56 million pesos for Spot No. IVA-18 in the Lucena-Calauag section, where there are very high and almost vertical slopes (Height 70 meters, Gradient 80° and Length 500 meters) at the both sides of the road, composed of highly weathered rocks with developed cracks. For this spot alone, 4500 cubic meters of re-cutting of rocks and 5900 square meters of concrete spraying (15 cm in thickness) were required costing 6.4 million pesos.

Except, Spot No. IVA-18 mentioned above, the average of the construction cost per spot for each section is shown in Table 8.2-9.

TABLE 8.2-9 AVERAGE OF CONSTRUCTION COST PER SPOT BY SECTIONS

November 1984 Price
Unit: Million Pesos
10% Contingency Included

Section	No. of Spot	Total Construction Cost	Average Construction Cost
Lucena-Calauag	6	11.81	1.97
Allen-Calbayog	14	27.03	1.99
Naguilian Road	15	15.20	1.01
Total	35	54.84	1.57

The average of construction cost per spot by type of disaster is presented in Table 8.2-10 excluding the cost for Spot No. IVA-18.

TABLE 8.2-10 AVERAGE OF CONSTRUCTION COST PER SPOT BY TYPE OF DISASTER .

November 1984 price
Unit: Million Pesos
10% Contingency included

Type of Disaster	No. of Spot	Total Construction Cost	Average Construction Cost
Cut Slope Failure	7	8.38	1.20
Embankment Slope Failure	8	3.09	0.39
Fall	17	36.47	2.15
Landslide	1	2.12	2.12
Debris Flow	2	4.79	2.40
Total	35	54.04	1.57

8.3 DETAILED ENGINEERING AND CONSTRUCTION SUPERVISION COSTS

Detailed engineering cost usually amounts to 3% to 5% of construction cost, however, in view of extensive subsurface investigations required as well as complicated topographic survey of mountainous terrain, detailed engineering cost was estimated at 7% of construction cost.

Construction superivision cost which usually amounts to 5% to 9% of construction cost was estimated at 7%.

8.4 LAND ACQUISITION COST

All sections are located in mountainous area. A road right-of-way of about 120 meters is usually obtained for a road in a mountainous section. All countermeasures were planned within a 120-meter right-of-way. No land acquisition cost was estimated.

8.5 PROJECT COST

Total project cost, in Novembr 1984 prices, was estimated at 74.50 million pesos of which the foreign currency component at 45.74 million pesos (61.4%), the local currency component at 19.35 million pesos (26.0%) and taxes at 9.41 million pesos (12.6%) (See Table 8.5-1 and 2, also refer to Appendix 8.5-1).

Project cost was adjusted in consideration of escalation rates forecasted by NEDA to develop a project cost in current prices. Total project cost in current prices was estimated at 127.17 million pesos; the foreign currency component at 67.59 million pesos and the local currency component including taxes at 59.58 million pesos (See Table 8.5-3, also refer to Appendix 8.5-2).

TABLE 8.5-1 SUMMARY OF PROJECT COST

—November 1984 Prices—

Unit: Million Pesos

	Foreign	Local	Tax	Total
Detailed Engineering Cost	2.97	1.37	0.23	4.57
Construction Cost				
Lucena-Calauag	13.44	5.81	3.08	22.33
Allen-Calbayog	16.82	7.22	3.79	27.83
Naguilian	9.54	3.58	2.08	15.20
Sub-Total	39.80	16.61	8.95	65.36
Construction Supervision Cost	2.97	1.37	0.23	4.57
Total	45.74 (61.4%)	19.35 (26.0%)	9.41 (12.6%)	74.50 (100%)

TABLE 8.5-2 PROJECT COST

Unit : ₱ x Million

SECTION / ITEM	LUCENA-CALAUAG SECTION				ALLEN-CALBAYOG SECTION				NAGUILIAN ROAD				T O T A L			
	Financial Cost	Component			Financial Cost	Component			Financial Cost	Component			Financial Cost	Component		
		F	L	T		F	L	T		F	L	T		F	L	T
Detailed Engineering	1.56	1.01	0.47	0.08	1.95	1.27	0.58	0.10	1.06	0.69	0.32	0.05	4.57	2.97	1.37	0.23
Construction Supervision	1.56	1.01	0.47	0.08	1.95	1.27	0.58	0.10	1.06	0.69	0.32	0.05	4.57	2.97	1.37	0.23
Consruction	22.33	13.44 (60.2)	5.81 (26.0)	3.08 (13.8)	27.83	16.82 (60.4)	7.22 (26.0)	3.79 (13.6)	15.20	9.54 (62.8)	3.58 (23.6)	2.08 (13.6)	65.36	39.80 (60.9)	16.61 (25.4)	8.95 (13.7)
Total Cost	25.45	15.46 (60.7)	6.75 (26.6)	3.24 (12.7)	31.73	19.36 (61.0)	8.38 (26.4)	3.99 (12.6)	17.32	10.92 (63.0)	4.22 (24.4)	2.18 (12.6)	74.50	45.74 (61.4)	19.35 (26.0)	9.41 (12.6)

Note : 1/ Includes 10% physical contingency.

( ) Shows % share of each component.

TABLE 8.5-3 PROJECT COST—CURRENT PRICE

Unit : Million Pesos

SECTION / ITEM	LUCENA - CALAUAG SECTION			ALLEN - CALBAYOG SECTION			NAGUILIAN ROAD			T O T A L		
	Total	Component		Total	Component		Total	Component		Total	Component	
		F	L & T		F	L & T		F	L & T		F	L & T
Detailed Engineering	2.38	1.36	1.02	2.96	1.70	1.26	1.61	0.92	0.69	6.95	3.98	2.97
Construction Supervision	2.66	1.51	1.15	3.31	1.88	1.43	1.80	1.04	0.76	7.77	4.43	3.34
Construction	38.51	19.98	18.53	47.96	25.01	22.95	25.98	14.19	11.79	112.45	59.18	53.27
T o t a l	43.55	22.85	20.70	54.23	28.59	25.64	29.39	16.15	13.24	127.17	67.59	59.58

CHAPTER 9 PROJECT EVALUATION

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CHAPTER 9 PROJECT EVALUATION

The Project was evaluated from the view points of technical, economic and financial viability as well as the various impacts contributed by the Project.

