PART C FEASIBILITY STUDY OF SELECTED SECTIONS

CHAPTER 7

A PROFILE OF EACH FEASIBILITY STUDY SECTION

7.1 DALTON PASS SECTION

7.1.1 Role

The only trunk road connecting Cagayan Valley with Metro Manila is the Maharlika Highway and no other alternative trunk road exists between two area. The Dalton Pass Section of the Maharlika Highway is located at the gateway to Cagayan Valley, thus the sections has a vast expanse of influence area stretching to 730 kilometers in length. The road transport has an overwhelming share of 99% of total transport demands in the Cagayan Corridor where main traffic generating sources are located at Ilagan in the Isabela Province and at Bayombong in Nueva Vizcaya Province.

7.1.2 Socio-Economic Features

Since the Dalton Pass section has an absolute influence on the Cagayan Valley, description of the society and economy are focused on this region.

1) Present Population

The development of population in Cagayan Valley during the last two decades is shown in Table 7.1-1. Identified as one of the country's least populated region, Cagayan Valley has also the lowest population density of 61 persons per square kilometer in 1980. Uneven distribution of provincial population is observed within the region wherein a relatively heavier population concentration is located in the province of Isabela and Cagayan.

7

2) Economy

The economic growth of Cagayan Valley depend heavily on agriculture with a contribution of 46 percent of the regional GRDP, in 1980 as shown in Table 7.1-2. The average labor productivity was only 58 percent, lower than the national average. However, compared with most other regions, Cagayan Valley has a vast potential for agricultural development given the necessary support. Barely 18 percent of its total land area have been devoted for agricultural purposes and still offers about 413,000 hectares of potential cropland for cultivation.

3) Crop Production

The region had been noted for significant surpluses in rice during the past years, with surpluses between 250 – 350 thousand M.T. in 1975–1980 (Refer to Appendix 7-1). However, for a region that considers rice as its most important crop, its contribution of 10.5% to the national rice production in 1980 is highly unsatisfactory performance. Despite the seemingly high surplus of the region, average yield per hectare still lags behind the target production of 4.95 tons per hectare.

TABLE 7.1-1 POPULATION DEVELOPMENT, PHILIPPINES AND CAGAYAN VALLEY, 1960 – 1980

	Population (In Thousand)			Population Density (Person/Sq.Km)	Average Annual Growth (%)		
	1960	1970	1980	1980	1960-1970	1970-1980	1960-1980
Philippines	27088	36684	48098	160	3.1	2.7	2.9
Cagayan Valley 1/	1202	1680	2216	61	3.4	2.8	3.1
Cagayan	445	581	711	79	2.7	2.0	2.4
Ifugao	77	93	111	56	1.9	1.8	1.8
Isabela	442	648	871	79	3.9	3.0	3.4
Kalinga-Apayao	90	136	185	26	4.2	3.1	3.7
Nueva Vizcaya	138 2/	172	242	60	2.2	3.5	2.8
Quirino	-	50	83	28	-	5.2	-

1/ Includes Batanes
2/ Includes Quirino

TABLE 7.1-2 GROSS REGIONAL DOMESTIC PRODUCT, EMPLOYMENT AND LABOR PRODUCTIVITY BY SECTOR IN 1980

	Agriculture, Fishery and Forestry	Industry	Services	All Sectors
Philippines				
GRDP (PM)	23695	33848	35249	92792
Employed Persons (1000)	9137	2519	5533	17289
Labor Productivity	2593	12924	6371	5367
Cagayan Valley				
GRDP (PM)	1125	533	781	2439
Employed Persons (1000)	544	79	165	788
Labor Productivity	2068	6747	4733	3095
Eastern Visayas				
GRDP (PM)	1254	309	701	2274
Employed Persons (1000)	680	98	206	984
Labor Productivity	1859	3153	3403	2311
Ilocos Region				
GRDP (PM)	1212	790	1316	3318
Employed Persons (1000)	741	176	371	1288
Labor Productivity	1636	4489	3547	2576
Baguio City				
GRDP (PM)	3	75	82	161
Employed Persons (1000)	1845	6790	22273	32
Labor Productivity	1880	11082	3690	5033

Source: Philippine Statistical Yearbook, NEDA Regional Development Staff, Baguio City Development Plan, NEDA (Region I)

4) Forestry

The vast forest resources of the region makes it one of the main producers of forestry products in the country. About 72% of the total land area is classified as public forest land.

As of 1980, Cagayan Valley has a total of 49 logging companies and 60 sawmills. Their combined output contributed 17 percent to total national log production and 20 percent for lumber production. The present production goes partly to export and partly to home consumption. The main domestic demand is located in Metro Manila and a constant flow of forestry products is going south passing through Dalton Pass. The ongoing structural changes from preliminary export of logs to increased industrialization of the forestry products in the country made Metro Manila as major destination of heavier tonnage of logs for processing (refer to Appendix 7-1).

7.1.3 Traffic

1) Influence Zone

Of the 2,128 vehicles daily traffic passing through Dalton Pass, about half, or 1,104 vehicles, originate in the Cagayan Valley. Of these, the largest volumes are generated in the Isabela, Nueva Vizcaya and Cagayan Provinces, with 505 vehicles/day, 334 vehicles/day and 186 vehicles/day, respectively. On the other hand, the Kalinga-Apayao, Ifugao and Quirino Provinces generate very little traffic, at about 30 vehicles/day each. The entire Cagayan Valley – centering around Ilagan, the provincial capital of Isabela, and all the way to Aparri at the northern end of the region – is strongly affected by the Dalton Pass section.

The Dalton Pass section is the sole passageway linking the Cagayan Valley and Metro Manila and can be described as a sort of watershed located midway between the two regions. Traffic through Dalton Pass originating in the Metro Manila side and heading toward the Cagayan Valley totalled 1,024 vehicles/day. Of these, as much as 472 vehicles/day are generated in Metro Manila. The areas south of Metro Manila generate little traffic through Dalton Pass, so that Metro Manila can be considered the virtual southern boundary of the influence zone.

2) Modal Split

The seven sections surveyed, excluding the Dalton Pass section, show an average modal split of 45 percent cars, 35 percent public transportation (bus, jeepney) and 20 percent trucks – indicating that passenger transport in these sections is greater than cargo transport. The Dalton Pass section, on the other hand, show a modal split of 28 percent cars, 22 percent public transportation and 50 percent trucks (see Figure 7.1-3).

The modal share of trucks is 2.5 times larger in Dalton Pass than in other sections.

3) Passenger Trip Purpose

There are obvious differences between the purpose composition of car passengers and that of public transportation passengers. There are 1,922 car passengers/day passing through Dalton Pass in both directions. A point to note is that business purposes ("at work/business") account for a substantial 49 percent of the trip purposes of car passengers. Since other sections also show high proportions of business purposes among car passengers, it is inferred that the high value added of business traffic offers the major motivation for car usage.

Public transportation passengers number 8,386 per day. The highest proportion, or 32 percent, are travelling to visit relatives, followed by 18 percent travelling for business purposes. Urbanization in the Philippines has been progressing at a rapid pace in recent years, accompanied with the usual inflow of population into urban areas such as Metro Manila, and the high proportion of visiting relatives as a trip purpose reflects this situation.

4) Commodity Flow

a) Commodity Items

The total volume of commodities originating in the Cagayan Valley was 6,350 tons/day, out of which 61 percent, or 3,867 tons/day, are logs and lumber. This is followed by milled rice, at 1,039 tons/day (16 percent), and palay, at 587 tons/day (9 percent). These three primary products account for 85 percent of commodity flow generated on the Cagayan side of Dalton Pass and 66 percent of commodity flow generated on both sides of Dalton Pass. Timber and rice are not only important for the regional economy of the Cagayan Valley, but are also essential to Metro Manila. From a macro-economic view based on the results of a surplus-deficit analysis made on a national level, 40 percent of the timber and rice consumed in Metro Manila are supplied by the Cagayan Valley.

In the other direction, secondary products (processed goods) are transported from the Metro Manila side passing Dalton Pass to the Cagayan Valley. The volume is 1,870 tons/day, which is much smaller than the 6,350 tons/day generated by the Cagayan Valley side. Due to this imbalance, some of the trucks moving from the Metro Manila side towards the Cagayan Valley are empty of cargo, so that transport efficiency is lowered. Major commodities originating from Metro Manila side are cement, gasoline, and manufactured food, transport volumes of which are 743 tons/day, 252 tons/day, and 406 tons/day, respectively (see Figure 7.1-5 and 7.1-7).

