5-3-10 Tunnel Design

Preliminary design of tunnel was undertaken based on investigation results on topography, geological conditions, traffic volume, environmental conditions and climatic conditions.

The design in the study includes items such as:

1) Design of ventilation system
2) Design of tunnel
3) Design of miscellaneous facilities

(1) Design of Ventilation System

1) Planning of Ventilation System

Planning of ventilation system is one of the most important and vital aspects in tunnel planning and design, and practically the basis for determining the cross sectional area of the tunnel.

After computing basic fresh air volume required for the tunnel, the type of ventilation system applicable was determined. The study was conducted on the required size and features of facilities. Furthermore, the stage construction on ventilation system and facilities were also considered.

<u>Estimation of Required Fresh Air</u>

An estimation of required fresh air was made based on the following conditions:

a) Number of lanes	:	Two-lane highway (bi-directional)
b) Classification of Road Standard	:	Category 3 - Grade 3 Rural, Mountainous (by Japanese Road Standards)
c) Design Speed	:	50 Km/hr.
d) Visibility	:	Visibility Index T =40%
e) Allowable Concentration	:	K =100 ppm
f) Design Traffic Volume in year 2015	:	7900 vehicle/day 1100 vehicles/hour (peak hour ratio K = 14%)

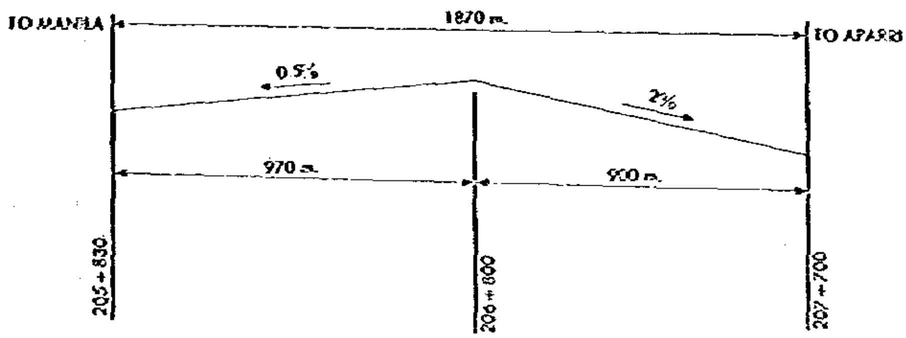
g) Composition of traffic :

Percentage of big-size vehicle	:	68% of AADT
Design Percentage of big sized vehicle (modification factor-mountainous 0.8)	:	68% × 0.8 = 54%
Percentage of diesel-engine vehicle		7% of AADT
Percentage of big-size vehicle	:	99%
Percentage to ordinary vehicle	:	30%

h) Cross sectional area of tunnel : 53.2 m^2

i) Geometric Features

The tunnel length and longitudinal road grade in tunnel are shown below:



Based on the factors and conditions required fresh air was estimated to be 430 m^3/sec.

Ventilation System:

Ventilation system is generally categorized into three (3) types depending on the flow of air in the tunnel.

a) Longitudinal Ventilation System

Fresh air flows longitudinally along the roadway. The most common types are the following:

a) Jet-fan type
b) Saccard type
c) Shaft type

b) Semi-transverse Ventilation System

Duct in tunnel having continous fresh air flue at both sides of tunnel serves to blow or exhaust air. The two types of Semi-Transverse System of tunnel ventilation are:

a) Blowing semi-transverse type
b) Exhaust semi-transverse type

c) Transverse Ventilation System

The tunnel is provided with blow and exhaust air ducts separately.

The characteristics and applicable limits of each ventilation system is shown in Table 5-3.7. Both shaft type and blowing semi-transverse type are considered as systems applicable for this tunnel under study. This is shown in Table 5-3.7.

If the semi-transverse type blowing shall be applied, the concentration of the carbon monoxide in the tunnel will be constant through the tunnel and the ventilation mechanism stable. The duct however, must be installed inside the tunnel and which will require an additional area of approximately 11 m^2.

Furthermore, since fresh air is blown through a small section duct, a larger amount of power compared to the shaft type is necessary. Recently, from the point of energy conservation policy in Japan, even for tunnels with a length of more than 4000 m, the longitudinal ventilation shaft types are usually applied. Similarly, for this project, the shaft type was also adopted.

2) Planning of Ventilation Facilities

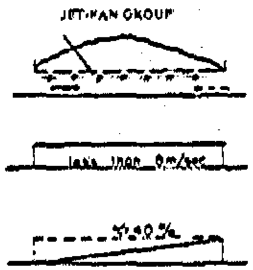
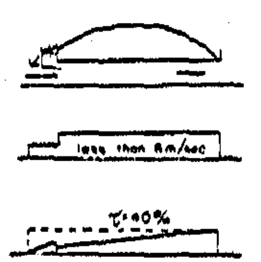
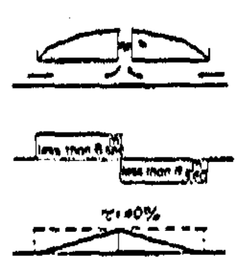
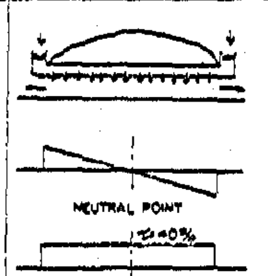
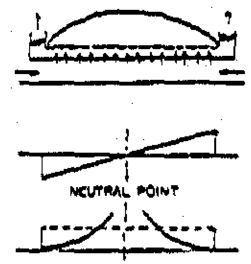
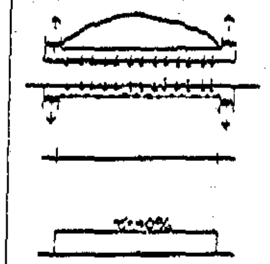
From the standpoint of topography of the project area, both the vertical and inclined shaft types can be used, however, a comparative study on their respective construction methods and costs adoptable to the tunnel operation (having the least disturbance to traffic) was undertaken.

<u>Ventilation Facilities for Vertical Shaft</u>
The vertical shaft must be located in a geologically stable area, considering safe and reliable construction. The shaft type with an area of 3000 m^2 is required in order to install the preparation facilities for construction.

Since the location of vertical shaft is limited by the elements of topography and geology, the duct connecting vertical shaft and point of suction for exhaust is necessary.

A ventilating station is needed to accommodate fan, electrical facilities, maintenance facilities for tunnel lighting and safety facilities, communication facilities and others.

TABLE 5-3.7 CHARACTERISTICS OF VENTILATION SYSTEM (FOR TWO-LANE HIGHWAY)

VENTILATION SYSTEM	LONGITUDINAL VENTILATION			SEMITRANSVERSE VENTILATION		TRANSVERSE VENTILATION
TYPE	JET-FAN GROUP TYPE	SACCARD SYSTEM	SHAFT TYPE (EXHAUST TYPE)	BLOWING SEMI-TRANSVERSE TYPE	EXHAUST SEMI-TRANSVERSE TYPE	
FEATURE	BY BOOSTING PRESSURE OF JET-FAN GROUP	BY BOOSTING OF INJECTED AIR	TAKEN IN FROM BOTH PORTAL EXHAUST FROM CENTER SHAFT	BLOWING BY BLOW DUCT IN TUNNEL	EXHAUST BY EXHAUST DUCT IN TUNNEL	BLOW-EXHAUST DUCTS IN TUNNEL AFFECTS EQUAL AMOUNT OF BLOW AND EXHAUST
SCHEMATIC DIAGRAM OF VENTILATION SYSTEM WIND VELOCITY IN TUNNEL CONCENTRATION OF GAS						
GENERAL FEATURES	1. The standard maximum tunnel length applicable is less than 1,000m. When traffic volume is small, it is applicable also for tunnel of more than 1,000 meters. 2. Installation of fans is possible even after construction is completed. 3. Installation cost is inexpensive. 4. When the tunnel is long and traffic volume is large, the maintenance cost will be high. 5. Reversing the circulation of fan, blowing to both directions is possible. 6. Since the duct is not necessary, the cross section area of the tunnel is small. 7. Studies on noise originated by the fan is necessary.	1. The length applicable is the same as jet-fan type. 2. Since the fan is installed at the ventilating facilities at portal, maintenance is easy. 3. The effect of boosting pressure affecting passing vehicles must be investigated. 4. The blowing direction is limited to one side.	1. Applicable length is less than 3000 meters as standard. 2. Since exhaust is not blown from the portal, the environmental problems at portal area is not seen. 3. By the natural wind and the difference of traffic volumes in both directions, ventilating conditions of both the right and left sides of the shaft will be uneven. 4. Roadway is utilized as duct and cross sectional area of tunnel will be small.	1. Applicable length is less than 3000 meters as standard. 2. Concentration of harmfull gases in the tunnel is even. 3. Effect of natural wind is small.	1. The concentration of carbon monoxide of neutral point will be tremendously increased. 2. No environmental problems at portal area will be seen.	1. Application length is more than 2,000 meters. 2. Due to the absense of longitudinal windflow in the tunnel, the concentration of harmfull gases will be even. 3. Since two-ducts for blowing and exhaust, and also facilities for blowing and exhaust fans are necessary, installation and maintenance cost will be high.

Ventilation Facilities for Inclined Shaft

Similar to the vertical shaft, ventilation facilities for inclined shaft must also be located on a geologically stable area. It is necessary to provide sufficient yard for preparation works.

The comparative study on construction costs for both vertical and inclined shaft was made. The unit costs adopted were estimated on the basis of experience in Japan.

It was ascertained that the construction cost for both vertical and inclined shaft are almost the same.

As the installation of this ventilation facility is to be undertaken only after 19 years from the opening of the tunnel, the construction methods and procedures that will have the least inconvenience and disturbance to vehicle operations inside the tunnel shall be adopted.

For the reasons aforementioned, the inclined shaft type was adopted. (See Fig. 5-3.14)

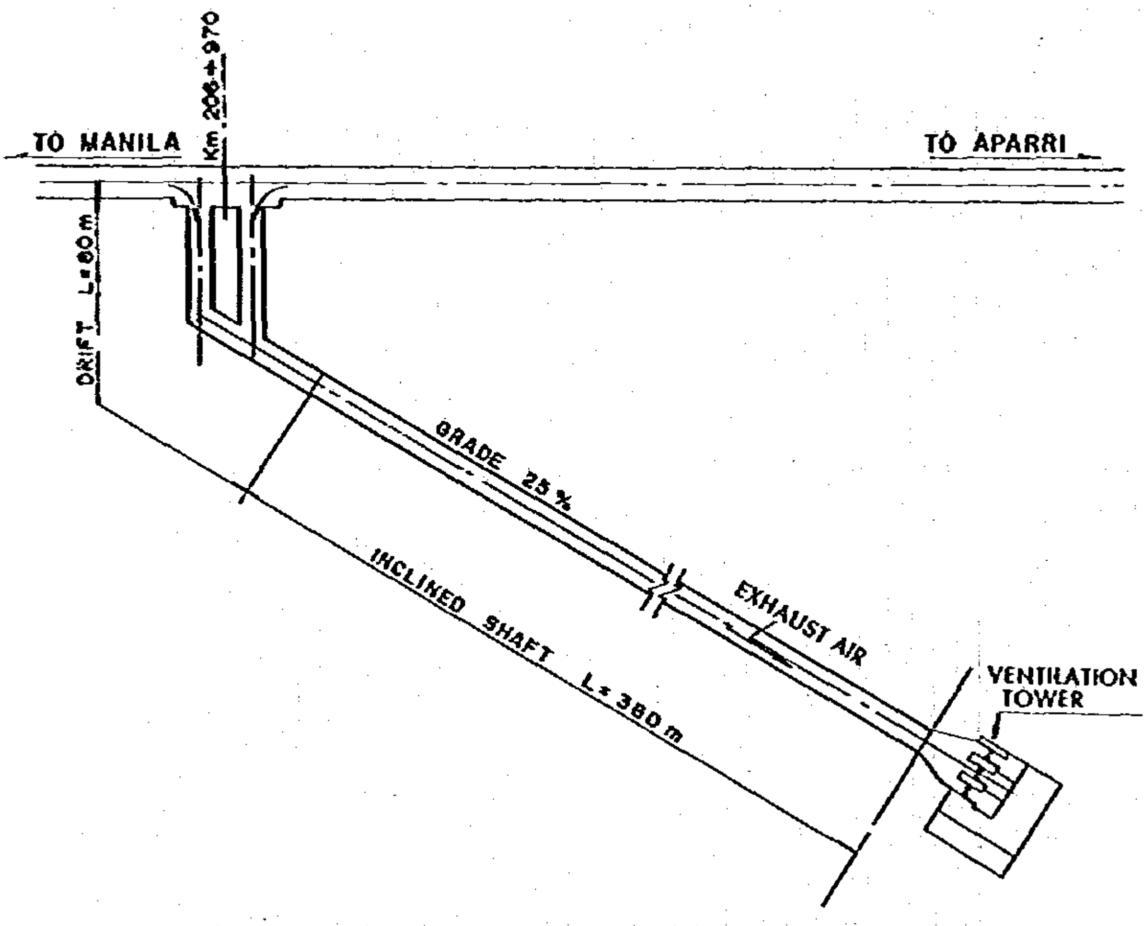


Fig. 5-3.14 VENTILATION SYSTEM BY INCLINED SHAFT

3) Stage Construction of Ventilation System

As discussed in the preceding section the shaft type was selected as a ventilation system for this tunnel. However, since the construction costs of this facility is fairly high it is not economically beneficial to install the facilities right away since the traffic volume is relatively low at the opening of the tunnel.

Therefore, stage construction for the ventilation facilities was considered. At the first stage, the ventilation system of jet-fan type in which the number of fans can be increased depending on the increase of traffic volume shall be installed. When the traffic volume will have reached the capacity which jet-fan can no longer cope, the system shall be changed to the shaft type ventilation facilities.

The number of jet fans required was computed corresponding to the traffic volume in the tunnel. Design factors in addition to those mentioned previously are as follows:

Diameter of Fan	$\phi = 1030$ mm (large size)
Blowing velocity	30 *m/sec*

The result of analysis is shown in Fig. 5-3.15.

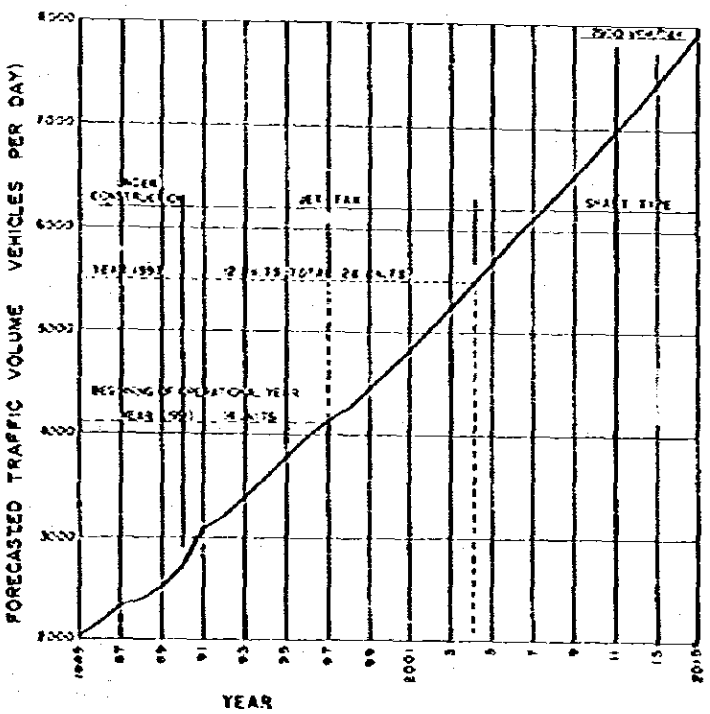


Fig. 5-3.15 VENTILATION SYSTEMS VERSUS TRAFFIC VOLUME

From the beginning of the operational year to the eyar 1997, 14 units will be sufficient. From then on to the year 2004, additional twelve units will be necessary. Finally starting year 2004 the ventilation system will be entirely changed to the shaft type.

(2) Design of Tunnel

1) Standard Cross Section

This item was already explained under Section 5-3-1, Geometric Design Standards.

2) Design of Parking Bay

The emergency parking bay must be constructed for the tunnel length of more than 1,500 m. Emergency parking bay of 3 meters wide for both directions including shoulder was allocated at appropriate intervals for emergency purposes inside the tunnel.

The typical cross section is shown in Fig. 5-3.16. The horizontal lay-out is shown in Fig. 5-3.17. The intervals of these bays shall be approximately 750 m.

Since the excavation area of the section with bay is as much as $100m^2$, considering the safety in construction, the bay must be located at a geologically stable section.

3) Design of Steel Arch Support

As soon as the excavation is completed, the supporting work shall be executed to support the grounds for secured, safe and efficient excavation operations, up to the time the lining is completed.

The natural ground load acting into a tunnel varies, depending on rock mass classification, degree of weathering size and interval of cracks, existence of springwater and others.

Estimate of load was made by the Terzagahi's equation and the design of support was based on the Proctor and White method.

The size and spacing of support corresponding to rock mass classification was computed as follows:

Rock Mass Classification	Cross Section of Steel Support	Spacing of Support (cm)
A	H—175	150
B	H—175	110
	H—200	120
C	H—200	100
D	H—200	75

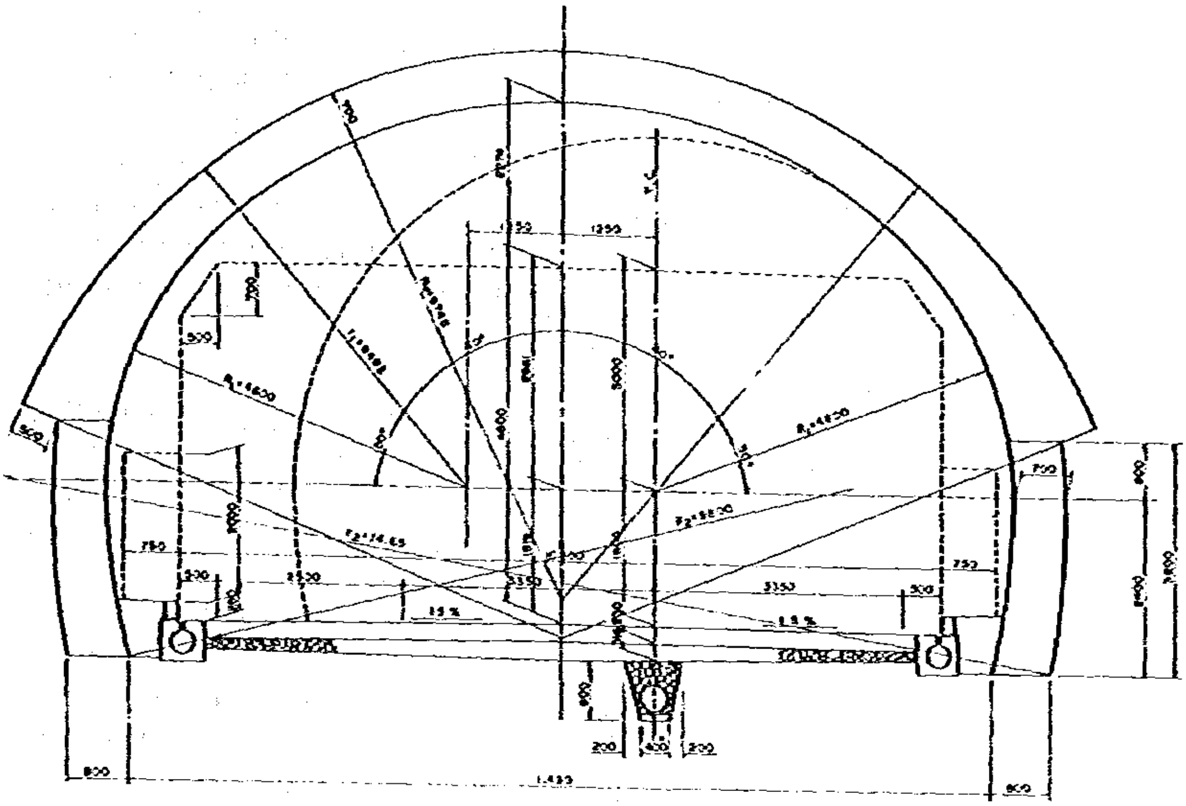


Fig. 5-3.16 TYPICAL CROSS SECTION WITH EMERGENCY PARKING BAY

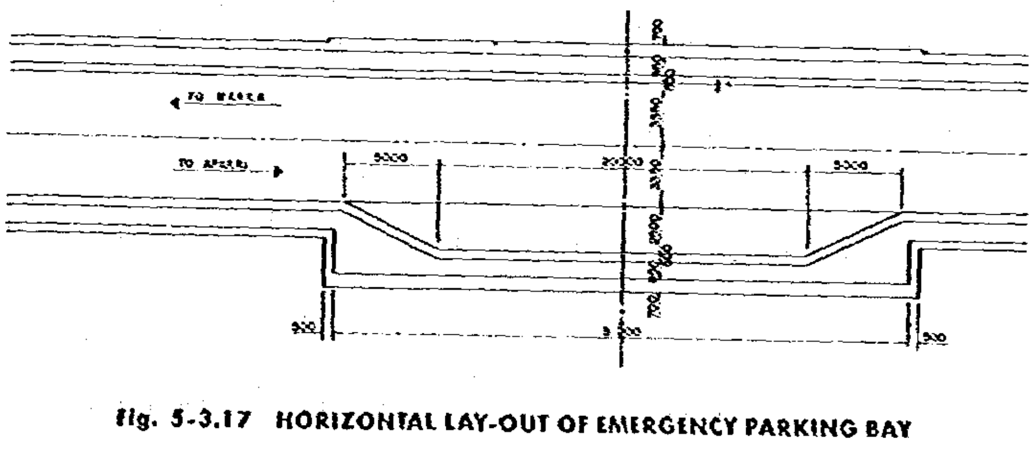


Fig. 5-3.17 HORIZONTAL LAY-OUT OF EMERGENCY PARKING BAY

4) Design of Portal

The geology around the tunnel portal is generally covered by topsoil and unsolid sediment (talus). The stratum is uncomplicated and it is easily affected by running water and groundwater.

The tunnel under study also allows the same conditions. At the northern portal especially, talus is thickly sedimented and the amount of running water due to the complicated stratus is abundant, and therefore the presence of underground water is presumed.

On the other hand, at the southern portal, the stratum is completed with slightly oblique loaded topography adjacent to the steep slope.

For practical purposes the location of the portal should provide ample space for preparation works and during construction of tunnel.

If the portal is located deep inside the mountain and excavation is planned the stability of slope will be unbalanced and this will cause failures and landslide. The portal therefore should be located as close as possible to the natural slope.

A detailed analysis should be undertaken at the detailed design phase, based more on detailed surveys. Based on the geological investigation and topography, the location of the south portal at Km 205 + 830 is considered suitable.

The northern portal however was planned at Km 207 + 700, at the boundary of natural ground and flat plane piled up by loose talus. The flat plane shall be excavated up to the foundation level for construction, and utilized as preparatory yard during construction. After completion of construction, this yard shall be utilized as emergency safety area.

Several types of portals are considered, however, in selecting the type to be used. It is also important to consider the beautification aspect, which should match the surrounding environment.

From this veiwpoint of matching natural environment, a portal of bell-mouth type is most preferred, since this type of portal presents a natural view to drivers.

Since at the northern portal, talus is widely spread out and original topography is gentle, a bell-mouth type for this portal is most preferred.

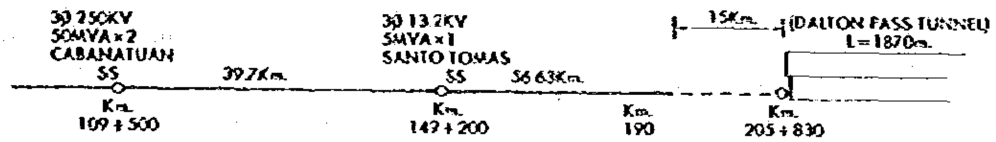
At the southern portal, the ground is loose and shows complicated stratum which will require landscaping. However, a bell-mouth type is also preferable.

(3) Design of Miscellaneous Facilities

1) Power Resources

A study was undertaken in order to diligently cover all aspects regarding power resources. Data on these were gathered from the offices that are covered by the project area; namely, Nueva Vizcaya Electric Company (NUVELCO) and National Power Corporation, Bayombong NV Sub-station. Through interviews with officers and engineers of the above-mentioned offices, several results were drawn up and are summarized hereunder.

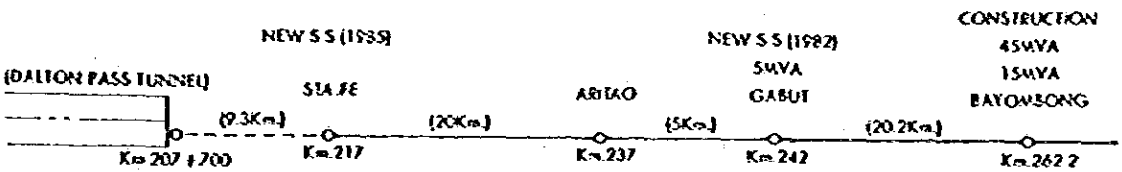
South Portal Side (Manila Side)



a) The nearest transmission line ends approximately 15 km. before the tunnel. This is transmitted along Route 5 by timber poles from Santo Tomas Sub-station at Km. 149 + 200 and is a 3-phase 3 lines with 60 hertz and 13,200 volts.

b) The volume of electric power providing electricity to the transmission line is equivalent to 5 MVA (5,000 KVA) thus still having an excess of approximately 2500 KVA. However, the capacity of the transmittal line was not determined.

North Portal Side (Aparri Side)



a) The transmittal lines to Sta. Fe of 60 hertz and 13,200 volts are presently being installed, using timber poles. These lines utilize a volume of 1.0 MW (1000 kw) power supply.

b) At Gabut which is approximately 25 km. away from Sta. Fe, a new sub-station is scheduled for construction in 1982 with a volume of 5 MVA.

c) Voltage of either 240 V or 480 V will be transmitted from the proposed Gabut sub-station. However, this voltage may be converted to varied voltages.

d) Construction cost for electric line per kilometer is P40,000 — (P36,000 for materials and P4,000 for labor). The standard distance between poles is 70 to 80 m.

e) As of September 1981, electric rates are P1.10 per kilowatt hour.

f) In 1985, a new sub-station will be constructed at Sta. Fe, Nueva Vizcaya. However, it is presumed that distribution to Dalton Pass Tunnel from this sub-station will not be acceptable to the National Power Corp.

g) No problems are foreseen regarding electric power lines from Sta. Fe to the tunnel.

2) Power Supply

The required power supply per year for the tunnel is shown in Fig. 5-3.18.

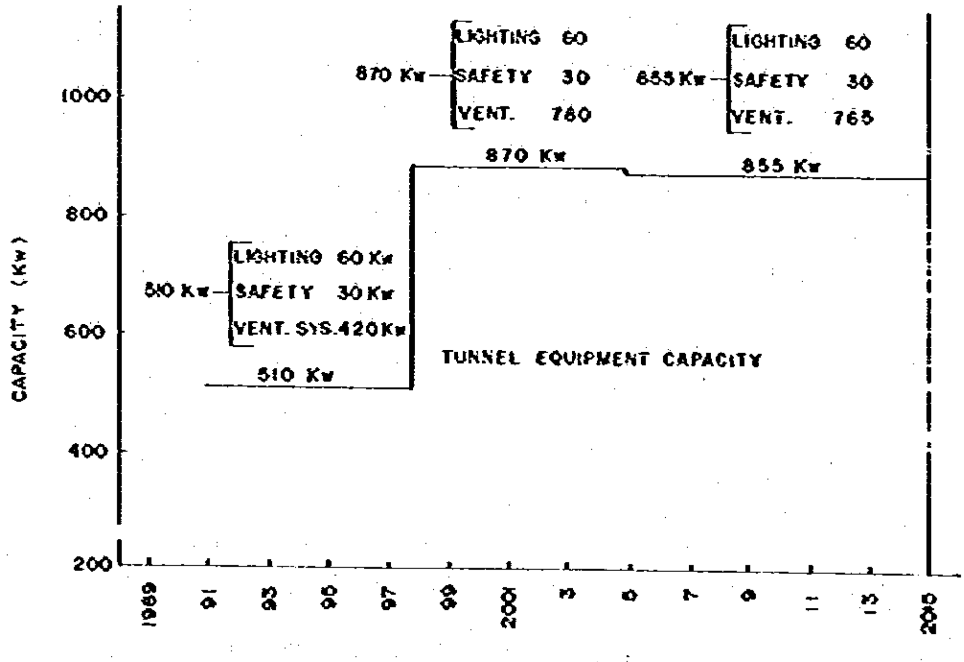


Fig. 5-3.18 REQUIRED POWER SUPPLY

The maximum power supply required for the tunnel facilities under study is approximately 1000 kw. The power will be supplied from the northern portal considering the following factors:

a) Length of distribution line up to the tunnel
b) Conditions of existing distribution lines
c) Balance of existing power supply of substations and maintenance
d) Future plan of power supply firms
e) Others

The power supply shall be secured by constructing overhead distribution line with 3-phase - 60 hz - 13200 V, connecting with Gabut substation, which will be constructed in 1982 and with capacity of 5000 KVA. The total length of the transmission lines will be approximately 35 km.

In 1985, a new substation at Sta. Fe which is approximately 9 km. away from the tunnel's north portal is to be constructed. Even though the capacity and other specifications are not clear at the moment, the deductions of maintenance costs due to reductions of length of distribution lines is expected. The general plan of distribution line is illustrated in Fig. 5-3.19.

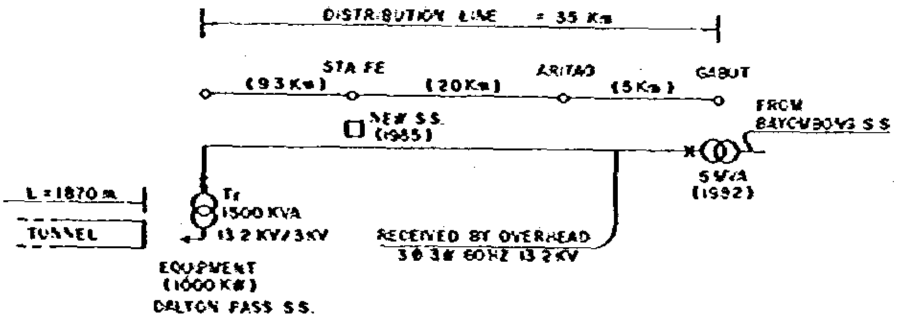


Fig. 5-3.19 GENERAL PLAN OF DISTRIBUTION LINE

Comparative Analysis on Power Supply System

The comparative analysis on power supply systems by two methods was made: a) Generator and b) construction (extension) of distribution lines. The results are shown in Table 5-3.8. The items common to both methods are omitted for analysis.

As shown in Table 5-3.8 the construction cost of distribution lines is lower than the one of generator systems by Fifty Six Million Yen or 1.9 Million Pesos. Moreover, if the generator systems are adopted it is really troublesome to have supply of cooling water, fuel and regular maintenance. A complete overhaul once in a while is also necessary. This system requires more maintenance costs after the operation than the distribution lines.

Due to the aforementioned reasons, it was decided to adopt the system of distribution lines which received power supply from substations of electric companies of the tunnel under study.