In the technical evaluation, emphasis was placed on the aggravation of disaster conditions that will quickly deteriorate year by year if no countermeasures are applied.

Various benefits, not only from traffic but also social and developmental benefits, will be derived from the Project. However, a few of them can be quantifiable which are discussed in the economic evaluation. The non-quantifiable benefits, on the other hand, are assessed under the Project impact evaluation.

The financial viability was examined under the assumption that the foreign currency component of the Project requirement will be procured from foreign sources.

9.1 TECHNICAL EVALUATION

9.1.1 Lucena-Calauag Section

—Disaster Spots and Types

Of the total 38 disaster spots identified, 8 spots were evaluated to be of Heavy and Medium disaster potential. The dominant type of failure is fall which is most dangerous to road users.

—Aggravation of Disaster Condition

A considerable number of fall has occurred on slopes composed of severely weathered limestone with developed cracks.Since limestone is a rock easily weathered, slope conditions will be quickly aggravated in their degree and size, unless proper measures are undertaken.

9

—Traffic Interruption

The average number of traffic interruption is estimated 8 days a year but will become longer in the near future, should aggravation of slope condition continues.

—Maintenance and Restoration

Immediate restoration work is required for embankment slope failures and regular maintenance is needed to remove materials falling or flowing down on the road.

—Detour Road

The proposed detour road is the old zigzag road with very steep longitudinal gradient and sharp curves which cause loaded trucks to have difficulty in passing through. Hence, this road can not be practically called a detour road.

From viewpoint of technical assessment mentioned above, the implementation of the project is justified.

9.1.2 Allen-Calbayog Section

—Disaster Spots and Types

Of the total 41 disaster spots identified, 17 spots were evaluated to be of Heavy and Medium disaster potential. Fall has the greatest number with 9 spots. Falling rocks on the road are very dangerous to traffic.

—Aggravation of Disaster Condition

Because of the formation of bedrocks which sandwich weak strata between sandstone layers, the aggravation of slope conditions will hasten year by year if no countermeasures are applied.

—Traffic Interruption

The section is exposed to the danger of rock fall and is regularly closed to traffic for an average of 9 days a year. The majority of slopes are still in unstable condition so that the road is forecasted to be closed for longer periods in the near future.

—Maintenance and Restoration

Maintenance work may be easily done because it only requires removal of fallen rocks. However, restoration may call for the same size of works which were proposed as countermeasures.

—Detour Road

Along the proposed detour road, there exist 21 temporary bridges which have narrow widths and insufficient loading capacities for trucks and buses. Therefore, this road cannot be practically used as a detour road.

From viewpoint of technical assessment mentioned above, the implementation of the project is justified.

9.1.3 Naguilian Road

—Disaster Spots and Types

Of the total 44 disaster spots recorded, 18 spots were evaluated to be of Heavy and Medium disaster potential. Embankment failures are dominant and account for 8 spots.

—Aggravation of Disaster Condition

It should be noted that the road is entirely cut in case of embankment failure. If no measures are applied, it would result to more costly restoration later on.

—Traffic Interruption

Road disasters are estimated to have occurred at an average of two times a year causing traffic interruption of about 4 days. Aside from closing the road to traffic, road cut due to embankment failure is deemed highly dangerous to road users.

—Maintenace and Restoration

Restoration work is absolutely needed in case of embankment failure to ensure traffic. Stone masonry retaining wall is proposed for restoration as well as for countermeasure.

—Detour Road

The Kennon Road, after its improvement, is expected to be utilized as a detour road. The capacity of the Kennon Road may be insufficient after 2000 when used as the detour road. Moreover, there is no access for inhabitants living in the municipalities along the Naguilian Road, when the road is closed.

From viewpoint of technical assessment mentioned above, the implementation of the project is rationalized.

9.2 ECONOMIC EVALUATION

9.2.1 General

1) Benefit of the Project

The traffic interruption on a road section especially on a major thoroughfare imposes direct and indirect constraints upon people's life activities as well as in the economic and development activities within the influence area of the road. Likewise, the incidence of traffic interruption create the belief of unreliability of the road which, in turn, discourages, to a certain degree, the private sector's intentions of investing in the area affected, and thus, hampers sound area development. On the part of the Government, large amount of investments are spent every year to restore damaged road sections.

When the project is implemented, such adverse impacts will be relieved. Such relief is considered "benefits" of the project. Quantifiable benefits will be mainly derived from savings in reduced vehicle operation costs, improved traffic efficiency and savings in construction and restoration related cost, as shown in Table 9.2-1. The assessment of the unquantifiable benefits from the projects are discussed in Section "Project Impact". The procedure on benefit estimates is graphically presented in Figure 9.2-1.

TABLE 9.2-1 QUANTIFIABLE BENEFITS

Project Contribution	Quantifiable Benefits
• No traffic interruption	• Savings in detour cost • Savings in commodity opportunity cost
• Improve vehicle running condition	• Savings in traffic accident cost • Savings in travel time cost
• No restoration work	• Savings in restoration cost