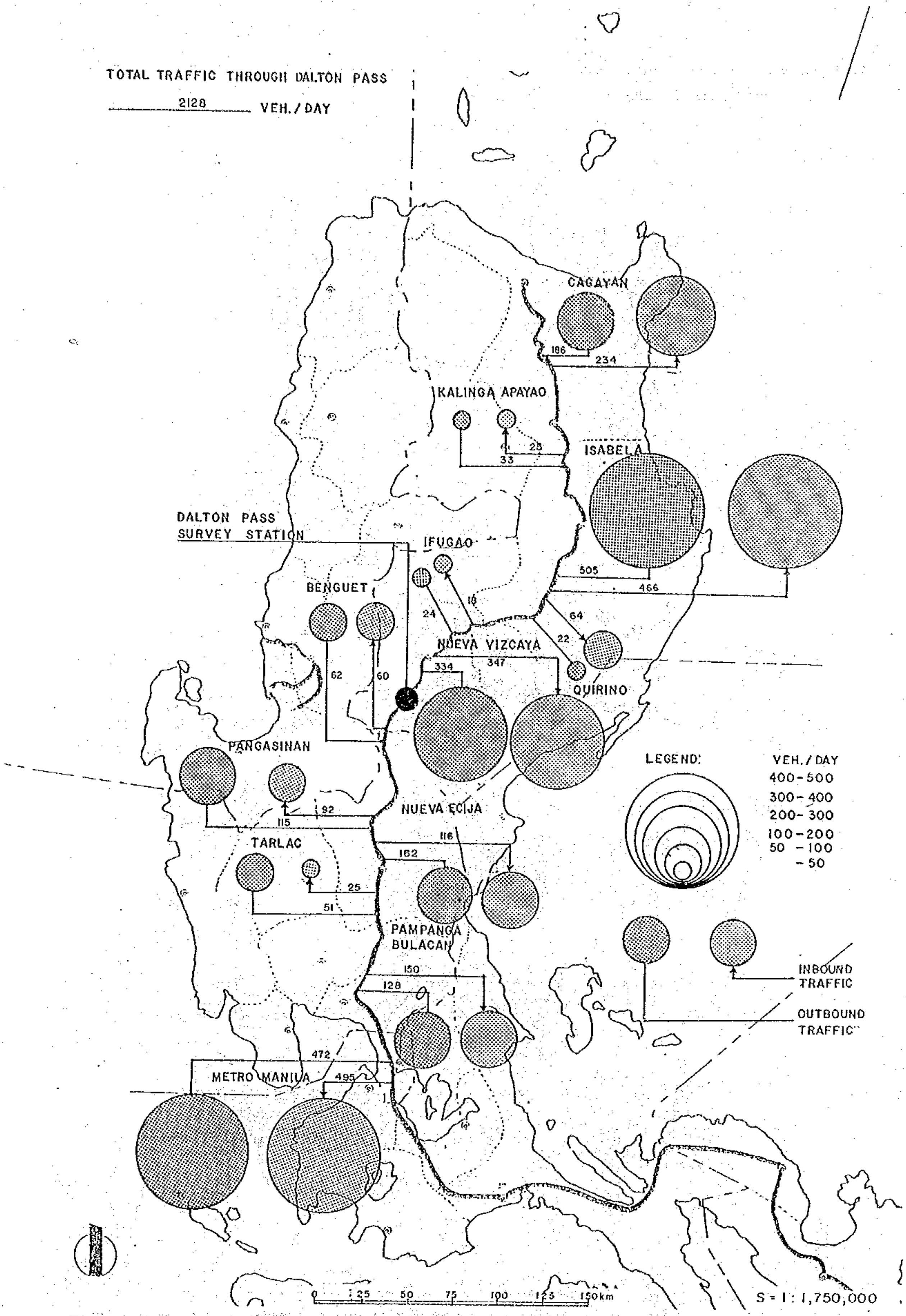


FIGURE 7.1-1 ORIGIN AND DESTINATION OF TOTAL TRAFFIC THROUGH DALTON PASS SECTION OF MAHARLIKA HIGHWAY

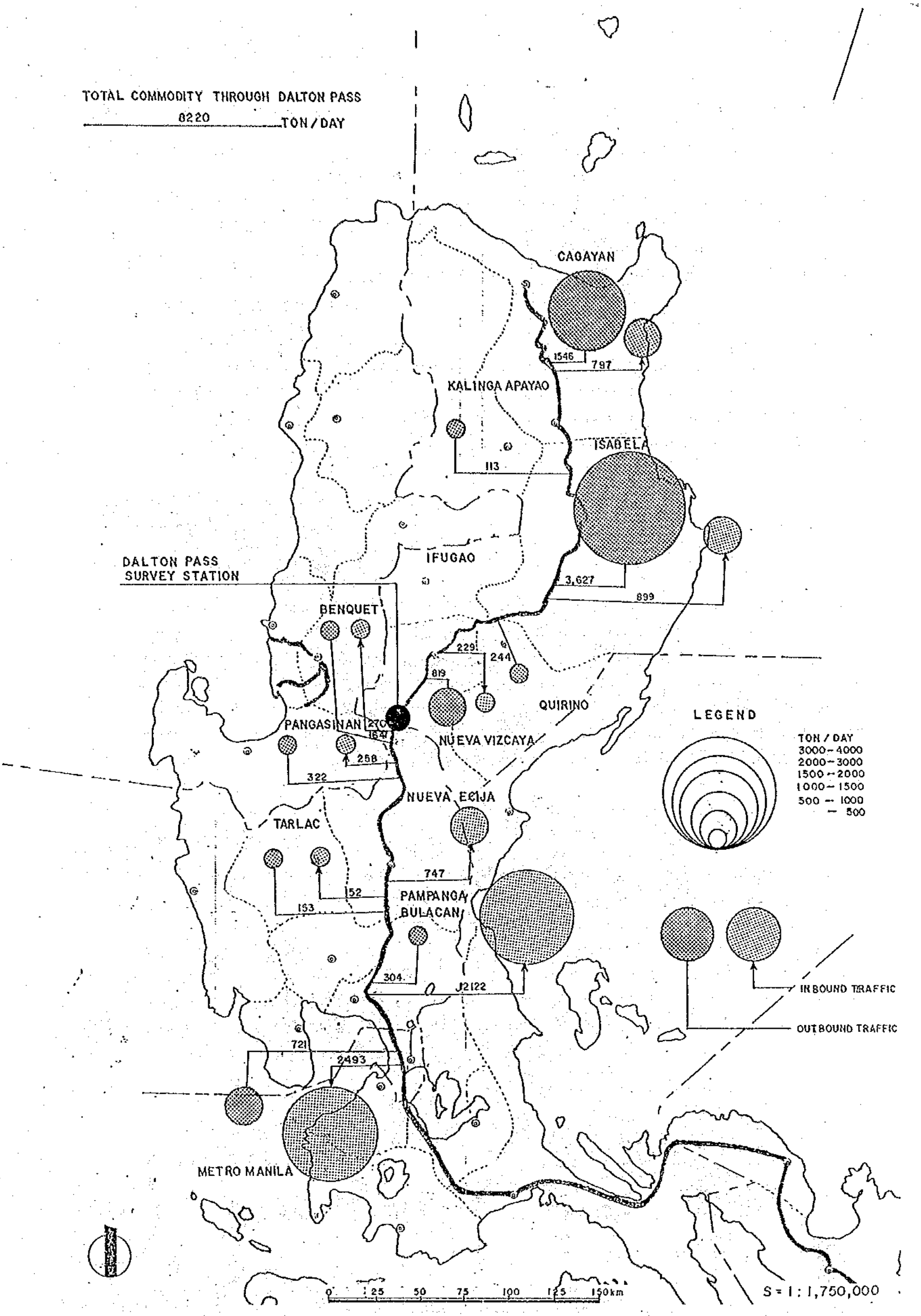


FIGURE 7.1-2 ORIGIN AND DESTINATION OF TOTAL COMMODITY THROUGH DALTON PASS SECTION AND MAHARLIKA HIGHWAY

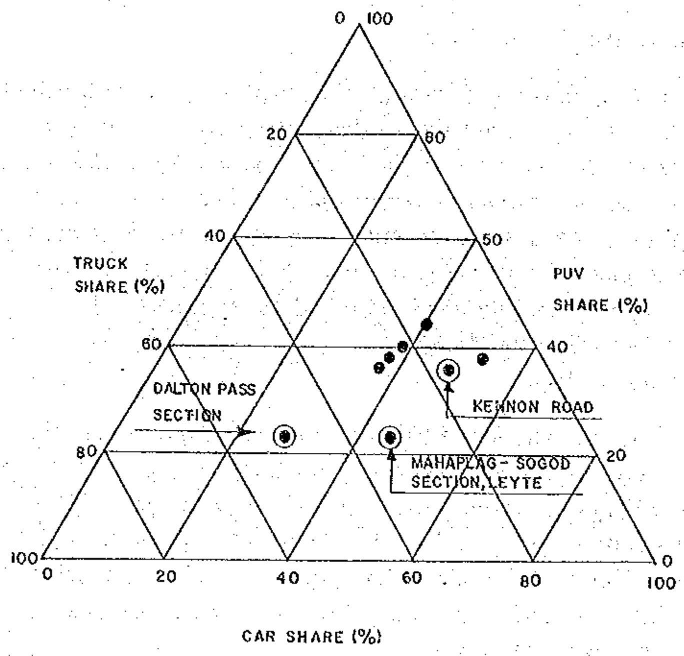


FIGURE 7.1-3 MODAL SHARE BY SECTION

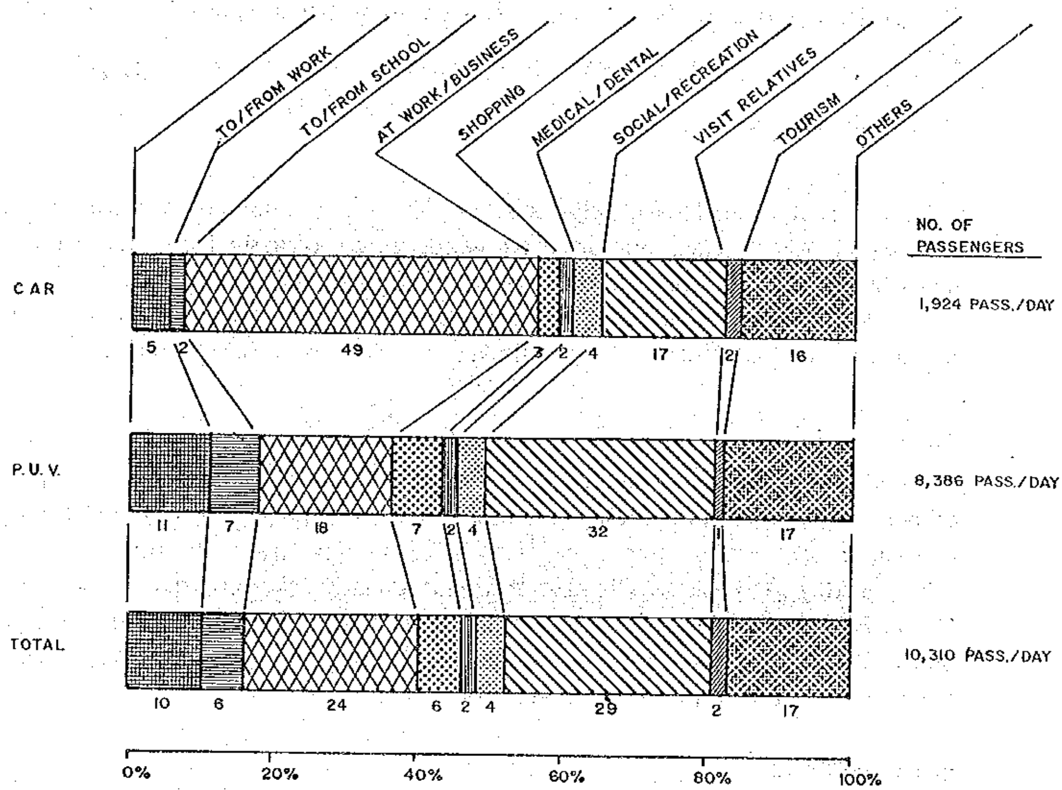


FIGURE 7.1-4 PURPOSE COMPOSITION OF PASSENGERS AT DALTON PASS SECTION

b) Truck Traffic Composition

Of the 1,067 trucks passing through Dalton Pass daily, 409 vehicles/day (38 percent) are two-axle, trucks, 528 vehicles/day (50 percent) are three-axle trucks and 130 vehicles/day (12 percent) are trailers (see Figure 7.1-6). The preponderance of heavy-duty trucks such as three-axle trucks and trailers is a characteristic of this section. Because of this, the avarage weight of cargo per truck is considerably heavy – 7.7 tons when trucks without cargo are included and 13.1 tons otherwise. Frequent cases of overloading, incidentally, were observed during the surveys.

c) Commodity Origin

3,630 tons/day, 57 percent of the commodities originating in the Cagayan Valley totalling 6,350 tons/day are shipped out from the Isabela Province. This is followed by the Cagayan and Nueva Vizcaya Provinces, at 1,550 tons/day (24 percent) and 820 tons/day (13 percent), respectively. The commodities are transported to Metro Manila, Bulacan and Nueva Ecija. The fact that Metro Manila receives the greatest volume, 2,490 tons/day, is hardly surprising, but the fact that Bulacan receives nearly as much, 2,120 tons/day, is to be noted.

Commodity flow in the opposite direction mostly originates in Metro Manila, Pangasinan and Bulacan, these regions account for 721 tons/day, 322 tons/day and 304 tons/day, respectively.

Rough descriptions of the flows of major commodities are given below (see Appendix 7-3).

Rice (Milled Rice, Palay)

Milled rice and palay show different flow patterns. Palay is transported from the Cagayan Province to Nueva Ecija, where it is sent to the numerous rice mills located in the region. Milled rice, on the other hand, moves directly from the rice-producing areas to the areas of consumption, namely from the Isabela and Cagayan Provinces to Metro Manila and Bulacan. Isabela ships out the greatest volume of milled rice and palay combined, at 780 tons/day, followed by Cagayan, at 680 tons/day.

Timber

Timber is shipped either as logs and lumber or in processed forms to raise its value added, but an overwhelming proportion of timber shipments from the Cagayan Valley is made in the former form – the ratio is 3,870 tons/day of the former compared to 170 tons/day of the latter. Timber from the Cagayan side originate in the Isabela and Nueva Ecija Provinces, accounting for 2,340 tons/day and 580 tons/day, respectively. Metro Manila and Bulacan receive 1,670 tons/day and 1,360 tons/day, respectively, of timber for consumption or further processing.

Processed Food

Processed food flow from the Metro Manila side to the Cagayan Valley. Main items are cooking oil and canned food and the total flow of processed food is 580 tons/day. Metro Manila, Bulacan and Pangasinan together account for 88 percent, or 510 tons/day, of total shipment.