TABLE 5-3.8 COMPARATIVE ANALYSIS ON POWER SUPPLY SYSTEM

IN THOUSAND YEN

a) GENERATOR SYSTEM				b) DISTRIBUTION LINES			
ITEM	QUANTITY	UNIT PRICE	PRICE	ITEM	QUANTITY	UNIT PRICE	PRICE
750 KVA (900PS) ACCESSORIES	1 SET		¥ 91,000	DISTRIBUTION LINES	35Km	41,000, Km	¥143,500
				TRANSFORMER 1.5 MVA	1 UNIT	15,000	15,000
1250 KVA (1500PS) ACCESSORIES	1 SET		143,000				
				HIGH VOLTAGE SWITCH GEAR	2 UNITS	6,000	12,000
BUILDING	1 SET		30,000				
				HIGH VOLTAGE CONTROL BOX	1 UNIT	5,000	5,000
SUB-TOTAL			264,000	SUB-TOTAL			175,500
ORIENTATION ADJUSTMENT	1 SET		29,000	ORIENTATION ADJUSTMENT	1 SET		33,500
TOTAL			¥293,000	TOTAL			¥209,000

3) Lighting

a) Planning of fundamental lighting requirement

Design Standards

Design standards adopted for fundamental lighting requirements are as follows:

Average Surface Illuminance

Based on the Japanese standards, the surface illuminance corresponding to design speed of 60 km/hr was determined to be 2.3 cd/m^2. Assuming the pavement to be portland concrete cement, the average surface illuminance shall be 30 lx.

Source of Light

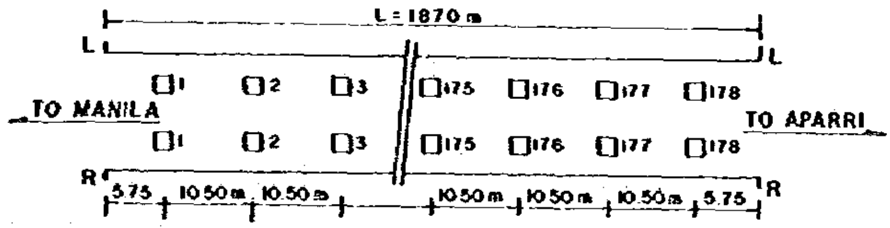
Considering the effect by the exhaust gas and light effectiveness, low pressure sodium light which is widely used in Japan was adopted.

Height of Light

The height of light shall be 4.7 m above the pavement surface, considering delineation of vehicles and maintenance purposes.

Disposition of Light

There are three types of light disposition such as alternate array, opposed array and central array. Considering the illuminance disposition at night time, the opposed array type was adopted for this design. The disposition of light is shown in Fig. 5-3.20.



NOTE: Number of Lights is 178 x 2 = 356 units

Fig. 5-3.20 DISTRIBUTION OF LIGHTS

b) Entrance Lighting

Entrance lighting shall be installed to reduce visual trouble of the driver due to rapid change in luminance when the car enters the tunnel at daytime. Based on surface illuminance L and spacing l, the disposition and number of lights were determined. The results are shown in Drawing FS-27. The The installation of lights in a tunnel is shown in Fig. 5-3.21.

4) Emergency Facilities

a) Standards for Installation

Planning and design of emergency facilities including spacing and required number of units was based on "Standards on Emergency Facilities in Tunnel (Draft), March 1981, Japan Road Association."

The installation level of emergency facilities is classified into five classes depending on the tunnel length and the traffic volume. The facilities required for each class are shown in Table 5-3.9.

The total length of tunnel under this study is 1,870 m. The estimated traffic volume in the year 2015 is 7,900 vehicles per day.

Based on the aforementioned traffic volume and length, the tunnel under study is classified as Class A. For this particular tunnel, considering the difficulty in maintenance and the countermeasures for accidents all the facilities that are marked such as automatic fire detector, smoke suctioning facilities and others were omitted.

However, since the emergency parking bay is to be constructed in a tunnel, with reference to Japanese experience, a hydrant in the bay was included in the design.

b) Communication and Alarm System

Emergency Telephone

The telephone is installed at an interval of every 200 m. and also at emergency parking bay. The installation height shall be 1.2 to 1.5 meters. The telephone should be stored in a box and lighted to make the location clear with the sign of "Emergency Telephone".

Manual Communication Equipment

The equipments are installed at an interval of every 50 m. with alternate array. The equipments shall be indicated clearly.

Emergency Alarm System

(i) Alarm Message Sign

There are three types of message signs such as the electrically illuminated type (many embedded electric bulbs forming works), word representation type (unit is projected from outside or inside the board), and signboard.

In Dalton Pass Tunnel, considering the climatic and topographic conditions, an electrically illuminated type, so-called variable message sign was adopted. The contents of information to be provided will be studied at the Detailed Engineering phase.

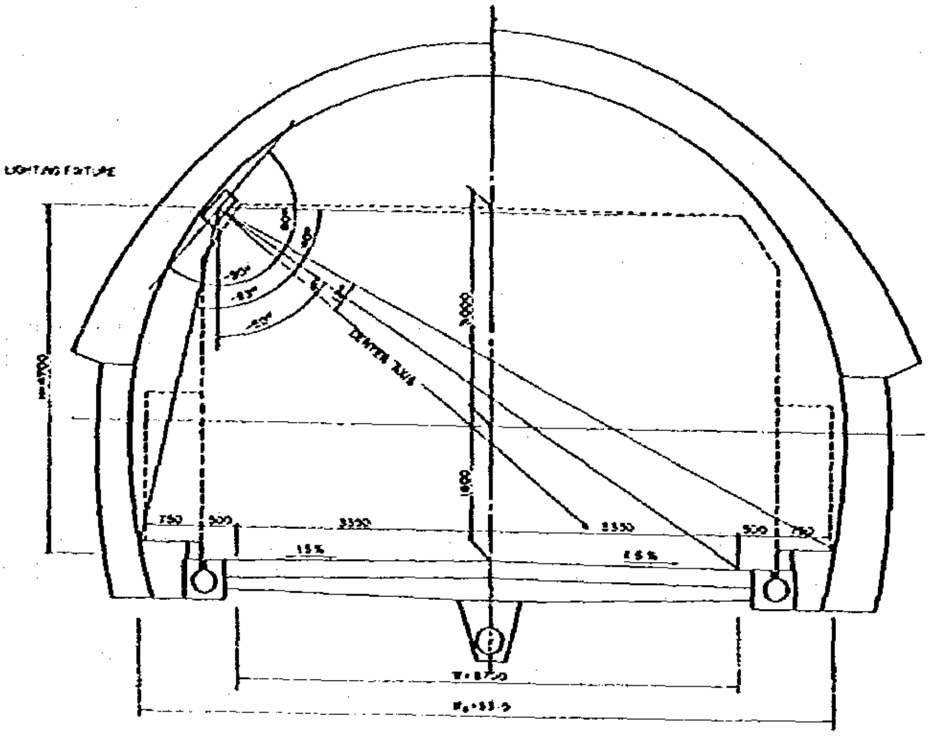


Fig. 5-3.21 INSTALLATION OF LIGHTS

TABLE 5-3.9 EMERGENCY FACILITIES REQUIRED FOR EACH CLASS

EMERGENCY FACILITIES \ CLASS		AA	A	B	C	D
COMMUNICATION AND ALARM SYSTEM	EMERGENCY TELEPHONE	O	O	O	O	
	MANUAL COMMUNICATION EQUIPMENT	O	O	O	O	
	AUTOMATIC FIRE DETECTOR	O	Δ			
	EMERGENCY ALARM SYSTEM	O	O	O	O	
FIRE-EXTINGUISHING FACILITY	FIRE EXTINGUISHER	O	O	O		
	FIRE HYDRANT	O	O			
REFUGE	GUIDE BOARD	O	O	O		
	SMOKE - SUCTIONING FACILITY	O	Δ			
OTHERS	HYDRANT	O	Δ			
	RAPID COMMUNICATION SYSTEM	O	Δ			
	LOUD-SPEAKER	O	Δ			
	SPRINKLER	O	Δ			
	SURVEILLANCE SYSTEM	O	Δ			

LEGEND: O REQUIRED AS A RULE

Δ REQUIRED DEPENDING ON SITUATION

(ii) Flashing Lamp (Red or Amber)

Flashing lamps shall be installed on the signboard. In case of accident and fire, red flashing light is turned on and amber for ongoing construction work in the tunnel.

(iii) Alarming Horn

The magnitude of volume of horn shall be more than 90 phons and less than 120 phons at distance of 20 m. from the source of sound.

5) Fire Extinguishing Facilities

The fire hydrant shall be 40 mm type and the water pressure shall be not less than 3.0 kg/cm^2. The capacity of supply per hose head shall be more than 130 l/minute.

A hose with 30 m length is connected to the water line in the side wall to extinguish fire. This shall be contained in the box installed at a distance of every 50 m. on the side wall of the tunnel.

The hydrant to be installed at both portals of the tunnel shall be the 65 mm type and the water pressure shall not be less than 3.0 kg/cm^2. The capacity of drain per hose head shall be more than 400 l/minute. The reservoir with a capacity of 38 m^3 for both fire hydrants and hydrants shall also be installed.

The facilities to be installed in tunnel are shown in Fig. 5-3.22. All the details of each facility are shown in Drawing FS-29.

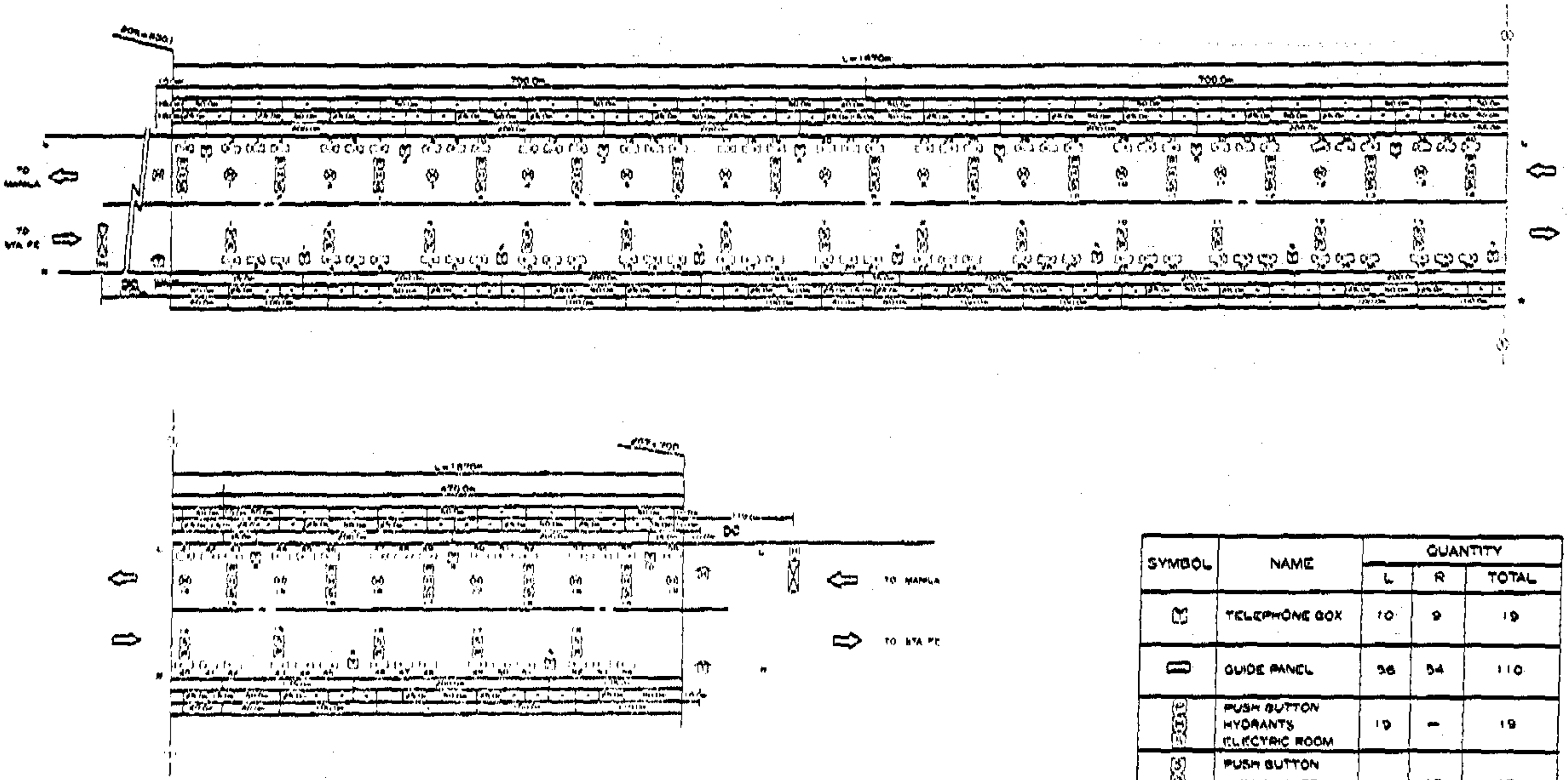
6) Planning of Distribution of Power for Tunnel

The comparative study on following sytems of distribution was conducted:

(i) The required capacity covering ventilation lighting and emergency facilities in a tunnel is gathered together and distribution of power shall be made from the northern portal side.

(ii) The required capacity is divided into two sections and the distribution of power shall be made from both portals.

The results of study showed that the systems of (ii) mentioned above is more economical. Therefore, the system in which the distribution of power to be made from both portals was adopted. The general plan of distribution is shown below.



SYMBOL	NAME	QUANTITY		
		L	R	TOTAL
	TELEPHONE BOX	10	9	19
	GUIDE PANEL	56	54	110
	PUSH BUTTON HYDRANTS ELECTRIC ROOM	19	–	19
	PUSH BUTTON EXTINGUISHER	–	18	18
	HYDRANTS	19	–	19
	ROAD INFORMATION PANEL	1	1	2
	CONTROL BOX	1	1	2
	ELECTRIC ROOM	1	1	2

Fig. 5-3.22 ARRANGEMENT DISPOSITION IN TUNNEL

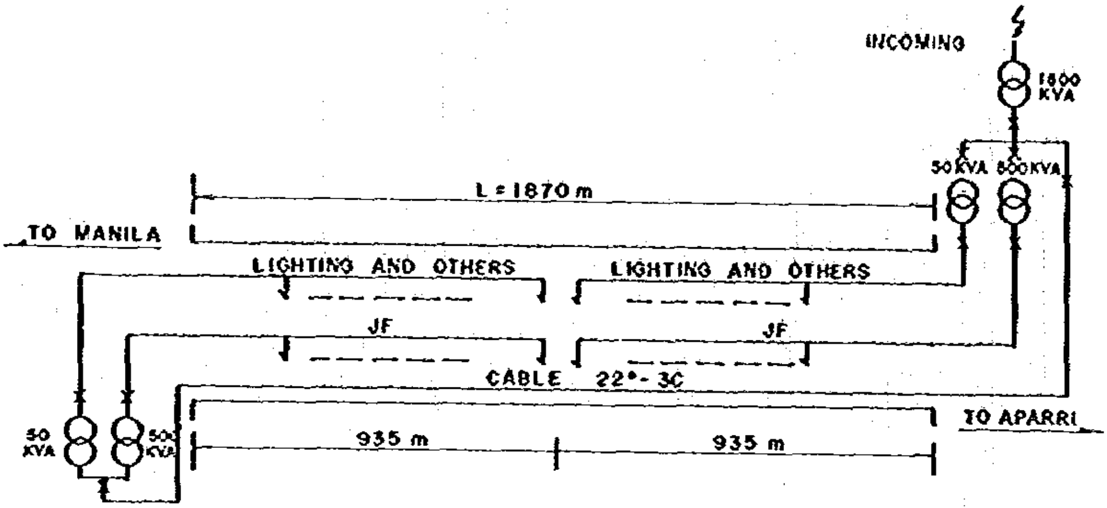


Fig. 5-3.23 GENERAL PLAN OF DISTRIBUTION

5-4 Estimation of Construction Cost

5-4-1 Construction Quantities

The quantities for all work items were computed based on the plans prepared under the preliminary designs. Construction quantities are summarized in Table 5-4.2. The detailed construction quantities for main work and facilities of tunnel is shown in Table 5-4.3.

(1) Manner of Computing the Quantities

1) Earthwork

a) Clearing and Grubbing

Computed on the basis of area requirement of the proposed road sections

b) Stripping

Computed on the basis of cross sections requirement.

c) Surplus Material of Excavation

The difference in volume of excavation and embankment was computed on the basis of cross section and mass diagram. After reviewing the classification of materials indicated on the cross sections, the cut volume was segregated into 40% common soil, 30% soft rock and 30% hard rock. The classification of materials in a tunnel was assumed as 20% of common soil, 40% of soft rock and 40% of hard rock.

The soil conversion factor assumed in the volume computation are as follows:

Classification	Cut Section	Tunnel Section
Common soil	0.9	1.0
Soft Rock	1.1	1.3
Hard Rock	1.3	1.5

d) Embankment

The embankment volume was similarly computed based on cross section. (See Fig. 5-4.1)

2) Slope protection

The amount of necessary slope protection was computed on the basis of cross sections considering the geological condition. The following slope protection measures were adopted:

Embankment Section	:	Seeding with top soil
Cut section	:	Slope protection using wooden materials on soil and/or sand. Netting or concrete pitching were planned on slopes consisting of rock
Tunnel portal	:	Precast concrete frame

3) Minor Structures

Quantities for the following minor structures were computed based on cross sections:

Retaining Wall	:	Two types of wall, gravity wall and Inverted T section wall were adopted
Stone Masonry	:	Mainly adopted at the toe of embankment in the sections adjacent to rivers

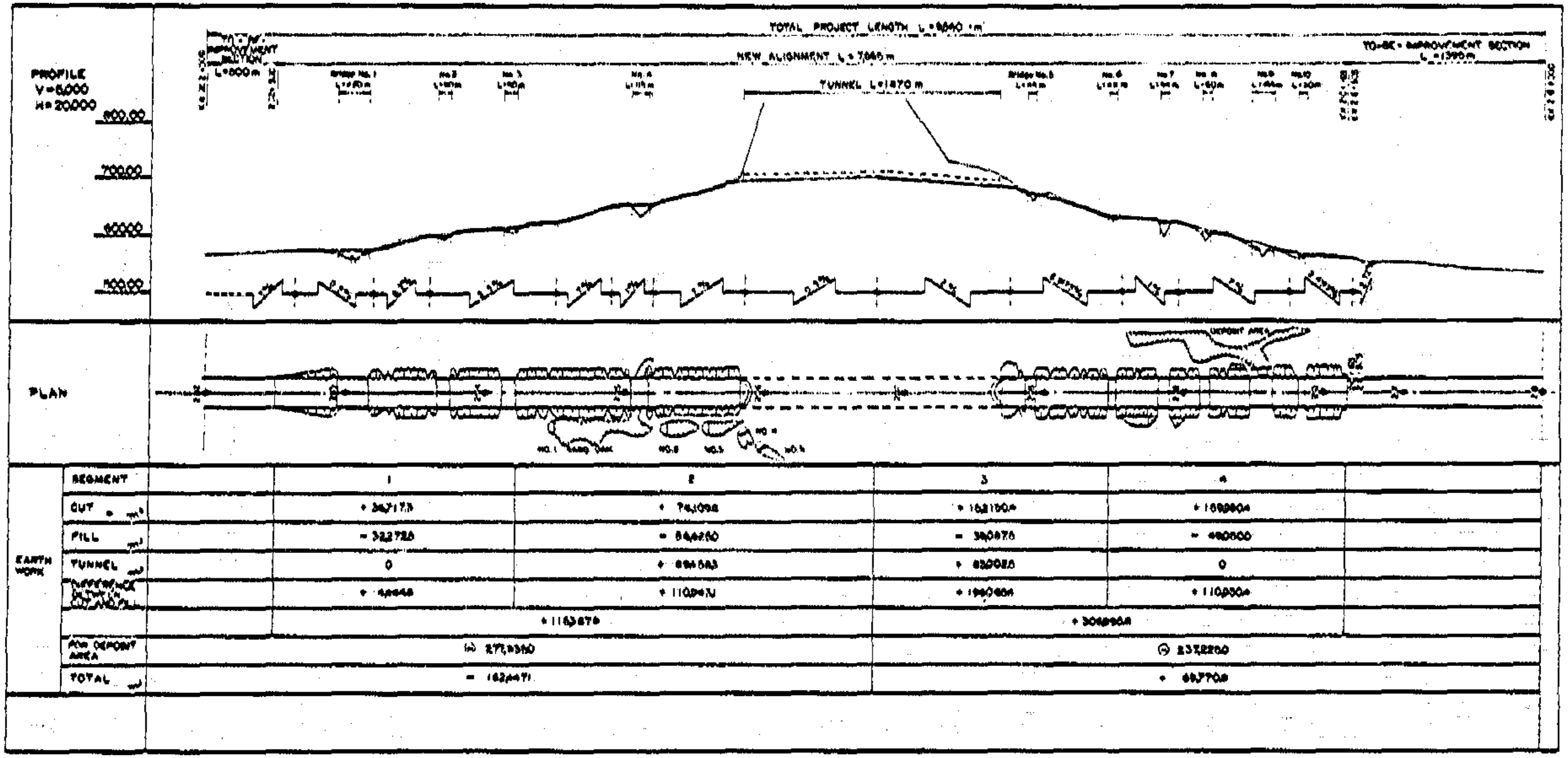


Fig. 5-4.1 MASS DIAGRAM

4) Pavement

Quantities were computed based on the typical cross sections and the length of road and tunnel sections

5) Drainage

The number of structures were computed based on the drainage requirements using the following types:

Pipe culvert	:	Generally used as cross drains
Box Culvert	:	Used in small streams or major drainage facility
Side Ditch	:	Concrete side ditch (0.5m × 0.5m) throughout cut sections

6) Tunnel

Quantities were computed item by item considering ventilation system and construction procedures.

7) Bridge

Estimates for bridge quantities are computed from actual plans prepared.

8) Sabo

Quantities for Sabo were computed on the basis of the general plans prepared for the specific structure.

9) Road Improvements

Road improvement quantities were computed based from preliminary design.

10) Miscellaneous Works

Preparatory works and safety facilities are included. This was assumed to be 15% of the total direct construction cost.

11) Right-of-Way

The width of the right-of-way shall be at least 40 m. Quantities were computed based on area requirement and land use.

5-4-2 Unit Costs

Unit prices of construction items and materials were gathered from available information in the MPWH, suppliers, recent bid prices and other sources. These data were examined and January 1981 price level was used in the estimates.

Since no construction cost data for tunneling projects are available in the Philippines, unit costs adopted for this study were based mainly on available data of similar projects in Japan.

The unit costs of each work item adopted for this study is broken down into economic and financial costs is shown in Table 5-4.1

<u>Land Acquisition and Compensation Costs</u>
The land acquisition and compensation cost was also estimated based on the available information. The unit costs adopted are as follows:

Uncultivated land	₱2.50/ m^2
Cultivated land	₱6.00/ m^2
Forest	₱7.50/ m^2
Crops	₱13.00/hill
Nipa building	₱14.00/ m^2

5-4-3 Total Project Cost

The total cost of the Project involving the construction of about 7.3 km. of road and 1,870 linear meters of tunnel in a new alignment, is approximately ₱521,751,000. This was estimated on the basis of the quantities and facilities described in the preceding sections multiplied by the corresponding unit prices. The indicated amount is also regarded as the total Financial Cost of the Project.

The summary of the project cost estimates broken down separately into each work item is shown in Table 5-4.2.

The direct project construction cost comprised of nine items are shown in the Table is approximately ₱404,326,000. Out of this the cost of the tunnel (including facilities) is about ₱308,428,000 or approximately 76% of the direct construction cost. The other 24% or about ₱95.9 M, is generally the share for the road section including structures and sabo works.

TABLE 5-4.1 UNIT COST

Item No.	Items	Unit	Financial	Tax	Economic
I	EARTH WORK				
100	Clearing and Grubbing	m^2	0.85	0.11	0.74
102	Stripping	m^3	20.83	2.75	18.08
105(2)	Excavation of Common Surplus Material	m^3	13.05	1.93	11.12
105(3)	Excavation of H-Rock Surplus	m^3	16.36	2.42	13.94
105(4)	Excavation of S-Rock Surplus	m^3	41.40	6.13	35.27
109(1)	Formation of Embankment from Roadway Excavation in Common Material	m^3	18.19	2.53	15.66
109(2)	In Soft Rock Material	m^3	22.92	3.19	19.73
109(3)	In Hard Rock Material	m^3	61.05	8.49	52.56
109(4)	Formation of Embankment from Borrow Excavation in Common Material	m^3	23.39	3.25	20.14
113(1)	Compaction of Existing Ground	m^2	2.83	0.38	2.45
113(2)	Compaction of Cut Section	m^2	2.25	0.31	1.94
I-1	SLOPE PROTECTION				
Sp13(1)	Gabions	each	455.85	63.36	392.49
	Matted Gabions	each	533.51	74.16	459.35
	Clearing of Boulder Stone	m^2	2.60	0.36	2.24
512(2)	Placing Topsoil	m^2	6.18	0.86	5.32
512(3)	Seeding	m^2	0.97	0.11	0.86
Sp1	Planting Work	L.M.	180.30	20.19	160.11
II	MINOR STRUCTURES				
106(1)	Retaining wall H=3	m^3			
	Retaining wall H=4				
	Retaining wall H=5		See Appendix		
	Retaining wall H=6				
	Retaining wall H=7				
500(1)	Stone Masonry	m^3	412.35	52.39	359.98
(2)	Grouted Riprap	m^3	383.84	48.75	335.09

Item No.	Items	Unit	Financial	Tax	Economic
III	PAVEMENT				
108(a)	Sub base course	m^3	57.79	8.44	49.35
200	Crushed Gravel Base course	m^3	115.43	16.85	98.58
302	Prime Coat	m^2	4.03	0.59	3.44
303	Tack Coat	m^2	2.02	0.29	1.73
316	Portland Cement Concrete 0.23m.	m^2	161.38	23.56	137.82
III-1	SAFETY FACILITY				
508(a)	Pavement Marking White w=0.15	m	4.07	0.59	3.48
508(b)	Yellow w=0.15	m	3.96	0.58	3.38
508(d)	Traffic Road Sign	each	809.31	118.16	691.15
510	Kilometer Post	each	236.33	34.50	201.83
	Pavement Stud	each	69.81	10.19	59.62
	Delineator		57.57		
511(1)	Metal Beam Type Guard	m	457.21	74.98	382.23
511(2)	Guard Rail End Place	each	413.19	67.76	345.43
511(3)	Concrete Post for Guard		197.16	27.41	169.75
IV	OVERLAY				
302		m^3	750.00	109.50	640.50
V	DRAINAGE				
	Grouted Side Ditch	L.M.	171.76	25.94	145.82
	Concrete Side Ditch w=0.5m	L.M.	433.18	65.41	367.77
	Sub-Drainage	L.M.	170.85	25.80	145.05
	Reinforced Concrete Pipe Culvert (1.22m)	L.M.	1312.44	185.05	1127.39
	Reinforced Concrete Box				
	Culvert 1.50 × 1.50	L.M.	3443.71	458.01	2985.70
	2.40 × 2.40	L.M.	5397.64	717.89	4679.75
	2 — 3.00 × 3.00	L.M.	14378.05	1912.28	12465.77
	Clean and Repair Existing Culvert	L.M.	62.38	8.30	54.08
	Clean out existing Ditches	L.M.	4.21	0.56	3.65
	Inlet and Outlet Headwall	set	27074.00	3600.84	23473.16
VI	TUNNEL		See Table 5-4.3		
VII	BRIDGE		See Table 5-4.3		

TABLE 5-4.2 SUMMARY OF CONSTRUCTION COST AND QUANTITIES (P1000) as January 1981

DESCRIPTION (ITEM / SEGMENT)	UNIT	1 Quantity	1 Cost	2 Quantity	2 Cost	3 Quantity	3 Cost	4 Quantity	4 Cost	Total Quantity	Total Cost	Remarks
1. EARTH WORK			1,237		4,661		4,655		4,366		16,339	
1) Clearing and Grabbing	Sq M	10,370	9	25,894	22	24,663	21	32,406	28	93,333	80	
2) Stripping	Cu M	1,077	22	2,589	54	2,466	51	3,241	67	9,373	194	
3) Surplus Material of Excavation	Cu M	44,445	165	110,943	2,618	196,065	4,627	110,930	2,618	422,383	9,958	
4) Embankment	Cu M	322,723	1101	56,625	1,931	39,059	1,333	47,650	1,673	177,036	6,038	
5) Compaction of Cut Section	Sq M	0	0	16,154	36	10,221	23	0	0	26,325	59	
2. SLOPE PROTECTION			2,658		2,976		2,454		1,419		8,907	
1) For Embankment by Planting	Sq M	8,433	31	19,207	69	11,802	42	18,155	65	57,597	207	
2) For Cut by Planting	Sq M	3,250	195	15,125	909	3,730	224	21,390	1,266	43,495	2,614	
3) For Embankment by Structure	Sq M	12,246	1,832	12,245	1,998	13,902	2,188	456	68	38,814	6,066	
3. MINOR STRUCTURES			0		1,109		1,080		4,345		6,525	
1) Retaining Wall	M	0	0	105	790	0	0	315	2,905	420	3,695	
2) Stone Masonry	M	0	0	250	319	710	1,080	750	1,440	1,720	2,830	
4. PAVEMENT	M	1,325	1,192	2,450	3,513	1,665	1,570	1,367	2,017	6,757	9,092	Including side walk and climbing lane
5. DRAINAGE			917		1,345		764		3,032		5,958	
1) Pipe Culvert	M	54	72	1117	156	97	129	69	92	1,337	449	
2) Box Culvert	M	0	0	0		0	0	39	2,145	39	2,145	
3) Side ditch and etc.	M	1,265	845	1,745	1,189	81	575	1,092	795	4,920	3,404	
6. TUNNEL	M		0	935	147,714	935	150,714		0	1,870	308,428	
1) Main Work		—	—		86,950		85,950				173,960	
2) Traffic Safety and Control		—	—		60,734		60,734				121,468	
3) Distribution Line					0		13,000	—	—		13,000	See Table 5-4-3
7. BRIDGE		430	9,627	115	2,435	45	963	378	9,525	958	22,600	See Table 5-4-4
1) Long Span L≥50m	M	430	9,627	115	2,485	0	0	270	7,078	765	19,190	
2) Short and Medium Span L<50m	M	0	0	0	0	45	963	108	2,447	153	3,410	
8. SABO		0	0	5	12,665	0	0	3	10,289	8	22,974	
1) For Digdig River	each	—	—	5	12,665	—	—	—	—	5	12,665	
2) For Santa Fe River	each	—	—	—	—	—	—	2	10,169	2	10,169	
3) Others		—	—	—	—	—	—	1	120	1	120	
9. IMPROVEMENT			507		0		0		2,056		2,563	
1) Overlay	M	500	375	0		0		0	0	500	375	
2) Others (Drainage etc)	M	500	132	0		0		1,650	1,629	2,150	1,761	
3) Santa Fe Intersection	each	—	—	—	—	—	—	1	427	1	427	
10. DIRECT COST			16,238		176,479		174,590		37,069		404,376	Total of 1 to 9
11. MISCELLANEOUS WORK			2,435		26,471		26,130		5,560		60,645	10×0.15
12. SUB TOTAL			18,673		202,950		200,720		42,629		464,972	10+11
13. RIGHT-OF-WAY	Sq M	53,000	318	59,500	351	28,200	71	54,730	137	195,530	877	See Table 5-4-5
14. SUB TOTAL COST			18,991		203,301		200,791		42,766		465,849	12+13
15. DESIGN & SUPERVISION			2,279		24,396		24,095		5,132		55,902	13×0.12
16. TOTAL COST			21,270		227,697		224,886		47,898		521,751	14+5