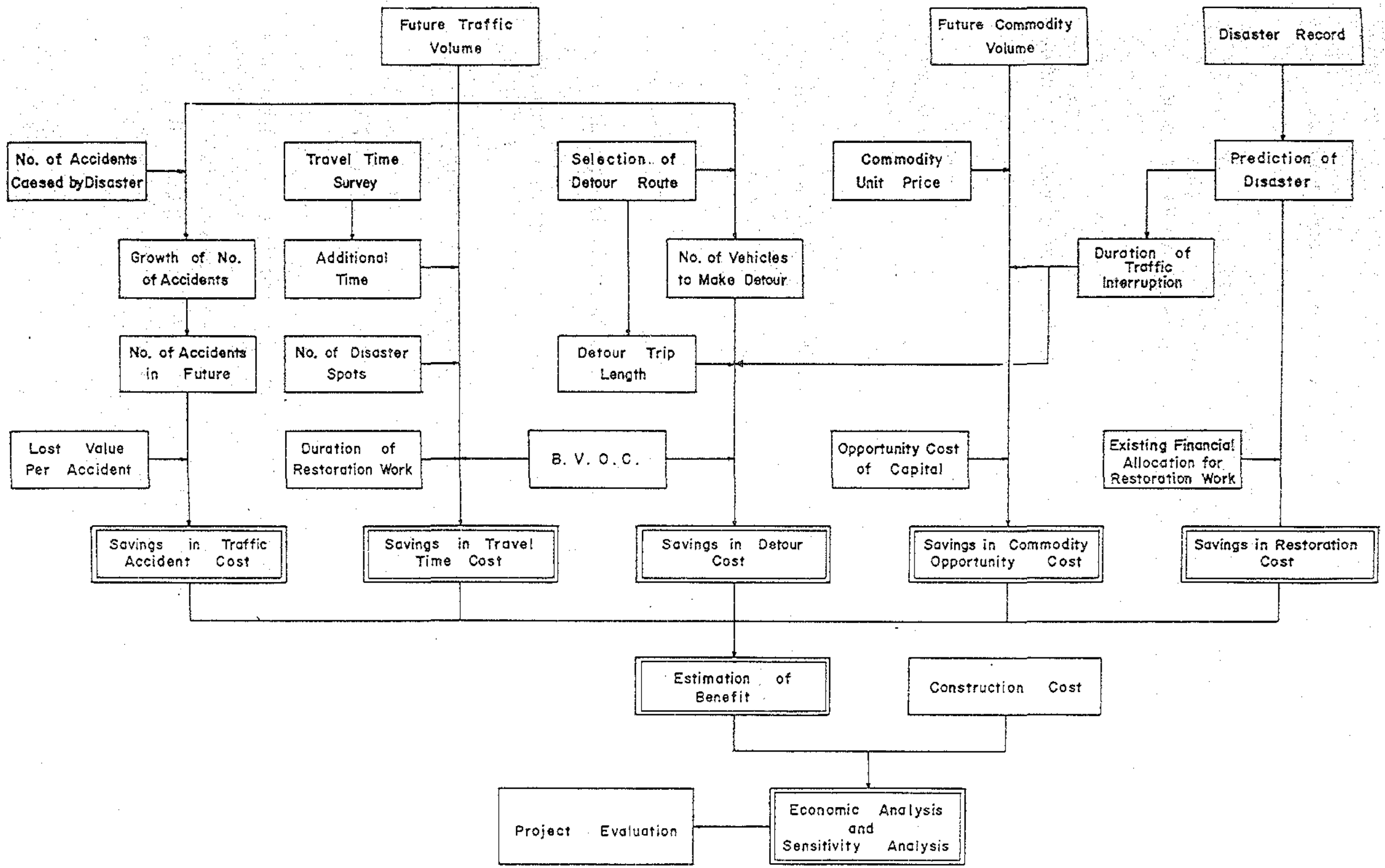

FIGURE 9.2-1 PROCEDURE OF ECONOMIC ANALYSIS

2) Assumptions

Economic analysis will be carried out subject to the following assumptions:

- The opportunity cost of capital at 15 percent.
- 20-year of the project life.
- No salvage value of the structure after the project life.
- Duration of traffic interruption to be predicted based on disaster records.

3) Sensitivity Analysis

A sensitivity test will be conducted to determine the risk of the project in terms of the following events:

Case—1: Construction Cost (-20%)
Case—2: Construction Cost (+20%)
Case—3: Project Benefits (+20%)
Case—4: Project Benefits (-20%)
Case—5: Construction Cost (-20%) and Project Benefits (+20%)
Case—6: Construction Cost (+20%) and Project Benefits (-20%)

9.2.2 Traffic Benefit

1) Basic Vehicle Operating Cost

The basic vehicle operating cost (BVOC) is composed of the following costs:

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

- Basic Fixed Cost: That portion of the vehicle operating cost which is calcual - ted in units of time traveled.

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

The BVOC value was updated to the price level of Novembr 1984, based on data obtained from the Planning Service of the Ministry of Public Works and Highways (MPWH) and in accordance with the procedures outlined in MPWH's Highway Planning Manual. Data obtained under the Study are average vehicle occupancy rates and trip purpose compositions. A summary of the BVOC is given in Table 9.2-2 (refer to Apopendix 9.2-1 for details).

TABLE 9.2-2 BASIC VEHICLE OPERATIONS COSTS BY VEHICLE TYPE

Section	Vehicle Type	Basic Running Cost (Vehicle/km)	Basic Fixed Cost (Vehicle/hour)	Passenger Time Cost (Vehicle/hour)
Lucena-Calauag Section	Car	1.19	4.78	41.12 1/
	Jeepney	1.15	20.21	4.78
	Bus	2.24	27.36	34.65
	Truck	2.71	26.97	—
Allen-Calbayog Section	Car	1.18	3.50	31.85 1/
	Jeepney	1.15	20.21	17.85
	Bus	2.78	28.56	32.58
	Truck	2.39	24.50	—
Naguilian Road	Car	1.22	4.26	32.35 1/
	Jeepney	1.15	20.21	14.70
	Bus	2.87	28.75	46.61
	Truck	2.65	27.58	

Note: 1/ Passenger time cost of car is considered only for the business purpose trip.

2) Saving in Detour Cost

When a road section becomes impassable due to a disaster, people make detours even if it means extra cost, in order to sustain their normal socio-economic activities. The implementation of this Project will create the benefit of removing detours caused by road disasters.

Savings in detour cost are estimated based on assessments of the kinds of detour trips, detour lengths, duration of traffic interruption, future traffic volume and basic vehicle operation costs (refer to Appendix 9.2-2 for details).

a) Lucena-Calauag Section

The detour route of the Pagbilao—Atimonan Sub-section, which contains a lot of spots with high disaster potential, is the Old Zigzag Road. Detour route length is shorter than the length of subject section. However, extra traffic costs are required by the detour because of its many sharp curves and steep gradients.