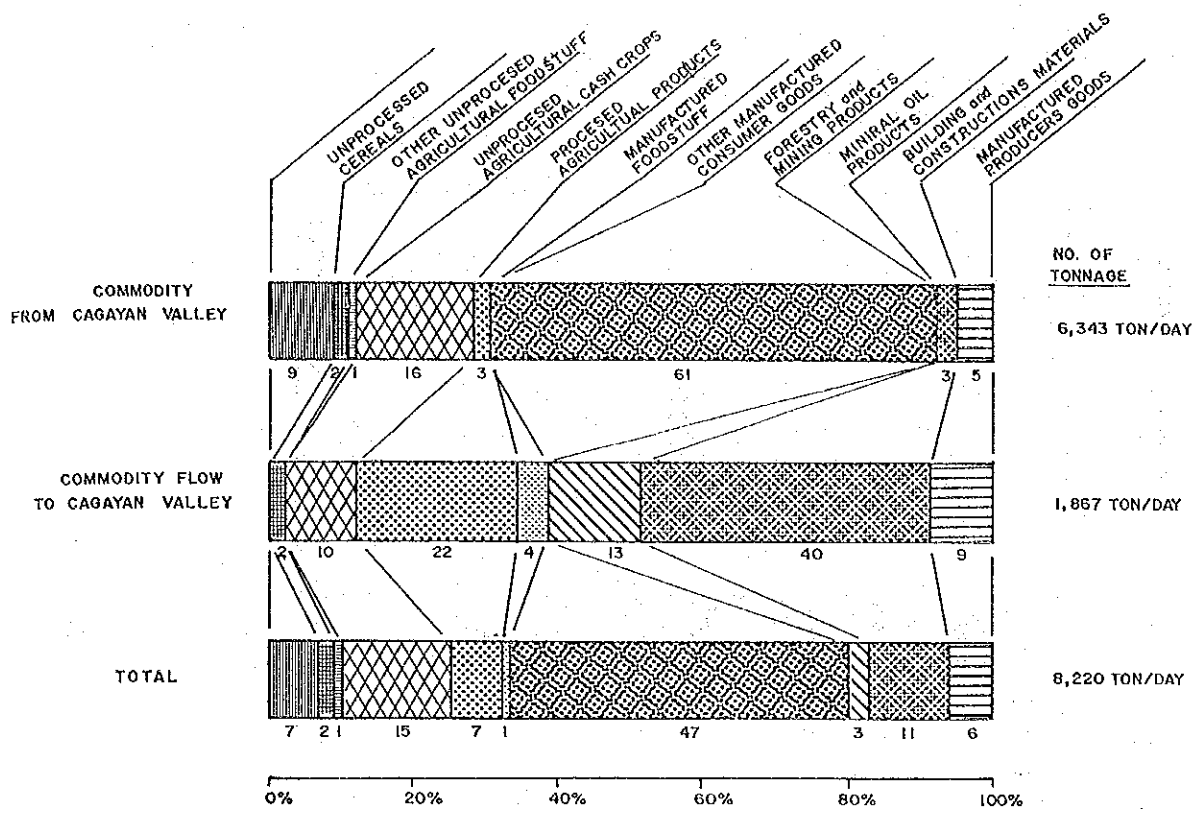


FIGURE 7.1-5 COMPOSITION OF COMMODITY AT DALTON PASS SECTION

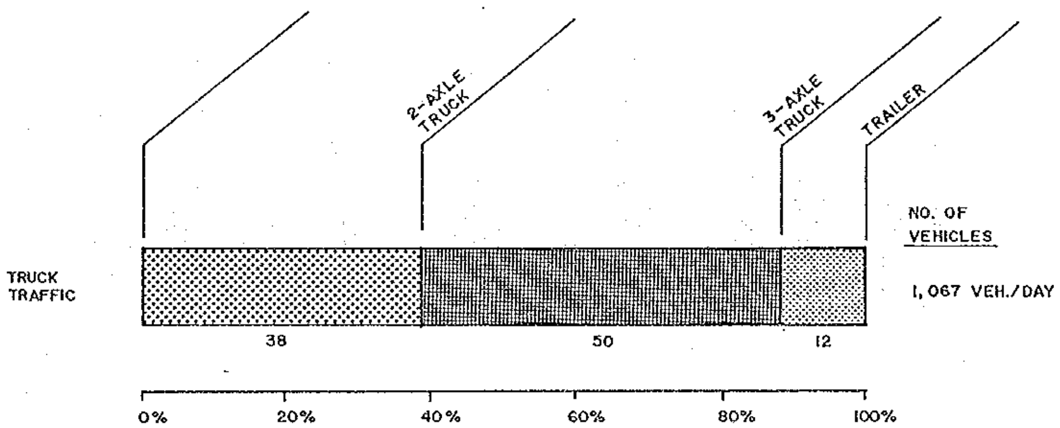


FIGURE 7.1-6 TRUCK TRAFFIC BY TYPE AT DALTON PASS SECTION

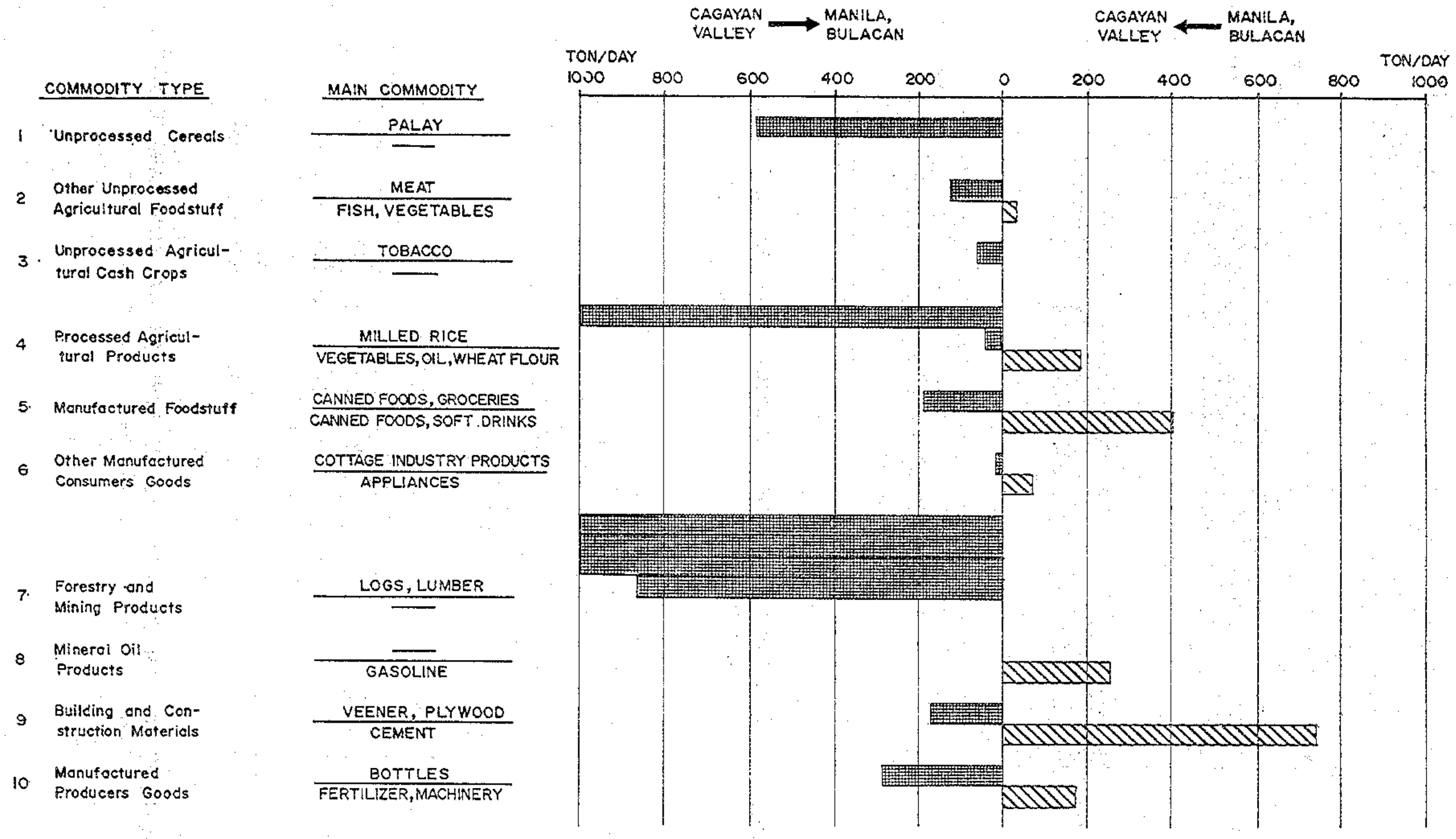


FIGURE 7.1-7 COMMODITY FLOW IN DALTON PASS SECTION

Gasoline

Gasoline is transported from the Benguet Province (Baguio) and Metro Manila through Dalton Pass to southern Cagayan Valley. Shipments to northern Cagayan Valley are made by boat to Aparri and then distributed to various areas by land. Total volume is 250 tons/day, with Benguet and Metro Manila each accounting for half of the volume.

Cement

Cement shipments also move from the Metro Manila side to the Cagayan Valley. Cement is a basic material essential to the infrastructure development of the Cagayan Valley. The region currently receives a fairly large volume of cement — 740 tons/day — and further increases are expected along with the implementation of future large-scale projects.

Industrial Products and Machinery

High value added products such as agricultural chemicals, electric appliances, and machinery are supplied by the Metro Manila side to the Cagayan Valley. The volume is 250 tons/day, of which 50 percent are shipped from Metro Manila.

7.2 MAHAPLAG-SOGOD SECTION

7.2.1 Role

The key section of the Maharlika Highway to link Southern Leyte and Tacloban City, the center of Region VIII, with the shortest access is the Mahaplag-Sogod Section. The influence area of the section is, at present, limited within Leyte Island, however, upon operation of the ferry service between Leyte and Mindanao Islands which is expected to start in 1984, the influence area will expand further to Mindanao Island. The said ferry service will finally realize the linkage of 4 major islands in the Philippines by vehicle traffic by way of the Maharlika Highway. This section is one of the critical sections to be improved to maintain continuity of the Maharlika Highway in view of road disaster potential.

7.2.2 Socio-Economic Features

Based on the origin/destination of vehicles passing through the Mahaplag — Sogod section (Leyte), the section's influence zone is established as the island of Leyte. The section has an especially strong influence on Southern Leyte.

Socio economic features are focused on Southern Leyte.

1) General

Eastern Visayas is a region that is trying to keep up with the pace of development in other parts of the country. A comparative analysis of regions in terms of their overall socio-economic situations will put the region on the extremest side opposite NCR (see Table 7.1-2). Great disparities exist between levels of development among the provinces comprising the region.

Southern Leyte had been identified as one of those provinces whose stage of development were set back. However, the municipalities traversed by the Maharlika Highway and those near urban and market centers exhibit relatively high levels of socio-economic well being. Southern Leyte is highly dependent on Leyte, centering on Tacloban, for socio-economic interaction. Southern Leyte population frew from 251,000 in 1970 to 296,000 in 1980. The present population density is 171 persons per sq. km.

2) Agriculture

The economic base of the region is agriculture and is highly dependent in coconut, rice and fishing production for economic sustenance. However, the total agricultural productivity barely meet the regional subsistence level due to unfavorable climatic condition and underdevelopment of existing cropland.

Southern Leyte occupies 173,480 hectares, or eight (8) percent of the regional total, of which about 51 percent is under cultivation.

a) Rice Production

Percentagewise, 8–10 percent of cultivated area in Southern Leyte is devoted to rice production. The total palay production in 1982 was estimated at 20,473 M.T., a decrease of 4,759 M.T. from 1981 production. This means a deficiency supply level of 20.2 thousand M.T. from the total provincial demand of 40.7 thousand M.T. About a half of total provincial rice requirement would be supplied by Leyte passing through the project road (refer to Appendix 7-1).

b) Coconut Production

Coconut Production in the region is characterized by considerable annual variations due to adverse effects of typhoons. Eastern Visayas is heavily dependent on coconut production wherein the sale of copra is the main source of income (refer to Appendix 7-1).

Compared with the rest of the region, coconut plantation is not so concentrated in Southern Leyte. An estimated 11,402 M.T. of copra had been produced in the province in 1981, accounting for only 3 percent of regional copra production.