TABLE 5-43 CONSTRUCTION COST OF TUNNEL

Classification	Method	Unit	Quantity	Unit price	Amount	Note
Direct const. cost					139,167,850	
Excavation					92,521,100	
Top heading	Classification "B"	CU.M	24,630	496	12,191,850	Pattern (I)
Heading	Classification "C"	CU.M	25,380	525	13,324,500	Pattern (II)
Heading	Classification "D_1"	CU.M	2,160	580	1,252,800	Pattern (III)
Heading	Classification "D_2"	CU.M	25,250	640	16,160,000	Pattern (III)(IV) INVERT
Bench	Classification "B"	CU.M	21,550	250	5,387,500	
Bench	Classification "C"	CU.M	21,120	275	5,808,000	
Bench	Classification "D_1"	CU.M	1,830	320	585,600	
Bench	Classification "D_2"	CU.M	12,150	150	1,822,500	
Side drift	Classification "D_2"	CU.M	14,690	735	10,797,150	INCLUDE SUPPORT
Invert	Classification "D"	CU.M	2,620	350	917,000	
Steel support	H-100	SET	1,950	7,715	15,275,700	
Subsidized method	(GROUP)	CU.M	2,100	4,265	8,955,500	220m³×0.12×85ml
Concrete lining					38,565,850	
Arch concrete		CU.M	20,980	810	16,993,800	Pattern (I)~(IV)
Side wall		CU.M	11,090	1,165	12,243,400	
Invert		CU.M	2,780	930	2,565,400	
Arch form		SQ.M	25,190	155	3,904,450	
Wall form		SQ.M	12,080	235	2,838,800	
Drainage & sidewalk		m	1,870	2,320	4,338,400	
Portal		SET	2	535,710	1,071,420	COMMON MACHINE
Pavement		m	1,870	1,428	2,670,360	
Miscellaneous minor works		SET	1		34,791,670	COMMON MACHINE Yard of Temporary Facilities
Total cost					(173,959,000)	
(1) First stage				50,860,000		(YEAR 1991)
Tunnel lighting					3,310,000	
Lighting fixture	450V	SET	516	5,126	(2,645,000)	
Cable	3.5²−3C	m	9,900	17	(165,000)	
Hard ware		SET	518	969	(500,000)	
Ventilation					15,400,000	
Jet fan	30KW	SET	14	8,028,57	11,240,000	
Cable	22²−3C	m	12,480	54	674,000	
Cable rack	w=300m/m	SET	1,250	1,218	1,520,000	
Measuring meter	VI.CO	m	2	437,000	874,000	
Cable	VI.CO	m	3,800	42	200,000	
Control board		SET	1	92,000	892,000	
Protection against Calamities					6,010,000	
Hydrant box	OUT DOOR	SET	40	40,030	1,603,300	
Push button	OUT DOOR	SET	18	6,944	365,000	
Guide plate		SET	110	2,691	296,000	
Road information panel	OUT DOOR	SET	2	3,630 0	726,000	
Control box	OUT DOOR	SET	3	47,526	1,425,800	
Pump		SET	3	21,000	63,000	
Pipe	150mm	m	1,000	437	832,000	
Wiring		m	10,830	66	662,000	
Control board	PUMP	SET	1	64,000	64,000	
Water tank	FRP 1m³	SET	1	33,000	33,000	
Power supply					13,000,000	
Cubicle	OUT DOOR	SET	3	371,000	1,113,000	
Cubicle	1,500 KVA. Tr.	SET	1		969,000	
Distribution line		KM.	36	311,943	10,918,000	
Distribution equipment					13,149,000	
Cubicle	IN DOOR	SET	2	325,630	651,200	
Cubicle	500 KVA tr	SET	1	379,000	399,000	
Cubicle	SKVA tr.	SET	2	264,530	529,000	
Control board	JET FAN	SET	1	836,600	836,600	
Building	CONCRETE	m²	200	9,630	1,924,000	
Cubicle	IN DOOR	SET	1	325,600	325,600	
Cable	3 KV CU 22²-C	m	2,000	122	244,000	
Measuring meter	VI	SET	1	325,850	325,850	
Control board	LIGHTING	SET	2	646,850	1,293,600	
Inverted board	15KVA	SET	1	3,845,000	3,845,000	
Cubicle	10 KVA Tr.	SET	2	194,000	388,000	
Emergency equipment	15 KVA	SET	1	788,000	788,000	
Cubicle	TELEMETE	SET	1	1,440,000	1,440,000	
Cable		m	200	151,000	150,000	

Classification	Method	Unit	Quantity	Unit price	Amount	Note
(2) Second stage					11,760,000	(YEAR 1998)
Ventilation					10,213,000	
Te Fan	30 KW	SET	12	803,000	9,636,000	
Cable	22² -3C	m	10,655	54	577,000	
Distribution equipment					1,567,000	
Cubicle	INDOOR	SET	1	326,000	326,000	
Cubicle	500kv, Tr	SET	1	401,000	401,000	
Control board	FAN	SET	1	840,000	840,000	
(3) Last stage					71,827,000	(YEAR 2000)
Electrical equipment					676,000	
Ventilation					4,600,000	
Cubicle	MOTOR	SET	9	3,202.22	2,882,000	
Control board	FAN	SET	1	775,000	775,000	
Measuring meter	VI	SET	1	422,000	422,000	
Crane	INDOOR	SET	1	667,000	667,000	
Wiring	VECO.		3,000	18	54,000	
Distribution equipment			3		1,960,000	
Cubicle	INDOOR	SET		367,500	775,000	
Cable	3kv 150					
	mm -3c	m.	1,550	190	265,000	
Cubicle	TELEMETE	SET	1	750	750,000	
Cable	TELEMETE	m.	2,000	75	150,000	
Construction cost					42,031,000	
Direct const. cost					31,665,000	
Drift					4,264,400	
Excavation		CU.M	3,790	710	2,090,900	INCLUDE SUPPORT
Concrete lining		CU.M	930	1,430	(1,329,900)	INCLUDE FORSE
Invert concrete		CU.M	160	1,160	185,600	
Inclined shaft					19,045,200	
Excavation		CU.M	12,130	1,150	14,183,400	
Concrete lining		CU.M	3,000	1,430	4,290,000	
Invert concrete		CU.M	530	1,150	814,800	
Ventilation building					8,413,400	
Fixtures of site		SQ.M	3,400	90	306,000	
Building		CU.M	6,750	1,120	7,560,000	
Air duct		CU.M	650	805	547,400	
Miscellaneous	MINOR WORK	SET			6,856,000	
Access road					1,600,000	
Earth work		m.	200	2,000	400,000	
Bridge		m.	100	12,000	1,200,000	
Ventilation equipment					22,936,000	
Fan			3	4,529,000	13,587,000	
Damper			3	431,000	1,293,000	
Motor			3	1,311,000	3,933,000	
Miscellaneous work			3	1,311,000	3,933,000	
					3,823,000	

TABLE 5-4.4 CONSTRUCTION COST OF BRIDGE

STA. (KM.)	BRIDGE NAME	TYPE	LENGTH (m)	DIRECT COST (P)	P/m²
202 +560.0	S.D.P. No. 1	PCG	220	5,355,000	3010
203 +702.5	S.D.P. No. 2	PCG	90	2,130,800	2930
204 +180.0	S.D.P. No. 3	PCG	90	2,140,800	2940
205 + 95.0	S.D.P. No. 4	RCDG PCG	115	2,484,500	2670
	SUB-TOTAL		515	12,111,600	
207 +900.0	N.D.P. No. 1	RCDG	45	963,200	2650
208 +474.0	N.D.P. No. 2	PCG	48	1,035,300	2670
208 +872.0	N.D.P. No. 3	RCDG PCG	55	1,695,700	3820
209 +160.0	N.D.P. No. 4	PCG	60	1,811,400	3740
209 +558.5	N.D.P. No. 5	PCG	155	3,570,900	2850
299 +830.0	N.D.P. No. 6	RCDG	30	566,900	2460
216 +400.0	Sta. Fe	PCG	30	814,800	3360
	SUB-TOTAL		423	10,488,200	
	GRAND TOTAL		938	22,599,800	

TABLE 5-4.5 LAND ACQUISITION AND COMPENSATION COST
as of January 1981

SEG	STA. KILO-POST	LENGTH	LAND Uncultivated ₱2.5/m^2	Cultivated ₱6/m^2	Forest ₱7.5/m^2	BLDG. Nipa ₱44/m^2
	202+500					
	202+950	450.0		108,000		1 (44.0)
	203+170					
1	203+657.5	487.5		117,000		1 (44.0)
	203+747.5					
	204+135	387.5		3,000		1 (44.0)
	SUB-TOTAL		(0)	(318,000)	(0)	3 (132.0)
	204+225					
	204+500	275.0	27,500			
	205+037.5	537.5			161,250	
2	205+152.5					
	205+830	677.5		162,600		
	SUB-TOTAL		(27,500)	(162,600)	(161,250)	
	207+700					
	207+877.5	177.5	17,750			
3	207+922.5					
	208+450	527.5	52,750			
	SUB-TOTAL		(70,500)			
	208+488					
	208+845	347.0	34,700			
	208+890					
	209+130	231.0	23,100			
4	209+180					
	209+481	291.0	29,100			
	209+636					
	209+815	179.0	17,900			
	209+845	320.0	32,000			
	210+165					
	SUB-TOTAL		136,800			
		TOTAL	234,800	480,600	161,250	3 (132.0)

Note: The width of the right-of-way shall be 40 m.

To arrive at the total project cost, other cost items such as i) Miscellaneous work, ii) Right-of-way and iii) Design and Supervision were added to the direct construction cost. Miscellaneous work was taken as 15% of the direct cost while Design and Supervision was taken as 12% of the sum of direct construction cost plus miscellaneous work. The cost of right-of-way was estimated from the area needed for the new road section and the unit prices discussed previously.

The Economic Cost of the project is taken as the Financial Cost less taxes (9%). This cost is particularly relevant for the economic evaluation of the project. The total economic project cost is estimated at P474.8 Million. Details of the derivation is discussed in Chapter 8.

5-4-4 Currency Components

Foreign and local currency components of each construction item were estimated based on the following classifications on basic cost elements.

The foreign currency component consists of the following:

- Imported equipments (depreciation) materials and supplies
- Domestic materials which the country is a net importer
- Wages of expatriate personnel; and
- Overhead and profit of foreign firms

The local currency component consists of the following:

- Domestic materials and supplies which the country is a net exporter
- Wages of local personnel
- Overhead and profit of local firm; and
- Taxes

The results of analysis on currency components are shown in Table 5-4.6.

The percentage of foreign currency components is approximately 75% which is fairly high compared to other previous civil works undertaken in the Philippines.

The main reason for this high percentage of foreign currency is because the construction of tunnel is mainly undertaken by machines and equipment and also the facilities are presumed to be imported. The construction costs of tunnel use up almost 60% of the total construction costs with the 80% of foreign currency components.

TABLE 5-4.6 CURRENCY COMPONENTS OF CONSTRUCTION COST

		COMPONENTS (₱1000)				PERCENTAGE (%)		
	DESCRIPTION	FOREIGN	LOCAL	TAX	TOTAL	FOREIGN	LOCAL	TAX
EARTH WORK	Clearing and Grubbing	49	21	10	80	60.7	26.8	12.5
	Stripping	119	49	26	194	61.4	25.4	13.2
	Surplus Material of Excavation	6,698	1,794	1,476	9,963	67.2	18.0	14.8
	Embankment	4,124	1,075	839	6,038	68.3	17.8	13.9
	Compaction of Cut Section	39	12	8	59	66.8	19.6	13.6
	TOTAL	11,029	2,951	2,359	16,339	67.5	18.1	14.4
SLOPE PROTECTION	For Embankment by Mounting	25	159	23	207	12.2	76.6	11.2
	For Cut by Planting	319	2,002	293	2,614	12.2	76.6	11.2
	For Embankment by Structure	4,157	1,083	846	6,086	68.3	17.8	13.9
	TOTAL	4,501	3,244	1,162	8,907	50.5	36.4	13.1
MINOR STRUCTURES	Retaining Wall	1,981	1,223	491	3,695	53.6	33.1	13.3
	Stone Masonry	1,534	937	359	2,830	54.2	33.1	12.7
	TOTAL	3,515	2,160	850	6,525	53.9	33.1	13.0
	PAVEMENT	5,206	3,327	1,459	9,992	52.1	33.3	14.6
DRAINAGE	Pipe Culvert	263	123	63	449	58.6	27.3	14.1
	Box Culvert	1,150	710	285	2,145	53.6	33.1	13.3
	Side Ditch and Others	1,532	1,358	514	3,404	45.0	39.9	15.1
	TOTAL	2,945	2,191	862	5,998	49.1	36.5	14.4
TUNNEL	Main Work	144,735	16,874	12,351	173,960	83.2	9.7	7.1
	Traffic Safety and Control	101,062	11,782	8,624	121,468	83.2	9.7	7.1
	Distribution Line	7,969	3,484	1,547	13,000	61.3	26.8	11.9
	TOTAL	253,766	32,140	22,522	308,428	82.3	10.4	7.3
	BRIDGE	13,695	5,198	3,706	22,600	60.6	23.0	16.4
	SABO	10,959	9,167	2,848	22,974	47.7	39.9	12.4
IMPROVEMENT	Overlay	195	125	55	375	52.1	33.3	14.6
	Others (Drainage,...etc.)	923	512	326	1,761	52.4	29.1	18.5
	Sta. Fe Intersection	288	77	62	427	67.5	18.1	14.4
	TOTAL	1,406	714	443	2,563	54.9	27.9	17.2
	DIRECT COST	307,023	61,092	36,211	404,326	75.9	15.1	9.0
	MISCELLANEOUS WORK	46,030	9,158	5,458	60,646	75.9	15.1	9.0
	SUB TOTAL	353,053	70,250	41,669	464,972	75.9	15.1	9.0
	RIGHT-OF-WAY	0	877	0	877	0	100.0	0
	SUB TOTAL COST	353,053	71,127	41,669	465,849	75.8	15.3	8.9
	DESIGN AND SUPERVISION				55,902			≑ (9%)
	TOTAL COST				521,751			

Note: Economic Construction Cost = ₱521,751,000×0.91 = ₱474,794,000

5-4-5 Maintenance Costs

(1) Maintenance Cost for the Existing Road Sections

Upon the completion of new road of the Dalton Pass Section the maintenance cost of Route 5 quoted at the moment which is approximately ₱36,000 per kilometer per year will be deleted.

The amount for the section from Sta. 207 to Sta. 217 with a total length of 15 km. is estimated as follows:

Maintenance Cost for the Section Per Year

= ₱36,000×15 km. =₱540,000/year

(2) Maintenance Cost for the New Road Alignment

No costs were quoted for the new road alignment, since no maintenance would be required for this section in the next 25 years, other than minor routine work such as clearing of drainage structures and roadside maintenance.

(3) Maintenance and Operating Costs of Facilities in Tunnel

In order to maximize the functions of a tunnel, facilities for lighting, emergency, ventilation and power supplies should be installed. If these facilities are constantly well maintained to the condition as it was at the beginning of operation, other functions of the tunnel will also continue well past into future years to come.

Thus, well-programmed maintenance and operations are necessary. In Japan, the regulations and methods on maintenance and operation of electrical facilities are set by the law. It includes regulations on periods for maintenance such as:

a) Routine inspection; more than twice a month
b) Regulatory inspection; once every six months
c) Detailed inspection; every two years.

Generally, the warranty by suppliers includes maintenance of facilities for the first year of operation.

Thus, study on maintenance and operating costs for the Dalton Pass Tunnel were made based on Japanese experience. Estimates were made on the necessary costs for maintaining and operating the facilities. All changed parts shall be imported from Japan; however, changing these parts shall be done mostly by local technicians except where otherwise indicated.

1) Maintenance

a) Lighting Facilities

Lighting in the tunnel shall be done by sodium lights, which shall be imported from Japan. The life time of the lamps is assumed to be 9,000 hours.

b) Emergency Facilities

Operation tests and regular inspections on hydrants in a tunnel and variable message signs installed at both portals are required. The main works under these tests and inspections include change of damaged lamps and defective relay apparatus, adjustments of operating units, and refill of battery liquid. Maintenance on these facilities shall be the same as what is done in Japan.

c) Ventilation Facilities

i) Jet Fans

Change of bearings will be the major work done in jet fans. Change in noise absorbers of circular tubes in later years is partially included. The change of bearings for the Dalton Pass Tunnel shall be once for 15,000 hours. Overhauling and dismantling outside the tunnel shall be done by local technicians.

ii) Shaft Type Ventilation Facilities

Based on the experience in Japan an interval of 5 years is sufficient for overhaul inspection and repairs of accessory equipment such as fans and dumpers. When necessary, change in parts and repair shall be done. Changed parts shall be imported from Japan. Overhauling, inspections and repairs shall be done mainly by local technicians with assistance of experts from Japan because these shaft type facilities would need more technical know-how wherein experience is called for.

iii) Equipment and Apparatus

For visual index apparatus, change of defective lamps and adjustment for beam axis are included. Cleaning of sampling pipe filters and change of cylinder of span-gas and zero-gas are necessary for CO measuring apparatus. These works shall be done every other month.

d) Power Supply Facilities

Under this item, major work will be maintenance of transformers and controllers. In cases where change of insulated oil in a transformer is deemed necessary, a Japanese expert shall be called for to do the work. Otherwise, all other works shall be done by local technicians.

e) Inspection fo Distribution Lines

Inspection of high voltage distribution lines for power supply shall be done twice a year. However, after typhoon the damages on lines and poles should be inspected. In case defects and irregularities are found, necessary repair shall be done immediately.

2) Operating Costs

The operating costs (electrical costs) per year for each facility after the operation of tunnel were estimated. The unit costs of electrical power was assumed to be P1.10/kwh.

a) Lighting Facilities

i) Inside the tunnel, 356 lamps of sodium light with 35 watts shall be used for 15 hours for day time and 9 hours for night time daily.

ii) Lighting hours of 160 sodium lights at the entrance with a combination of 35 watts, 90 watts and 135 watts shall be used for 3 hours per day for fair days and 6 hours for cloudy days.

b) Emergency Facilities

i) Lights indicating emergency telephones and hydrants shall be open for 24 hours per day using 10 watts.

ii) Tests for various message signs with capacity of 3 kw shall be done three times a year.

iii) Tests for fire extinguishing pump facilities with capacities of 21 kw shall be done twice a year at half an hour for each test.

c) Ventilation Facilities

i) Jet Fan Type

Operating hours for each stage (first stage-14 units-30 kw; second stage-26 units-30 kw) shall be for a maximum of 6 hours per day. The operating hours of intermediate years were estimated in proportion to the traffic volume at the same year.

ii) Shaft Type

Three fans with 255 kw shall operate for a maximum of 6 hours per day. The operating hours for years up to the final stage were estimated in proportion to the traffic volume at the same year.

Estimated annual maintenance cost based on the above-mentioned assumptions is shown in Table 5-4.7. This maintenance cost is considered to be "cost" in the economic evaluation.

TABLE 5-4.7 COST ESTIMATE OF TUNNEL MAINTENANCE

P1000

YEAR	MAINTENANCE COST					ELECTRICAL COST 1.1P/KWH				
	LIGHTING	EMERGENCY FACILITIES	VENTILATION (JET FAN)	ELECTRICAL EQUIPMENT	SUB-TOTAL	LIGHTING	EMERGENCY FACILITIES	VENTILATION (JET FAN)	SUB-TOTAL	TOTAL
1991	35	10	23	20	88	209	7.4	809.6	1026.0	1114.0
92	35	10	24	20	89	209	7.4	843.7	1060.1	1149.1
93	35	10	26	20	91	209	7.4	893.7	1109.6	1200.6
94	35	10	27	20	92	209	7.4	943.8	1160.2	1252.2
95	35	10	29	20	94	209	7.4	994.4	1210.8	1304.8
96	35	10	30	20	95	209	7.4	1012.0	1228.4	1323.4
97	35	10	39	45	129	209	7.4	1503.7	1720.1	1849.1
98	35	10	41	45	131	209	7.4	1534.5	1750.9	1881.9
99	35	10	42	45	132	209	7.4	1597.2	1813.6	1945.6
2000	35	10	44	45	134	209	7.4	1659.9	1876.3	2010.3
1	35	[illegible]	46	45	136	209	7.4	1722.6	1939.0	2075.0
2	35	10	48	45	138	209	7.4	1816.1	2032.5	2170.5
3	35	10	50	45	140	209	7.4	1878.8	2095.2	2235.2
4	35	10	87	70	202	209	7.4	1259.5	1475.9	1677.9
5	35	10	90	70	205	209	7.4	1321.1	1537.5	1742.5
6	35	10	94	70	209	209	7.4	1381.6	1598.0	1807.0
7	35	10	98	70	213	209	7.4	1412.4	1628.8	1841.8
8	35	10	101	70	216	209	7.4	1474.0	1690.8	1906.4
9	35	10	104	70	219	209	7.4	1504.8	1721.2	1940.2
10	35	10	107	70	222	209	7.4	1566.4	1782.8	2004.8
11	35	10	112	70	227	209	7.4	1628.0	1844.4	2071.4
12	31	10	115	70	230	209	7.4	1688.5	1904.9	2134.9
13	35	10	118	70	233	209	7.4	1720.4	1936.8	2169.8
14	35	10	123	70	238	209	7.4	1782.0	1998.4	2236.4
15	35	10	126	70	241	209	7.4	1842.5	2058.9	2299.9

5-4-6 Unskilled Labor Requriements

The number of unskilled labors required for the construction during the period of five years was estimated.

The output of major works are assumed as follows:

ITEM	OUTPUT
Concrete	3-14 men/m^3 (Tunnel - 2.6 men/m)
Reinforcing Steel Bar	0.64 men/100 kg.
Excavation	1.17 men/m^3 (Tunnel - 0.77 men/m^3)

The total number of unskilled labors required for this construction project are estimated as shown in Table 5-4.8.

The total number of labors required is 1,002,970 persons. Assuming the working days a month to be 20 days, the average work of labors a day is computed as follows:

No. of labors = 1,002,978 ÷ 5 years ÷ 12 months ÷ 20 days
= 836 persons (say 840 persons)

TABLE 5-48 TOTAL NUMBER OF UNSKILLED LABORS REQUIRED

BRIDGE WORK			
Concrete	10,663 $m^3 \times 3.14$	=	33,450
Excavation	10,787 $m^3 \times 3.14$	=	12,632
Reinforcing Steel Bar	973.7t × 6.4	=	6,179
Others	5 × 20 × 12 × 2 × 4		9,600
	yr. day mo. seg.		63,861 persons
SABO WORK			
Concrete	20,300 × 3.14	=	63,742
Excavation	30,450 × 1.17	=	35,627
Channel work	1100 × 4.5 × 3.16 × 2	=	31,284
Others	5 × 20 × 12 × 2 × 2	=	4,800
			135,453 persons
EARTHWORK			
Excavation	426,957 × 1.17	=	499,540
Concrete	19,845 × 3.14	=	62,313
Others	5 × 20 × 12 × 2 × 4	=	9,600
			571,453 persons
TUNNEL WORK			
Excavation	149,600 × 0.77	=	115,192
Concrete	40,392 × 2.60	=	105,019
Others	5 × 20 × 12 × 5 × 2	=	12,000
			232,211 persons
TOTAL		=	1,002,978 persons

5-5 Implementation Plan and Schedule

5-5-1 Access Road for Construction

In accordance with the construction procedure drawn for the project, access roads for construction will be necessary. Discussion on this requirement is presented segment by segment as follows:

a) Segment 1
The Digdig River bed shall be utilized.

b) Segment 2
Based on the Fig. 5-5.1 the construction procedure is as follows:

1) Sabo dam No. 3 shall be first constructed. Deposit area shall be constructed from the excavated materials of Section ②

2) Sabo dam No. 2 shall be constructed. Deposit area shall be constructed from excavated materials of Section ④

3) Following above-mentioned construction works, the main roadway shall be constructed. Simultaneously, the construction of tunnel shall be undertaken by bringing in materials and equipment using an access road (L=400m) passing through the left side of Digdig River bed. This shall be utilized for the construction of the access road.

c) Segment 3
For Segment 3, the necessary access roads ⓐ and ⓑ are as shown in Fig. 5-5.2. The plan and profile of these routes are also shown in Fig. 5-5.2.

d) Segment 4
The existing forest road shall be utilized.

5-5-2 Construction Method

Based on the results of geological investigation and topography of the tunnel considering prospective applicable equipment, selection of excavation method was made also drawing attention to the experience of tunnel construction in Japan.

As an excavation method for this tunnel, the upper-half heading method is used for the main work and the application of a supplemental method was partially adopted.

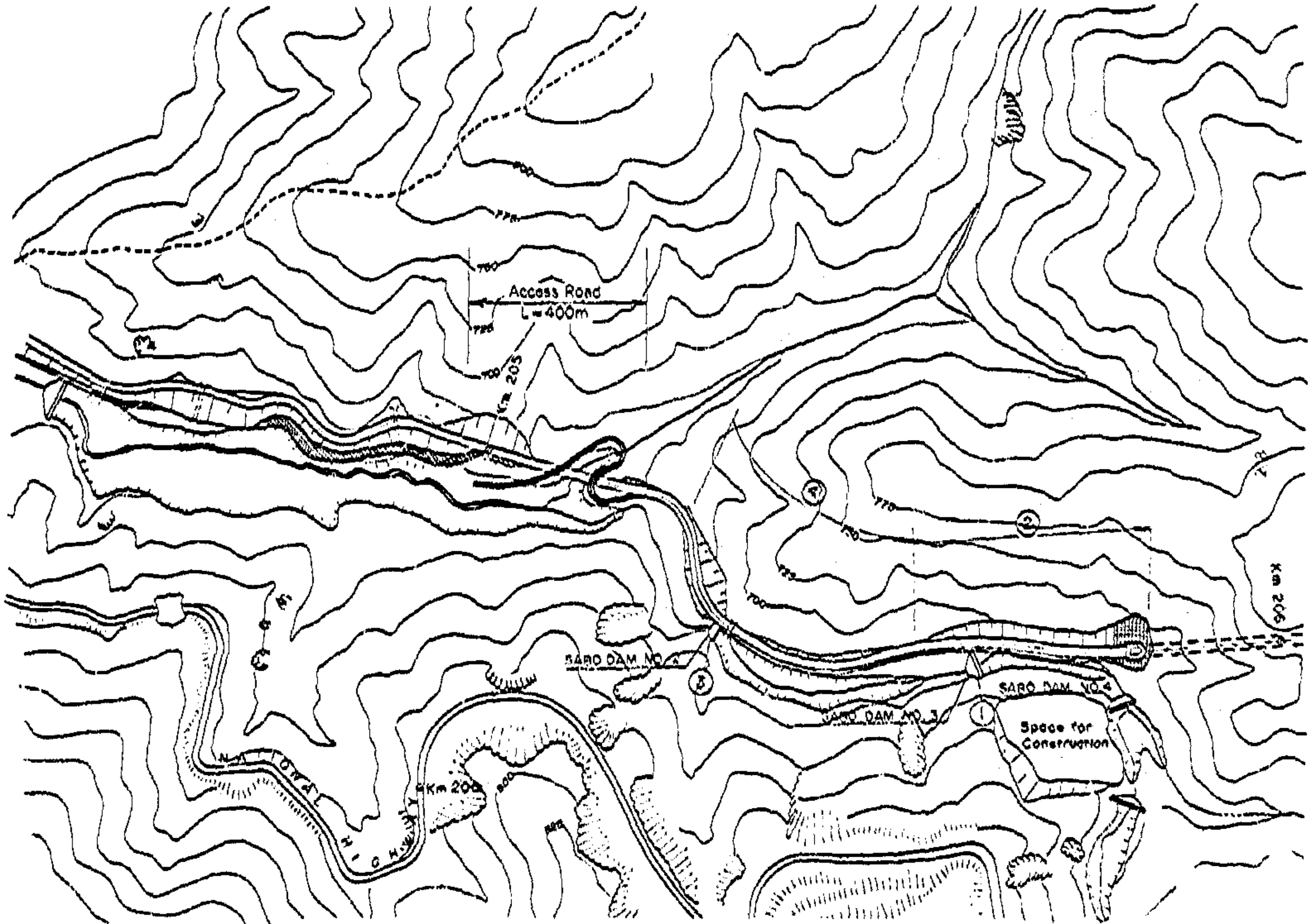


Fig. 5-5.1 ACCESS ROAD AND WORKING SCHEDULE (Capintalan Side)

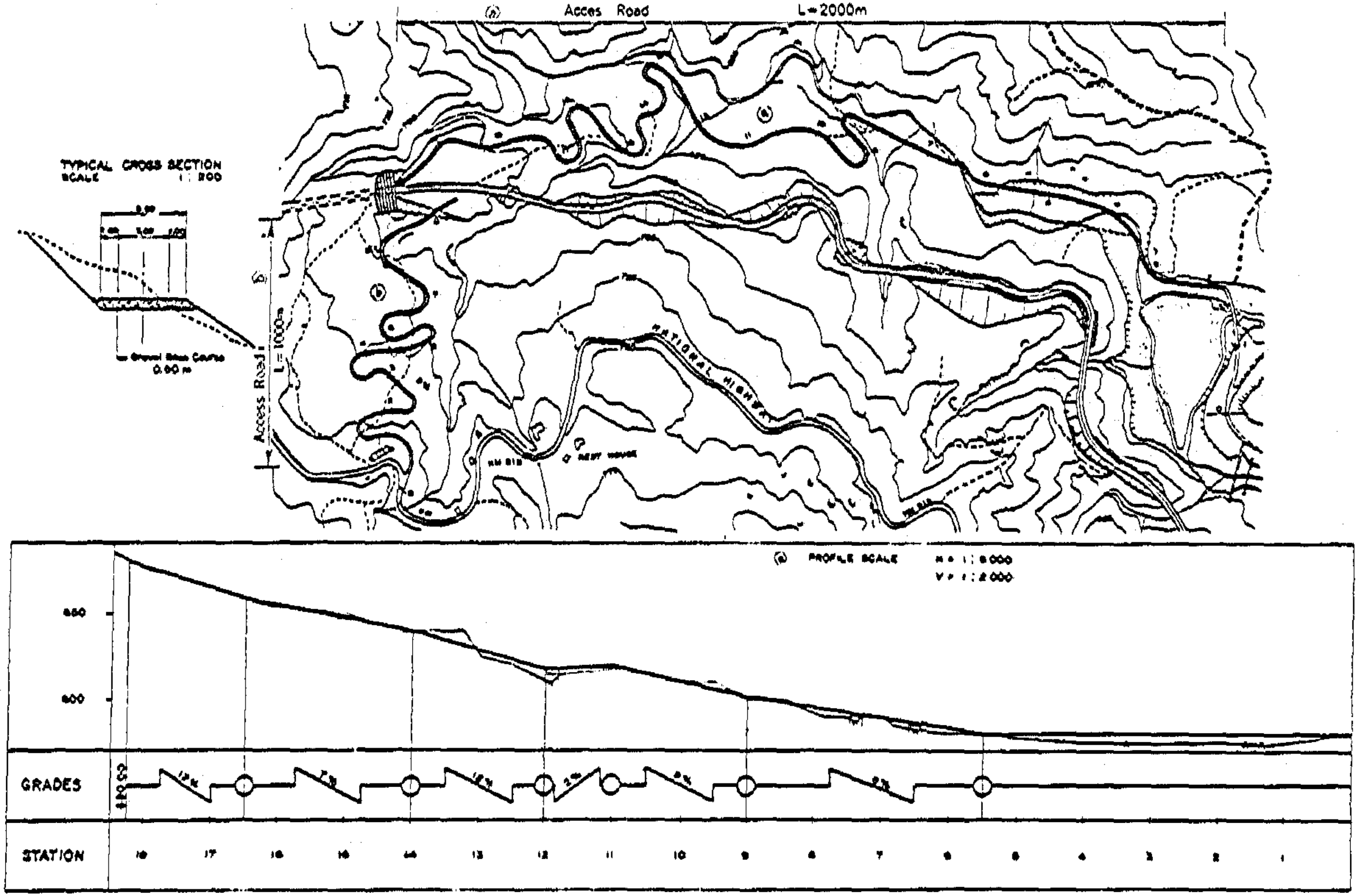


Fig. 5-5.2 ACCESS ROAD FOR TUNNL CONSTRUCTION (Sta Fe Side)

For the section of 450 m at the north-end portal and 140 m at the south-end portal where geological condition is poor, in order to prevent sinking of arch and collapse at the excavation, the application of side drifts method was adopted. At the time concrete grouting for this section is completed the method shall be changed to upper-half heading method.