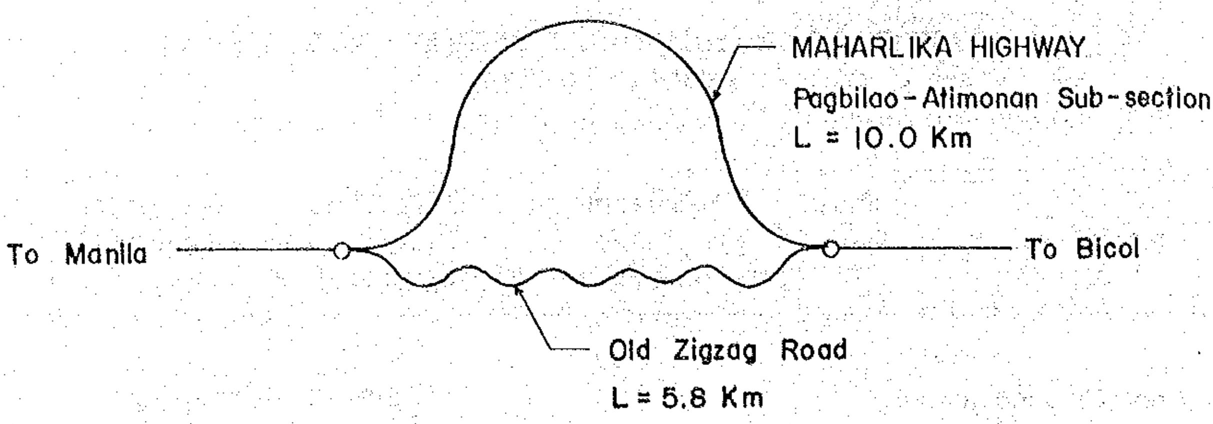

FIGURE 9.2-2 DETOUR ROUTE OF LUCENA-CALAUAG SECTION

b) Allen-Calbayog Section

The detour route of the Allen-Calbayog Section is via the Calbayog North Road and the Allen-Catarman Road. Heavy vehicles can not pass thru the Calbayog North Road, since it has many temporary bridges which have narrow timber floors and low loading capacities. It was assumed that the only light vehicles such as cars and jeepneys are expected to detour. Benefits in relation to discontinued traffic is difficult to quantity and was not calculated. Therefore, the benefits calculated for this road section is considered to be conservative.

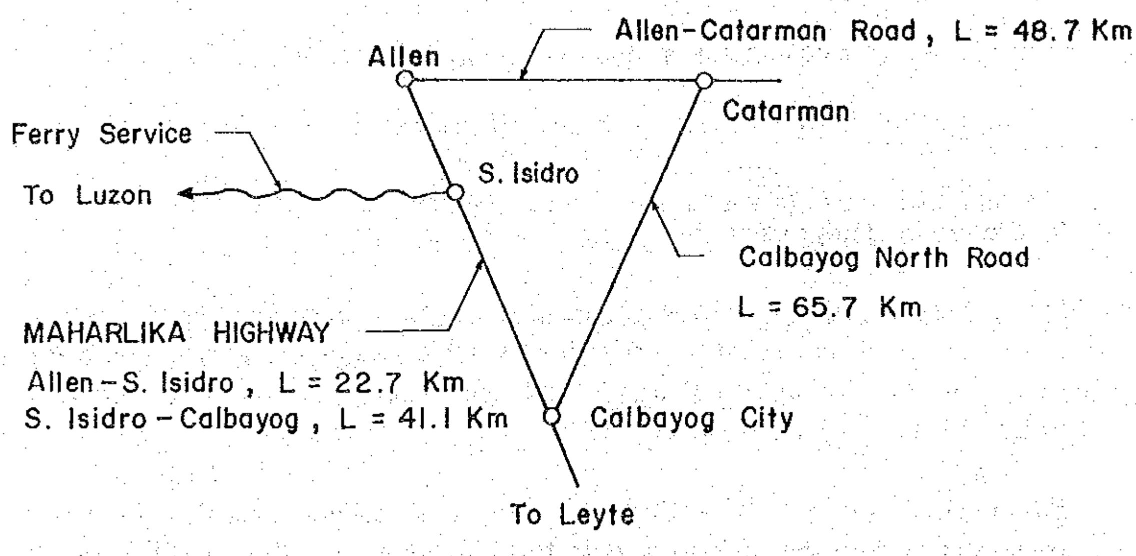

FIGURE 9.2-3 DETOUR ROUTE OF ALLEN-CALBAYOG SECTION

c) Naguilian Road

The Stage I Study recommended that the road disaster project for the Kennon Road should be implemented with first priority. It is assumed that prior to implementation of the Naguilian Road, the construction of disaster prevention work of the Kennon Road would have been completed and that the Kennon Road could be used as a detour route of the Naguilian Road.

When the Naguilian Road will be closed and traffic will be diverted to the Kennon Road, severe traffic congestion will be observed and the extra traffic costs will be incurred in the Kennon Road. This extra traffic costs are considered as benefits.