TABLE 7.2-1 POPULATION DEVELOPMENT, 1970 – 1980 POPULATION ('000)

	1970	1975	1980	Average Growth Rate (%) 1970-1975	1975-1980	1970-1980
Region VIII	2381	2600	2800	1.8	1.5	1.6
Leyte (Including Biliran)	1110	1203	1303	1.6	1.6	1.6
Southern Leyte	251	276	296	1.9	1.4	1.7
Eastern Samar	271	287	321	1.2	2.3	1.7
Northern Samar	306	354	379	3.0	1.4	2.2
Western Samar	442	472	501	1.3	1.2	1.3

7.2.3 Traffic

1) Influence Zone

Figures 7.2-1 and 7.2-2 show the volumes generated by each region of vehicles and commodities passing through the Mahaplag-Sogod section.

There are 134 vehicles/day of traffic passing through the Mahaplag-Sogod section, all of which either originate or terminate in Southern Leyte. Traffic between Southern and Eastern Leyte is an overwhelming 123 vehicles/day (92 percent), followed by traffic between Southern and Western Leyte, at 9 vehicles/day (7 percent), and Southern Leyte and Metro Manila, at 2 vehicles/day (1 percent). Thus, the Mahaplag-Sogod section services traffic within Leyte island, especially traffic between Southern and Eastern Leyte and its influence zone is limited to Leyte at present. However, ferry service between Southern Leyte and Mindanao is expected to start operating in the near future, at which time the influence zone of this section should expand to include northern Mindanao.

2) Modal Split

Modal split in the Mahaplag-Sogod section is 45 percent passenger cars, 23 percent public transportation (bus, jeepney) and 32 percent trucks. Motorcycles are used as public transportation substituting buses and jeepneys in this section, but the modal share of public transportation is small. One reason for this is that mountain ranges run east to west and north to south through the province, centering around Sogod in Southern Leyte. This makes access from Southern Leyte to another provinces difficult, so that the sphere of daily activities tend to be limited to within the province (See Figure 7.1-3).

3) Passenger Trip Purpose

Passengers through the Mahaplag-Sogod section are 511 persons/day, of which 36 percent ride cars and 64 percent ride public transportation. When compared to the 81 percent and 82 percent shares of public transportation in the Dalton Pass section and Kennon Road, respectively, it becomes even clearer that the share of public transportation is small in this section.

Business purposes account for a substantial 53 percent of the trip purposes of car passengers. At work/business, to/from work, shopping and visit relatives are high among the trip purposes of public transportation passengers, at 25, 21, 21, and 20 percent, respectively.

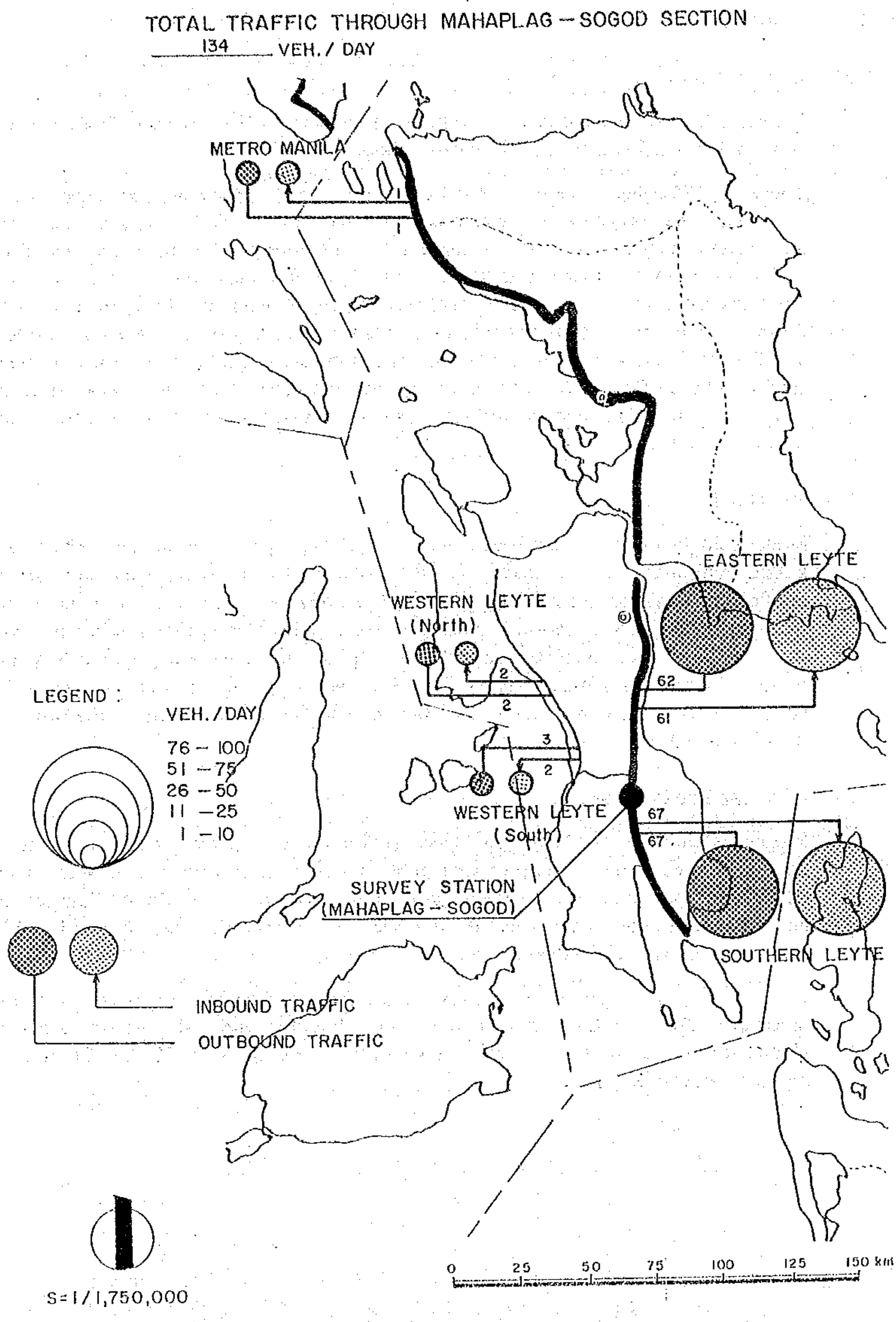


FIGURE 7.2-1 ORIGIN AND DESTINATION OF TOTAL TRAFFIC THROUGH MAHAPLA-SOGOD SECTION OF MAHARLIKA HIGHWAY IN LEYTE

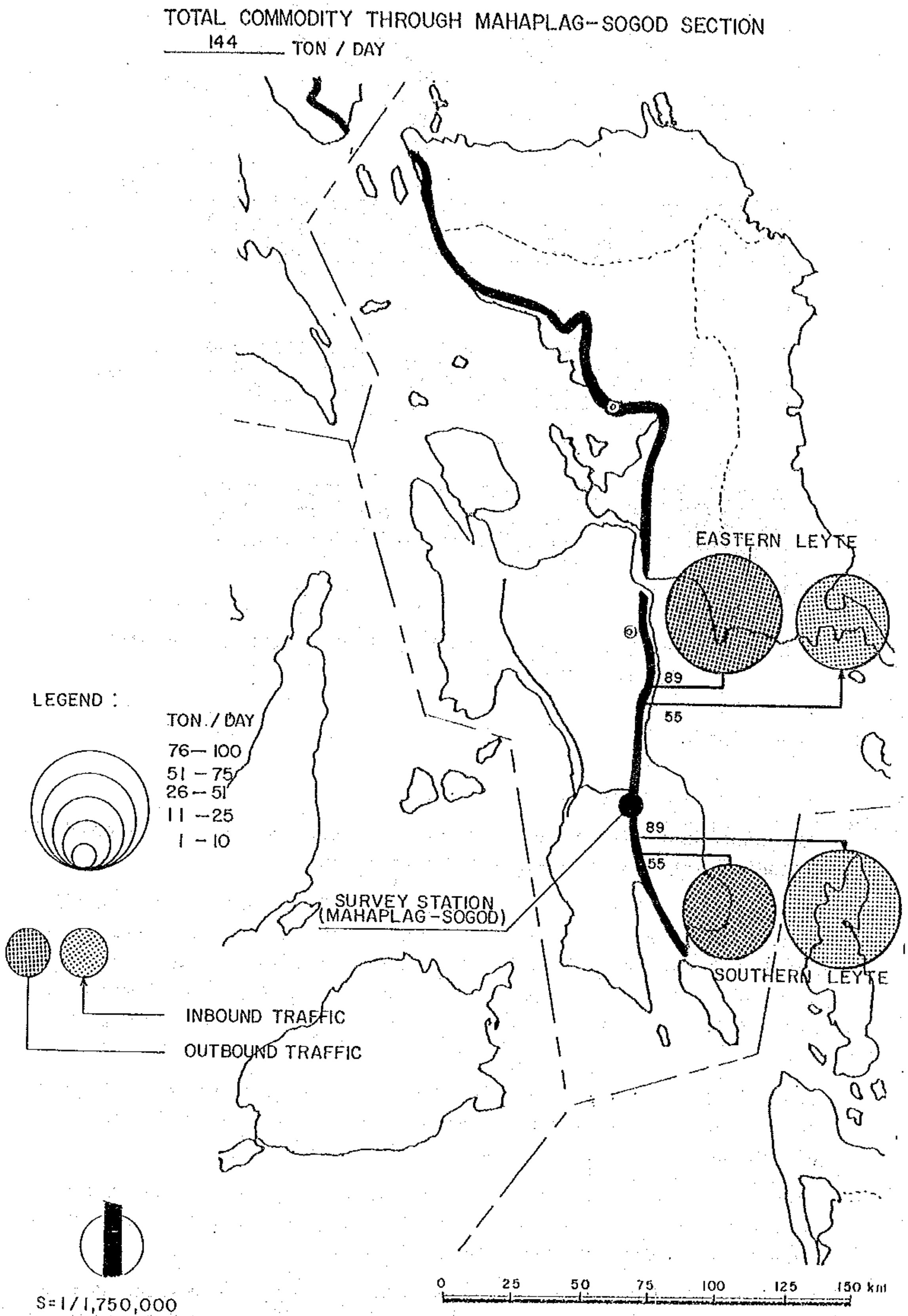


FIGURE 7.2-2 ORIGIN AND DESTINATION OF TOTAL COMMODITY THROUGH MAHAPLAG-SOGOD SECTION OF MAHARLIKA HIGHWAY IN LEYTE

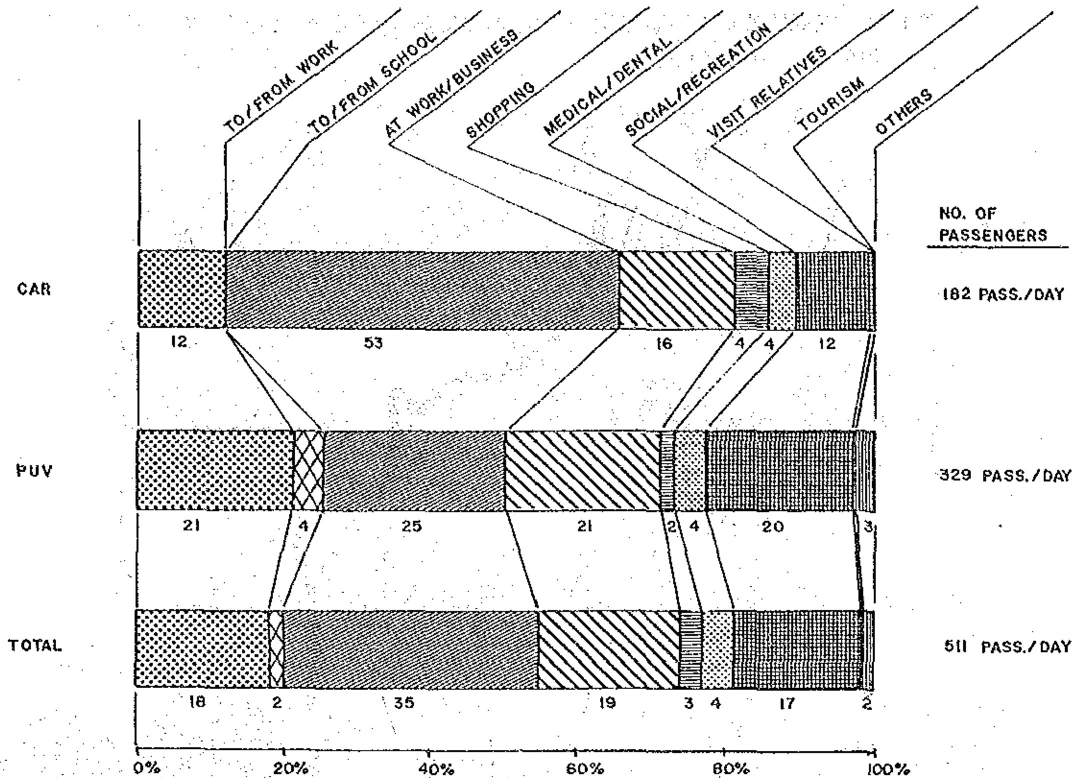


FIGURE 7.2-3 PURPOSE COMPOSITION OF PASSENGERS AT MAHAPLAG-SOGOD SECTION (LEYTE)

4) Commodity Flow

a) Commodity Items

Commodity flow through the Mahaplag-Sogod section is 144 tons/day, all of which are cargo moving between Southern and Eastern Leyte.