Sequence of the construction by upper-half heading method is illustrated in Fig. 5-5.3 Sequence of the construction by side drifts method which is applicable to the loose rock foundation area is illustrated in Fig. 5-5.4.

(1) Preparatory Works

1) Equipment and Facilities for Tunnel Construction

Since the excavation is scheduled to be propelled from both portals, all the facilities for preparation works are programmed to be located at both ends of tunnel. All the necessary equipment and facilities are shown in Table 5-5.1.

2) Power Supply Required for Preparatory Works

Since the equipment and facilities for tunnel construction is scheduled to be located at both ends of tunnel, facilities for power supply system shall also be located at the same place.

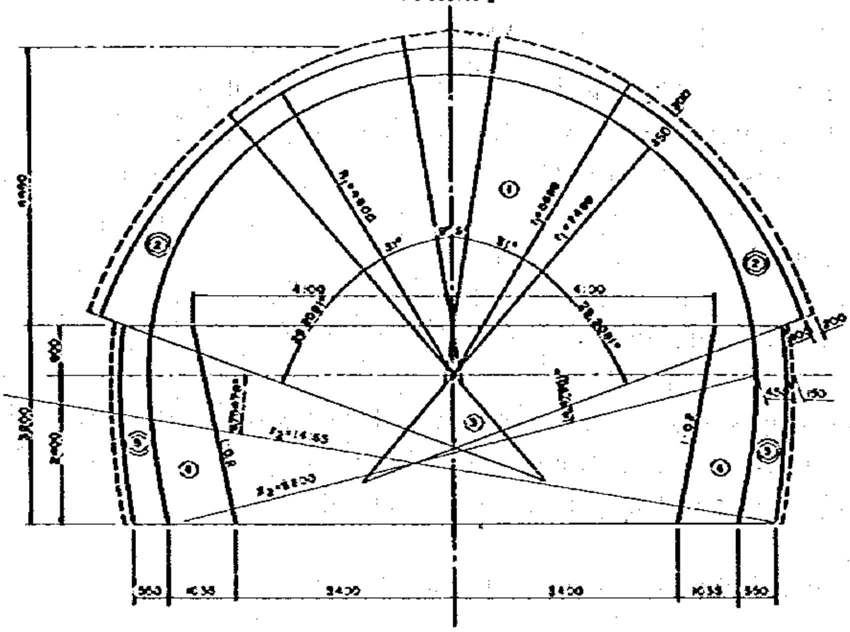
The required capacity for preparation works according to the construction plan are as follows:

		for Manila side		for Aparri side	
Equipment	Unit	Qty	Capacity	Qty	Capacity
Compressor	150 kw	2	300 kw	2	300 kw
Others	set	18	255.5	14	240.7
TOTAL	set	20	555.5	16	540.7

For a compressor, the receiving voltage of 3 phase, 3000V is used as it is. The transformer which is required for other equipment shall be installed.

The capacity of transformer (T.r.) is determined by 255.5 kw at the south approach and facilities shall be located at both ends of the tunnel.

Pattern I

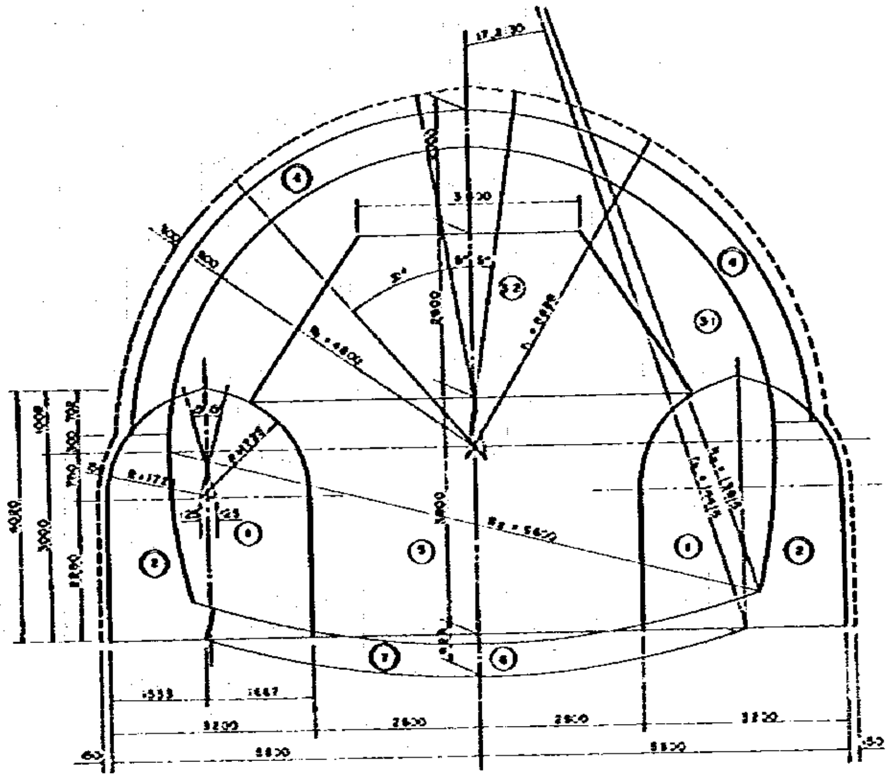


SECTIONAL AREA OF TUNNEL

No	Contents of Work	Net Area (m2)	Area (m2)	Remarks
①	Upper half heading	359	391	
②	Concrete lining of arch	74	89	
③	Excavation of bench	242	242	
④	Excavation of wall	90	100	
⑤	Concrete lining of side wall	30	40	
	EXCAVATION	691	733	
	CONCRETE LINING	104	129	

Fig. 5-5.3 SEQUENCE OF CONSTRUCTION (UPPER HALF HEADING METHOD)

Pattern IV



SECTIONAL AREA OF TUNNEL

No	Contents of Work	Net Area (m^2)	Area (m^2)	Remarks
①	Excavation of side drifts	22.9	24.9	
②	Concrete lining of side wall	7.9	8.9	
③	Upper half heading	37.5	42.8	Pre. cut 29.0 m^2 Core 13.6 m^2
④	Concrete lining of arch	9.3	12.6	
⑤	Excavation of bench	20.6	20.6	
⑥	Excavation of invert	3.7	3.7	
⑦	Invert concrete	4.3	4.3	
	EXCAVATION	84.7	92.0	
	CONCRETE LINING	21.5	25.8	

Fig. 5-5.4 SEQUENCE OF CONSTRUCTION (SIDE DRIFTS METHOD)

TABLE 5-5.1 NECESSARY EQUIPMENT AND FACILITIES FOR TUNNEL CONSTRUCTION

EQUIPMENT	METHOD	UNIT	FOR MANILA SIDE	FOR APARRI SIDE
EXCAVATION				
2-BOOM JUMBO	CATERPILLAR TYPE, AIR 25KW		2	2
LEG DRILL	39 Kg.		4	4
PICK HAMMER	CA-7		4	4
TRACTOR SHOVEL	1.6 m³		2	2
DUMP TRUCK	11 t		5	5
DUMP TRUCK	2 t		3	3
BREAKER	OIL. HB1200 0.7 m³		1	1
SUB-FAN	11Kw		1	1
CONCRETE LINING				
CONCRETE PUMP	60 m³/hr		2	2
CONCRETE MIXER TRUCK	6 m³		3	3
STEEL FORM	TRAVELLING FORM 10.5m 11 kW	SET	1	1
STEEL CENTERING	USE ARCH 6 m	SET	1	1
WALL FORM	1.5 m × 5 Span	SET	1	1
WALL FORM	1.5 m × 2 Span	SET	1	1
CONCRETE PIPE	ϕ8"		50	100
VIBRATOR	ϕ43 m/m ELECTRIC 1kW		4	4
COMMON MACHINE OF TUNNEL				
EXHAUST FAN	FAN 30 Kw × 2 UNITS	SET	1	1
AIR PIPE (VENTILATION)	ϕ900mm steel	m	900	900
DRAINAGE PUMP	SUMP PUMP 3.7 Kw		4	—
DRAINAGE PIPE	ϕ4 PUMP 3.7 Kw	m	800	—
BACKFILL GROUTING MACH.		SET	1	1
WELDING MACHINE	ELECTRIC TYPE 10 Kw		1	1
SURFACE INSTALLATION				
COMPRESSER	150 Kw		2	2
RECEIVER TANK	2 m³	SET	1	1
COOLING TOWER	MI 5010	SET	1	1
POLISH MACHINE OF BIT			1	1
WELDING MACHINE	ELECTRIC TYPE 10 Kw		2	2
WELDING MACHINE	GAS		2	2
CUTTING MACHINE	HIGH SPEED 5.5 Kw		1	1
GRINDER	1.5 Kw		2	2
CRANE	15 Kw		1	1
TRUCK CRANE			1	1
BELT CONVEYER	L=7 m 0.3 Kw		4	4
ORDINARY TRUCK	6t		1	1
SUPPLY WATER PUMP	ϕ4" 10 Kw		1	1
PURIFY EQUIPMENT OF DRAINAGE	30 t/hr 40 Kw	SET	1	1
AIR PIPE	ϕ4" GAS PIPE	m	900	900
WATER PIPE (SUPPLY)	ϕ4" GAS PIPE	m	900	900

$$T.r = \frac{P \times \alpha}{\mu \times \cos \theta} \quad (KVA)$$

P = Equipment Capacity 255.5 kw

α = Equipment demand factor 0.9

μ = Equipment power factor 0.9

$\cos \theta$ = Equipment power factor 0.9

$$Tr = \frac{255.5 \times 0.9}{0.9 \times 0.9} = 283.9 \text{ KVA}$$

(say 300 KVA)

Voltage was determined to be primary 3300 V and secondary 200V
The electric wiring is shown below. (See Fig. 5-5.5)

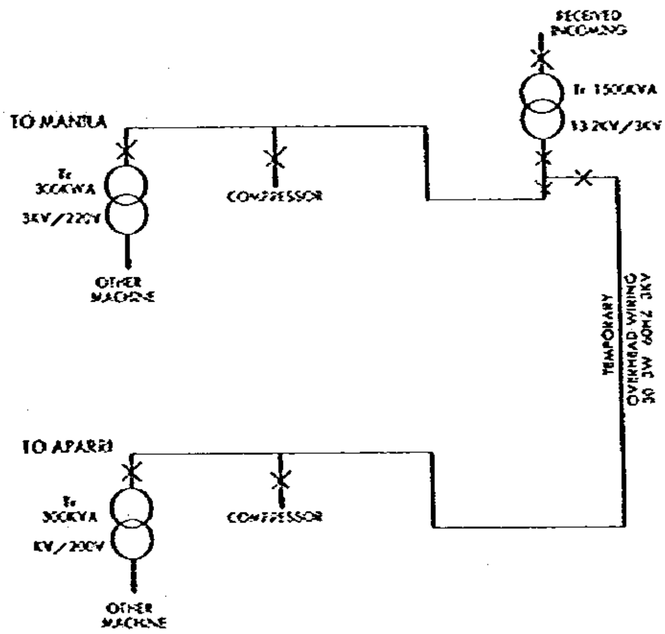


Fig. 5-5.5 ELECTRIC WIRING

5-5-3 New Austrian Tunneling Method

Preliminary design of tunnel under study was planned based on the data and information gathered and presuming that the prevailing construction method in Japan be adopted.

This method is the type in which the steel support and concrete lining are applied, and the road shall be borne by the strength of supporting members.

Recently, a new construction method called New Austrian Tunneling Method (NATM) has been used in some tunnel projects in Japan as well. In this method, the weakness of natural ground shall be strengthened by rock-bolts and sprayed concrete and the natural ground itself acts as support in order to fully utilize the resistance force which the natural ground has.

Based on the data available on the features of rocks, considering the type of support for each category of rocks, cross sections shown in Figs. 5-5.6 and 5-5.7, were prepared.

For determination of adoption of this method, more detailed geo-technical investigations are required.

The NATM should be further studied and further considered as an alternative method when more detailed geo-technical information are undertaken during the detailed engineering phase.

5-5-4 Construction Schedule

(1) Construction Schedule for Tunnel

Since the construction period of tunnel is considered critical, the construction schedule was at first programmed.

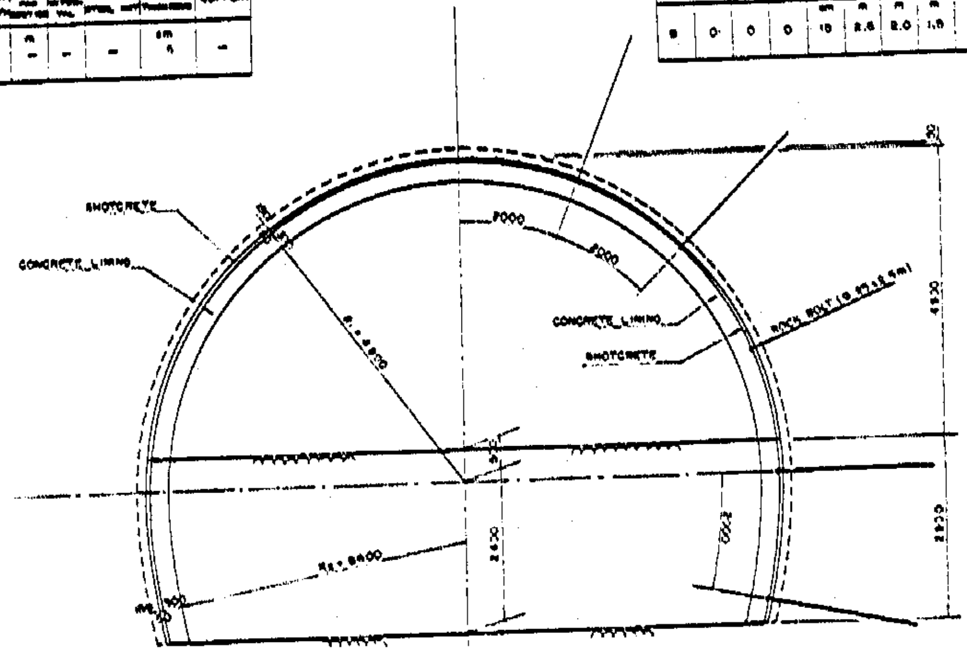
The progress or accomplishment per month for each construction item and classification of rocks to program the construction schedule of tunnel is assumed as follows, based on the previous experience in Japan with the actual working days per month of twenty days.

<u>Upper-Half Heading Method</u>

Classification	Top Heading	Arch Lining	Bench	Side Wall Excavation Lining	Invert Arch
A	65m/mon	105	115m/mon	105m/mon	
B	60m/mon	105	130m/mon	105m/mon	
C	50m/mon	105	130m/mon	105m/mon	
D	40m/mon	105	130m/mon	105m/mon	100m/mon

PATTERN	ALLOWANCE OF DEFORM			PAY LINE	ROCK BOLT			SHOTCRETE		STEEL SUPPORT
	ARCH	SIDE WALL	INVERT		LENGTH	[illegible]	[illegible]	STEEL NET	THICKNESS	
A	0	0	0	cm 15	m –	m –	–	–	cm 5	–

PATTERN	ALLOWANCE OF DEFORM			PAY LINE	ROCK BOLT			SHOTCRETE		STEEL SUPPORT
	ARCH	SIDE WALL	INVERT		LENGTH	[illegible]	[illegible]	STEEL NET	THICKNESS	
B	0	0	0	cm 15	m 2.5	m 2.0	m 1.5	–	cm 5	–



PATTERN A

PATTERN B

Fig. 5-5.6 CROSS SECTION FOR NATM (1)

Pattern	ALLOWANCE OF DEFORM			PAY LINE	ROCK BOLT			SHOTCRETE		STEEL SUPPORT
	Arch	Side Wall	Invert		Length	Per Section	Interval	Steel net	Thickness	
C	0	0	0	15 cm	3.0 m	1.0 m	1.2 m	Arch 90°	10 cm	---

Pattern	ALLOWANCE OF DEFORM			PAY LINE	ROCK BOLT			SHOTCRETE		STEEL SUPPORT
	Arch	Side Wall	Invert		Length	Per Section	Interval	Steel net	Thickness	
D	10 cm	0	0	10 cm	4.0 m	1.2 m	1.0	Arch	15 cm	MU-29

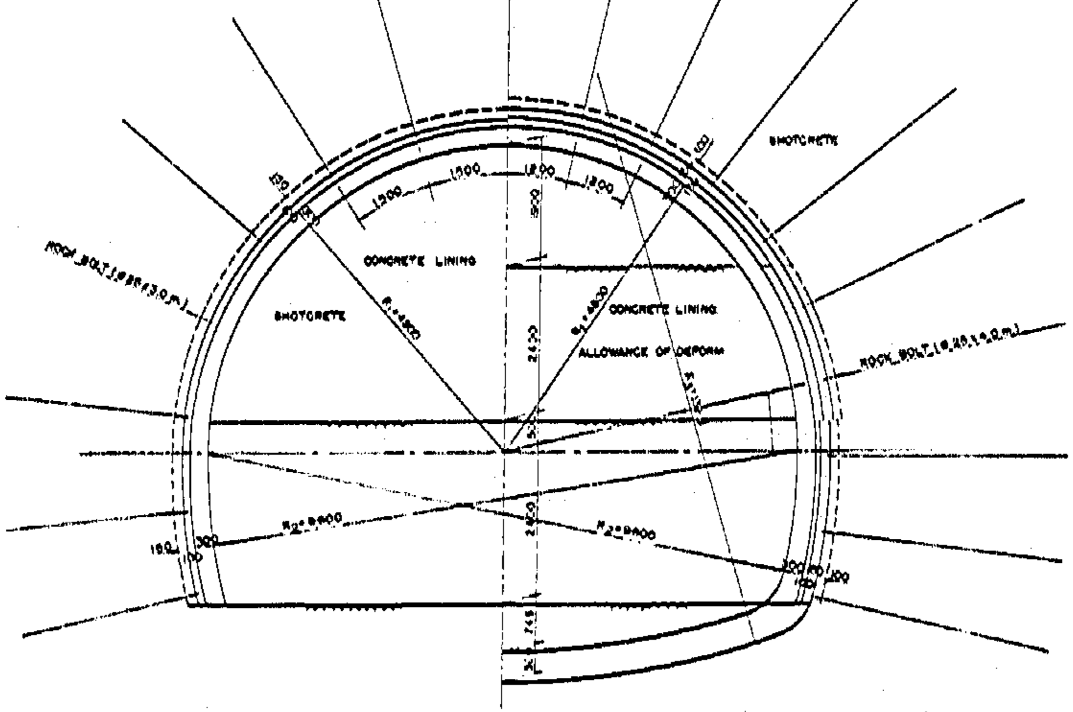


Fig. 5-5.7 CROSS SECTION FOR NATM (2)

Side Drifts Method

	Classification D_2
Side Drift	70 m/mon
Top Heading	40 m/mon
Bench	90 m/mon
Lining of Arch	105 m/mon
Lining of side wall	105 m/mon

Based on the factors discussed above, the construction schedule for tunnel section was determined as shown in Fig. 5-5.8

(2) Stage Construction for Tunnel Facilities

Based on the study on traffic demand, stage construction for tunnel facilities was considered. At the beginning of operation year in 1991, the tunnel main structures shall be completed and a ventilation system with 14 units of jet-fans shall be installed.

When the traffic volume will increase and reach a capacity which 14 units jet-fan groups can not cope with, probably in the year 1987, additional 12 units of jet-fan shall be installed.

Furthermore, when the traffic volume will increase and reach a capacity which a jet fan ventilation system can not cope with later on (presumed to be in the year 2004) the system shall be totally changed to the shaft type ventilation facilities.

Only the period in which the main construction work and intallation of ventilation systems which meet the requirements at the first stage was considered in the construction schedule under this study.

(3) Implementation Schedule

The prospective Implementation Schedule is shown in Fig. 5-5.9. Preceding the commencement of construction works in the year 1986, pre-construction preparatory works such as detailed engineering, land acquisition and compensation and bidding process are required.

The period of two years is necessary for the detailed engineering considering perspective activities and works involved. As soon as a plan is prepared section by section, the negotiation on land acquisition and financial assistance procedure (if necessary) must be studied.

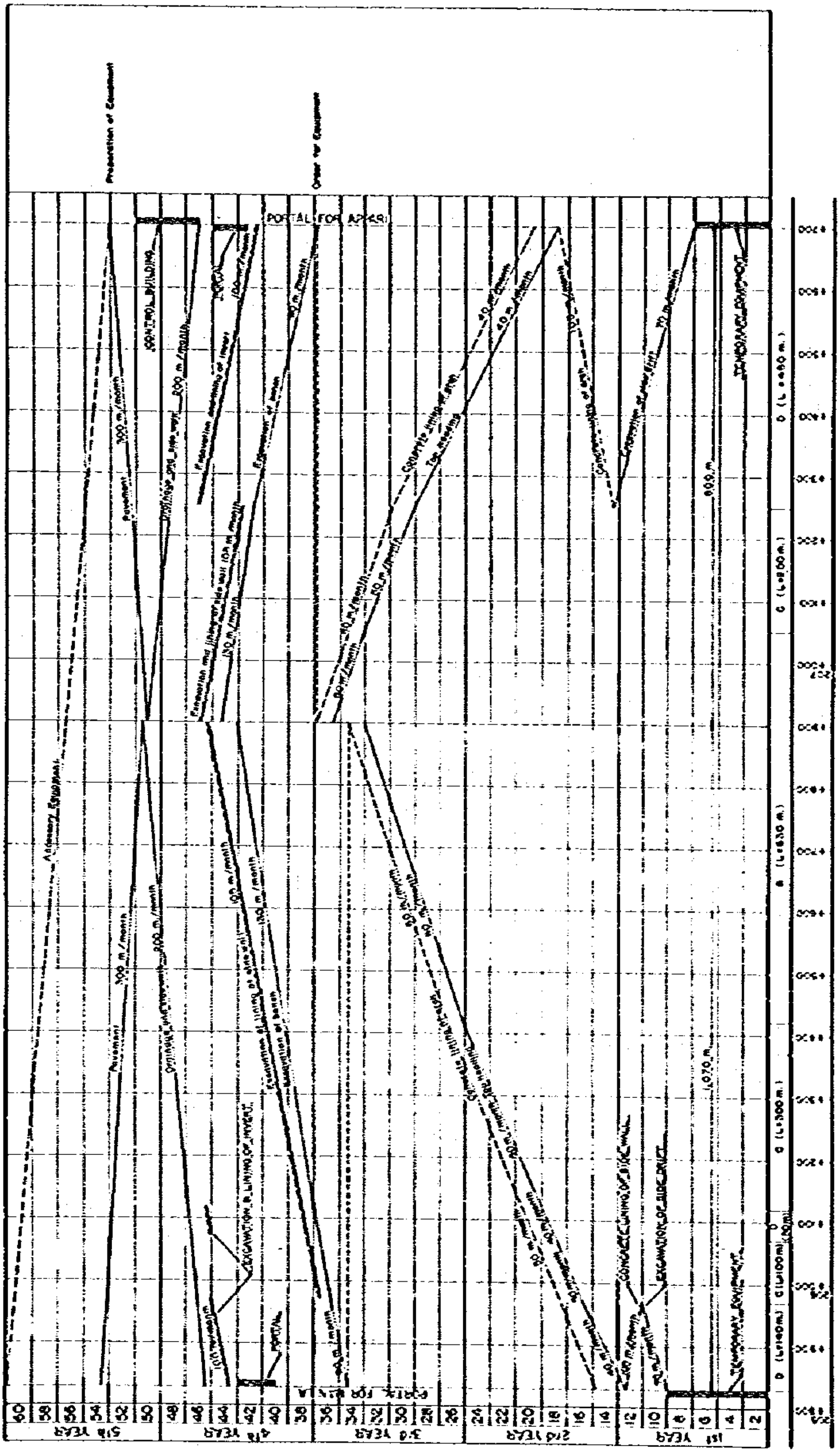
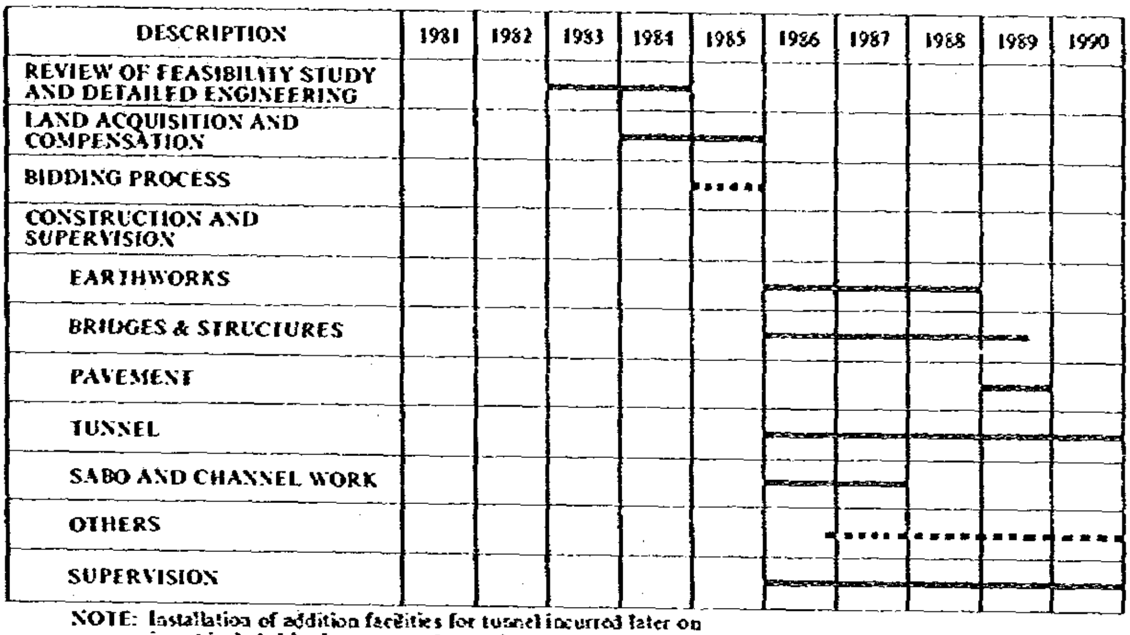


Fig. 5-5.8 CONSTRUCTION SCHEDULE OF TUNNEL

The construction period of five years is also considered to be slightly tight based on the experience in Japan. Therefore, it is suggested that as soon as the final report of this feasibility study is accepted, procedure for detailed engineering and the succeeding activities shall proceed for completion as per proposed schedule.



NOTE: Installation of addition facilities for tunnel incurred later on is not included in the construction period.

Fig. 5-5.9 IMPLEMENTATION SCHEDULE

Chapter 6.

ENVIRONMENTAL IMPACT

CHAPTER 6
ENVIRONMENTAL IMPACTS

6-1. General

The improvement of the standards of living through the provision of basic infrastructures increases the awareness of the population against the adverse impacts on the environment, and therefore it has been increasingly imperative, during the planning of these infrastructure projects to undertake careful assessment of all environmental impacts of the project on the area characteristics (physical, social, ecological, aesthetic, etc.).

Elements of environmental impacts to be considered are divided into two main categories as follows:

1) Impacts on the health of human beings.
2) Impacts on natural environment.

Environmental elements included in each category are shown in Table 6-1.1.

TABLE 6-1.1 ENVIRONMENTAL ELEMENTS

	Impacts on the Health of Human Beings	Impacts on Natural Environment	Others
Environmental Elements	• Noise • Vibration • Pollution of Air • Pollution of Water • Pollution of Soil • Stench • Sinking of Ground	• Topography, Geology • Plants • Wild Life • Historical Place • Natural Monument • Historical Natural Features • Natural Beauty	• Sun Beam • Drying of Ground Water • Radio Interference • Division of Local Communities
Cause of Environmental Impact	Execution of Construction and Operation of Facilities	Existence of Facilities	

6-2 Impacts on the Health of Human Beings

Since the project is located in the isolated mountainous region of Cagayan Valley, the impacts on the health of human beings is presumed to be very minimal except for water and air pollution.

Control measures against pollution of surface water (rivers) were considered in the planning and designing phase. However, more careful and greater attention must be given to this problem during the execution of construction work. Both Digdig and Sta. Fe rivers should be studied thoroughly with regards to the pollution aspects under the detailed engineering phase.

The impacts of exhaust gas from the tunnel were also assessed. The forecast traffic volume in the year 2015 or the last year of the assumed economic project life under this study is 7,900 vehicles per day. Assuming the peak hour factor to be 10%, the hourly traffic volume would be only 790 vehicles. The amount of exhaust gas from these vehicles is not very appreciable and the impact on the surrounding trees and natural vegetation is presumed to be very minimal.