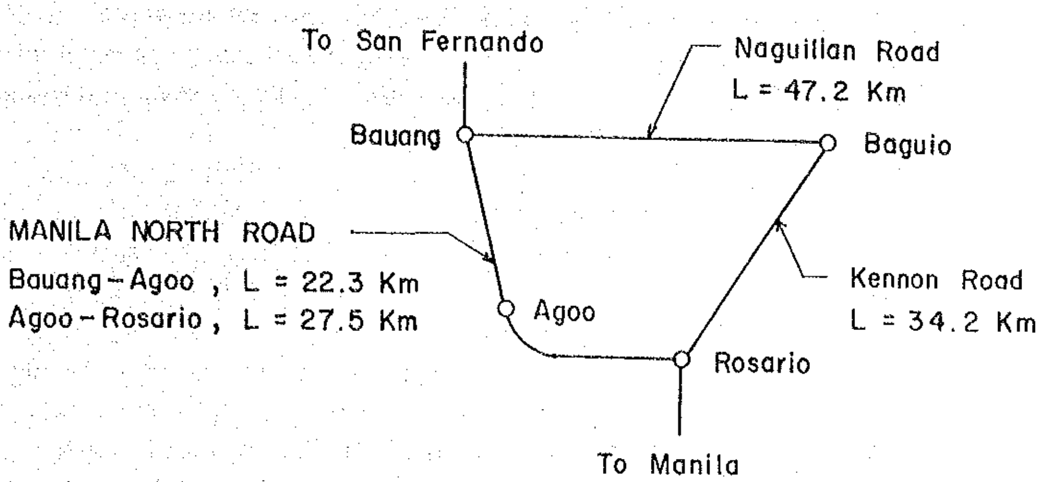

FIGURE 9.2-4 DETOUR ROUTE OF NAGUILIAN ROAD

3) Savings in Commodity Opportunity Cost

When cargo truck trips are stopped or delayed by traffic interruptions or by detours, commodities lose opportunity cost. The implementation of this project will eliminate delay due to road disasters.

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 Naguilian Road. Similarly due to the small commodity volume on the Allen-Calbayog section, this benefit is negligible.

4) 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. However, according to the traffic accident records, there have been a few traffic accidents caused by road disaster. Therefore, this benefit was considered negligible.

5) Savings in Travel Time Cost

Savings in travel 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. (refer to Appendix 9.2-2 for detail)

9.2.3 Savings in Restoration Cost

1) Conditions

Without the Project, or in other words if no countermeasures are applied to potential disaster spots, disasters will recur every year and restoration expenditures will be required. With the Project, such expenditures will become unnecessary and they can be added as project benefits.

Basic conditions considered were as follows:

a) Road Service Level

The service level of the Study Sections is currently low because of the facts that there are sections where soil and gravel still remain on the road surface even after restoration work, and that only one lane is open to traffic because of partial restoration. In a with-and-without project analysis, the service level should be the same in order to make a proper comparison. Therefore, it was assumed that under the without-project case, the restoration work would be undertaken perfectly to ensure two-lane traffic as well as to provide such smooth road surface conditions that traffic flows freely.

b) Restoration Method

It was assumed that current restoration methods would continue to be used in the future: removal of earth and rock from road surface in the case of cut slope failures, landslide and debris flows and stone masonry in the case of embankment slope failures.

c) Restoration Cost

Number of typhoons by typhoon scale was predicted in Section 5.7.4. Restoration cost was calculated for super-scale typhoons, and such costs for large, medium and small-scale typhoons were obtained by multiplying the restoration cost for super-scale typhoons with a certain ratio. The ratio was determined on the basis of 24-hour rainfall, which was one of the criteria used in determining typhoon scale.

d) Disasters Caused by Tropical Storms and Depressions

Past records show that tropical storms and depressions sometimes cause road disasters, while typhoons sometimes do not. From the fact that there were about the same number of tropical storms and depressions that caused road disasters and typhoons that did not, disasters caused by tropical storms and depressions were considered to be taken into account by assuming that all typhoons cause road disasters.

2) Restoration Cost

a) Lucena-Calauag Section

It was assumed that all spots with disaster potential of H and M would be damaged by any large scale typhoon. The extent of damage in such a case was assumed for each type of disasters to be as follows:

- Cut Slope Failure

  Disaster Potential H : The entire road surface is covered by earth and sand from the failure.

  Disaster Potential M : Half (road shoulder + one lane) of the road surface is covered by earth and sand from the failure.

- Embankment Slope Failure

  Corresponds to the extent of damage confirmed thru field surveys.

- Falls

  Disaster Potential H : Half (road shoulder + one land) of the road surface is covered with fallen rocks.

  Disaster Potential M : Half the extent of disaster potential H.

- Debris Flow

  Disaster Potential H : The entire road surface is covered by 2.0 meters of debris.

  Disaster Potential M : The entire road surface is covered by 1.0 meter of debris.

Under the aforecited conditions, restoration of damages caused by a large scale typhoon will cost about 3.07 million pesos (refer to Appendix 9.2-3). Of this, amount the cost of applying stone masonry to embankment slope failures is 0.13 million pesos. Stone masonry will protect embankment slopes fairly well, such that the slopes will not fail everytime there is a typhoon. However, there is still danger that the slopes, ro adjacent slopes, will fail due to inadequate drainage facilities (such as lack of groundwater drainage and inadequate side ditches). For this reason, it was assumed that embankment slopes restored with stone masonry would be damaged again by about four times during the Project life of 20 years (or once every five years).

Disasters other than embankment slope failures occur everytime there is a typhoon. Restoration cost by typhoon scale was estimated as follows:

TABLE 9.2-3 RESTORATION COST BY TYPHOON SCALE

Typhoon Scale	24-Hour Rainfall	Restoration Cost (Million ₱)	Ratio
Large	more than 300 mm	2.94	1.00
Medium	150-300 mm	1.76	0.60
Small	less than 150 mm	0.88	0.30

Taking the typhoon cycle and restoration cost by typhoon scale into consideration, the total cost of restoration (excluding restoration of embankment slope failures) was calculated as follows:

TABLE 9.2-4 RESTORATION COST PER TYPHOON CYCLE

Year	Typhoon Scale	Restoration Cost (Million ₱)
n	Small + Medium	0.88 + 1.76 = 2.64
n + 1	Medium + Large	1.76 + 2.94 = 4.70
Total		= 7.34

Then, the average annual restoration cost was calculated as follows:

Restoration Cost excluding Embankment Slope Failures	7.34/2 years	= 3.67
Restoration Cost for Embankment Slope Failures	0.13/5	= 0.03
		Total = 3.70

Average annual restoration cost was estimated at 3.70 million pesos for the Lucena-Calauag Section.