Commodity flow from the Eastern Leyte side to Southern Leyte is 89 tons/day, of which 87 tons/day are food (canned food, soft drinks, beer, etc.) processed or produced in Eastern Leyte. These are basic commodities necessary for maintaining the community life of Southern Leyte. Other than these items, a small quantity of construction materials such as cement is transported from Eastern Leyte to Southern Leyte.

Commodity flow from the Southern Leyte side to the Eastern Leyte side is 55 tons/day, of which 24 tons/day are unprocessed agricultural products such as coconuts and 31 tons/day are miscellaneous cargoes such as empty bottles.

Economic activities in Southern Leyte are still undeveloped at present, and coconuts are the main source of income. *Rice and vegetables are also produced in this region* but are believed to be consumed locally.

Manufactured goods are not available in Southern Leyte, so that supply demands on transports from other provinces. Similar situations can be seen in the Cagayan Valley, which is the Dalton Pass section's hinterland area, and Benguet, which is the Kennon Road's hinterland area. As one indicator of the economic vitality of each F/S section's hinterland area, the volumes (commodity flow) of manufactured goods carried into

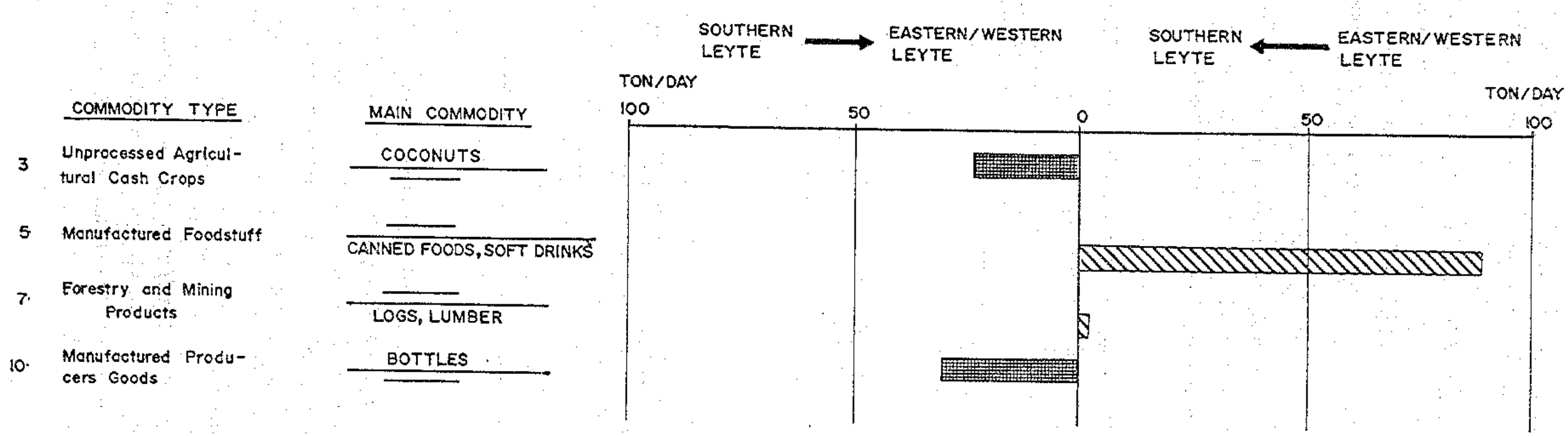


FIGURE 7.2-4 COMMODITY FLOW IN MAHAPLAG-SOGOD SECTION IN LEYTE

the hinterlands per 1,000 persons are analyzed, as shown in Table 7.2-2. Based on this, the following points can be observed concerning the Mahaplag-Sogod section:

- The volume of a basic commodity (food stuff) carried into Southern Leyte is the same as the volume shipped to Benguet and more than the volume shipped to the Cagayan Valley. The volume of food carried into the Cagayan Valley is considered to be small because locally-produced meat and other food are available for consumption.

- The volume of electric appliance, machinery, construction materials, etc. transported to Southern Leyte is much smaller than the volumes transported to the other two hinterlands, indicating that economic activities in Southern Leyte are still undeveloped.

TABLE 7.2-2 INBOUND MANUFACTURED COMMODITY AND ITS VOLUME PER 1,000 PERSONS

		DALTON PASS SECTION	MAHAPLAG-SOGOD (LEYTE) SECTION	KENNON ROAD SECTION
1. MANUFACTURED CONSUMER'S GOODS (BASIC COMMODITY)	COMMODITY (TON/DAY)	577	87	209
	COMMODITY PER 1000 PERSONS	0.26	0.59	0.59
2. MANUFACTURED CONSUMER'S GOODS (NON-BASIC COMMODITY)	COMMODITY (TON/DAY)	323	0	34
	COMMODITY PER 1000 PERSONS	0.15	0.00	0.10
3. MANUFACTURED PRODUCER'S GOODS/CONSTRUCTION MATERIALS	COMMODITY (TON/DAY)	917	2	402
	COMMODITY PER 1000 PERSONS	0.41	0.01	1.13
(1) + (2) + (3)	COMMODITY (TON/DAY)	1,817	89	645
	COMMODITY PER 1000 PERSONS	0.82	0.60	1.82
POPULATION IN INFLUENCE AREA	(X 1000)	2,215	148	355

Judging only from the above, Southern Leyte is being supplied with basic commodities necessary for maintaining community life but are not being supplied with commodities needed to actively expand and develop the region. If one is to go along with the government's objective of the formulation of a well balanced country, more positive investments from the government and the private sector will be desired.

b) Truck Traffic Composition

Of the 43 trucks passing through the Mahaplag-Sogod section daily, 72 percent are two-axle trucks, 23 percent are three-axle trucks and 5 percent are trailers. Average loadage is 3.3 tons/truck when loaded including empty trucks, and 5.0 tons/truck when only loaded trucks are included.

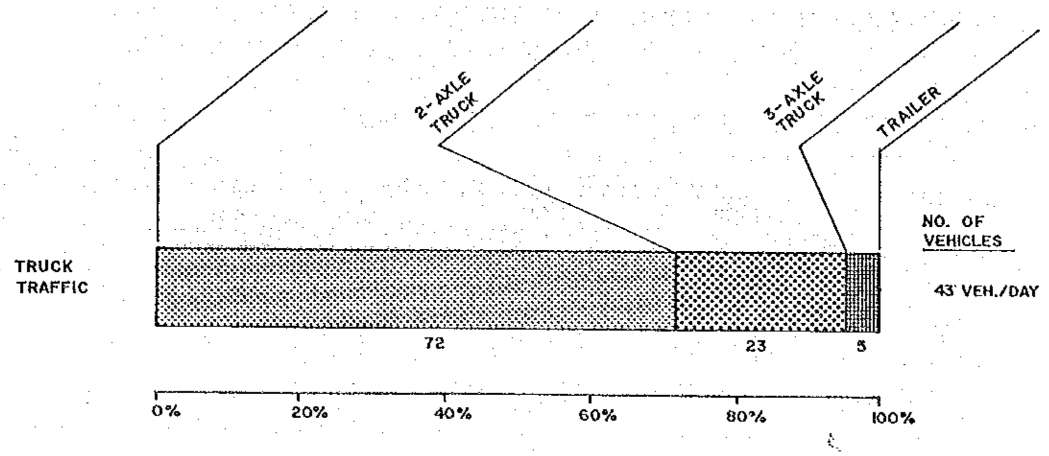


FIGURE 7.2-5 TRUCK TRAFFIC BY TYPE AR MAHAPLAG-SOGOD SECTION (LEYTE)

7.3 KENNON ROAD

7.3.1 Role

Baguio City, largely depending on the tourism and education industries, has strong linkage with Metro Manila. The shortest access is provided by Kennon Road which serves approximately 98 percent of traffic between the said two areas. It has a long stretch of influence area extending to 310 kilometers in length. Its traffic is mainly composed of inter-regional trips and commuting trips. Thus, Kennon Road has two functions; one, as an inter-regional trunk road and the other, as a local road.

7.3.2 Socio-Economic Features

Since the Kennon Road has an absolute influence on the Benguet Province, especially Baguio City, descriptions of the society and economy are focused on Benguet.

1) General

Baguio City is the country's tourist mecca and serves as an international, commercial and convention centers. The development of population in the city during the last two decades is shown in Table 7.3-1.

The city also serves as the educational and cultural center in the north, having 6 colleges and universities, 16 high schools and 47 elementary schools. Almost 50 percent of the total student population belong to college and university level. University student population was 39,000 in 1981.

TABLE 7.3-1 POPULATION DEVELOPMENT OF BAGUIO CITY BENGUET PROVINCE AND REGION I, 1960 – 1980

	Population (In Thousand)			Average Annual Growth Rate (%)		
	1960	1970	1980	1960-1970	1970-1980	1960-1980
Region I	2,428,000	2,991,000	3,540,893	2.1	1.7	1.9
Benguet Province	184,000	264,000	354,751	3.7	3.0	3.3
Baguio City	50,436	84,538	119,009	5.3	3.5	4.4

Table 7.1-2 shows the estimated contribution of the city's GDP to regional GRDP. The comparative analysis shows that while the city's contribution to GRDP was 5 percent, the city's total labor productivity was more than twice that of the regional level. Almost 70 percent of total employment is in the service sector. The leading income generator of Region I, Baguio City, contributed 19–30 percent of the total income in 1980–1982.

2) Tourism

Baguio is the gateway to the wonders of the northern Luzon and is one of the country's major tourist destination outside Metro Manila. Significant increases in the volume of visitor arrivals were noted in Baguio City. An estimated 203,172 tourists visited the city in 1981, out of which 39 percent were foreign visitors. This was an increase of almost 40 percent from 1975 visitor arrivals. The preliminary survey result conducted by Ministry of Tourism showed Baguio City as a major and competitive tourist destination in the country. Majority of the tourist traffic was generated from Manila and Central Luzon wherein Kennon Road is the most popular route. Various infrastructure projects were being carried out in the city for continued projection of Baguio as a primary tourist destination and convention center (refer to Appendix 7-2).

7.3.3 Traffic

1) Influence Zone

Figures 7.3-1 and 7.3-2 show the volumes of vehicles and commodities generated in each province on the Kennon Road.