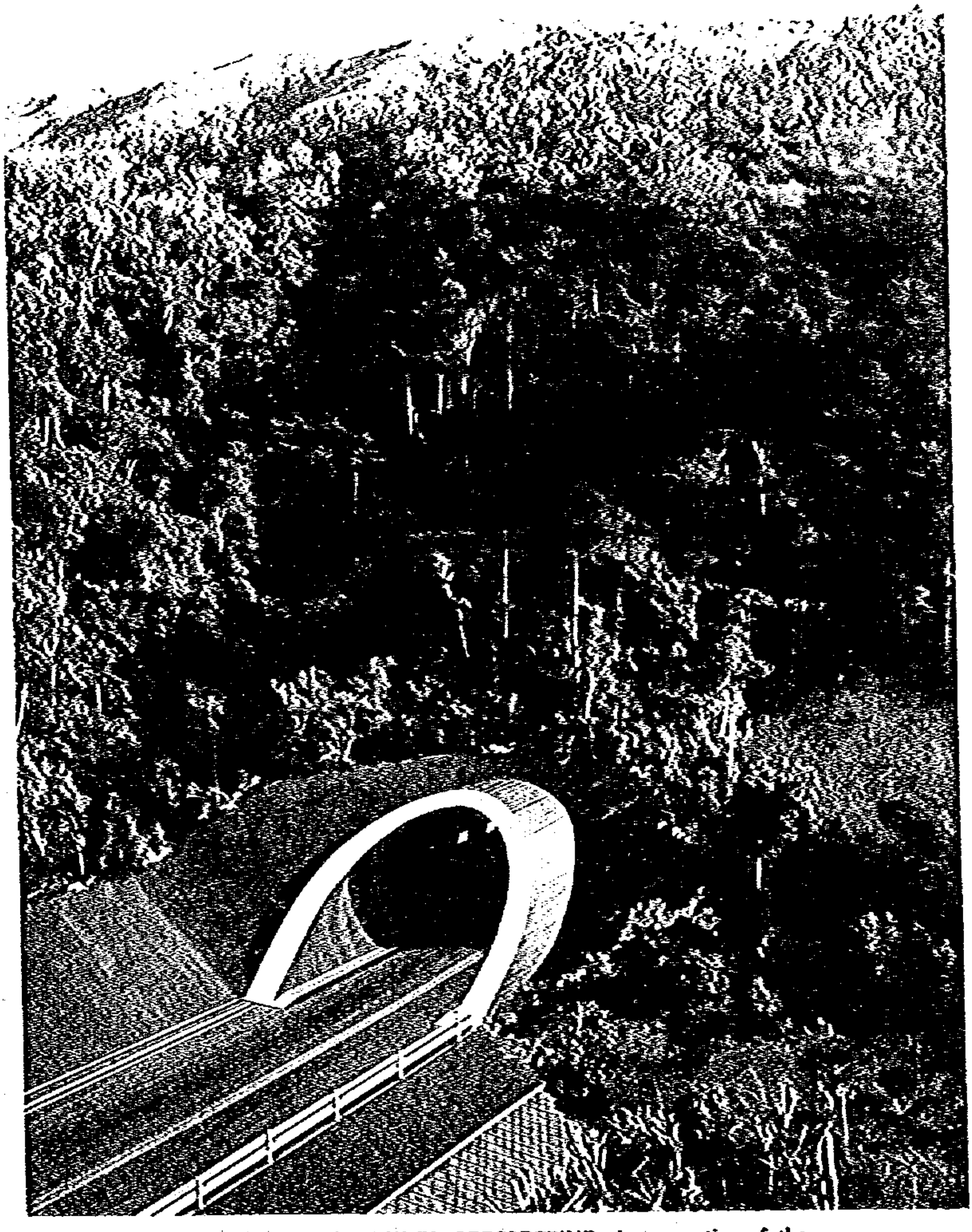
6-3 Impacts on Natural Environments

The impact on the beauty or aesthetics of the natural environment is just as critical. Since the project is located in a beautiful mountainous and forested terrain, therefore, the existence of man-made or artificial structures will be in a sense destroying the natural beauty, inspite of the accepted beneficial effects of the project to the development of the region.

Special attention was given to maintain the natural beauty of the project area or even enhance the attractiveness of the landscape. Where applicable, the slope design incorporates contour tree planting as erosion control measure.

The architectural design of the tunnel portals has likewise been given careful attention and it was decided to adopt the bell-mouth type which blends beautifully with the surrounding natural environment and preserve the aesthetic elements in the area.

Impacts on other environmental elements are presumed to be very minor.



DALTON PASS TUNNEL PERSPECTIVE. A perspective of the southern portal of the proposed Dalton Pass tunnel. Aesthetic values were given due consideration, thus the tunnel's portals were designed to blend with the existing natural environment.

6·4 Other Environmental Impacts

Under this category, the negative effects of drying up of ground water resources is one of the most serious impacts. Efforts were exerted to altogether avoid or even just minimize this impact of the project through an exhaustive and rigid selection of the road and tunnel alignment. However, inspite of the seven different alignment alternatives studied, there are still portions where this problem will be encountered. Some rice paddies, especially at sections adjacent to the north portal, will be affected by the construction of the road.

The tunnel ground water was also estimated. The volume of the ground or seepage water at the tunnel elevation is not major, but it might affect the surrounding ricefield. Therefore, more detailed analysis and study in this impact shall be further undertaken.

In designing the alignment, great care was taken to avoid and/or minimize passing through cultivated land and residential areas. However, there are still some cultivated areas and houses to be acquired within the right-of-way of the chosen alignment.

During the land acquistion process, sufficient explanation of the importance of the project should be made and just compensation shall be made to the landowners to achieve a smooth execution of the project.

Chapter 7.

BENEFIT OF THE PROPOSED TUNNEL

CHAPTER 7
BENEFIT OF THE PROPOSED TUNNEL

7-1 Normal Traffic Benefits

7-1-1 *Savings in Vehicle Running Cost*

(1) System for Estimation

The system for estimating the saving in running costs is summarized as shown in Fig. 7-1.1

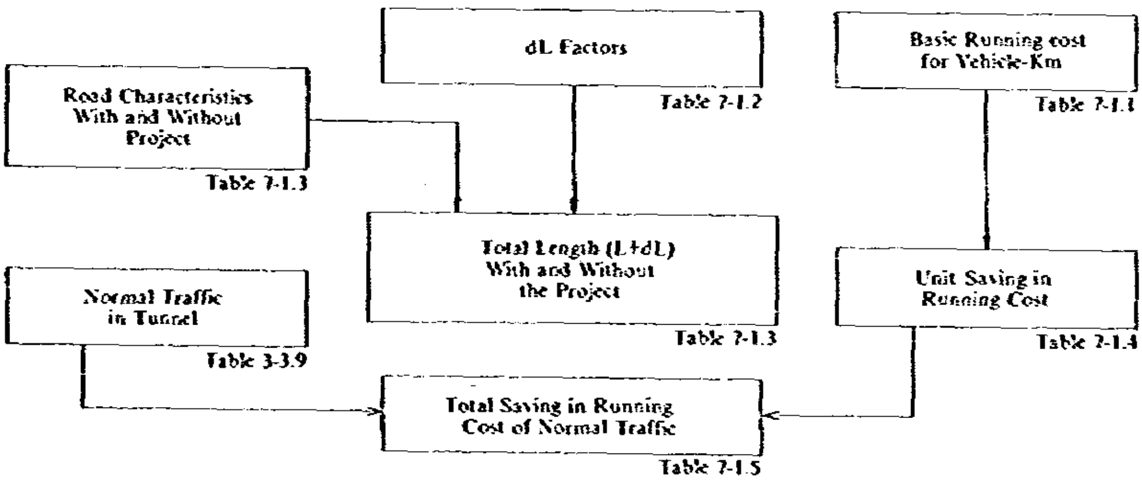


Fig. 7-1.1 FLOW CHART FOR ESTIMATING THE SAVING IN RUNNING COST OF NORMAL TRAFFIC

(2) Basic Running Cost

The basic running costs per vehicle-km. are estimated on the basis of cost data presented by PPDO-MPWH in the "Working Papers for Basic Vehicle Operating Costs -- January 1981". In the case of vehicle group cars, additional data concerning the percentage share of bantam (B), light (L), heavy (H) and jeep (J) in the existing traffic mix are furnished by the on-going National Transport Planning Project (NTPP) from their October 1980 traffic surveys at Km. 160.0 along Route 5 at San Jose. The basic running costs would, thus be as shown in Table 7-1.1 below, taxes and duties excluded.

TABLE 7-1.1 BASIC RUNNING COSTS (IN CENTAVOS) PER VEHICLE-KM. JANUARY 1981 PRICES

Cost Item	Car	Van	Small Bus (Diesel)	Big Bus (Diesel)	Big Truck (Diesel)
Fuel	35.96	32.42	39.04	58.56	68.32
Oil	0.44	0.41	2.60	3.12	3.64
Tires	3.46	3.52	6.32	17.30	16.36
Maintenance: Parts	7.85	7.04	14.64	26.58	26.32
Maintenance: Labor	6.02	5.56	4.96	5.21	8.34
Depreciation	12.39	9.15	20.74	35.30	20.37
TOTAL	66.12	58.10	88.30	146.07	143.35

Basic Running Costs are defined as the costs which would be incurred by vehicles using roads under conditions as follows ("Working Papers for Basic Vehicle Operating Costs 1981"):

— reasonably good paved surface as found on some of the new asphalt concrete surfaces financed by local funds;

— at least 6.0 meters carriageway width with shoulder widths of more than or equal to 2 × 2 meters;

— gradients below 1%;

— design speeds of no less than 70 kph for cars and 60 kph for buses and trucks;

— minimum roadside friction and traffic volume with no effect on driver behaviour (free flow condition);

— average Filipino driver behaviour.

(3) Estimation of dL

The dL system which only affects the running cost calculations utilizes the extra costs incurred by vehicles operating on roads with poor surface conditions, substandard geometric features or in other ways deviating from the "ideal" situation stated in Section (2) above, by transforming such extra costs into imaginary road length called dL. Factors expressing the relationship between running costs on substandard roads and running costs on ideal roads are used in the process.

Table 7-1.2 show the dL factors generally used by government transport agencies:

TABLE 7-1.2 dL FACTORS FOR SURFACE TYPE, CONDITION AND GRADIENT

Surface Type	Surface Condition	Gradient (%)	Factors Light Veh.	Factors Heavy Veh.	Surface type	Surface Condition	Gradient (%)	Factors Light Veh.	Factors Heavy Veh.
Paved	Good	<3	0.00	0.00	Gravel	Good	<3	0.15	0.20
Paved	Fair	<3	0.20	0.30	Gravel	Fair	<3	0.30	0.40
Paved	Bad	<3	0.40	0.60	Gravel	Bad	<3	0.60	0.90
Paved	Very Good	<3	0.60	0.90	Gravel	Very Bad	<3	0.90	1.30
Paved	Good	3-5 (≤.4 km.)	0.15	0.20	Gravel	Good	3-5 (≤.4 km.)	0.30	0.45
Paved	Good	3-5 (>.4 km.)	0.15	0.75	Gravel	Good	3-5 (>.4 km.)	0.30	1.60
Paved	Fair	3-5 (≤.4 km.)	0.35	0.50	Gravel	Fair	3-5 (≤.4 km.)	0.45	0.70
Paved	Fair	3-5 (>.4 km.)	0.35	1.00	Gravel	Fair	3-5 (>.4 km.)	0.45	1.20
Paved	Bad	3-5 (≤.4 km.)	0.55	0.75	Gravel	Bad	3-5 (≤.4 km.)	0.75	1.05
Paved	Bad	3-5 (>.4 km.)	0.55	1.30	Gravel	Bad	3-5 (>.4 km.)	0.75	1.60
Paved	Very Bad	3-5 (≤.4 km.)	0.75	1.00	Gravel	Very Bad	3-5 (≤.4 km.)	1.05	1.45
Paved	Very Bad	3-5 (>.4 km.)	0.75	1.60	Gravel	Very Bad	3-5 (>.4 km.)	1.05	2.00
Paved	Good	6-7 (≤.4 km.)	0.35	0.45	Gravel	Good	6-7 (≤.4 km.)	0.45	0.65
Paved	Good	6-7 (>.4 km.)	0.40	1.60	Gravel	Good	6-7 (>.4 km.)	0.50	1.80
Paved	Fair	6-7 (≤.4 km.)	0.50	0.70	Gravel	Fair	6-7 (≤.4 km.)	0.60	0.90
Paved	Fair	6-7 (>.4 km.)	0.55	1.80	Gravel	Fair	6-7 (>.4 km.)	0.65	2.00
Paved	Bad	6-7 (≤.4 km.)	0.70	1.00	Gravel	Bad	6-7 (≤.4 km.)	0.90	1.30
Paved	Bad	6-7 (>.4 km.)	0.75	2.10	Gravel	Bad	6-7 (>.4 km.)	0.95	2.40
Paved	Very Bad	6-7 (≤.4 km.)	0.90	1.30	Gravel	Very Bad	6-7 (≤.4 km.)	1.20	1.65
Paved	Very Bad	6-7 (>.4 km.)	0.95	2.40	Gravel	Very Bad	6-7 (>.4 km.)	1.25	2.80
Paved	Good	>7 (≤.4 km.)	0.65	0.80	Gravel	Good	>7 (≤.4 km.)	0.75	1.00
Paved	Good	>7 (>.4 km.)	0.75	2.00	Gravel	Good	>7 (>.4 km.)	0.85	2.20
Paved	Fair	>7 (≤.4 km.)	0.80	1.05	Gravel	Fair	>7 (≤.4 km.)	0.90	1.25
Paved	Fair	>7 (>.4 km.)	0.90	2.20	Gravel	Fair	>7 (>.4 km.)	1.00	2.40
Paved	Bad	>7 (≤.4 km.)	1.00	1.35	Gravel	Bad	>7 (≤.4 km.)	1.20	1.60
Paved	Bad	>7 (>.4 km.)	1.10	2.50	Gravel	Bad	>7 (>.4 km.)	1.30	2.80
Paved	Very Bad	>7 (≤.4 km.)	1.20	1.65	Gravel	Very Bad	>7 (≤.4 km.)	1.50	2.00
Paved	Very Bad	>7 (>.4 km.)	1.30	2.80	Gravel	Very Bad	>7 (>.4 km.)	1.60	3.20

SOURCE: "Working Papers for Basic Vehicle Operating Costs 1981" PPDO

TABLE 7-1.3 CALCULATION OF dL AT THE RELEVANT DALTON PASS SECTION

Section (Km. Post)	Without Project: Surface Type and Condition	Without Project: Gradient %	Without Project: dL for Light Veh. (Km)	Without Project: dL for Heavy Veh. (Km)	With Project: Surface Type and Condition	With Project: Gradient %	With Project: dL for Light Veh. (Km)	With Project: dL for Heavy Veh. (Km)
202 — 203	Paved Bad	4	0.55	1.30	Paved Good	1.5	0	0
203 — 204	Paved Bad	5	0.55	1.30	Paved Good	5	0.15	0.75
204 — 205	Paved Bad	5	0.55	1.30	Paved Good	5	0.15	0.75
205 — 206	Paved Bad	6	0.75	2.10	Paved Good	6	0.40	1.60
206 — 207	Paved Bad	6	0.75	2.10	Paved Good	−0.5	0	0
207 — 208	Paved Bad	6	0.75	2.10	Paved Good	−2	0	0
208 — 209	Paved Bad	5	0.55	1.30	Paved Good	−3.5	0.15	0.75
209 — 210	Paved Bad	−6	0.75	2.10	Paved Good	−6	0.40	1.60
210 — 211	Paved Bad	−5	0.55	1.30	Paved Good	−5	0.15	0.75
211 — 212	Paved Bad	−5	0.55	1.30				
212 — 213	Paved Bad	−6	0.75	2.10				
213 — 214	Paved Bad	−6	0.75	2.10				
214 — 215	Paved Bad	−3	0.40	0.60				
215 — 216	Paved Bad	−4	0.55	1.30				
216 — 217	Paved Bad	−2	0.40	0.60				
Total dL			9.15	22.9			1.4	6.2
Total Length (L+dL)			24.15	37.9			10.4	15.2

Using the dL factors in Table 7-1.2 the dL of the relevant Dalton Pass Section was calculated as shown in Table 7-1.3

(4) Running Cost Savings

Applying the basic cost in Table 7-1.1 to the total length (L+dL) in Table 7-1.3, the unit savings shown in Table 7-1.4 are obtained. Then applying the unit saving to the normal traffic in Table 3-3.9, the total saving in vehicle running cost is shown in Table 7-1.5.

The equation used in estimation of total savings in Table 7-1.5 is as follows:

$$Bnk = Qnk \cdot (365 - 14) \cdot Sk \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7\text{-}1.1)$$

Where: Bnk: total savings of vehicle k in year n (Table 7-1.5)
Qnk: normal traffic of vehicle k in year n (Table 7-1.5)
Sk: running cost savings per vehicle k (Table 7-1.4)
14 annual average interruption days of Dalton Pass (see Section 7-3).

TABLE 7-1.4 SAVINGS IN RUNNING COST DUE TO THE PROJECT (PESOS)
(In January 1981 rices)

ITEM \ TYPE		Car	Big Bus	Mini Bus	Big Truck	Others
Basic Running Cost/vehicle per km (pesos)		0.66	1.46	0.88	1.43	0.58
Total Length (L+dL) (Km.)	Without Project	24	38	24	38	24
	With Project	10	15	10	15	10
Running Cost/Vehicle (pesos)	Without Project	15.8	55.5	21.1	54.3	13.9
	With Project	6.6	21.9	8.8	21.5	5.8
Savings in Running Cost/ Vehicle (pesos)		9.2	33.6	12.3	32.8	8.1

TABLE 7-1.5 TOTAL SAVING IN VEHICLE RUNNING COST OF NORMAL TRAFFIC
(In 1000 pesos and in 1981 prices)

YEAR	CAR	BIG BUS	MINI BUS	BIG TRUCK	OTHERS	TOTAL
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1991	2564	5173	232	17323	185	25477
1992	2698	5534	248	18153	194	26826
1993	2831	5894	264	18983	203	28175
1994	2964	6279	282	19812	212	29550
1995	3098	6664	299	20642	221	30924
1996	3246	7073	317	21472	230	32338
1997	3379	7482	336	22406	240	33843
1998	3528	7915	355	23339	249	35387
1999	3676	8348	375	24169	258	36826
2000	3839	8806	395	25103	268	38411
2001	3987	9263	416	26036	278	39980
2002	4150	9720	436	27074	289	41669
2003	4313	10201	458	28007	299	43278
2004	4491	10706	480	29044	310	45033
2005	4654	11211	503	29978	320	46667
2006	4832	11741	527	31015	332	48445
2007	4995	12270	550	32053	343	50211
2008	5173	12799	574	33090	354	51990
2009	5366	13353	599	34127	365	53809
2010	5543	13930	625	35268	377	55744
2011	5736	14508	651	36306	388	57588
2012	5929	15085	677	37447	400	59537
2013	6121	15686	704	38588	412	61512
2014	6314	16288	731	39729	425	63486
2015	6522	16913	759	40870	437	65501

7-1-2 Time Cost Saving

(1) System for Estimation

The process of estimating the time cost savings for the normal traffic is shown in Figure 7-1.2

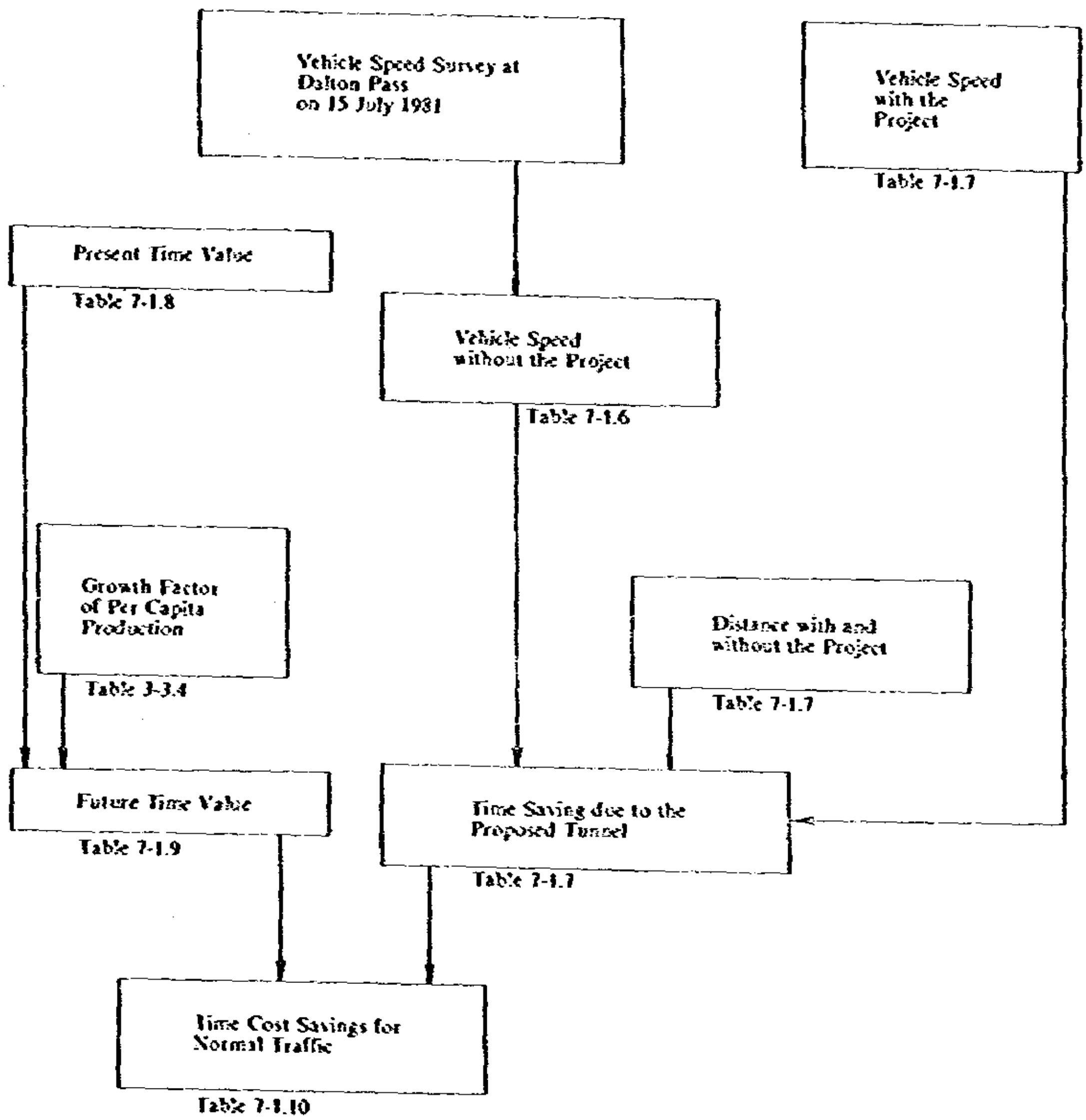


Fig. 7-1.2 FLOW CHART FOR ESTIMATING THE TIME COST SAVINGS FOR NORMAL TRAFFIC

(2) Time Savings

For the purpose of estimating the actual vehicle operating speed on the relevant Dalton Pass section, a survey was carried out on July 15, 1981 for both directions i.e., to and from Manila.

The method of survey is to record the plate number and passing time of each selected sample at both ends of the section. The results of the survey are summarized in Table 7-1.6

TABLE 7-1.6 SUMMARY OF VEHICLE SPEED SURVEY AT DALTON PASS

ITEM / TYPE	From Manila				To Manila				Average Speed Km/h
	No. of Samples	Total Hour (min.)	Average Hour (min.)	Average Speed (Km/h)	No. of Samples	Total Hour (min.)	Average Hour (min.)	Average Speed (Km/h)	
CAR	15	373	25	33	8	228	29	28	31
BIG BUS	5	125	25	33	8	235	29	28	31
MINI BUS	2	78	39	21	1	36	36	23	22
HEAVY TRUCK	18	563	32	26	18	1654	104[1]	8	17

Includes the engine cooling hour at Sta Fe. (Average 30 minutes)

Vehicle operating speed o the proposed tunnel section has been (as shown in Table 7-1.7) assumed to be somewhat lower than the standard speed.

TABLE 7-1.7 TIME SAVINGS ON DALTON PASS WITH THE PROJECT

ITEM / TYPE		CAR	BIG BUS	MINI BUS	BIG TRUCK	OTHERS
Length (Km.)	Without Project	15	15	15	15	15
	With Project	9	9	9	9	9
Savings in Distance (Km.)		6	6	6	6	6
Speed (Km/h)	Without Project	31	31	22	17	22
	With Project	60	60	50	40	50
Travel Time (min.)	Without Project	29	29	41	53	41
	With Project	9	9	11	14	11
Savings in Travel Time (min.)		20	20	30	39	30

Thus, the saving in travel time is estimated and shown in the lower most column of Table 7-1.7

(3) Time Value

In this study the time savings is valued at the marginal time cost, i.e., the time cost of crew and passenger (see the following figure). Thus it is possible to make the time value grow with the per capita income.

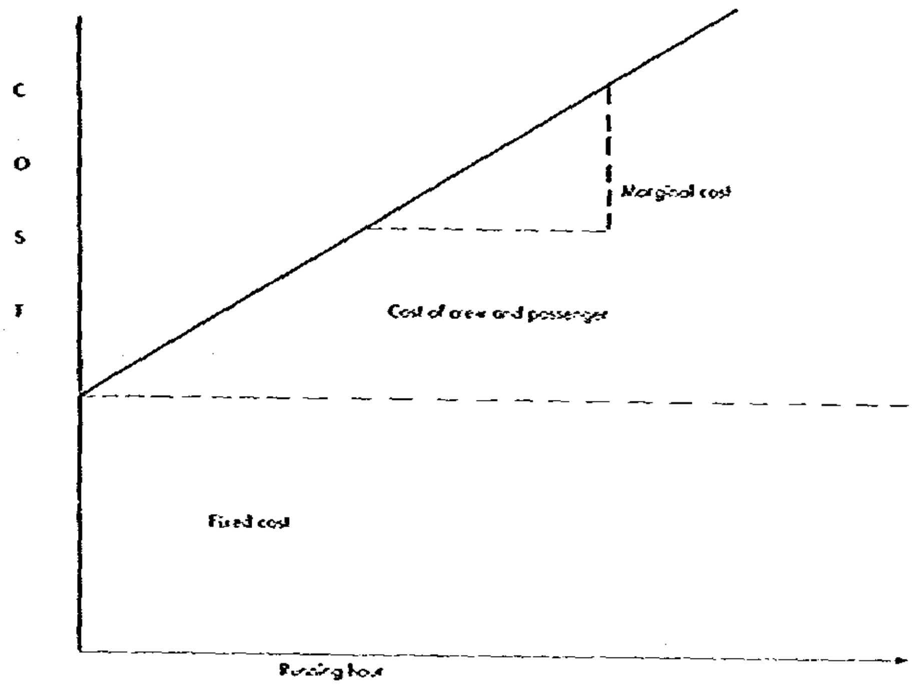


Fig. 7-1.3 MARGINAL TIME COST

The time value used in the study is shown in Table 7-1.8

TABLE 7-1.8 TIME VALUE (Peso/Min. in Jan. 1981 Prices)

TYPE OF VEHICLE	TIME VALUE
Car	0.37
Big Bus	1.73
Mini Bus	0.53
Big Truck	0.14
Others	0.095

The time value mentioned above has been estimated by the following equations:

1) Car:
(4 passengers (note 1) × 5.5₱ (note 2)) ÷ 60 min.
= 0.37 ₱/min. 7-1.2

2) Big Bus:
(1 driver × 4.8₱ (note 3) + 1 conductor × 4.4₱
(note 3) + 27 passengers (note 1) × 3.5₱ (note 2))
÷ 60 min. = 1.73₱/min 7-1.3

3) Mini Bus:
(1 driver × 3.6₱ (note 3) + 1 conductor × 3.6₱
(note 3) + 9 passengers (note 1) × 2.75₱ (note 2))
÷ 60 min. = 0.53₱/min. 7-1.4

4) Big Truck:

(1 driver × 4.3₱ (note 3) + 1 assistant × 2.1₱
(note 3)) ÷ 60 min. = 0.14 ₱/min. 7-1.5

5) Others
(1 driver × 3.6₱ (note 3) + 1 assistant
× 2.1₱ (note 3)) ÷ 60 min. = 0.095₱/min. 7-1.6

Note 1: Confirmed by the OD survey at Sta. Fe on July 1981
Note 2: See "Feasibility Review Study West Leyte Roads" April 1981, p. 98
Note 3: See "Feasibility Review Study West Leyte Roads" April 1981, p. 97

The growth factor of the per capita income may be regarded as that of time value for the following reasons :

i) Laborers, in general convert their time into money
ii) Assuming the working hours per day to be constant, time value grows at the same rate as that of income.
iii) As the working hours per day decrease, time value grows at a higher rate than income.

Therefore, applying the growth factor in Table 3-3.3 to the present time value in Table 7-1.8, the future value in Table 7-1.9 was computed.

(4) Time Costs Savings

Applying the future time value in Table 7-1.9 to the normal traffic in Table 3-3.9, the time cost savings of normal traffic in Table 7-1.10 was computed. The equations used for this estimation is as follows :

$$Bnk = Qnk \cdot Vnk \cdot Tk \cdot (365 - 14) \quad \cdots\cdots\cdots\cdots \quad 7\text{-}1.7$$

Where: Bnk : time saving benefit of vehicle k in year n (Table 7-1.10)

Vnk : time value of vehicle k in year n (Table 7-1.9)

Tk : Time saving of vehicle k (Table 7-1.7)

14 : Annual Average duration of Dalton Pass closure (See Section 7-3)

Qnk : Normal Traffic of Vehicle k in year n (Table 3-3.9)

7-1-3 Total Normal Traffic Benefit

Summing up the running cost savings (Table 7-1.5) and the time cost savings (Table 7-1.10), the total normal traffic benefit was estimated as shown in Table 7-1.11

TABLE 7-1.9 FUTURE TIME VALUE (₱/Minute in Jan. 1981 Prices)

YEAR	CAR	BIG BUS	MINI BUS	BIG TRUCK	OTHERS
1986	0.49	2.28	0.70	0.18	0.13
1987	0.51	2.39	0.73	0.19	0.13
1988	0.56	2.61	0.80	0.21	0.14
1989	0.60	2.82	0.86	0.23	0.15
1990	0.64	3.01	0.92	0.24	0.17
1991	0.68	3.20	0.98	0.26	0.18
1992	0.72	3.37	1.03	0.27	0.19
1993	0.76	3.55	1.09	0.29	0.19
1994	0.79	3.70	1.13	0.30	0.20
1995	0.83	3.86	1.18	0.31	0.21
1996	0.86	4.01	1.23	0.32	0.22
1997	0.89	4.15	1.27	0.34	0.23
1998	0.92	4.29	1.31	0.35	0.24
1999	0.94	4.41	1.35	0.36	0.24
2000	0.97	4.53	1.39	0.37	0.25
2001	1.00	4.65	1.43	0.38	0.26
2002	1.02	4.77	1.46	0.39	0.26
2003	1.04	4.88	1.49	0.39	0.27
2004	1.07	5.00	1.53	0.40	0.27
2005	1.09	5.09	1.56	0.41	0.28
2006	1.11	5.19	1.59	0.42	0.29
2007	1.13	5.29	1.62	0.43	0.29
2008	1.15	5.38	1.65	0.44	0.30
2009	1.17	5.47	1.67	0.44	0.30
2010	1.19	5.55	1.70	0.45	0.30
2011	1.21	5.64	1.73	0.46	0.31
2012	1.22	5.73	1.75	0.46	0.31
2013	1.24	5.80	1.78	0.47	0.32
2014	1.25	5.86	1.80	0.47	0.32
2015	1.27	5.95	1.82	0.48	0.33

TABLE 7-1.10 TIME COST SAVINGS OF NORMAL TRAFFIC
(In 1000 Pesos and in Jan. 1981 Prices)

YEAR	CAR	BIG BUS	MINI BUS	BIG TRUCK	OTHERS	TOTAL
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1991	3816	9854	555	5335	121	19680
1992	4231	11112	626	5892	133	21994
1993	4668	12443	701	6478	146	24436
1994	5103	13838	779	7058	159	26937
1995	5557	15304	862	7663	173	29558
1996	6057	16899	952	8292	187	32387
1997	6524	18492	1041	8951	202	35211
1998	7037	20214	1138	9635	218	38243
1999	7540	21922	1235	10259	232	41187
2000	8090	23757	1338	10948	247	44381
2001	8627	25658	1445	11659	263	47652
2002	9213	27625	1556	12439	281	51114
2003	9783	29623	1668	13147	297	54519
2004	10440	31862	1794	13973	316	58384
2005	11006	33943	1912	14671	331	61863
2006	11660	36271	2043	15489	350	65812
2007	12294	38664	2177	16327	369	69831
2008	12940	40991	2308	17131	387	73757
2009	13638	43450	2447	17952	406	77893
2010	14313	46047	2593	18846	426	82224
2011	15041	48702	2743	19702	445	86633
2012	15785	51417	2896	20633	466	91197
2013	16495	54114	3047	21519	486	95660
2014	17217	56859	3202	22419	507	100204
2015	18045	59914	3374	23403	529	105265

TABLE 7-1.11 TOTAL NORMAL TRAFFIC BENEFIT
(In 1000 Pesos and In Jan. 1981 Prices)

YEAR	CAR	BIG BUS	MINI BUS	BIG TRUCK	OTHERS	TOTAL
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1991	6380	15027	787	22658	306	45157
1992	6929	16645	874	24045	327	48820
1993	7499	18338	965	25460	349	52612
1994	8067	20117	1061	26870	371	56487
1995	8654	21968	1161	28305	394	60482
1996	9303	23972	1269	29765	417	64726
1997	9903	25974	1377	31357	442	69053
1998	10565	28130	1493	32974	467	73629
1999	11215	30271	1609	34429	467	73629
2000	11929	32563	1733	36051	516	82791
2001	12614	34921	1861	37695	542	87632
2002	13364	37345	1992	39512	570	92783
2003	14097	39824	2126	41155	596	97797
2004	14931	42568	2275	43017	626	103417
2005	15660	45154	2414	44649	652	108530
2006	16492	48011	2569	46504	681	114258
2007	17289	50934	2728	48380	712	120042
2008	18113	53790	2883	50221	741	125747
2009	19003	56803	3046	52079	770	131702
2010	19856	59977	3218	54114	803	137968
2011	20777	63210	3394	56008	833	144221
2012	21714	66502	3572	58080	866	150734
2013	22616	69800	3751	60106	899	157172
2014	23531	73147	3933	62148	931	163691
2015	24567	76827	4133	64273	966	170766

7-2 Induced Traffic Benefits

(1) System for Estimation

The system of estimating the benefits to the induced traffic is shown in Fig. 7-2.1.