b) Allen-Calbayog Section

The same assumptions under the Lucena-Calauag Section were used in estimating the extent of damages for this section. The cost of restoring damages caused by a large scale typhoon was estimated at 4.03million pesos, of which 0.50 million pesos was the cost of restoring embankment slope failures and 3.53 million pesos was the cost of restoring all other damages. Restoration cost excluding that of embankment slope failure by typhoon scale was estimated as follows:

TABLE 9.2-5 RESTORATION COST BY TYPHOON SCALE

Typhoon Scale	24-Hour Rainfall	Restoration Cost (Million ₱)	Ratio
Large	more than 300 mm	3.53	1.00
Medium	150-300 mm	2.12	0.60
Small	less than 150 mm	1.06	0.30

Average annual restoration cost was calculated based on the typhoon attack pattern assumed in Section 5.7.4 and restoration cost by typhoon scale. It was estimated at 4.52 million pesos for the Allen-Calbayog Section.

c) Naguilian Road

The cost of restoring damages caused by super-large scale typhoons was estimated at 1.75 million pesos under the same assumptions which were used for the Lucena-Calauag Section. Of this, amount the cost of restoring embankment slope failures was 0.79 million pesos and the cost of restoring all other damages was 0.96 million pesos. Restoration cost (excluding that of embankment slope failures) by typhoon scale and average annual restoration cost are shown in the following two tables:

TABLE 9.2.6 RESTORATION COST BY TYPHOON SCALE

Typhoon Scale	24-Hour Rainfall (mm)	Restoration Cost (Million ₱)	Ratio
Super-large	600 or more	0.96	1.00
Large	400 - 600	0.77	0.80
Medium	200 - 400	0.58	0.60
Small	200 or less	0.38	0.40

TABLE 9.2-7 RESTORATION COST BY TYPHOON CYCLE

Year	Typhoon Scale	Restoration Cost (Million ₱)
n	Super + Medium + Small	0.96 + 0.58 + 0.38 = 1.92
n + 1	Large + Medium + Medium	0.77 + 0.58 + 0.58 = 1.93
n + 2	Medium + Small	0.58 + 0.38 = 0.96
Total		= 4.81
• Restoration cost excluding *embankment slope failures*	4.81/3	= 1.60
• Restoration cost excluding embankment slope failures	0.79/5	= 0.16
Total		= 1.76

Average annual restoration cost was estimated at 1.76 million pesos for the Naguilian Road.

9.2.4 Economic Evaluation

The streams of costs and benefits for the Study Sections including their respective economic evaluation results are shown in Table 9.2-9 to 9.2-11. The results of the economic analysis and sensitivity tests conducted are presented hereunder.

TABLE 9.2-8 RESULTS OF ECONOMIC ANALYSIS

		Lucena-Calauag Section	Allen-Calbayog Section	Naguilian Road
Best Estimate Case	IRR (%)	16.04	14.37	15.43
	NPV (Million Pesos)1/	1.34	-0.96	0.40
	B/C1/	1.07	0.96	1.03
			IRR (%)	
Sensitivity Tests	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
	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

Note: 1/ Discount rate at 15%.

1) Lucena-Calauag Section

The economic analysis under the best estimate case shows a favorable result for this section, indicating an IRR of 16.04%, NPV of 1.34 million pesos and B/C of 1.07. The total Project benefits (before discounting) are derived from savings in restoration cost (77%), savings in detour cost (21%) and savings in travel time cost (2%). With regards to sensitivity tests, IRRs under the optimistic cases (cases 1 and 3) are about 20%, while those under the pessimistic cases (cases 2 and 4) are about 13%. The project is economically feasible.

2) Allen-Calbayog Section

IRR under the best estimate case of this project is 14.37%. Savings in restoration cost accounting for 87% have the highest share of the total benefits. The sensitivity tests show that IRRs under optimistic cases are about 19%, while under the pessimistic cases are about 11%. The project is judged to be marginally feasible under the economic evaluation.

3) Naguilian Road

The best estimate case of the economic analysis for the Naguilian Road indicates a favorable result showing an IRR of 15.43%, NPV of 0.40 million pesos and B/C of 1.03. Of the total project benefits, the highest share is contributed by savings in restoration cost (53%), followed by savings in detour cost (39%). The results of the sensitivity tests indicate that IRRs under the optimistic cases are about 19%, while those under the pessimistic cases are about 12.5%. The project is economically viable.

TABLE 9.2-9 ECONOMIC COST-BENEFIT STREAMS OF LUCENA-CALAUAG SECTION

(Unit : MP at 1984 Prices)

	BEFORE DISCOUNT					AFTER DISCOUNT (15%)	
		BENEFITS					
	Cost	Saving in Detour Cost	Saving in Travel Time Cost	Saving in Restoration Cost	Total	Cost	Benefit
1988	0.59	-	-	-	-	0.69	-
1989	0.89	-	-	-	-	0.99	-
1990	12.44	-	-	-	-	11.60	-
1991	8.29	0.13	0.02	1.11	1.26	6.88	0.98
1992	-	0.41	0.05	3.33	3.79	-	2.67
1993	-	0.44	0.06	3.33	3.83	-	2.35
1994	-	0.47	0.06	3.33	3.86	-	2.06
1995	-	0.50	0.06	3.33	3.89	-	1.80
1996	-	0.53	0.06	3.33	3.92	-	1.58
1997	-	0.56	0.07	3.33	3.96	-	1.39
1998	-	0.59	0.07	3.33	3.99	-	1.22
1999	-	0.62	0.07	3.33	4.02	-	1.07
2000	-	0.85	0.08	3.33	4.26	-	0.98
2001	-	0.91	0.08	3.33	4.32	-	0.87
2002	-	0.97	0.08	3.33	4.38	-	0.76
2003	-	1.03	0.09	3.33	4.45	-	0.67
2004	-	1.09	0.09	3.33	4.51	-	0.59
2005	-	1.14	0.10	3.33	4.57	-	0.52
2006	-	1.20	0.10	3.33	4.63	-	0.46
2007	-	1.26	0.11	3.33	4.70	-	0.41
2008	-	1.32	0.11	3.33	4.76	-	0.36
2009	-	1.38	0.12	3.33	4.83	-	0.32
2010	-	1.44	0.12	3.33	4.89	-	0.28
2011	-	1.03	0.09	2.22	3.34	-	0.17
Total	22.21	17.87	1.69	66.60	86.16	20.16	21.50