There are 1,815 vehicles/day of traffic on the Kennon Road. Of the 1,815 vehicles daily traffic, an overwhelming 98 percent, or 1,786 vehicles/day, of traffic either originate or terminate in Baguio City. Expressing traffic flow (trips) as straight lines with one end at Baguio, the other end most often is at Metro Manila, Pangasinan or Rosario Agoo. There are 751 vehicles/day of traffic between Baguio and Metro Manila, 582 vehicles/day between Baguio and Pangasinan, and 187 vehicles/day between Baguio and Rosario Agoo. There is little traffic from points further south than Metro Manila, and thus Metro Manila can be considered as the virtual southern boundary of the influence zone of the Kennon Road.

2) Weekly Fluctuation

Baguio City, the hinterland of the Kennon Road, is the most famous summer resort in the Philippines. There are many week-end visitors, so that traffic increases from Friday through Sunday.

Figure 7.3-3 shows the daily fluctuation of traffic on the Kennon Road, prepared on the basis of toll gate data. Whereas weekday traffic is 1,800 to 1,900 vehicles/day, weekend traffic is 3,100 vehicles/day, showing a manifest increase over the week-end. The increase is mainly accounted for by car traffic, which jumps from 900 vehicles/day on weekdays to 2,100 vehicles/day during weekends. Public transportation, which are mostly buses, show only a slight increase during weekends.

3) Modal Split

Modal split on the Kennon Road is characterized by a high proportion of cars and low proportion of trucks. The modal shares of cars, public transportation and trucks are 48 percent, 35 percent and 17 percent, respectively. The modal split is greatly influenced by the fact that Baguio City is the administrative, educational, tourist and medical center north of Metro Manila.

4) Passenger Trip Purpose

There are 2,931 passengers/day riding cars and 13,776 passengers/day riding public transportation on the Kennon Road, or a substantial total of 16,707 passengers/day. Public transportation passengers represent 82 percent of the total number of passengers.

Business purposes account for a substantial 38 percent of the total trip purposes of car passengers. The highest proportion, or 27 percent, of public transportation passengers are travelling to visit relatives, followed by 23 percent travelling for business purposes. These figures are based on surveys made on weekdays, and tourist traffic is expected to account for a larger share during weekends.

5) Commodity Flow

a) Commodity Items

Commodity flow into and out from Baguio are made via the Naguilian and Kennon Roads. Commodity flow along Naguilian Road is 1,400 tons/day, which is slightly greater than the 1,100 tons/day on the Kennon Road. But the two roads at any rate each handle about half of the commodity flow involving Baguio.