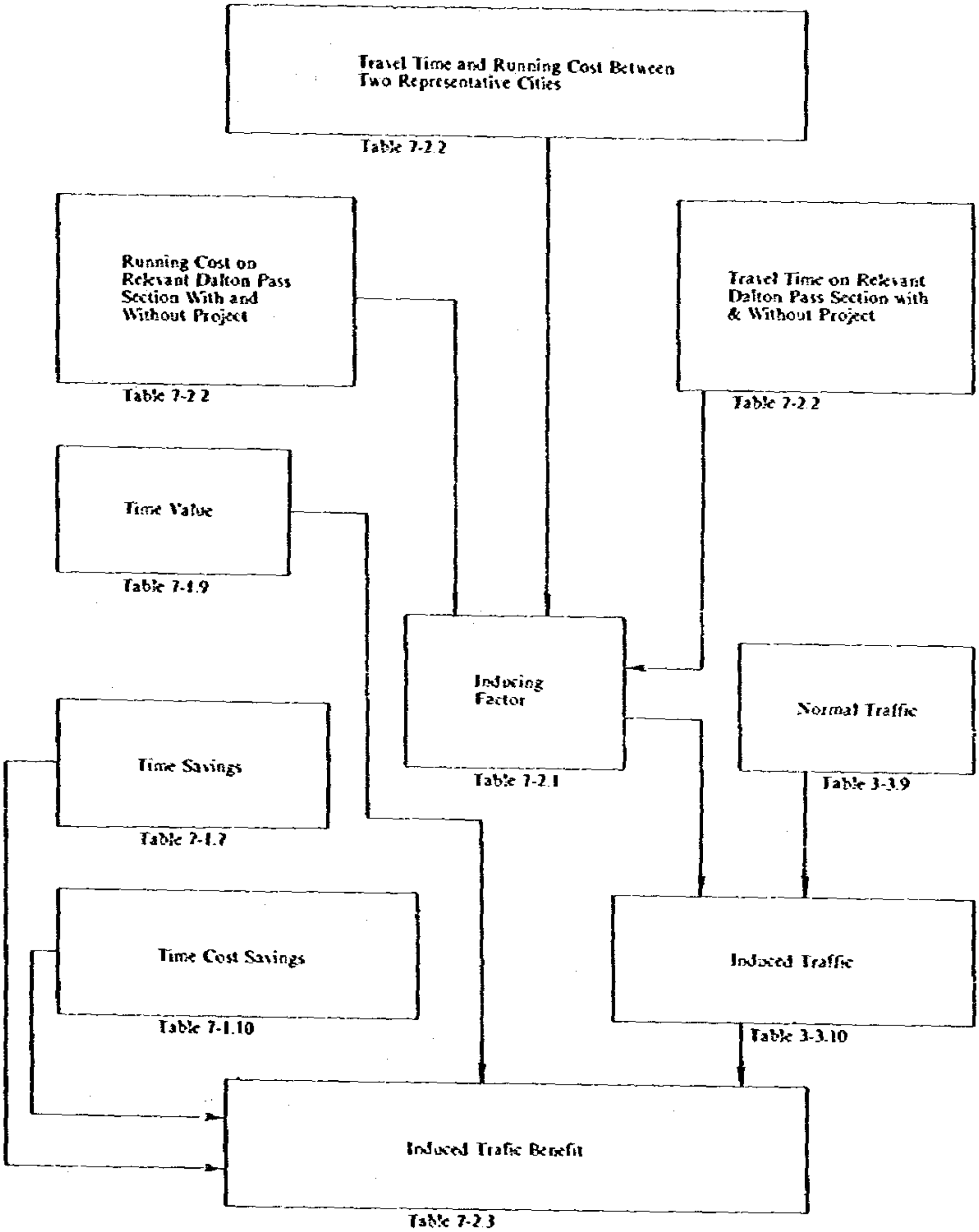


Fig. 7-2.1 FLOW CHART FOR ESTIMATING THE INDUCED TRAFFIC BENEFIT

(2) Induced Traffic

Traffic inducing factor was estimated by the following equation:

$$Rij = \frac{Dij\beta}{D'ij\beta} - 1 \quad \cdots\cdots \quad 7\text{-}2.1$$

Where: Rij : traffic inducing factor between i and j due to an improvement project

Dij : trip cost between i and j without project

D'ij : trip cost between i and j with project

The equation (7-2.1) is induced from so called gravity model below.

$$Tij = Pi'Pj' \frac{\alpha}{Dij'\beta} \quad \cdots\cdots \quad 7\text{-}2.2$$

$$T'ij = Pi'Pj' \frac{\alpha}{D'ij\beta} \quad \cdots\cdots \quad 7\text{-}2.3$$

Tij : traffic between i and j without project

T'ij : traffic between i and j with project

Pi : Population of i

Pj : Population of j

Then:

$$\begin{aligned} Rij &= \frac{T'ij - Tij}{Tij} = \frac{T'ij}{Tij} - 1 \\ &= (Pi'Pj' \frac{\alpha}{D'ij\beta}) / (Pi'Pj' \frac{\alpha}{Dij\beta}) - 1 \\ &= \frac{Dij\beta}{D'ij\beta} - 1 \quad \cdots\cdots \quad 7\text{-}2.4 \end{aligned}$$

The equation which was actually used in the study is as follows:

$$\begin{aligned} Rk = \; & ((T1k + Tk) + TVk = C1k + Ck)^2 \, / \\ & ((T2k + Tk) \times TVk + C2k + Ck)^2 \quad \cdots\cdots \quad 7\text{-}2.5 \end{aligned}$$

Where:

Rk : traffic inducing factor of the proposed tunnel of vehicle k (Table 7-2.1)

T1k : travel time on relevant Dalton section without the project (Table 7-2.2)

T2k : travel time on relevant Dalton section with the project (Table 7-2.2)

C1k : running cost on relevant Dalton section without the project (Table 7-2.2)

C2k : running cost on relevant Dalton section with the project (Table 7-2.2)

Tk : travel time between the two representative cities i.e., Tuguegarao and Manila, but excluding the travel time on the relevant Dalton section (Table 7-2.2). Tuguegarao is one of the largest cities in Cagayan Valley and it is situated midway from Sta. Fe to Patapat.

Ck : running cost between the two representative cities i.e., Tugegarao and Manila, but excluding the running cost on the relevant Dalton section (Table 7-2.2)

TVk : time value (Table 7-1.8)

Applying the inducing factor in Table 7-2.1 to the normal traffic in Table 3-3.9 the induced traffic in Table 7-2.3 was computed

(3) *Induced Traffic Benefit*

The induced traffic benefit in Table 7-2.3 is calculated by the following equation:

$$Bnk = Qnk \cdot (Vnk \cdot Tk + Sk) \cdot 1/2 \cdot 365 \quad \text{..................... 7-2.6}$$

Where:

Bnk : induced traffic benefit of vehicle k in year n (Table 7-2.3)

Qnk : induced traffic of vehicle k in year n (Table 3-3.10)

Vnk : time value of vehicle k in year n (Table 7-1.9)

Tk : time savings of vehicle k (Table 7-1.7)

Sk : running cost saving of vehicle k (Table 7-1.4)

1/2 : As a general rule, only one-half of the total induced traffic benefit is included in the project.

TABLE 7-2.1 TRAFFIC INDUCING RATE DUE TO THE PROPOSED TUNNEL

TYPE OF VEHICLE	RATE
Car	0.0653
Big Bus	0.0834
Mini Bus	0.0727
Big Truck	0.0856
Others	0.0571

TABLE 7-2.2 VARIABLES USED IN THE ESTIMATION OF INDUCING FACTOR
(In Jan. 1981 prices)

Vehicle (k)		CAR (k=1)	MINI BUS (k=2)	BIG BUS (k=3)	BIG TRUCK (k=4)	OTHERS (k=5)
Travel Time at Dalton pass (minutes) (see Table 7-1.7)	Without Project (T1k)	29	29	41	53	41
	With Project (T2k)	9	9	11	14	11
Time Value TVk (pesos/minute) (see Table 7-1.7)		0.37	1.73	0.53	0.14	0.095
Vehicle Running Cost at Dalton Pass (pesos) (see Table 7-1.4)	Without Project (C1k)	15.8	55.5	21.1	54.3	13.9
	With Project (C2k)	6.6	21.9	8.8	21.5	5.8
Fixed Time and Cost between two representative Cities (see equation 7-2.5)	Travel Time (min.) (Tk) (1)	393	464	557	557	557
	Running Cost (pesos) (Ck) (2)	361	828	480	811	329

NOTE: 1) These figures are calculated by the "National Transportation Planning Project Interim Report on Central and North Luzon Part III, Book 3 of 3 (Page 1 of 9).

2) As for the basic running cost, see Table 7-1.1 and as for the distance (L+dL, Table 7-1.3.)

TABLE 7-2.3 INDUCED TRAFFIC BENEFIT (In 1000 pesos and In Jan. 1981 Prices)

Year	Car	Big Bus	Mini Bus	Big Truck	Others	Total
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1991	217	652	30	1009	9	1916
1992	235	722	33	1070	10	2071
1993	255	796	36	1133	10	2231
1994	274	873	40	1196	11	2394
1995	294	953	44	1260	12	2563
1996	316	1040	48	1325	12	2741
1997	336	1127	52	1396	13	2924
1998	359	1220	56	1468	14	3117
1999	381	1313	61	1533	15	3302
2000	405	1413	65	1605	15	3504
2001	428	1515	70	1678	16	3708
2002	454	1620	75	1759	17	3925
2003	479	1728	80	1832	18	4137
2004	507	1847	86	1915	19	4374
2005	532	1959	91	1988	19	4589
2006	560	2083	97	2070	20	4831
2007	587	2210	103	2154	21	5075
2008	615	2334	109	2236	22	5316
2009	646	2464	115	2319	23	5566
2010	674	2602	122	2409	24	5831
2011	706	2742	128	2493	25	6094
2012	738	2885	135	2586	26	6369
2013	768	3028	142	2676	27	6641
2014	799	3173	149	2767	28	6916
2015	835	3333	156	2861	29	7214

7-3 Detour Traffic Benefit

(1) System for Estimation

The flow chart for estimating the detour traffic benefit is shown in Fig. 7-3.1

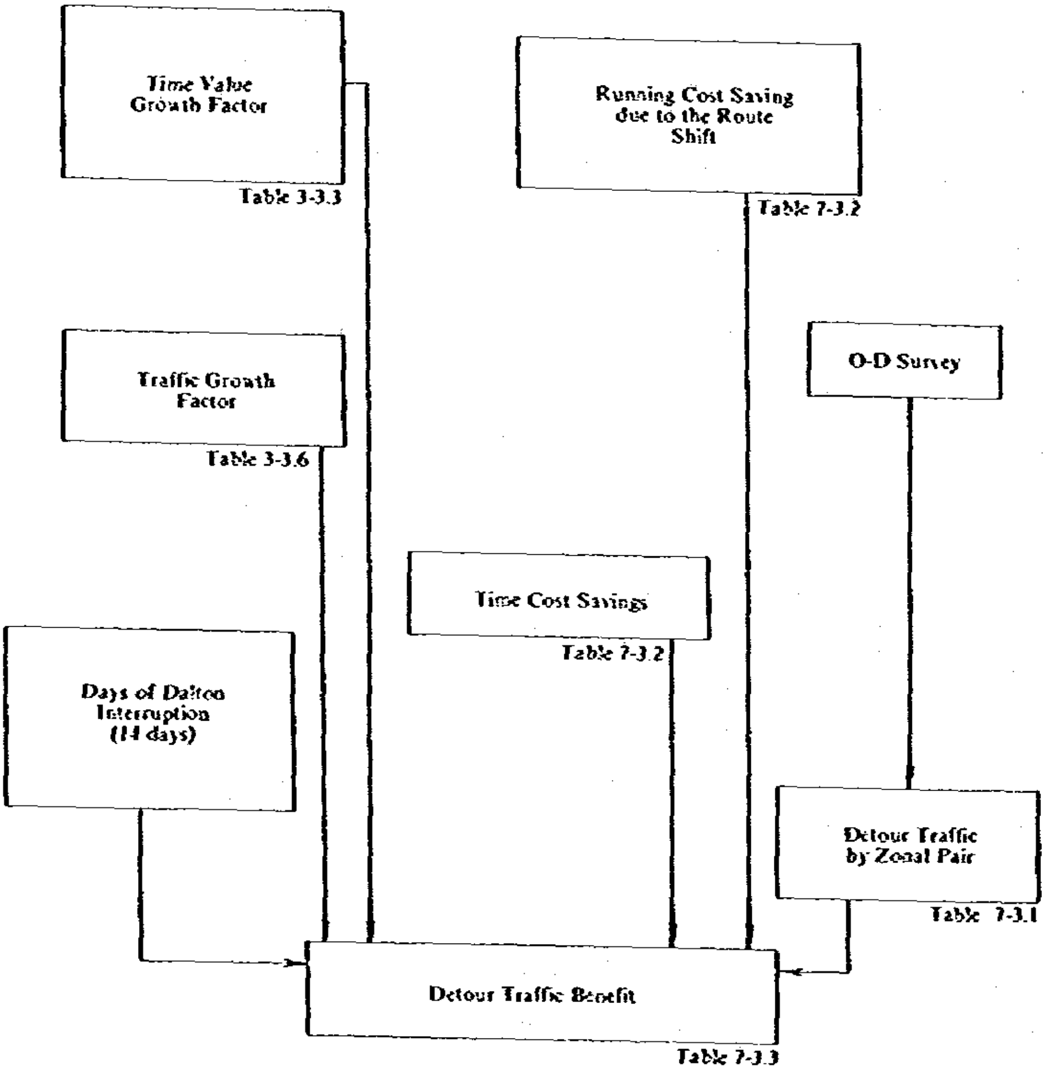


Fig. 7-3.1 FLOW CHART FOR ESTIMATING THE DETOUR TRAFFIC BENEFIT

(2) Basic Concept

According to the interview survey, it is generally accepted that the average interruption period in which the people in Cagayan Valley is compelled to give up the trip to Manila due to land sliding at Dalton Pass may be about 2 weeks, say 14 days.

Judging from the results of the O-D survey at Pasuquin, the traffic which uses the detour route via Patapat during the 14 day period is not zero but is nearly equal to zero (see Fig. 7-3.2).

After opening of the proposed tunnel, the traffic in this 14 days which is now latent will reappear on Dalton Pass. Thus, this traffic, referred to as detour traffic hereafter, is a kind of induced traffic.

Considering the fact that the detour traffic via Patapat is not zero but is almost equal to zero (see Table 3-1.3), it was concluded that the highest utility of this detour traffic is equal to the users' cost via Patapat and the lowest one is equal to the users' cost via Dalton Pass.

Therefore, the highest users' benefit of the detour traffic may be equal to the users' cost savings due to the shift from Patapat to Dalton Pass, and the lowest users' benefit is, of course, zero.

Thus, the average benefit of the detour traffic may be one half of the users' cost savings due to the shift from Patapat to Dalton Pass.

(3) Detour Traffic

The zonal pair traffic which, when Dalton is closed, is likely to use the detour via Patapat, is shown in Table 7-3.1.

This detour traffic shares the 92 percent of the total traffic on Dalton Pass, and the 64 percent of the detour traffic originates in Manila (Including the zones north of Manila).

In Table 7-3.1 the detour traffic originating in the northern part of Dalton Pass is concentrated in Manila as the representative city.

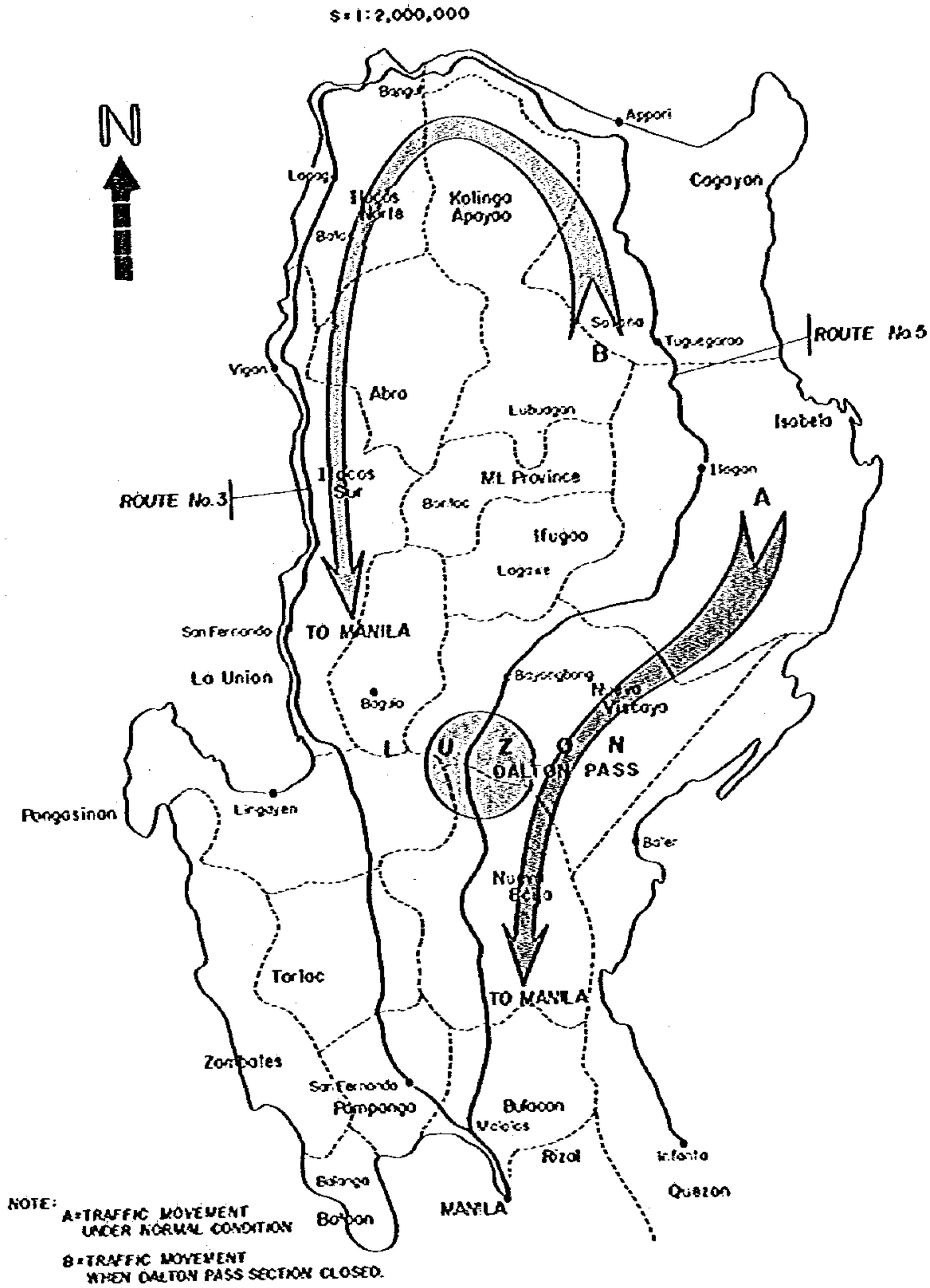


Fig. 7-3.2 DETOUR DUE TO CLOSURE AT DALTON PASS SECTION
S=1:2,000,000

TABLE 7-3.1 ZONAL PAIR INFORMATION

				Between South of Dalton Pass (Metro Manila as the Representative) and						
				Bayombong	Cordon	Cawayan	Ilagan	Tugue-garao	Magapit	Total
Zonal Pair Traffic (vehicles/day) (July, 1981)			Car	128	68	95	64	64	18	437
			Big Bus	10	13	50	15	43	55	186
			Mini Bus	9	3	4	2	0	2	20
			Big Truck	142	96	234	189	114	74	849
			TOTAL	289	180	383	270	221	149	1492
Distance (Km)	Via Dalton Pass (With Project)	Actual distance L		250.0	302.2	359.7	386.3	472.7	544.1	—
		dL	for light vehicle	44.0	56.4	62.7	65.2	75.0	82.8	—
			for heavy vehicle	56.4	77.9	86.6	90.8	104.2	114.0	—
		L+dL	for light vehicle	294.0	358.6	422.4	451.5	547.7	626.9	—
			for heavy vehicle	306.4	380.1	446.3	477.1	576.9	658.1	—
	Via Patapat	Actual distance L		1000.6	948.4	890.9	864.3	777.9	706.5	—
		L	for light vehicle	86.0	73.6	67.3	64.8	55.0	47.2	—
			for heavy vehicle	108.0	86.5	77.8	73.6	60.2	50.4	—
		L+dL	for light vehicle	1086.0	1022.0	958.2	929.1	832.9	753.7	—
			for heavy vehicle	1108.6	1034.9	968.7	937.9	838.1	756.9	—
Travel time (min)	Via Dalton Pass (With Project)		Car	196	252	305	328	402	463	—
			Big Bus	228	293	355	382	469	540	—
			Mini Bus	273	351	425	458	561	647	—
			Big Truck	276	354	428	461	564	650	—
	Via Patapat		Car	939	883	830	807	733	672	—
			Big Bus	1099	1033	971	944	858	786	—
			Mini Bus	1315	1236	1162	1130	1026	941	—
			Big Truck	1315	1236	1162	1130	1026	941	—

(4) Comparison between the Two Alternative Routes

Table 7-3.1 compares distance and time of both routes (based on the "Interim Report on Central and North Luzon", Book 3 of 3, 1981). The comparison has been made assuming completion of both Dalton Pass Tunnel and Laoag-Allacapan Road.

Table 7-3.2 shows the various savings. For example, between Tuguegarao and Manila, a car saves 305 Km., 5.5 hours and P188.00 by passing Dalton Pass.

TABLE 7-3.2 ADVANTAGE OF THE ROUTE VIA DALTON

		Between South of Dalton Pass (Manila as the Representative) and					
		Bayombong	Cordon	Canayan	Ilagan	Tuguegarao	Magapit
Savings in Distance (L+dL) (Km.)	Car	793	663	536	477	265	127
	Big Bus	803	655	523	451	261	99
	Mini Bus	793	663	536	477	265	127
	Big Truck	803	655	523	451	261	99
Savings in Time (minutes)	Car	743	631	525	479	331	269
	Big Bus	871	740	616	562	359	246
	Mini Bus	1042	865	737	672	455	294
	Big Truck	1039	852	734	669	452	291
Savings in Vehicle Running Cost (per vehicle, in pesos)[1] (in January, 1981 prices)	Car	523	438	354	315	158	84
	Big Bus	1172	956	764	673	361	145
	Mini bus	698	583	472	420	251	112
	Big Truck	1145	937	745	659	373	142
Time Cost Savings in 1991 (per vehicle, in pesos) (1&2)	Car	565	429	357	326	225	142
	Big Bus	2787	2368	1971	1795	1178	443
	Mini bus	1021	867	722	659	456	268
	Big Truck	270	229	191	174	120	76

Note: (1) See Tables 7-1.1., 7-1.8 and 7-1.9
(2) Time value increases every year, therefore, the time cost savings in 1991 (opening year of the proposed tunnel) is shown here.

(5) Detour Traffic Benefit

The detour traffic benefit shown in Table 7-3.3 has been calculated by the following equation.

$$Bnk = \Sigma [(S1kp + S2kp \cdot R2n) \cdot Qkp \cdot R1nk \cdot DS \cdot 1/2] \quad \ldots\ldots\ldots \quad (7\text{-}3.1)$$

Where:

Bnk	:	benefit of detour traffic of vehicle in year n (Table 7-3.3)
S1kp	:	running cost savings of vehicle k and of zonal pair p (Table 7-3.2)
S2kp	:	time cost savings of vehicle k and of zonal pair p (Table 7-3.2)
R2n	:	growth factor of time value (Table 3-3.3)
Qkp	:	daily traffic of vehicle k and of zonal pair p (Table 7-3.1)
R1nk	:	traffic growth factor (Table 3-3.6)
DS	:	annual average days of Dalton Pass interruption (DS = 14)
1/2	:	see equation 7-2.6

TABLE 7-3.3 DETOUR TRAFFIC BENEFIT
(in 1,000 pesos, Jan. 1981 prices)

Year	Car	Big Bus	Mini Bus	Big Truck	Total
1991	3,900	5,600	400	9,100	19,000
1992	4,300	6,300	500	9,200	20,200
1993	4,600	7,100	500	9,800	22,100
1994	5,000	7,700	500	10,500	23,700
1995	5,400	8,500	600	11,100	25,600
1996	5,700	9,100	600	11,800	27,300
1997	6,100	10,000	700	12,500	29,300
1998	6,500	10,900	800	12,600	38,000
1999	6,900	11,900	800	13,200	32,800
2000	7,300	12,800	900	13,900	34,900
2001	7,700	13,400	900	14,600	36,600
2002	8,100	14,500	1,000	15,300	38,800
2003	8,500	15,400	1,100	16,000	41,000
2004	8,900	16,900	1,200	16,700	43,600
2005	9,300	17,900	1,200	17,300	45,800
2006	10,000	19,000	1,300	18,100	48,300
2007	10,500	20,100	1,400	18,800	50,600
2008	10,900	21,100	1,400	19,500	52,900
2009	11,300	22,200	1,500	20,200	55,200
2010	11,700	23,700	1,600	20,900	58,000
2011	12,500	24,900	1,700	21,600	60,600
2012	12,900	26,400	1,800	22,300	63,500
2013	13,400	27,600	1,900	23,000	65,800
2014	14,100	29,100	2,000	23,700	69,000
2015	14,600	30,300	2,000	24,500	71,500

7-4 Other Benefits

7-4-1 Maintenance Cost Savings

The stream of estimated total economic maintenance expenditures, based on the "with" and "without" project assumptions are shown in Table 7-4.1. From the Government viewpoint, the maintenance expenditures incurred using the "without" project case correspond to the existing road. However, on the "with" project case, the costs shall be for maintaining the proposed tunnel and the approaches only, following the 100 percent traffic diversion assumption and totally abandoning the existing road theoretically.

TABLE 7-4.1 MAINTENANCE COST (₱1000)

Year	Maintenance Cost of	
	Proposed Tunnel[1]	Present Road[2]
1991	1003	464
1992	1034	464
1993	1081	464
1994	1127	464
1995	1175	464
1996	1191	464
1997	1664	464
1998	1694	464
1999	1751	464
2000	1809	464
2001	1868	464
2002	1954	464
2003	2012	464
2004	1510	464
2005	1569	464
2006	1626	464
2007	1658	464
2008	1715	464
2009	1746	464
2010	1805	464
2011	1864	464
2012	1922	464
2013	1953	464
2014	2012	464
2015	2070	464

Note: [1]excluding 10% tax
[2]excluding 14% tax

In the benefit-cost analysis for this feasibility study, the Study Team has therefore deviated from the traditional analytical procedure of estimating the maintenance cost savings as the difference between the "without" and the "with" project maintenance costs. Instead, the annual maintenance requirement for the proposed tunnel is included in the cost side as a recurrent expenditure while the maintenance cost for the existing road has been counted in the benefits.

The per kilometer economic maintenance cost for the existing road and the proposed tunnel, in January 1981 prices, are given in Section 5-4.5 of this report.

7-4-2 Net Increase in Income of Local Labor

All unskilled local labor to be employed by the construction of the proposed tunnel may be composed of totally unemployed or semi-employed labor.

The working hours of the unemployed labor in the rural area is shown on Table 7-4.3.

Based on Table 7-4.3, the average working hours per week of the totally or semi-employed labor in the rural area may be estimated at 16 hours (excluding the group working 40 hours and over).

Meanwhile, as shown in Table 7-4.4, the wage level per hours of the unskilled labor in the vicinity of Sta. Fe is ₱2.50 on the average.

Therefore, the average weekly opportunity cost of the unskilled local labor to be employed by the construction of the proposed tunnel is estimated at ₱40.00/week (16 hours × ₱2.50 = ₱40.00), say ₱5.70/day.

On the other hand, the amount actually expected to be received by the local labor employed for the construction of the proposed tunnel is ₱45 per day.

Accordingly, the net increase in income of unskilled local labor due to the project may be estimated at the amounts shown in Table 7-4.2. The amounts have been estimated as follows:

840[1] persons × 240 days (₱45 − ₱5.7) = ₱7,922,880
₱7,992,880 × 5 years = ₱39,614,400

[1]Refer to 5-4-6

Table 7-4.2 NET INCREASE IN INCOME OF LOCAL LABOR

Year		Income
1986		7,922,880
1987		7,922,880
1988		7,922,880
1989		7,922,880
1990		7,922,880
	TOTAL	39,614,400

This figure is based on computation in Section 5-4-6.

TABLE 7-4.3 WORKING HOURS PER WEEK OF TOTALLY UNEMPLOYED AND WANTING ADDITIONAL WORK
(in 1976, in Rural Area)

		PERCENTAGE
TOTALLY UNEMPLOYED		25.5
WANTING ADDITIONAL WORK	Working Under 20 Hours	7.9
	Working 20 to 29 Hours	15.8
	Working 30 to 39 Hours	16.5
	Working 40 Hours and Over	34.3
TOTAL		100.0

Source: "Labor Force (NCSO), August 1976" Table 9.
NOTE: Average working hour per week is estimated by following equation using above Table.

$(0 \times 25.5 \div 65.7) + (10 \times 7.9 \div 65.7) + (25 \times 15.8 \div 65.7) + (35 \times 16.5 \div 65.7)$
$= 16.2$ hours/week.