NPV = 1.34 MP
B/C = 1.07
IRR = 16.04 %

TABLE 9.2-10 ECONOMIC COST-BENEFIT STREAMS OF ALLEN-CALBAYOG SECTION

(Unit : MP at 1984 Prices)

	BEFORE DISCOUNT					AFTER DISCOUNT (15%)	
		BENEFITS					
	Cost	Saving in Detour Cost	Saving in Travel Time Cost	Saving in Restoration Cost	Total	Cost	Benefit
1988	0.74	-	-	-	-	0.87	-
1989	1.11	-	-	-	-	1.23	-
1990	15.35	-	-	-	-	14.48	-
1991	10.36	0.11	0.01	1.36	1.48	8.60	1.15
1992	-	0.34	0.02	4.07	4.43	-	3.12
1993	-	0.36	0.02	4.07	4.45	-	2.73
1994	-	0.38	0.02	4.07	4.47	-	2.38
1995	-	0.41	0.02	4.07	4.50	-	2.09
1996	-	0.43	0.02	4.07	4.52	-	1.82
1997	-	0.45	0.02	4.07	4.54	-	1.59
1998	-	0.47	0.02	4.07	4.56	-	1.39
1999	-	0.49	0.02	4.07	4.58	-	1.21
2000	-	0.51	0.02	4.07	4.60	-	1.06
2001	-	0.54	0.03	4.07	4.64	-	0.93
2002	-	0.58	0.03	4.07	4.68	-	0.82
2003	-	0.61	0.03	4.07	4.71	-	0.71
2004	-	0.65	0.03	4.07	4.75	-	0.63
2005	-	0.69	0.03	4.07	4.79	-	0.55
2006	-	0.72	0.03	4.07	4.82	-	0.48
2007	-	0.76	0.04	4.07	4.87	-	0.42
2008	-	0.79	0.04	4.07	4.90	-	0.37
2009	-	0.83	0.04	4.07	4.94	-	0.32
2010	-	0.86	0.04	4.07	4.97	-	0.28
2011	-	0.61	0.03	2.71	3.35	-	0.17
Total	27.74	11.59	0.56	81.40	93.55	25.18	24.22

NPV = 0.96 MP
B/C = 0.96
IRR = 14.37 %

TABLE 9.2-11 ECONOMIC COST-BENEFIT STREAMS OF NAGUILIAN ROAD

(Unit : MP at 1984 Prices)

	BEFORE DISCOUNT					AFTER DISCOUNT (15%)	
		BENEFITS					
	Cost	Saving in Detour Cost	Saving in Travel Time Cost	Saving in Restoration Cost	Total	Cost	Benefit
1988	0.40	-	-	-	-	0.47	-
1989	0.60	-	-	-	-	0.67	-
1990	8.48	-	-	-	-	7.91	-
1991	5.66	0.19	0.05	0.53	0.77	4.70	0.60
1992	-	0.62	0.15	1.58	2.35	-	1.66
1993	-	0.66	0.16	1.58	2.40	-	1.47
1994	-	0.70	0.17	1.58	2.45	-	1.31
1995	-	0.74	0.18	1.58	2.50	-	1.16
1996	-	0.79	0.18	1.58	2.55	-	1.03
1997	-	0.83	0.19	1.58	2.60	-	0.91
1998	-	0.87	0.20	1.58	2.65	-	0.81
1999	-	0.91	0.21	1.58	2.70	-	0.72
2000	-	0.96	0.22	1.58	2.76	-	0.64
2001	-	1.04	0.23	1.58	2.85	-	0.57
2002	-	1.13	0.25	1.58	2.96	-	0.52
2003	-	1.22	0.26	1.58	3.06	-	0.46
2004	-	1.31	0.28	1.58	3.17	-	0.42
2005	-	1.40	0.29	1.58	3.27	-	0.37
2006	-	1.49	0.31	1.58	3.38	-	0.34
2007	-	1.58	0.32	1.58	3.48	-	0.30
2008	-	1.67	0.34	1.58	3.59	-	0.27
2009	-	1.76	0.35	1.58	3.69	-	0.24
2010	-	1.85	0.37	1.58	3.80	-	0.22
2011	-	1.30	0.26	1.06	2.62	-	0.13
Total	15.14	23.02	4.97	31.61	59.60	13.75	14.15

NPV = 0.40 MP
B/C = 1.03
IRR = 15.43 %

9.3 FINANCIAL EVALUATION

9.3.1 Expenditures on Road Development

The MPWH expenditures (highway portion only) from 1970 to 1984 are presented in Table 9.3-1. About 60% to 70% of total MPWH expenditures were invested on construction and improvement of roads. In 1984, expenditures on road construction and improvement were drastically reduced to 2,691 million pesos compared to the 1983 level of 3,632 million pesos.