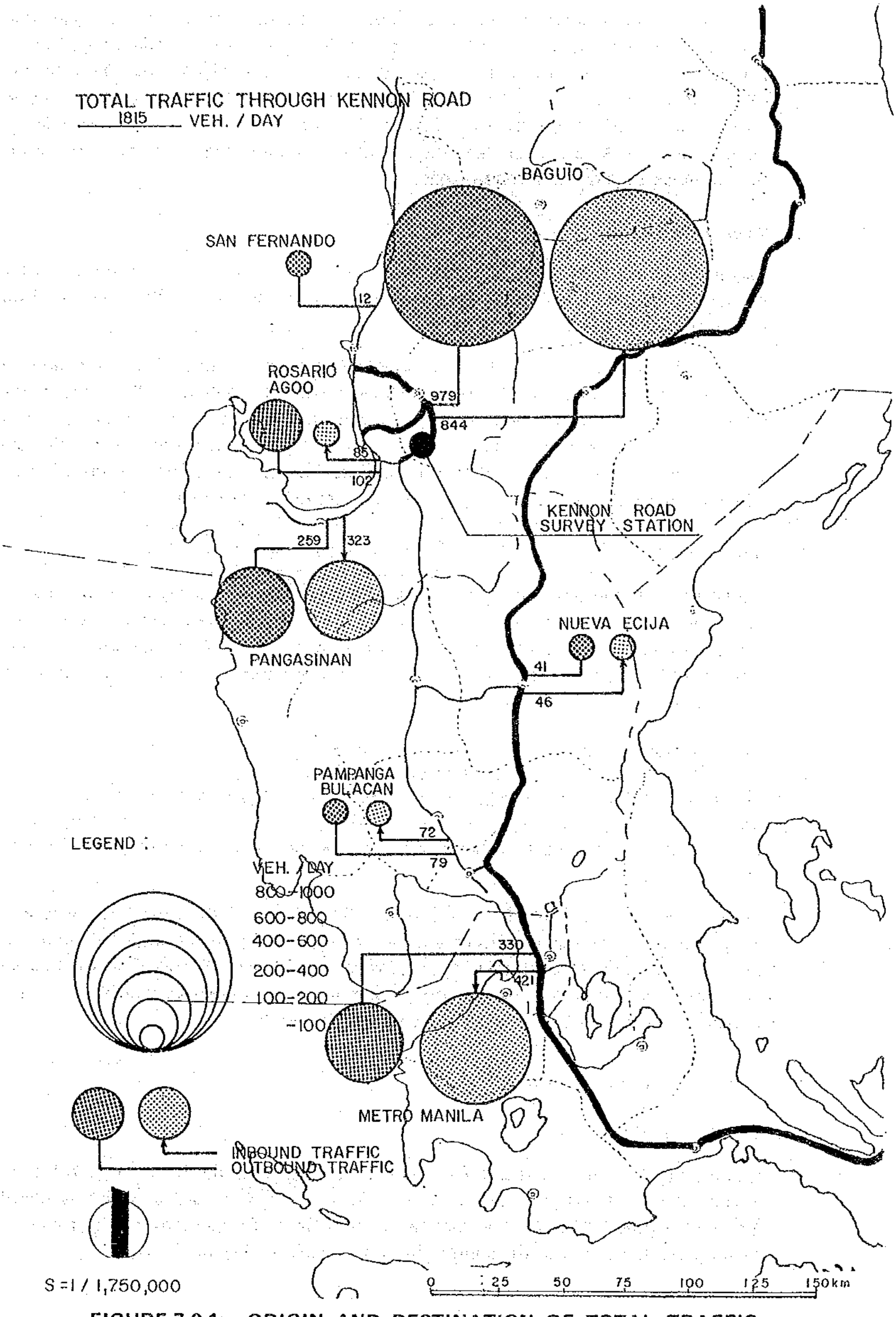


FIGURE 7.3-1 ORIGIN AND DESTINATION OF TOTAL TRAFFIC THROUGH KENNON ROAD

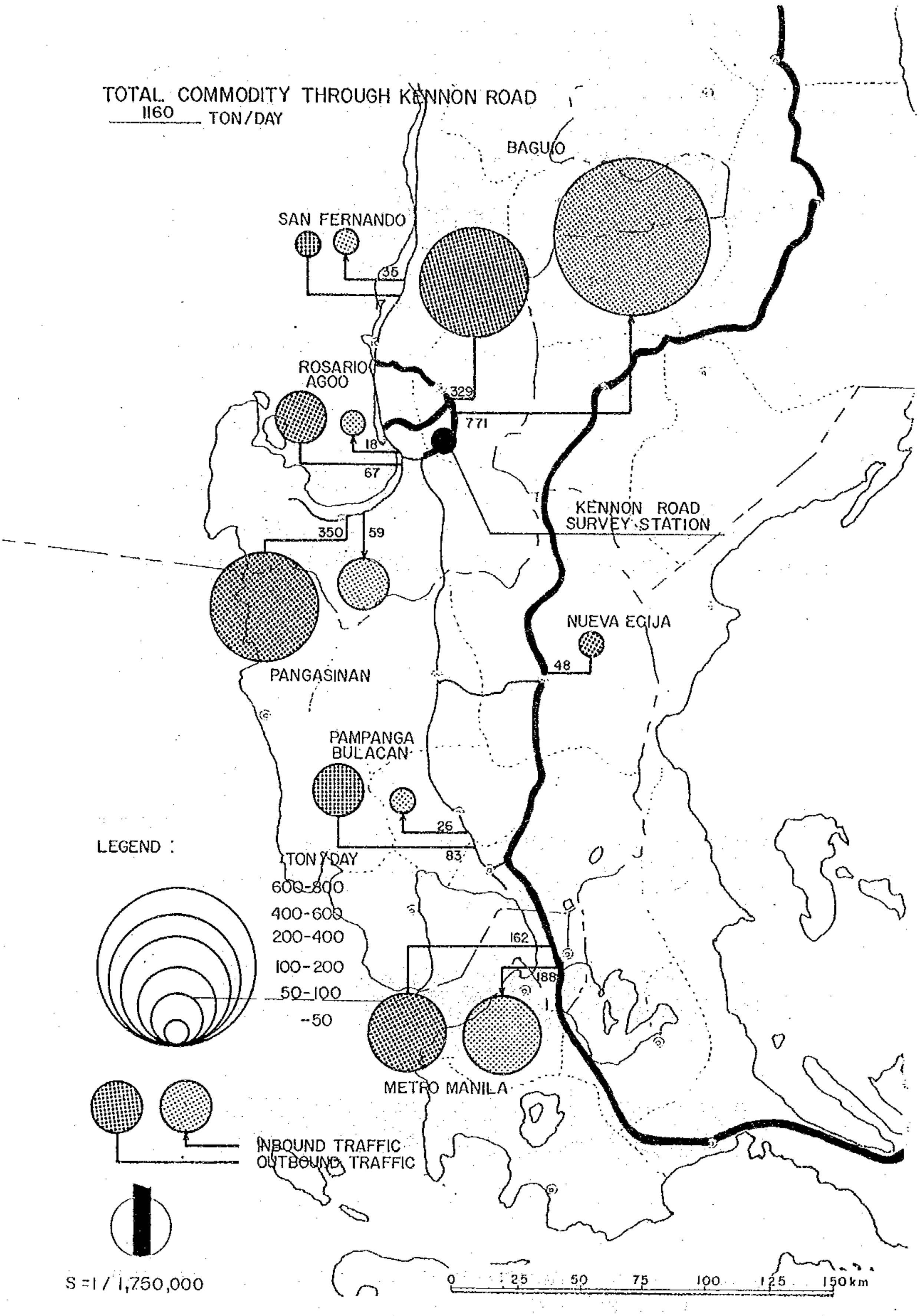


FIGURE 7.3-2 ORIGIN AND DESTINATION OF TOTAL COMMODITY THROUGH KENNON ROAD

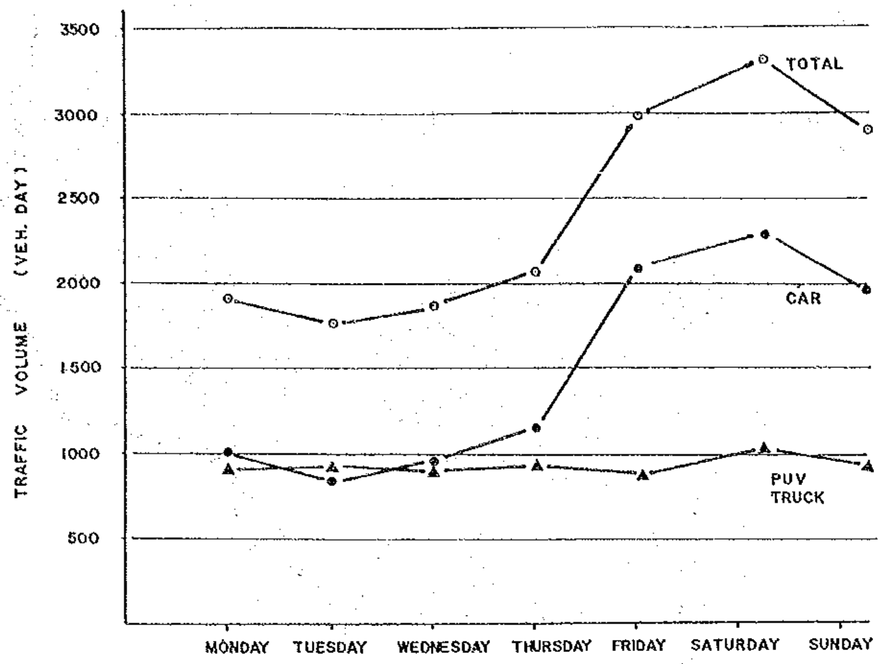


FIGURE 7.3-3 DAILY FLUCTUATION OF TRAFFIC IN KENNON ROAD

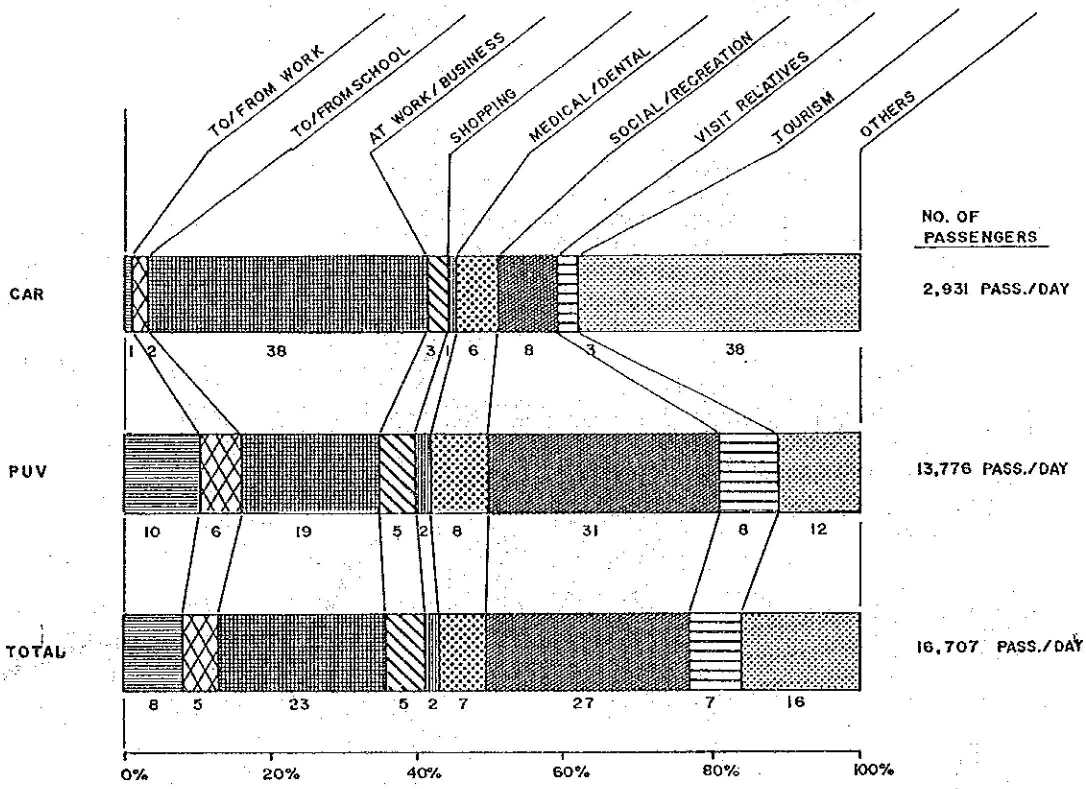


FIGURE 7.3-4 PURPOSE COMPOSITION OF PASSENGERS AT KENNEON ROAD SECTION

Of commodities transported into Baguio, gasoline and construction materials such as timber and cement are shipped via the Naguilian Road and processed food such as milled rice, sugar, canned food and soft drinks and high-level manufactured goods such as machinery are shipped via the Kennon Road. Of commodities shipped out from Baguio, perishable food (vegetable) have a dominant share. Copper, an important product of the city, is shipped to San Fernando via the Naguilian Road. Simply put, the Naguilian Road is used to transport industrial products, as represented by construction materials, and the Kennon Road is used to transport everyday commodities, as represented by food, to Baguio City.

Commodity flow on the Kennon Road is 1,100 tons/day. Of these, 329 tons/day originate in Baguio and 771 tons/day originate in Pangasinan and Metro Manila and head toward Baguio.

b) Truck Traffic Composition

Of the 308 trucks passing through the Kennon Road daily, 289 vehicles/day (94 percent) are two-axle trucks and 19 vehicles/day (6 percent) are three-axle trucks. The lack of trailer traffic is due to the narrow width of the roads, indicating that transport efficiency has worsened through the little use of larger trucks. Average loadage is 3.6 tons/truck when loaded and empty trucks are included and 5.5 tons/truck when only loaded trucks are included. This is about half the average loadage seen in the Dalton Pass section.

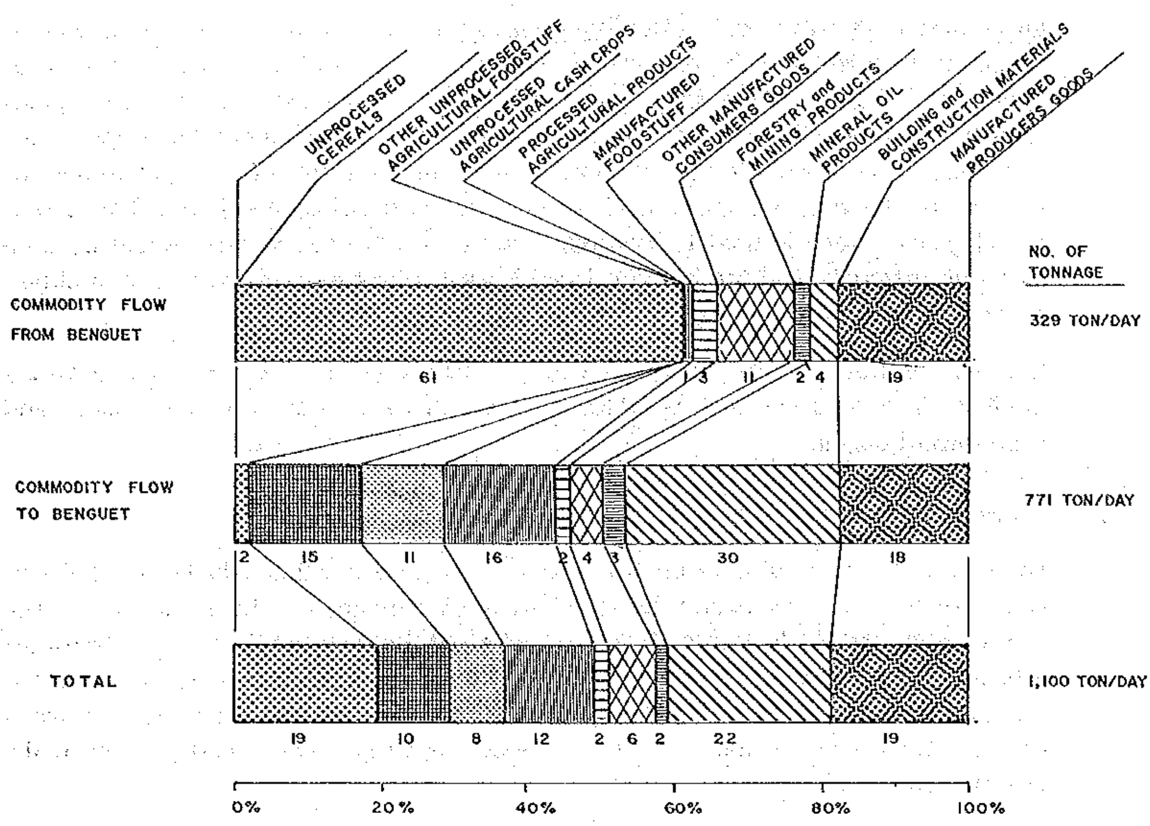


FIGURE 7.3-5 COMPOSITION OF COMMODITY AT KENNON ROAD SECTION

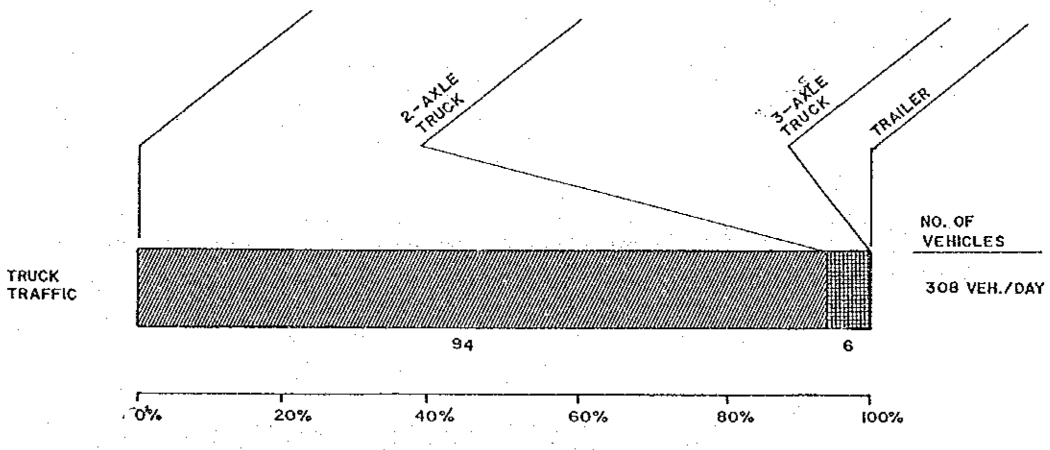


FIGURE 7.3-6 TRUCK TRAFFIC BY TYPE AT KENNON ROAD SECTION

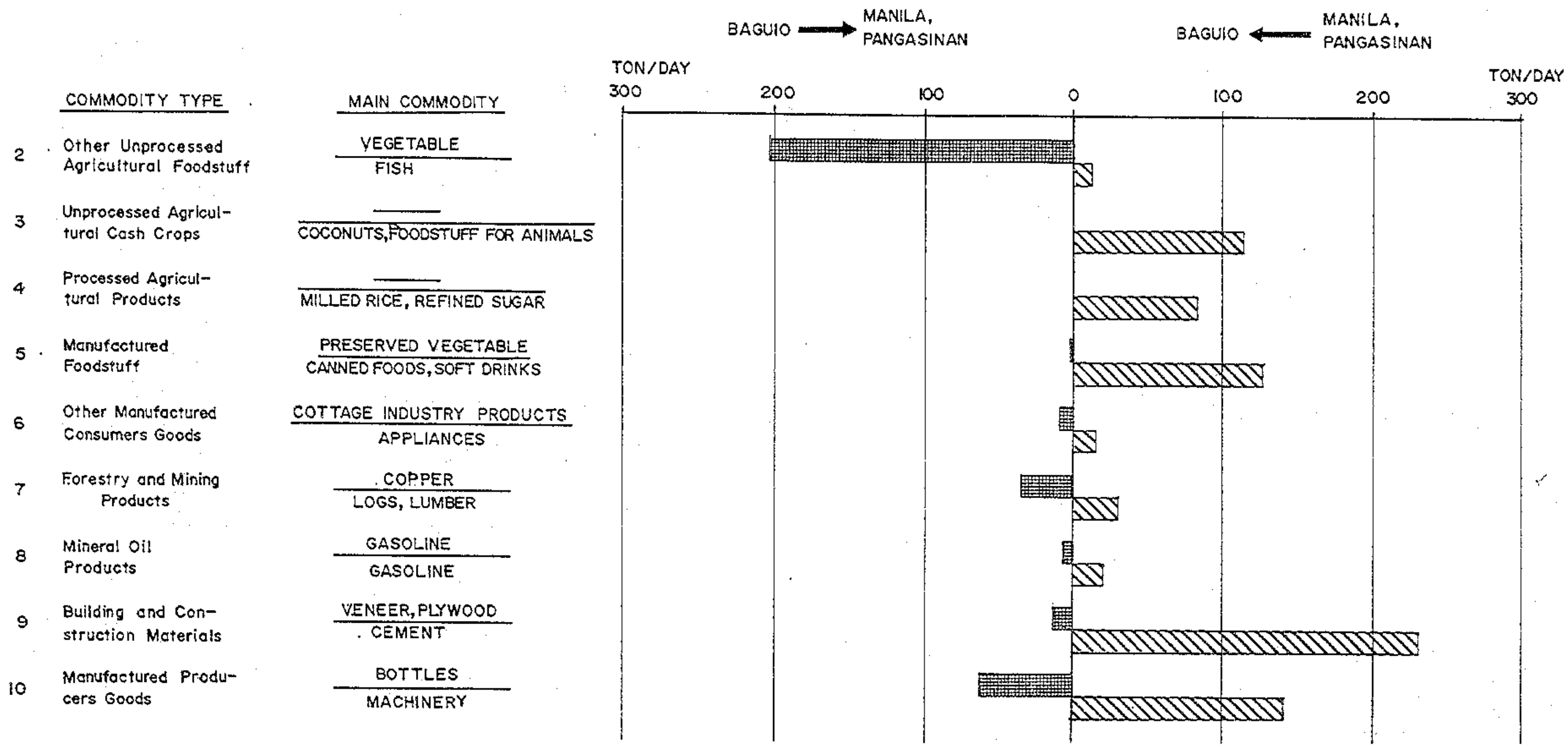


FIGURE 7.3-7 COMMODITY FLOW IN KENNON ROAD SECTION

CHAPTER 8

EXISTING CONDITION OF ROAD DISASTER

8.1 DALTON PASS SECTION

This section has a largest number of 102 spots with disaster potential in the 24 sections subject to the study. Among them there are 73 spots evaluated disaster potential A or B, which need immediate countermeasures.