TABLE 7-4.4 THE WAGE LEVEL IN THE VICINITY OF STA. FE
(THIS IS A SUMMARY OF THE INTERVIEW SURVEY ON LABOR COST AND WAGE LEVEL)

INTERVIEWEE	Category/ Establishment/ Company	Type of Unskilled Labor	No. of Hours Rendered Day/Week/Mo.	Wage/ Salary	Other Benefit Received	Total Income Per Hour (₱/hour)
B. B. Briosos	Infrastructure	Laborer	8	₱ 14.95/d	₱3.35 daily Allowance	2.3
P. Gutierrez	Gov't employee/ Farmer	Agri. Worker	8	15.00/d	W/meals	3.1[1]
--	Trucking Service	Utility Man	--	18.00/d	₱10 daily Allowance	3.5
Tomas C. Garra	Infrastructure (Municipal)	Laborer	8	12.00/d	None	1.5
H.D.E. Office (Bayombong)	Infrastructure (Nat'l)	Laborer	8	14.95/d	₱3.35/d Living Allowance	2.3
H.D.E. Office (Bayombong)	Private Hirer	Laborer	8	20.00/d	None	2.5
H.D.E. Office (Bayombong)	Gov't. (Mun. Off. in Sta. Fe)	Laborer	8	12.00/d	₱1.75 daily Allowance	1.7
Ms. Pascual	Saber Inn	Utility Man	8	500.00/mo.	None	2.8[2]
Ms. Pascual	Saber Inn	Janitors	8	300.00/mo.	Free Meals	3.0[3]
C. Bernabe	Agri. Workers	Rice Planter	8	15.00/d	None	1.9

Note:
(1) $(15 + 10) \div 8 = 3.1$
(2) $500 \div 22 \div 8 = 2.8$
(3) $[(300 \div 22) + 10] \div 8 = 3.0$

Average ₱2.5/hour.

7-5 Economic Impact

7-5-1 Reduction in Stock Investment

Even if Dalton Pass is closed to traffic, neither commodity supply stops nor price level soars in Cagayan Valley. This means that the merchants in Cagayan Valley hold sufficient stock to provide for the entire duration of closure of Dalton Pass.

According to the interview survey, the merchants in Cagayan Valley increase their stock before every rainy season. This additional stock is theoretically expected to satisfy the demand during the average 14 days closure.

Therefore, if the proposed tunnel removes the anxiety for Dalton Pass, as a matter of course, the 14 days stock is expected to disappear. Thus, stock investment decreases and accordingly, interest burden is mitigated, or in other words, the benefit due to stock saving appears.

Table 7-5.1 gives this benefit in 1981. Applying the growth factors of truck registration in Table 3-3.7 to the benefit in Table 7-5.1, Table 7-5.2 is obtained.

TABLE 7-5.1 SAVINGS IN INTEREST ON STOCK INVESTMENT (in 1981)

Article	Cargos Crossing Dalton Pass (tons)		(2) Price Pesos/Ton (Price level in Aug. 1981)	Stock Investment for 14 days (1000 pesos)	(6) Benefit of Stock Reduction (Interest for 14 day stock investment) (1000 pesos)
	(1) for one day	for 14 days			
Lumber	1375	19250	455	8759	22
Cereal	2969	41566	1350	56114	139
Cement	795	11130	850	9461	23
Fuel	385	5390	3600	19404	48
Construction Materials	260	3640	3000(3)	10920	27
Drinks	216	3024	1085(4)	3281	8
Others	630	8820	1400(5)	12348	31
Total	6630	92820	—	120287	298

Note: (1) Source: O-D survey at Sta. Fe, July 1981.
(2) Source: Interview survey in Cagayan Valley on commodity price.
(3) Steel pipe
(4) Coca-cola
(5) Flour
(6) Year interest rate =0.16, i.e.,
(6) daily interest rate = 0.0001766

TABLE 7-5.1 SAVINGS IN INTEREST DUE TO STOCK INVESTMENT

Calendar Year	Savings in Interest due to Stock Investment (1000 pesos)
1991	497
1992	521
1993	544
1994	568
1995	593
1996	618
1997	643
1998	669
1999	695
2000	722
2001	749
2002	776
2003	804
2004	833
2005	862
2006	891
2007	921
2008	951
2009	981
2010	1013
2011	1044
2012	1076
2013	1107
2014	1140
2015	1173

However, the benefit of stock saving is theoretically included in the detour traffic benefit discussed earlier. These two benefits are dependent on each other.

7-5-2 Price Stabilization due to the Proposed Tunnel

In August 1981, a field interview survey was carried out in Cagayan Valley to determine the rise in commodity price due to closures of Dalton Pass.

Deductions from the survey are as follow:

(1) When Dalton Pass is closed, groceries and construction materials are sometimes transported via Patapat.

(2) The freight rate via Patapat is 20-100 percent more than the rate via Dalton Pass.

(3) When Dalton Pass closure lasts for more than one week, then the comodity price begins to rise in Cagayan Valley, not only because of higher frieght charges, but also because of restriction in sales.

(4) The rise in price is from 5-20 percent according to the duration of Dalton Pass closure.

(5) Dealers of groceries and construction materials usually increase their stocks before the rainy season sets in.

After completion of the proposed tunnel, the problem of price level disturbance mentioned above would be solved.

7-5-3 General Economic Impact

(1) Flow Effect

The proposed investment in the construction of the Dalton Pass tunnel is anticipated to generate, according to the "multiplier-accelerator" principle, an increase in final demand which consequently would push up general production. As a by-product of this increase, further investments take place with a result that consumption and employment are even further increased until an equilibrium level is reached.

The total amount of magnitude of the production thus induced cannot be easily measured but may be several times larger than the construction cost of the tunnel.

(2) Stock Effect

The construction of the tunnel shall improve transportation in the region and reduce transport expenditures for passengers and goods. Reduced transport costs, when passed on to the producers, would bring down commodity prices, both consumer and producer goods, and would give rise to increases in final demand. When there exists a great demand for goods and services, the natural tendency for production is to go up, pulling up with it, employment.

The resultant higher level of employment then would bring about higher income, followed by a second "wave" of increase in demand. Production increase likewise would take place.

These chains of actions and reactions would continue and thus, a new economic development process begins. This is the strongest justification for the proposed investment in Dalton Pass Tunnel Project.

However, the impacts on the aforementioned Flow Effect and Stock Effect were not quantified, since these impacts were somehow already included in the other traffic benefits. The aforementioned indirect impacts are thus explained without further quantitative analysis and were not used for the succeeding economic evaluations.

Chapter 8.

ECONOMIC EVALUATION

CHAPTER 8
ECONOMIC EVALUATION

8-1 Cost Benefit Analysis

(1) A 25-year planning period (1991–2015) has been used in the analysis

(2) For discounting future values, 12, 14, 16 and 18 percent discount rates are used in consonance with the information from the MPWH and NEDA which states that the opportunity cost of capital in the transport sector lies somewhere in this range of values.

(3) Construction is estimated to take the whole 5-year period, 1986 – 1990.

(4) Project cost is composed of construction and maintenance cost of the proposed tunnel.

(5) Project benefit is composed of user benefit, maintenance cost of existing road, net increase in local labor's income and residual value of the final year.

(6) Sensitivity analysis is carried out for the 4 cases as follows :

Case 1 : Best Estimates (actual costs and benefits figures)

Case 2 : Plus 10% on Construction Cost

Case 3 : Plus 20% on Traffic Growth Factor, Minus 20% on Construction Cost

Case 4 : Minus 20% on Traffic Growth Factor, Plus 20% on Construction Cost

(7) Yearly depreciation and residual value are calculated as follows: (See Table 8-1.1)

$$D = \sum_i [(Ki - Si)/Li]$$

where: D = Yearly depreciation
Ki = amount of investment i
Si = expected salvage value of investment i
Li = lifetime of investment i (year)

$$R = \sum_i Ki - \sum_n Dn$$

where: R = residual value in the final year
Dn = depreciation in year n

(8) Flow Chart is shown in Fig. 8-1.1

(9) Results of analysis are shown in Table 8-1.2, 8-1.3, and 8-1.4

(10) The Economic Costs of Construction cost, Maintenance cost of the proposed tunnel and Maintenance cost of the existing road is taken as the financial costs of each item less taxes of 9%, 10% and 14% respectively.

TABLE 8-1.1 INVESTMENT CHARACTERISTICS (excluding 9% Tax)

INVESTMENT YEAR	INVESTMENT AMOUNT (₱100,000)	LIFE TIME (YEAR)	SALVAGE VALUE (₱100,000)
1986	948.6	25	47.4
1987	871.6	25	43.6
1988	791.9	25	39.6
1989	818.5	25	40.9
1990	556.6	25	27.8
1997	107.2	25	5.4
2003	377.7	25	18.9
2004	275.7	25	13.8
TOTAL	4,747.8		237.4

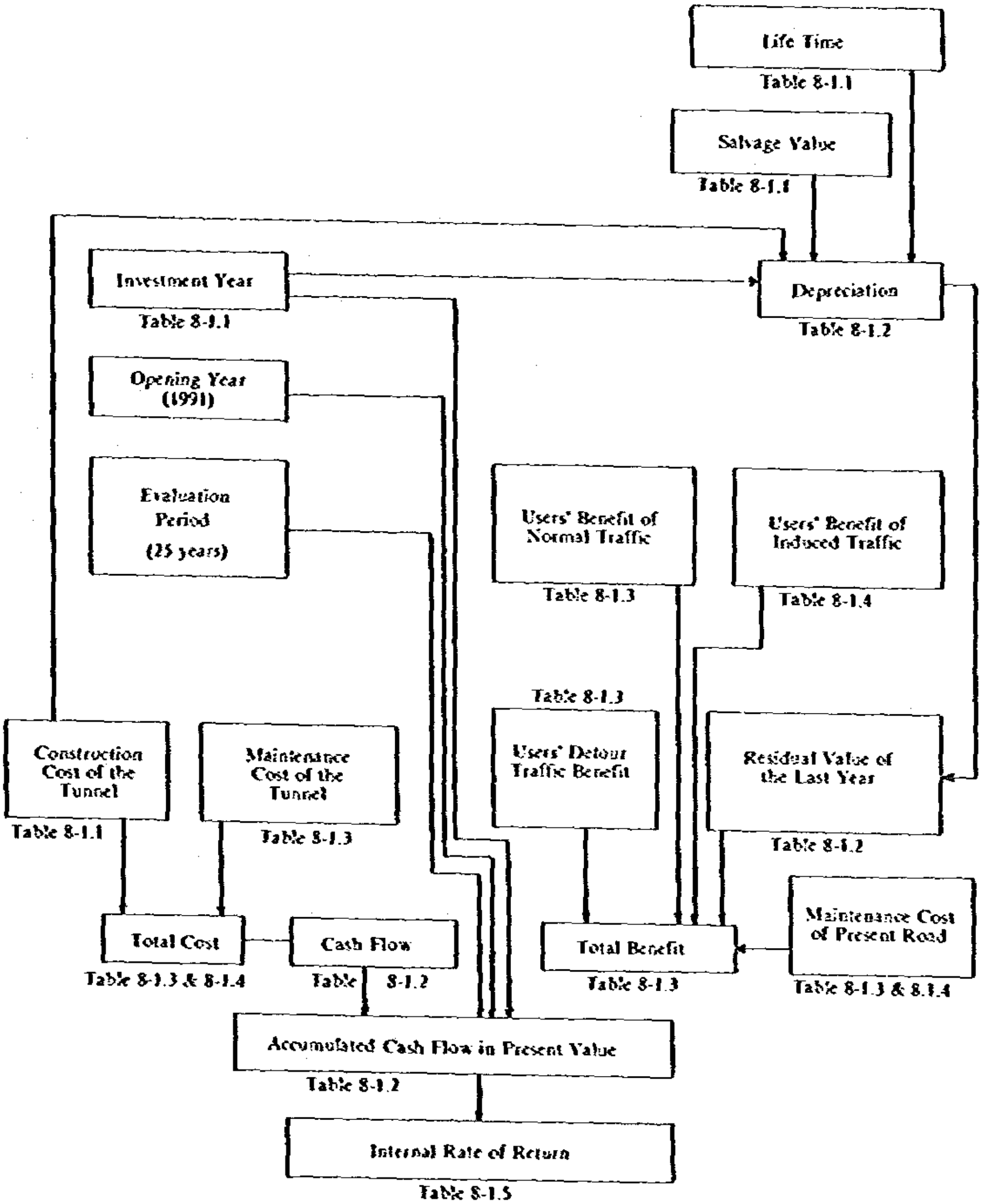


Fig. 8-1.1 SYSTEM FOR COST BENEFIT ANALYSIS

TABLE 8-1.2-(1) ACTUAL COSTS AND BENEFIT FIGURES

Case 1: Best Estimate (₱100,000)

YEAR	INVESTMENT	DEPRECIATION	RESIDUAL VALUE	TOTAL BENEFIT	TOTAL COST	CASH FLOW	ACCUMULATED CASH FLOW IN PRESENT VALUE
1986	949	0	949	79	949	− 870	− 870
1987	872	30	1790	79	872	− 793	−1542
1988	792	59	2523	79	792	− 713	−2056
1989	818	85	3256	79	818	− 739	−2508
1990	557	114	3699	79	557	− 478	−2757
1991	0	135	3564	665	10	655	−2468
1992	0	135	3430	716	10	705	−2204
1993	0	135	3295	774	11	763	−1961
1994	0	135	3160	830	11	819	−1740
1995	0	135	3026	891	12	879	−1533
1996	0	135	2891	952	12	940	−1356
1997	107	135	2864	1017	124	894	−1209
1998	0	139	2725	1080	17	1063	−1060
1999	0	139	2587	1146	18	1128	− 926
2000	0	139	2448	1217	18	1199	− 805
2001	0	139	2309	1284	19	1265	− 697
2002	0	139	2171	1360	20	1340	− 599
2003	378	139	2409	1434	398	1036	− 535
2004	276	153	2532	1519	291	1227	− 471
2005	0	164	2369	1594	16	1578	− 401
2006	0	164	2205	1679	16	1662	− 338
2007	0	164	2042	1762	17	1745	− 282
2008	0	164	1878	1844	17	1827	− 232
2009	0	164	1715	1929	17	1912	− 188
2010	0	164	1551	2023	18	2005	− 149
2011	0	164	1388	2114	19	2095	− 114
2012	0	164	1224	2211	19	2191	− 83
2013	0	164	1061	2301	20	2281	− 55
2014	0	164	897	2401	20	2381	− 31
2015	0	164	734	3233	21	3213	− 3

IRR = 17.8%
Discounted Total Benefit = 3139
Discounted Total Cost = 3139
Discounted Net Benefit = 0
Benefit/Cost Ratio = 1.00

TABLE 8-1.2-(2) ACTUAL COSTS AND BENEFIT FIGURES

Case 2: Plus 10% on Construction Cost (₱100,000)

YEAR	INVESTMENT	DEPRECIATION	RESIDUAL VALUE	TOTAL BENEFIT	TOTAL COST	CASH FLOW	ACCUMULATED CASH FLOW IN PRESENT VALUE
1986	1043	0	1043	79	1043	− 964	− 964
1987	959	33	1969	79	959	− 880	−1719
1988	871	64	2776	79	871	− 792	−2302
1989	900	94	3582	79	900	− 821	−2820
1990	612	126	4069	79	612	− 533	−3108
1991	0	148	3921	665	10	655	−2804
1992	0	148	3773	716	10	705	−2523
1993	0	148	3625	774	11	763	−2263
1994	0	148	3476	830	11	819	−2023
1995	0	148	3328	891	12	879	−1802
1996	0	148	3180	952	12	940	−1600
1997	118	148	3150	1017	135	883	−1427
1998	0	153	2998	1080	17	1063	−1269
1999	0	153	2845	1146	18	1128	−1115
2000	0	153	2693	1217	18	1199	− 976
2001	0	153	2540	1284	19	1265	− 849
2002	0	153	2388	1360	20	1340	− 735
2003	415	153	2650	1434	436	998	− 661
2004	304	168	2786	1519	319	1200	− 586
2005	0	180	2606	1594	16	1578	− 500
2006	0	180	2426	1679	16	1662	− 423
2007	0	180	2246	1762	17	1745	− 354
2008	0	180	2066	1844	17	1827	− 292
2009	0	180	1886	1929	17	1912	− 236
2010	0	180	1707	2023	18	2005	− 186
2011	0	180	1527	2114	19	2095	− 140
2012	0	180	1347	2211	19	2191	− 100
2013	0	180	1167	2301	20	2281	− 64
2014	0	180	987	2401	20	2381	− 32
2015	0	180	807	3307	21	3286	7

IRR = 16.6%
Discounted Total Benefit = 3526
Discounted Total Cost = 3526
Discounted Net Benefit = 0
Benefit/Cost Ratio = 1.00

TABLE 8-1.2-(3) ACTUAL COSTS AND BENEFIT FIGURES
Case 3: Plus 20% on Traffic Growth Factor, Minus 20% on Construction Cost (₱100,000)

YEAR	INVEST-MENT	DEPRE-CIATION	RESIDUAL VALUE	TOTAL BENEFIT	TOTAL COST	CASH FLOW	ACCUMULATED CASH FLOW IN PRESENT VALUE
1986	759	0	759	79	759	-680	-680
1987	697	24	1432	79	697	-618	-1185
1988	634	47	2019	79	634	-555	-1554
1989	655	68	2605	79	655	-576	-1867
1990	445	91	2959	79	445	-366	-2030
1991	0	108	2851	760	10	749	-1758
1992	0	108	2744	817	10	807	-1519
1993	0	108	2636	884	11	873	-1309
1994	0	108	2528	948	11	937	-1124
1995	0	108	2421	1017	12	1005	-962
1996	0	108	2313	1087	12	1075	-821
1997	86	108	2291	1161	102	1059	-707
1998	0	111	2180	1234	17	1217	-601
1999	0	111	2069	1308	18	1291	-508
2000	0	111	1958	1389	18	1371	-428
2001	0	111	1847	1467	19	1448	-359
2002	0	111	1736	1553	20	1534	-300
2003	302	113	1928	1638	322	1316	-258
2004	221	122	2026	1734	236	1498	-219
2005	0	131	1895	1820	16	1804	-181
2006	0	131	1764	1917	16	1900	-148
2007	0	131	1634	2012	17	1995	-120
2008	0	131	1503	2106	17	2089	-96
2009	0	131	1372	2204	17	2186	-75
2010	0	131	1241	2310	18	2292	-58
2011	0	131	1110	2414	19	2396	-43
2012	0	131	980	2525	19	2506	-30
2013	0	131	849	2628	20	2609	-19
2014	0	131	718	2742	20	2722	-10
2015	0	131	587	3443	21	3422	0

IRR = 22.5%
Discounted Total Benefit = 2,353
Discounted Total Cost = 2,353
Discounted Net Benefit = 0
Benefit/Cost Ratio = 1.00

TABLE 8-1.2-(4) ACTUAL COSTS AND BENEFIT FIGURES
Case 4: Minus 20% on Traffic Growth Factor, Plus 20% on Construction Cost (₱100,000)

YEAR	INVEST-MENT	DEPRE-CIATION	RESIDUAL VALUE	TOTAL BENEFIT	TOTAL COST	CASH FLOW	ACCUMULATED CASH FLOW IN PRESENT VALUE
1986	1138	0	1138	79	1138	-1059	-1059
1987	1046	36	2148	79	1046	-967	-1907
1988	950	70	3028	79	950	-870	-2578
1989	982	103	3908	79	982	-903	-3187
1990	668	137	4439	79	668	-589	-3536
1991	0	162	4277	571	10	561	-3245
1992	0	162	4116	614	10	603	-2970
1993	0	162	3954	664	11	654	-2709
1994	0	162	3793	713	11	701	-2463
1995	0	162	3631	765	12	753	-2231
1996	0	162	3470	817	12	805	-2014
1997	129	162	3437	873	145	728	-1842
1998	0	166	3270	927	17	910	-1653
1999	0	166	3104	983	18	966	-1477
2000	0	166	2937	1044	18	1026	-1313
2001	0	166	2771	1101	19	1083	-1161
2002	0	166	2605	1166	20	1147	-1020
2003	453	166	2891	1230	473	757	-939
2004	331	184	3039	1303	346	957	-848
2005	0	196	2843	1368	16	1353	-736
2006	0	196	2647	1440	16	1424	-633
2007	0	196	2450	1512	17	1495	-537
2008	0	196	2254	1582	17	1565	-450
2009	0	196	2058	1655	17	1637	-369
2010	0	196	1862	1735	18	1717	-295
2011	0	196	1666	1813	19	1795	-227
2012	0	196	1469	1896	19	1877	-165
2013	0	196	1273	1973	20	1954	-108
2014	0	196	1077	2059	20	2039	-56
2015	0	196	881	3024	21	3003	11

IRR = 14.0%
Discounted Total Benefit = 4023
Discounted Total Cost = 4023
Discounted Net Benefit = 0
Benefit/Cost Ratio = 1.00

TABLE 8-1.3 COST AND BENEFIT STATEMENT

Case: I Best Estimate (Actual Cost and Benefit Statement)

IN ₱100,000

Serial	Year	COST: Construction Cost	COST: Maintenance Cost of the Proposed Tunnel	TOTAL COST: Before Discount	TOTAL COST: After Discount at the rate of 12%	14%	16%	18%	BENEFIT: USER BENEFIT OF Normal Traffic	Induced Traffic	Detour Traffic	Maintenance Cost of the Proposed Tunnel	Net Increase in Local Labor's Income	Residual Value	TOTAL BENEFIT: Before Discount	TOTAL BENEFIT: After Discount at the rate of 12%	14%	16%	18%
1	1986	949	0	949	949	949	949	949	0	0	0	0	79		79	79	79	79	79
2	1987	872	0	872	779	765	751	739	0	0	0	0	79		79	71	69	68	67
3	1988	792	0	792	631	609	588	569	0	0	0	0	79		79	63	61	59	57
4	1989	818	0	818	583	552	524	498	0	0	0	0	79		79	56	53	51	48
5	1990	557	0	557	354	330	307	287	0	0	0	0	79		79	50	47	44	41
6	1991	0	10	10	6	5	5	4	452	19	190	5	0		665	378	346	317	291
7	1992	0	10	10	5	5	4	4	483	21	202	5	0		710	363	326	294	265
8	1993	0	11	11	5	4	4	3	526	22	221	5	0		774	350	310	274	243
9	1994	0	11	11	5	4	3	3	565	24	237	5	0		830	335	291	254	221
10	1995	0	12	12	4	4	3	3	605	26	256	5	0		891	321	274	235	201
11	1996	0	12	12	4	3	3	2	647	27	273	5	0		952	307	257	214	182
12	1997	107	17	124	36	29	24	20	691	29	293	5	0		1017	292	241	199	165
13	1998	0	17	17	4	4	3	2	736	31	308	5	0		1080	277	224	182	143
14	1999	0	18	18	4	3	3	2	780	33	328	5	0		1145	263	209	167	133
15	2000	0	18	18	4	3	2	2	828	35	349	5	0		1217	249	194	152	120
16	2001	0	19	19	3	3	2	2	876	37	366	5	0		1284	235	180	139	107
17	2002	0	20	20	3	2	2	1	928	39	388	5	0		1360	222	167	127	96
18	2003	378	20	398	58	45	32	24	978	41	410	5	0		1434	209	155	115	86
19	2004	276	15	291	38	26	20	15	1034	44	436	5	0		1519	197	144	105	77
20	2005	0	16	16	2	1	1	1	1085	46	456	5	0		1594	185	132	95	69
21	2006	0	16	16	2	1	1	1	1143	48	483	5	0		1679	174	122	86	61
22	2007	0	17	17	2	1	1	1	1200	51	506	5	0		1762	163	112	78	55
23	2008	0	17	17	1	1	1	0	1257	53	529	5	0		1844	152	103	70	48
24	2009	0	17	17	1	1	1	0	1317	56	552	5	0		1929	142	95	64	43
25	2010	0	18	18	1	1	1	0	1380	58	580	5	0		2023	133	87	57	38
26	2011	0	19	19	1	1	0	0	1442	61	606	5	0		2114	124	80	52	34
27	2012	0	19	19	1	1	0	0	1507	64	635	5	0		2211	116	73	47	30
28	2013	0	20	20	1	1	0	0	1572	66	658	5	0		2301	108	67	42	26
29	2014	0	20	20	1	1	0	0	1637	69	690	5	0		2401	101	61	38	23
30	2015	0	21	21	1	0	0	0	1708	72	715	5	0	734	3233	121	72	44	27
TOTAL		4748	408	5156	3456	3353	3236	3133	25382	1073	13669	125	396	734	38370	5806	4631	3745	3081

DISCOUNT RATE = 12%
DISCOUNTED TOTAL BENEFIT = 5806
DISCOUNTED TOTAL COST = 3456
DISCOUNTED NET BENEFIT = 2350
BENEFIT COST RATIO = 1.67

DISCOUNT RATE = 14%
DISCOUNTED TOTAL BENEFIT = 4631
DISCOUNTED TOTAL COST = 3353
DISCOUNTED NET BENEFIT = 1278
BENEFIT COST RATIO = 1.38

DISCOUNT RATE = 16%
DISCOUNTED TOTAL BENEFIT = 3745
DISCOUNTED TOTAL COST = 3236
DISCOUNTED NET BENEFIT = 509
BENEFIT COST RATIO = 1.16

DISCOUNT RATE = 18%
DISCOUNTED TOTAL BENEFIT = 3081
DISCOUNTED TOTAL COST = 3133
DISCOUNTED NET BENEFIT = −52
BENEFIT COST RATIO = 0.98

TABLE 8-1.4 COST AND BENEFIT STATEMENT

Case: 2, Case 1 plus 10% on Construction Cost

		COST							BENEFIT											
				TOTAL COST					USER BENEFIT OF						TOTAL BENEFIT					
					AFTER DISCOUNT at the rate of											AFTER DISCOUNT at the rate of				
Serial	Year	Construction Cost	Maintenance Cost of the Proposed Tunnel	Before Discount	12%	14%	16%	18%	Normal Traffic	Induced Traffic	Detour Traffic	Maintenance Cost of Existing Road	Net Increase in Local Labor's Income	Residual Value	Before Discount	12%	14%	16%	18%
1	1986	1043	0	1043	1043	1043	1043	1043	0	0	0	0	79		79	79	79	79	79
2	1987	959	0	959	856	841	827	813	0	0	0	0	79		79	71	69	68	67
3	1988	871	0	871	694	670	647	626	0	0	0	0	79		79	63	61	59	57
4	1989	900	0	900	641	608	577	549	0	0	0	0	79		79	56	53	51	48
5	1990	612	0	612	389	363	338	316	0	0	0	0	79		79	50	47	44	41
6	1991	0	10	10	6	5	5	4	452	19	190	5	0		665	378	346	317	291
7	1992	0	10	10	5	5	4	4	458	21	202	5	0		716	363	326	294	265
8	1993	0	11	11	5	4	4	3	526	22	226	5	0		774	350	309	274	243
9	1994	0	11	11	5	4	3	3	565	24	237	5	0		830	335	291	253	221
10	1995	0	12	12	4	4	3	3	665	26	256	5	0		891	324	274	234	201
11	1996	0	12	12	4	3	3	2	647	27	273	5	0		952	307	237	216	182
12	1997	118	17	135	39	32	26	22	681	29	293	5	0		1017	292	241	199	165
13	1998	0	17	17	4	4	3	2	736	31	308	5	0		1080	277	224	182	148
14	1999	0	18	18	4	3	3	2	793	33	328	5	0		1145	263	209	166	133
15	2000	0	18	18	4	3	2	2	828	35	349	5	0		1217	249	194	152	120
16	2001	0	19	19	3	3	2	2	876	37	366	5	0		1284	235	180	139	107
17	2002	0	20	20	3	2	2	1	928	39	388	5	0		1360	222	167	127	95
18	2003	415	20	436	43	47	35	26	978	41	430	5	0		1434	209	155	115	86
19	2004	304	15	319	41	30	22	16	1034	44	436	5	0		1519	197	144	105	77
20	2005	0	16	16	2	1	1	1	1065	46	458	5	0		1594	165	132	95	69
21	2006	0	16	16	2	1	1	1	1143	48	483	5	0		1679	174	122	86	61
22	2007	0	17	17	2	1	1	1	1200	51	506	5	0		1762	163	112	78	55
23	2008	0	17	17	1	1	1	0	1257	53	529	5	0		1844	152	103	70	48
24	2009	0	17	17	1	1	1	0	1317	56	552	5	0		1929	142	95	64	43
25	2010	0	18	18	1	1	1	0	1380	59	580	5	0		2023	133	87	57	38
26	2011	0	19	19	1	1	0	0	1442	61	606	5	0		2114	124	80	52	34
27	2012	0	19	19	1	1	0	0	1507	64	635	5	0		2211	116	73	47	30
28	2013	0	20	20	1	1	0	0	1572	66	658	5	0		2301	108	67	42	26
29	2014	0	20	20	1	1	0	0	1637	69	690	5	0		2401	101	61	38	23
30	2015	0	21	21	1	0	0	0	1708	72	715	5	0	807	3307	124	74	45	27
TOTAL		5223	408	5631	3828	3683	3555	3442	25392	1073	10669	116	396	807	35443	5839	4632	3745	3081

DISCOUNT RATE = 12%
DISCOUNTED TOTAL BENEFIT = 5839
DISCOUNTED TOTAL COST = 3828
DISCOUNTED NET BENEFIT = 2011
BENEFIT COST RATIO = 1.53

DISCOUNT RATE = 14%
DISCOUNTED TOTAL BENEFIT = 4632
DISCOUNTED TOTAL COST = 3683
DISCOUNTED NET BENEFIT = 950
BENEFIT COST RATIO = 1.26

DISCOUNT RATE = 16%
DISCOUNTED TOTAL BENEFIT = 3745
DISCOUNTED TOTAL COST = 3555
DISCOUNTED NET BENEFIT = 191
BENEFIT COST RATIO = 1.05

DISCOUNT RATE = 18%
DISCOUNTED TOTAL BENEFIT = 3081
DISCOUNTED TOTAL COST = 3442
DISCOUNTED NET BENEFIT = -361
BENEFIT COST RATIO = 0.90

8-2 Results of Evaluation

The Internal Rate of Return [IRR] was the main criterion used as indicator of economic feasibility of the proposed investments in the tunnel project. However, additional indicators are also calculated, namely, the projects Net Present Value and Benefit/Cost (B/C) ratios and presented at four different discount rates. The results of the sensitivity analyses discussed in Section 8-1 above, plus the B/C ratios and NPV's are summarized below.

Case	IRR (%)	B/C Ratio				NPV (100,000 ₱)			
		12%	14%	16%	18%	12%	14%	16%	18%
1	17.8	1.67	1.38	1.16	0.98	2,350	1,278	509	−52
2	16.6	1.53	1.26	1.05	0.90	2,011	950	191	−361
3	22.5								
4	14.0								

8-3 Conclusion

The results shown above indicate that the investments, with 15% cut-off rate of economic return for marginal projects is economically feasible, and may be given due consideration by the Government. It must be remembered that these indicators include only the benefits quantified in the analyses and thus may further appreciate if all the benefits are quantified.

The investments would yield an Internal Rate of Return of 17.8%, if all identified project costs and quantified benefits are included (or Case 1 in the sensitivity tests). At 16% discount rate, the project B/C ratio is 1.16 while the NPV is ₱50.9 Million.

Chapter 9.