TABLE 9.3-1 MPWH EXPENDITURES (Highway Portion)
Current Prices

Year	Administration	Maintenance	Construction and Improvement	Total
1970	55.0 (10)	10.4.0 (18)	414.4 (72)	573.4
1971	52.5 (13)	121.6 (30)	231.2 (57)	405.3
1972	70.2 (12)	155.6 (27)	354.1 (61)	579.9
1973	105.6 (12)	216.1 (25)	530.7 (63)	852.4
1974	179.4 (17)	269.9 (25)	609.4 (58)	1,058.7
1975	284.4 (13)	533.5 (25)	1,339.5 (62)	2,157.4
1976 1/	234.5 (6)	795.8 (20)	2,879.7 (74)	3,910.1
1977	238.9 (9)	874.9 (32)	1,618.5 (59)	2,732.3
1978	284.8 (10)	893.8 (32)	1,586.1 (57)	2,764.7
1979	305.6 (8)	871.8 (23)	2,664.0 (69)	3,841.4
1980	317.6 (9)	1,107.4 (30)	2,227.9 (61)	3,652.9
1981	249.6 (6)	1,138.7 (26)	2,948.0 (68)	4,336.3
1982	480.1 (10)	983.8 (21)	3,120.4 (68)	4,584.3
1983	325.6 (6)	1,429.6 (27)	3,631.7 (67)	5,386.9
1984	253.2 (6)	1,205.4 (29)	2,690.8 (65)	4,149.4

Notes: 1/ Expenditures from July 1, 1975 to December 31, 1976
2/ Figure in ( ) shows share in %
Source: MPWH

Table 9.3-2 shows the MPWH medium term infrastructure program from 1983 to 1992, which was prepared by the MPWH in November 1984. Due to the financial constraints the country is now suffering, investments on road construction and improvement will be scaled down and be limited to the required minimum for at least next 5 years, if there is no drastic improvement in economic condition.

TABLE 9.3-2 MPWH MEDIUM TERM INFRASTRUCTURE PROGRAM
—Current Prices—

Unit: Million ₱

Year	Major Road	Minor Road	Total
1983	3,155	476	3,631
1984	2,135	556	2,691
1985	1,794	396	2,190
1986	1,912	467	2,379
1987	2,013	490	2,503
1988	2,162	525	2,687
1989	2,305	545	2,850
1990	2,361	635	2,996
1991	2,453	696	3,149
1992	2,559	751	3,310

Source: MPWH (As of November, 1984)

9.3.2 Possible Amount of Budget Allocation to One Project

The budget allocation for the local portion of foreign assisted highway projects in 1983 and 1984 is presented in Table 9.3-3. The maximum budget allocation for one project was 253 million pesos in 1983 and 144 million pesos in 1984, which was equivalent to about 1/12 of the total budget for construction and improvement of major roads in 1983 and to about 1/15 in 1984.

TABLE 9.3-3 BUDGET ALLOCATION TO LOCAL PORTION OF FOREIGN ASSISTED PROJECTS

Budget Allocation (Million ₱)	1983 No. of Foreign Assisted Project	1983 A1/	1984 No. of Foreign Assisted Project	1984 A1/
Less than 50	27	—1/63	26	— 1/43
50 — 100	6	1/63—1/32	8	1/43—1/21
100—150	2	1/32—1/21	3	1/21—1/14
150—200	1	1/21—1/16	0	
200—250	2	1/16—1/13	0	
more than 250	1	1/13—	0	
Total No. of Foreign Assisted Project	39		37	
Maximum Budget Allocation to one Project	₱253 Million	1/12	₱144 Million	1/15
Average Budget Allocation	₱ 52 Million	1/61	₱ 38 Million	1/56

Note: 1/A = Budget for One Project/Budget for Major Roads
Source: MPWH Infrastructure Program (1983 and 1984)

In consideration of the tendency that budget allocation for one project is being scaled down due to financial constraints, the possible amount of budget allocation for the local portion of one project was estimated to be 1/18 of the total budget for construction/improvement of major roads under a high (or optimistic) assumption, 1/50 under a low (or pessimistic) assumption, and 1/30 under a medium (or most feasible) assumption. The results are shown in Table 9.3-4.

TABLE 9.3-4 POSSIBLE AMOUNT OF BUDGET ALLOCATION(LOCAL PORTION)
—Current Price—

Unit: Million ₱

Year	Estimated Budget for Major Roads	Possible Amount of Budget Allocation to One Project: Low Assumption (1/50)	Medium Assumption (1/30)	High Assumption (1/18)	Required Amount of Investment of the Project: Total	Local Portion
1984	2,135	43	71	119	—	—
1985	1,794	36	60	100	—	—
1986	1,912	38	64	106	—	—
1987	2,013	40	67	112	—	—
1988	2,162	43	72	120	2.7	1.1
1989	2,305	46	77	128	4.3	1.8
1990	2,361	47	79	131	70.3	33.0
1991	2,453	49	82	136	49.9	23.6
1992	2,559	51	85	142		

9.3.3 Financial Evaluation

As shown in Table 9.3-4, the maximum investment requirement of the Project is estimated to occur in 1990 at 70.3 million pesos of which 33.0 million pesos would be the local currency requirement. Both total and local currency requirements are within the estimated amount of possible budgetary allocation for one project under a medium assumption. Therefore, the project is financially viable.

The project could be financed from purely local sources. However, in view of tight budgetary limitations, financial assistance from a foreign country or international financing institution should be considered. The amount of 45.74 million pesos in November 1984 prices for the foreign currency portion of the project is recommended to be procured from foreign financial sources.

9.4 PROJECT IMPACTS

Benefits which could not be easily quantified but have direct socio-economic impact within the influence areas were assessed for each project and are summarized as project impacts. Generally, traffic interruption due to road disasters adversely affects socio-economic activities in the influence areas of a section. These adverse impacts of the "without project" case which are described hereunder will be alleviated when the projects are implemented.

9.4.1 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 it supplies in Metro Manila. Traffic flow 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 longer travel time and higher vehicle operation costs.

- In the year 2000, traffic volume will exceed the traffic capacity of the old zigzag road, greatly lowering the transport efficiency of the Maharlika Highway.

- 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.

9.4.2 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. There 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.

9.4.3 Naguilian 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 Naguilian 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 Naguilian 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 City is mostly transported through the Naguilian Road, stable supply of fuel will be seriously affected.

- About 10,000 passengers per day in 1984 will be directly affected.

9.5 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 show 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 undertaken immediately.

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

Allen-Calbayog Section

- The best estimate 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 suspend their trips when the Section is closed to traffic. Citizens' 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. The economic return from the investment on the ferry service project will be also hampered.

- Since 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.

Naguilian 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 product of Benguet Province are transported through this road, therefore, it is functioning as the life line of Baguio City and its adjcent 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 the 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.