ENGINEERING STUDY FOR SECTION B

CHAPTER 9
ENGINEERING STUDY FOR SECTION B

9-1 General

Section B is between Balaho-Capintalan and Sta. Fe-Baliling, with an aggregate length of about 40 km. On these sections, the scope of the studies was limited to assessment on the basis of field reconnaissance, concentrating on the "problem" sections. Recommendations on countermeasures and/or proposed improvement of these sections is supported with preliminary designs.

The work for this section began with basic data collections and logistic preparations for field work. Thereafter, field inventory and appraisal work followed, which included measuring, identifying and tabulation of existing structures, appraisal of their conditions and investigations of critical areas where no structures exist. After the field inventory and investigations and topographic and geological surveys along the existing highway were made, preparation of design parameters, design standards and study of alternate design solutions, such as realignment, channel work including consolidation, slope protections and reconstructed structures were involved. Methods of rehabilitating existing road structures were studied. Based on the field inventories, investigations and geological and topographic survey solutions were studied and optima proposed.

9-2 Field Survey

Topographic surveys were carried out on the selected sites to study countermeasures to be adopted for preventing damages caused on the road side slope. The results were drawn at a Scale of 1/1000 for plan and 1/200 for profile. Table 9-2.1 shows the list of sites where topographic surveys were conducted.

In Table 9-2.1 the sites under Section A from Km. 202 to Km. 217 are excluded, since the section is under the Feasibility Study in which the existing highway was presumed to be abandoned after the completion of the new tunnel section.

However, it is estimated that the tunnel shall be completed in the year 1990, which is still nine years hence. It is expected that up to then the existing highway shall be properly maintained.

Considering aforementioned factors for Section A, the same works undertaken for Section B were conducted. The results for Section A mentioned hereinafter is therefore for reference only. The sites to be improved or rehabilitated under Section A is shown in Table 9-2.2.

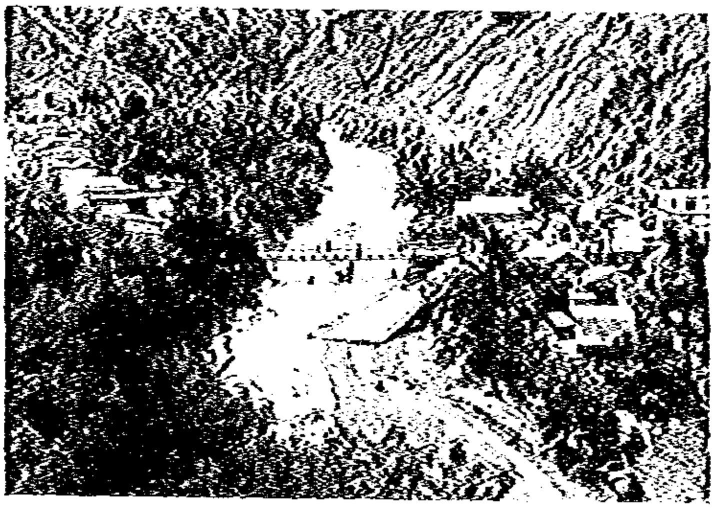
TABLE 9-2.1 LIST OF SITES WHERE TOPOGRAPHIC SURVEYS WERE CONDUCTED

No.	Station (Km)	Length of Topo-graphic survey	No. of Sheets		
			Plan	Cross section	Profile
1	Km 167+ 50 — Km 167+100	50	1	1	—
2	Km 167+400	100	1	1	—
3	Km 171+100 — Km 171 +800	700	1	6	1
4	Km 172+478 — Km 172+546	50	1	1	—
5	Km 173+110 — Km 173+180	200	1	1	1
6	Km 177+100 — Km 177+750	650	1	5	1
7	Km 181+100 — Km 181+500	400	1	2	1
8	Km 182+047 — Km 182+200	125	1	1	—
9	Km 185+690	—	1	1	—
10	Km 185+840	—	1	1	—
11	Km 185+965 — Km 186+275	310	1	2	1
12	Km 187+700 — Km 187+800	200	1	1	1
13	Km 188+085 — Km 188+335	200	1	1	—
14	Km 196+015 — Km 196+265	300	1	2	1
15	Km 198+880 — Km 199+060	250	1	4	1
16	Km 217+250 — Km 217+275	25	1	1	—
17	Km 219+400	—	1	1	—
18	Km 220+550 — Km 220+900	350	1	2	1

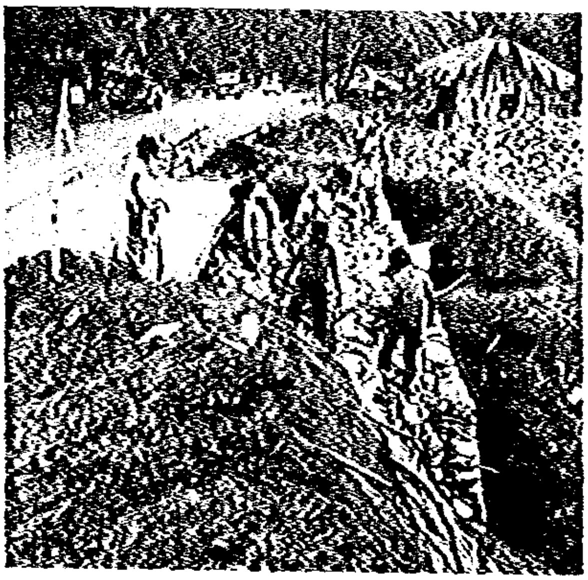
TABLE 9-2.2 LIST OF SITES WHERE TOPOGRAPHIC SURVEYS WERE CONDUCTED UNDER SECTION A

No.	Station (Km)	Length of Topo-graphic survey	No. of Sheets		
			Plan	Cross section	Profile
A-1	Km 201+937 — Km 202+060	200	1	1	—
A-2	Km 203+787.3	150	1	1	—
A-3	Km 204+950 — Km 205+150	200	1	1	—
A-4	Km 205+900 — Km 207+500	1600	1	13	1
A-5	Km 210+700	115	1	1	1
A-6	Km 213+400 — 550	150	1	1	1
A-7	Km 216+000 — 550	550	1	2	1
A-8	Km 216+720 — 880	160	1	1	—

KM. 171. This typical section is one of the sites recommended for improvement/rehabilitation. Recommended works include sabo, slope protection and construction of minor structures to prevent further landslides and erosions.



COLLAPSED STA. FE BRIDGE. The Sta. Fe Bridge has often been rendered impassable after heavy rains and floods that cause the overflow of Sta. Fe River.



KM. 219 + 300. Typical riprap work which is usually undertaken after typhoons cause serious damages to the area.

9-3 Preliminary Design of Countermeasure Works

9-3-1 Application of Reconnaissance Results

Based on the results obtained by topographic and geological survey, the preliminary design of countermeasure works to prevent the disasters were made. The main work items of countermeasures considered on preliminary design are as follows :

- Slope Failure : Slope protection by vegetation or structure, recutting
- Landslide : Cutting, drainage, counterweight embankment, piling
- Debris Flow : Sabo dam, ground sill, etc.
- Erosion by river : Revetment, spurdike, etc.

The selected sites to study countermeasures for preventing disasters is shown in Table 9-3.1 and 9-3.2

9-3-2 Cutting Slope

The study team provided a slope stability check table based on field reconnaissance.

(1) Condition of Side Slopes

Based on the topographical and geological feature of each side slopes, the condition are as follows :

a) Generally, the slope gradient is too steep for the material consisting of slopes, and the slope gradient of each material is the same.

b) Slope protection is not advisable for all side slopes for the purpose of failure observation.

c) There is no drainage preparation on side slopes. Running water and seepage water flows on the slopes resulting in the formation of the gullies.

Above-mentioned condition of side slopes and poor geological condition caused by heavy rain and high temperature causes the failure of side slopes.

(2) Countermeasure for Side Slopes

As observed during the field reconnaissance, side slopes along the existing road are of steep gradient bearing no slope protection for alteration and weathering. In effect, gullies are formed whenever typhoons and heavy rainfall occur causing failure on the side slopes. In such cases, countermeasures are necessary to avoid erosion and further landslide.

1) Side Slope Gradient and Protection

Generally, the side slope materials are classified into three groups :

— Topsoil including talus deposit, terrace deposit and weathered soil
— Soft rock induced by weathering and abundant open cracks
— Hard rock

The side slope gradient ratio for each material is as follows:

— Top soil 1:1.0 − 1:1.5 (Vertical vs. Horizontal)
— Soft Rock 1:0.8 − 1:1.0 − do −
— Hard rock 1:0.5 − 1:0.8 − do −

But on the existing road in this area, side slope gradient ratio for each material is the same, its gradient ratio is 1:0.3—0.5. Thus it is expected to have recutting based on material consisting of side slopes, although it is impossible, since the natural slope is steep and a long cutting slope will be needed for slope protection. Therefore, in this area, it is difficult to apply recutting as countermeasure for side slopes except in the gentle slope areas.

2) Slope Protection

Slope protection should be adopted for all the materials that consist of side slopes.The relation between material and slope protection are as follows :

Top soil: : Vegetation, concrete precast frame
Soft rock : Concrete spraying, rocknet, concrete precast frame
Hard rock : Rocknet, concrete spraying in case of open cracks.

TABLE 9-3.1 WORK ITEMS INVOLVED FOR COUNTERMEASURE WORKS FOR SECTION B

NO.	SITES	LENGTH OF TOPOGRAPHIC SURVEY(m)	PROPOSED CONSTRUCTION WORK						DEGREE OF IMPORTANCE
			SABO	SLOPE PROTECTION	ALIGNMENT	BRIDGE	DRAINAGE	MINOR STRUCTURE	
1.	KM 167+50 ~ KM 167+100	50 m.		●	●		●	●	C
2.	KM 167+400	100					●		C
3.	KM 171+100 ~ KM 171+800	700	●	●				●	A
4.	KM 172+478 ~ KM 172+546	50	●	●	●		●	●	C
5.	KM 173+110 ~ KM 173+180	200		●			●	●	C
6.	KM 177+100 ~ KM 177+750	650	●		●	●			A
7.	KM 181+100 ~ KM 181+500	400	●		●	●			A
8.	KM 182+047 ~ KM 182+200	125		●				●	B
9.	KM 185+690	—							C
10.	KM 185+840	—	●	●			●		C
11.	KM 185+965 ~ KM 186+275	310							B
12.	KM 187+700 ~ KM 187+800	200	●						B
13.	KM 188+085 ~ KM 188+335	200							C
14.	KM 196+015 ~ KM 196+265	300		●					C
15.	KM 198+880 ~ KM 199+060	250	●		●	●			B
16.	KM 217+250 ~ KM 217+275	25							C
17.	KM 219+400	—							C
18.	KM 220+550 ~ KM 220+900	350	●	●	●		●		A

TABLE 9-3.2 WORK ITEMS INVOLVED FOR COUNTERMEASURE WORKS UNDER SECTION A

NO.	SITES EXISTING HIGHWAY	LENGTH OF TOPOGRAPHIC SURVEY(m)	PROPOSED CONSTRUCTION WORK						DEGREE OF IMPORTANCE
			SABO	SLOPE PROTECTION	ALIGNMENT	BRIDGE	DRAINAGE	MINOR STRUCTURE	
A-1	KM 201+937 ~ KM 202+060	200	●						C
A-2	KM 203+787.3	150	●				●		C
A-3	KM 204+950 ~ KM 205+150	200			●				C
A-4	KM 205+900 ~ KM 207+500	1600	●	●			●	●	A
A-5	KM 210+700	1115	●				●		C
A-6	KM 213+400 ~ KM213+530	130		●			●		A
A-7	KM 216+000 ~ KM 216+550	550			●	●		●	A
A-8	KM 216+720 ~ KM 216+680	160	●	●				●	B

9-3-3 Embankment

Embankment in the existing road is composed of cutting and embankment. On the other hand, sections near the glen or small stream are fill-type.

(1) Condition of Embankment

Based on field reconnaissance, condition of embankment is as follows:

a) Embankment portion is mainly located at the glen or small stream, thus earth retaining structure is constructed at the end of the embankment slope
b) Gradient of embankment is 1:0.3 – 1:0.5
c) Slope protection is performed by masonry
d) Embankment height on the flat plane is less than 5.0 m. but at the cutting and embankment, its height is more than 5 to 10 meters because, in mountainous areas, the original topography is steep.

The above-mentioned condition of the embankment area will be easily eroded by stream water or running water inducing failure. Slope failure occurs caused by scouring of river at the foot of embankment slope and defective drainage system.

(2) Countermeasure for Embankment Failure

According to field reconnaissance, the main causes of embankment failure is that surface drainage, shoulder drainage and drainage pipe or culvert box in the embankment and revetment is not defective.

Thus it is necessary to protect the embankment failure by the following :
a) Rehabilitation of surface drainage and shoulder drainage
b) Reinforcement of structure foundation, especially in granitic area
c) Revetment at the scouring area
d) Installation of gully at the mountian side of road
e) Sweeping inside pipe and culvert box

9-3-4 Countermeasure for Landslide Existing along the Road

Landslide existing along the road is located at Km 206 + 500 to Km. 207 + 200. Sometimes the existing road is closed with landslides and failures caused by heavy rains and typhoons.

(1) Condition of Cutting Slope

Based on reconnaissance the condition of the cutting slope are as follows :

a) Slope gradient 1:1.2; 1:0.5 – 1:1.0
   Gradient of top cutting slope 1:0.5
b) Slope protection is not conducted
c) There are many small failures in this cutting slope
d) Ground water and seepage water in the cutting slopes are observed

(2) Geological Condition of Cutting Slope

The geological condition of the cutting slope between Km. 206+500 and Km. 207+200 are as follows :

a) The base rock in this area consists of diabase approximately at Km. 206+800. Boundary of diabase and andesite is confirmed by reconnaissance.
b) As a whole the base rock is sheared and rich in open cracks looking like detritus
c). The direction of cracks in N30E, 50SE. This direction of dipping is the reverse against the slope gradient.

(3) Condition of Landslide

Even though geo-technical investigation was not conducted but was based on the condition of cutting slope or geology and failure form or crack in the road, it will be considered that landslide in this area are as follows:

a) Sketch of landslide organization
b) Based on the above sketch, landslide is divided into two units. One is sliding of waste and the other is sliding in soft rock. These slidings are connected to each other. If the toe of waste sliding is eroded by river scouring, waste sliding will be induced and then sliding in soft rock will occur continously.
   Cracks existing in the road shoulder will develop to waste sliding.

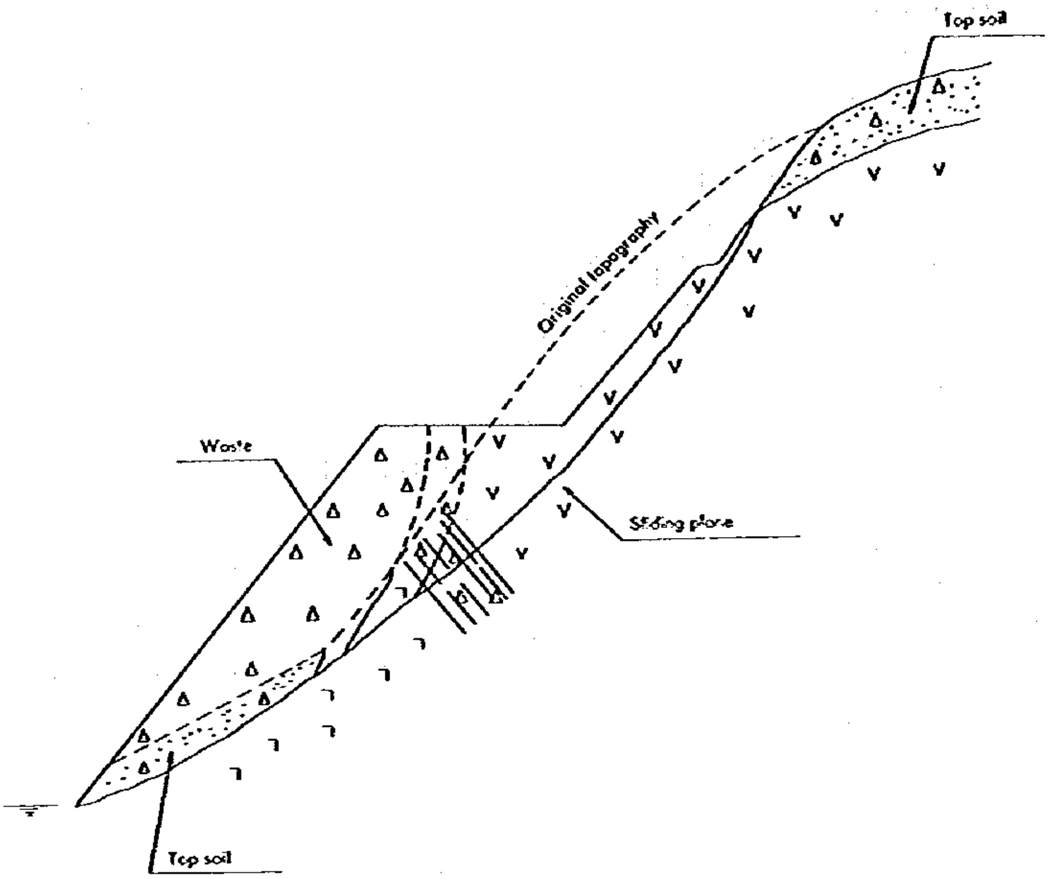


Fig. 9-3.1 LANDSLIDE ORGANIZATION

(4) Countermeasure Methods

Countermeasure method in the area will be considered by the following method

a) For the waste sliding
*River protection for scouring
*Counterweight for sliding

b) For the sliding in soft rock
*Recutting of upper part of slope

9-3-5 Hydrological Study

The results of analysis and study on hydrology for Section A were also adopted for Section B and were used as the fundamental basis for planning and design of countermeasure works.

9-3-6 Bridges and Structures

(1) Bridges

Allowable and maximum discharge of river for all bridge sites was studied. When the required depth (Hr) or the river against the maximum discharge at each site is more than the effective depth, the bridge shall be reconstructed, by either elevating and/or extending over the existing bridge.

Allowable discharge was computed as follows and the results are shown in Table 9-3.3 and 9-3.4. (See. Fig. 9-3.2)

TABLE 9-3.3 MAXIMUM DISCHARGE AT EACH BRIDGE SITE

KM	BRIDGE NAME	I	A	q	Q_{max}	REMARKS
166.0	TAYABO	—	—	—	—	IRRIGATION
171.64	LOMBOYBUKID	1/20	0.55	28	20	
173.30	NANLAGARIAN	1/20	0.69	28	20	
174.25	ISI-ISI	1/30	4.01	28	112	
177.26	PONCAN (I)	—	—	—	—	IRRIGATION
177.43	PONCAN (II)	1/25	38.28	20	770	
179.40	TAKTAK (I)	1/35	2.24	28	63	
181.30	TAKTAK (II)	1/15	1.27	28	36	
182.30	DIGDIG	1/55	139.90	20	2800	
195.45	POTLAN	1/40	37.25	20	750	
198.95	MINULI (I)	1/25	11.75	28	330	
199.05	MINULI (II)	1/35	3.00	28	84	
201.40	CAPINTALAN (I)	1/8	0.26	28	7	
203.10	CAPINTALAN (II)	1/20	5.25	28	147	
216.15	STA. FE	1/66	25.00	20	500	
217.898	CONSUELO	1/5	0.49	28	14	
220.618	BALILING	1/50	9.64	28	270	
222.02	MAGASAWANG KAHOY	1/60	2.71	28	76	
226.365	CALITLITAN	1/35	5.51	28	154	
234.340	NAGCUARTELAN	1/20	0.30	28	8	
236.532	KIRANG	1/65	25.59	20	520	

Where: Q_{max} = Maximum discharge (M^3/sec)
q = Specific discharge ($M^3/sec/KM^2$)
A = Catchment Area (KM^2)

TABLE 9-3.4 ALLOWABLE DISCHARGE AT EACH BRIDGE SITE

KM	BRIDGE NAME	Q_{max}	B	I	H_L	Q_a	Judg.	H_R
166.00	TAYABO	—	—	—	—	—	—	—
171.64	LOMBOYBUKID	16	10.0	1/20	1.7	155	OK	0.4
173.30	NANLAGARIAN	20	12.5	1/20	2.7	418	OK	0.4
174.25	ISI-ISI	112	10.0	1/30	1.2	71	OUT	1.6
177.26	PONCAN (I)	—	—	—	—	—	—	—
177.43	PONCAN (II)	770	40.0	1/33	2.0	631	OUT	2.3
179.40	TAKTAK (I)	63	10.5	1/35	0.8	35	OUT	1.1
181.30	TAKTAK (II)	36	6.8	1/35	0.9	28	OUT	1.1
182.30	DIGDIG	2800	65.0	1/55	7.5	7200	OK	4.3
195.45	POTLAN	750	22.0	1/40	3.7	880	OK	3.4
198.95	MINULI (I)	330	10.0	1/25	1.2	77	OUT	2.9
199.05	MINULI (II)	84	13.0	1/35	2.0	199	OK	1.2
201.40	CAPINTALAN (I)	7	6.5	1/8	2.2	244	OK	0.3
203.10	CAPINTALAN (II)	147	14.0	1/20	4.2	978	OK	1.3
216.65	STA. FE	500	24.0	1/66	2.2	314	OUT	2.9
217.898	CONSUELO	13	15.0	1/5	7.2	5146	OK	0.2
220.618	BALILING	270	27.0	1/50	1.4	191	OUT	1.7
222.02	MAGASAWANG KAHOY	76	11.0	1/60	6.3	871	OK	1.5
226.365	CALITLITAN	154	12.5	1/35	2.2	224	OK	1.6
234.34	NAGCUARTELAN	8	4.0	1/20	4.0	258	OK	0.5
236.582	KIRANG	520	57.0	1/65	2.0	641	OK	1.8

NOTE: Q_a = Allowable Discharge
Judg. = Judgement
OK = $Q_{max} < Q_a$
OUT = $Q_{max} > Q_a$

The bridges over channels wherein maximum discharge exceed allowable discharges will be reconstructed. Table 9-3.5 shows these bridges recommended for reconstruction. However, Baliling Bridge (Km. 220+618) does not require reconstruction except for channel and consolidation works as countermeasure to protect embankment, abutment and the structure itself.

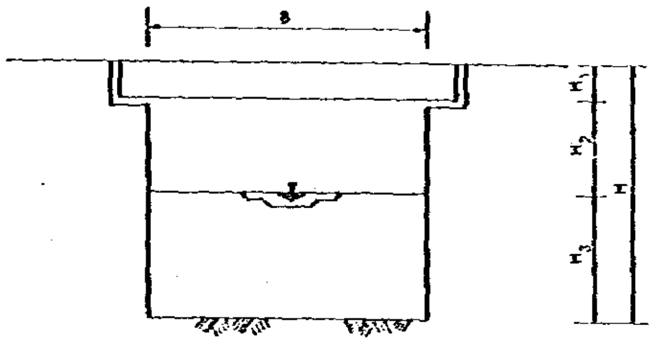


Fig. 9-3.2 GENERAL VIEW OF BRIDGE

$$Q = \frac{H^{\frac{5}{3}} \times B \times I^{\frac{1}{2}}}{N}$$

Where:

Q.	=	Allowable Discharge (M^3/sec)
B	=	Effective Width (M)
I	=	Grade of River
N	=	Roughness (0.035)
H	=	Average River Depth (M)
H_1	=	Girder Depth (M)
H_2	=	Extra Clearance
H_3	=	Effective Depth (M)

However, required depth (H_R) of the river against the maximum discharge at each bridge site is given in the following equation:

$$H_R = \left[\frac{N \cdot Q\,max}{B\sqrt{I}}\right]^{\frac{3}{5}}$$

TABLE 9-3.5 LIST OF BRIDGES TO BE RECONSTRUCTED

STA. (KM)	BRIDGE NAME	TYPE	LENGTH (M)
174 + 25.0	Isi-isi	RCDG	12.00
177 + 411.5	Poncan II	PCG	75.00
179 + 400.0	Taktak (I)	RCDG	12.00
181 + 300.0	Taktak (II)	RCDG	12.00
198 + 975.0	Minuli (I)	PCG	20.00
216 + 400.0	Sta. Fe	PCG	30.00

(2) Culverts and Retaining Walls

The results of investigation for box pipe culverts and retaining walls (stone masonry) showed structures that will be cleared and replaced as indicated in the following tables.

TABLE 9-3.6 LIST OF CLEARING LENGTH FOR CONCRETE PIPE CULVERT

SIZE	CLEARING LENGTH
0.6 m	56.5 m
0.7	2.0
0.8	3.0
0.85	4.0
0.9	112.8
1.0	68.6
1.1	3.0
1.2	11.0
1.3	—
1.4	2.5
1.6	1.5
2.6	—

TABLE 9-3.7 LIST OF CLEARING LENGTH FOR BOX CULVERT

SIZE	CLEARING LENGTH
1.7 × 1.7 m	1.5 m
2.2 × 2.2	4.7
2.5 × 2.5	5.1
2.6 × 2.6	---
2.7 × 2.7	1.8
2.8 × 2.8	—
3.0 × 3.0	3.5

TABLE 9-3.8 LIST OF REPLACED LENGTH FOR RETAINING WALL

HEIGHT of WALL	REPLACED LENGTH
1.0 m	490 m
3.0	208
4.0	36
5.0	24
10.0	30
30	32
35	100

9-3.7 Work Items Involved for Countermeasure Works

Countermeasure works designed on the selected sites are shown in Table 9-3.1 and 9-3.2.

9-4 Construction Cost

9-4-1 Estimate of Quantities

Quantities for countermeasure works were estimated based on the following items shown in Table 9-4.1. The detailed quantities are shown in plans attached as Drawings.

TABLE 9-4.1 WORK ITEMS FOR QUANTITIES ESTIMATION

DESCRIPTION	UNIT
Cut	Cu.m.
Embankment	Cu.m.
Structure Excavation	Cu.m.
Concrete Pavement (t=23cm)	L.M.
Side Ditch	L.M.
Guard Rail	L.M.
Plantation Work	L.M.
Vegetation Work	Sq.m.
Sodding	Sq.m.
Retaining Wall Gravity Type (H =)	L.M.
Stone Masonry (H =)	L.M.
Concrete Pipe ϕ	L.M.
− do − ϕ	L.M.
Concrete for Sabo	Cu.m.
Concrete for River Bed	Cu.m.
Grouted Riprap	Cu.m.
Fence for Falling Rock	L.M.
Bridge L=12.0 m	Site
Concrete Box Culvert	L.M.
Drop Inlet	Each
Outlet	Each
Gabion	Cu.m.
Drainage	L.M.
Reinforcing Steel Bar	Kg.

9-4-2 Cost Estimates

The cost estimate was made based on the quantities and unit costs adopted for works under Section A and Section B.

(1) Section B

1) Construction Cost of Countermeasure Works

The construction cost of countermeasure works is shown in Table 9-4.2.

TABLE 9-4.2 CONSTRUCTION COST OF COUNTERMEASURE WORKS

No.	STATION (KM)	ITEMS	Direct Cost (₱)
1	167 + 050 – 100	Slope protection, drainage and others	521,000
2	167 + 400	Drainage	56,000
3	171 + 100 – 800	Spur dike and others	18,014,000
4	172 + 478 – 546	Sabo Slope protection drainage and others	809,000
5	173+110–173+180	Slope protection, drainage	97,000
6	177 + 100 – 750	New alignment, bridge and others	3,128,000
7	181 + 100 – 500	Bridge and others	1,881,000
8	182 + 047 – 200	Slope protection and others	481,000
9,10, 11	185+660–180+240	Slope protection, drainage	1,483,000
12	187 + 700 – 800	Sabo	1,288,000
13	188 + 085 – 335	Slope protection	942,000
14	196 + 015 – 265	Slope protection	275,000
15	198+880–199+060	Bridge, alignment and others	1,810,000
16	217+250–217+275	Slope protection	913,000
17	219 + 400	Slope protection and others	1,723,000
18	220 + 550 – 900	Sabo, slope protection	19,880,000
		TOTAL	53,301,000

2) Construction Cost of Bridges

The construction cost of bridges to be reconstructed is shown in Table 9-4.3.

TABLE 9-4.3 CONSTRUCTION COST OF BRIDGES

STA. (KM)	BRIDGE NAME	TYPE	LENGTH (m)	DIRECT COST ₱	₱/m^2
174 + 25.0	Isi-isi	RCDG	12.00	316,400	3,260
179 + 400.0	Taktak (I)	RCDG	12.00	714,500	7,370
TOTAL			24.00	1,030,900	

3) Construction Cost of Culverts and Retaining Walls

The construction cost of culverts and retaining walls was estimated as follows :

TABLE 9-4.4 CONSTRUCTION COST OF CULVERTS AND RETAINING WALLS

ITEM	LENGTH	UNIT COST	COST	REMARKS
Concrete Pipe Culvert	147.8 m	62.38 ₱/L.M.	₱9,220	
Box Culvert	16.6	62.38 ₱/L.M.	₱1,036	
Retaining Wall (Stone Masonry)	653.0	1,750 ₱/L.M.	1,142,750	Ave. H=5m for Embankment
TOTAL			(1,153,006) 1,153,000	

(2) Secion A

1) Construction Cost of Countermeasure Works

The construction cost of countermeasure works is shown in Table 9-4.5.

TABLE 9-4.5 CONSTRUCTION COST OF COUNTERMEASURE WORKS UNDER SECTION A

NO.	STA. (KM)	ITEMS	DIRECT COST
A-1	201+937 – 202+060	Sabo and others	1,531,000
A-2	203+787.3	Sabo and channel work and others	338,000
A-3	204+950 – 205+150	New alignment	1,469,000
A-4	205+900 – 207+500	Slope protection, check dam, etc	14,510,000
A-5	210+700	Sabo, drainage and others	442,000
A-6	213+400 – 550	Slope protection	751,000
A-7	216+000 – 550	—	--
A-8	216+720 – 880	Sabo and others	418,000
		TOTAL	19,459,000

Note: A-7 is included in the new construction section.

2) Construction Cost of Retaining Walls and Culverts

The construction cost of culverts and retaining walls was estimated as follows :

TABLE 9-4.6 CONSTRUCTION COST OF CULVERTS & RETAINING WALLS

ITEM	LENGTH	UNIT COST	COST	REMARKS
Concrete Pipe Culvert	60.6 m	62.39 P/L.M.	P3,783	
Retaining Wall	268.0 m	1,750 P/L.M.	469,000	Ave H=5m for Embankment
	TOTAL		(472,783) 473,000	

9-5 Recommendation

Recommended work items for improvement and rehabilitation for each site are summarized in Table 9-3.1. In the same table, the degree of importance, which means how soon the improvement work must be performed is indicated. Category A means the site under this category is seriously damaged and must be urgently reconstructed or improved. Category B means sections where the damage is extensive and the improvement and/or rehabilitation are required. The sections mentioned include only fairly major sites for improvement. Besides these sites, there are many sites classified as minor sites, observed and considered to be rehabilitated through ordinary maintenance work. The draft recommended plans for implementation for each site were prepared. The number of sites to be improved or rehabilitated is summarized as follows :

TABLE 9-5.1 SUMMARY OF SITES TO BE IMPROVED OR REHABILITATED

CATEGORY / SECTION (SITES)	A	B	C	TOTAL
A	3	1	4	8
B	4	4	10	18

Note : A = Very serious and needs urgent improvement or rehabilitated
B = Serious and early improvement required
C = Sections where improvement or rehabilitation is recommended

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