After improvement of the Section in 1975, two (2) large scale road disasters interrupted traffic for about a month, caused by typhoons "Didang" in 1976 and "Aring" in 1980. In addition, a couple of considerable scale of road disasters occurred every year, disrupting traffic for 3 to 7 days.

The section with length of approximately 77.5 km. laying between San Jose (km. 159 + 100) and Aritao (km. 236 + 600) can be divided topographically into the following sub-sections: (See Figure 8.1-1)

- San Jose to Capintala (km. 159 + 100 – km. 202 + 000), about 43.0 km.: Mainly passes throught flat alluvial land and partially steep mountainous terrain along the Digdig River.
- Capintalan to Sta. Fe (km. 202 + 000 – km. 217 + 000), about 15.0 km.: Passes through steep mountainous areas including the Dalton Pass at altitude about 1,000 meters. The Dalton Pass Tunnel is Planned for this sub-section.
- Sta. Fe to Aritao (km. 217 + 000 – km. 236 + 600), about 19.0 km.: Mainly passes through alluvial land and partially steep mountainous terrain along the Sta. Fe River.

As for the number of spots evaluated as A or B by type of disaster of the total of 73 spots, cut slope failure is the greatest, at 39 spots, followed by debris flows, embankment slope failures, falls and overflows, at 14, 13, 6 and 1 respectively. Cut slope failures which are seen most often on rock cut slopes are weakened by weathering or fracturing. The inducement cause is scouring dueto the flow of surface or spring water.

Where the route passes a steep mountainous area along a river, there are many torrents on the mountain side. These torrents are not very big, but they cause debris flows every time it rains, causing traffic to be hindered.

Most of the embankment slope failures are along the Digdig and Sta. Fe Rivers. Some of the failures are very large and have even caused the road itself to be washed away.

Falls in masses, usually involving slopes of weathered or fractured rock, are classified as slope failures, while falls in single pieces of rock, usually involving slopes of highly cracked hard rock, are classified as falls. As mentioned earlier, most rocks in this section are weakened by weathering or fracturing. For this reason, the number of fall spots is one sixth the number of cut slope failure spots in this section.

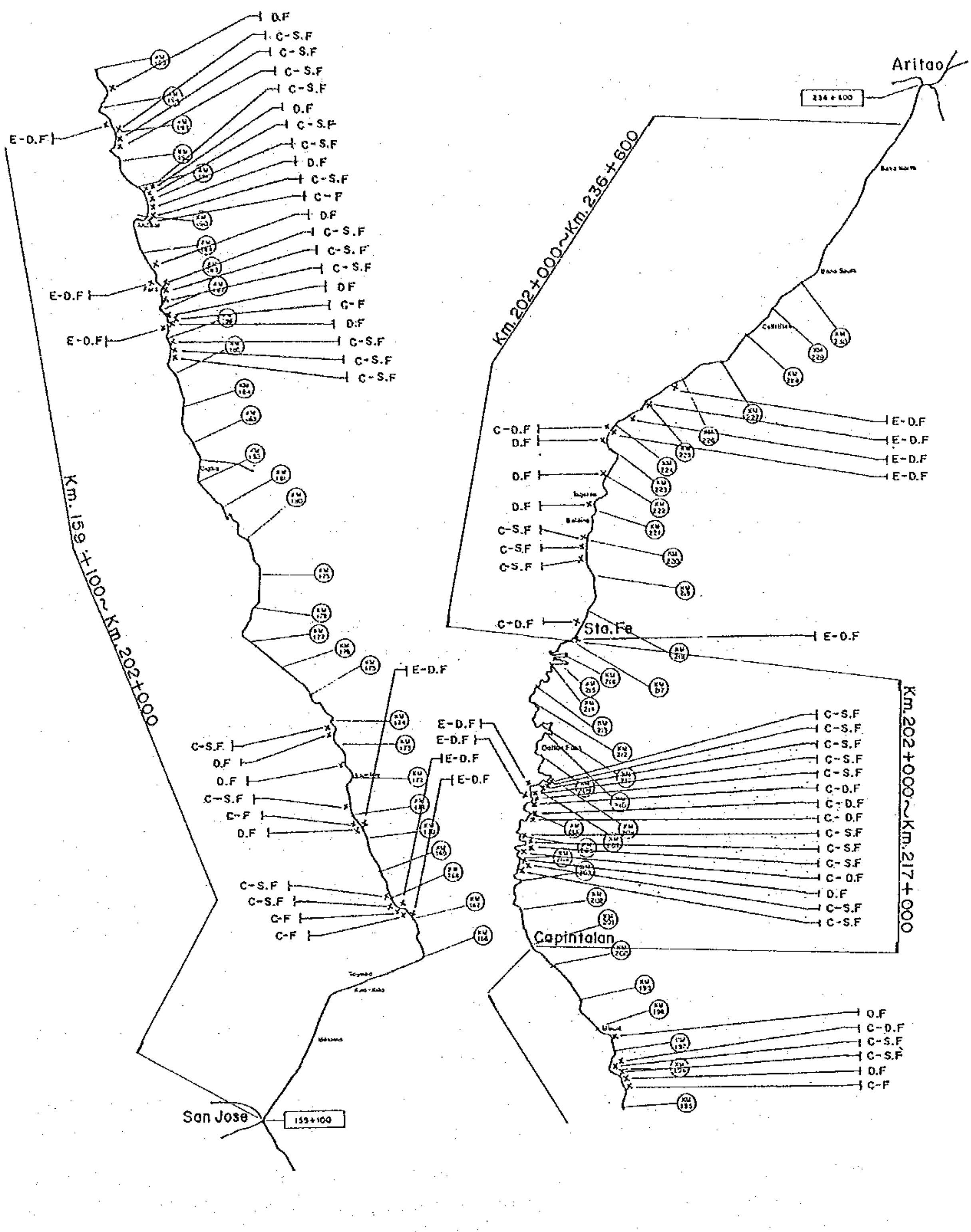


FIGURE 8.1-1 LOCATION OF DISASTER SPOTS IN DALTON PASS SECTION

The only overflow spot in this section is in the alluvial land along the Digdig River, where overflowing occurs due to a lack of cross drains.

Characteristics of each sub-section are as follows;

a) km. 159 + 100 to km. 202 + 000

The road passes through steep mountainous terrain along the Digdig River between km. 167 + 000 and 174 + 000, and km. 185 + 000 and 198 + 000. There are many cut slopes and riverside embankment slopes in both these stretches, and also many disasters spots. Main rocks seen between km. 167 + 000 and km. 174 + 000 are diorite, andesite, and volcaniclastes. These rocks show fairly large-scale failures due to fractures and weathering.

Embankment slope failures seen in this sub-section are mostly due to scouring by the Digdig River. Some bridge approaches in alluvial areas had been washed away due to overflowing of the Digdig River, but improvement works to lengthen the bridges by adding a span have been done.

There are also many debris flow spots, most of which are small-scale, however, traffic is obstructed at these spots every time it rains because the debris flow always extends to the road surface, these spots will also be studied for possible countermeasure work.

b) km. 202 + 000 to km. 217 + 000

There is a concentration of spots with disaster potential between km. 202 + 000 and the highest point of the Dalton Pass, km. 208 + 000. No spot with disaster potential exists between km. 208 + 000 and Sta. Fe km. 217 + 000. In the later section, there are two spots where cut slope failure and large-scale embankment slope failure occurred in the past, but they have already been improved. Most of the disasters seen in this sub-section are cut slope failures, occurring on slopes of fractured andesite and diabase.

c) km. 217 + 000 to km. 236 + 600

There is a concentration of cut slope failures in the steep mountainous stretch along the Sta. Fe River, and serious failures were seen at km. 219 + 500 and at km. 223 + 600. Embankment slope failures are due to scouring caused by the Sta. Fe River, and the pavement has been washed away at km. 224 + 400 and at km. 225 + 000. At km. 221 + 250, a large-scale debris flow occurred during typhoon Aring, causing many casualties.

The improvement work on the Dalton Pass section was completed in 1975, after which typhoon Didang in 1976 and typhoon Aring in 1980 created many serious disasters. Cut slopes in this section, however, seem to have stabilized somewhat often these improvement works, and it is judged that the size of the disasters will not enlarge over the years.

8.2 MAHAPLAG-SOGOD SECTION

The section has the third largest number of 48 spots with disaster potential in the sections subject to the Study. Among them, 40 spots were evaluated as disaster potential A or B.

Since the opening of the Section in 1978, months-long traffic interruptions occurred at least 5 times, due to continuous heavy rains and typhoons. The majority of slopes are still in unstable conditions, since only a few years have elapsed after the construction. The scale of failures in this section is predicted to become bigger year by year. This section, with length of approximately 36.7 km. laying between Mahaplag (junction with Baybay, km. 988 + 800) and Sogod (junction with Sogod, km. 1,025 + 650) can be divided topographically into the following sub-sections: (See Figure 8.2-1)

- The 16-kilometer sub-section between Mahaplag and km. 1,004 + 950, mainly passes through alluvial land and terraces along the Layog River.
- The 20-kilometer sub-section between km. 1,004 + 950 and Sogod runs through steep mountainous terrain for the most parts but partially passes through plateaus.

As for the number of spots evaluated as A or B by type of disaster of the total of 48 spots, cut slope failure is the greatest at 19 spots, followed by embankment slope failure, landslide, fall, debris flow and over flow at 14, 3, 2, 1, and 1, respectivelly.

In the first sub-section, there are only embankment slope failures because the route passes through flat terrain. Most of disaster spots concentrate in the second sub-section.

Rocks comprising cut slopes in this section are mainly unconsolidated andesite, tuff, and sandstone. These rocks are further fractured due to the Philippine Fault, which runs along the route, and are prone to failures. Failures are caused by erosion or scouring due to surface water flow.

The cut slope failure at km. 1,010 + 700 is the biggest in the sections subject to the Study. The slope is over 100 meters in height and is deeply scoured and gullied. Large quantities of materials from the slope flow over the road every time it rains. There is also a large cut slope failure caused by repeated scouring at km. 1,019 + 690.

Many large-scale embankment slope failures were also seen in this section, the biggest ones of which are at km. 1,010 + 650, km 1, 016 + 850 and km 1,017 + 700. The failure at km 1,017 + 700 is a new one formed on January 27, 1984. All these failures are caused by inadequate side ditches, which allowed water from the mountain side to run down the road surface and flow down the embankment slope. Pavements have also been washed away.

There are two fall spots and one debris flow spot in this section, all of which are medium-scale and without any special points to note.

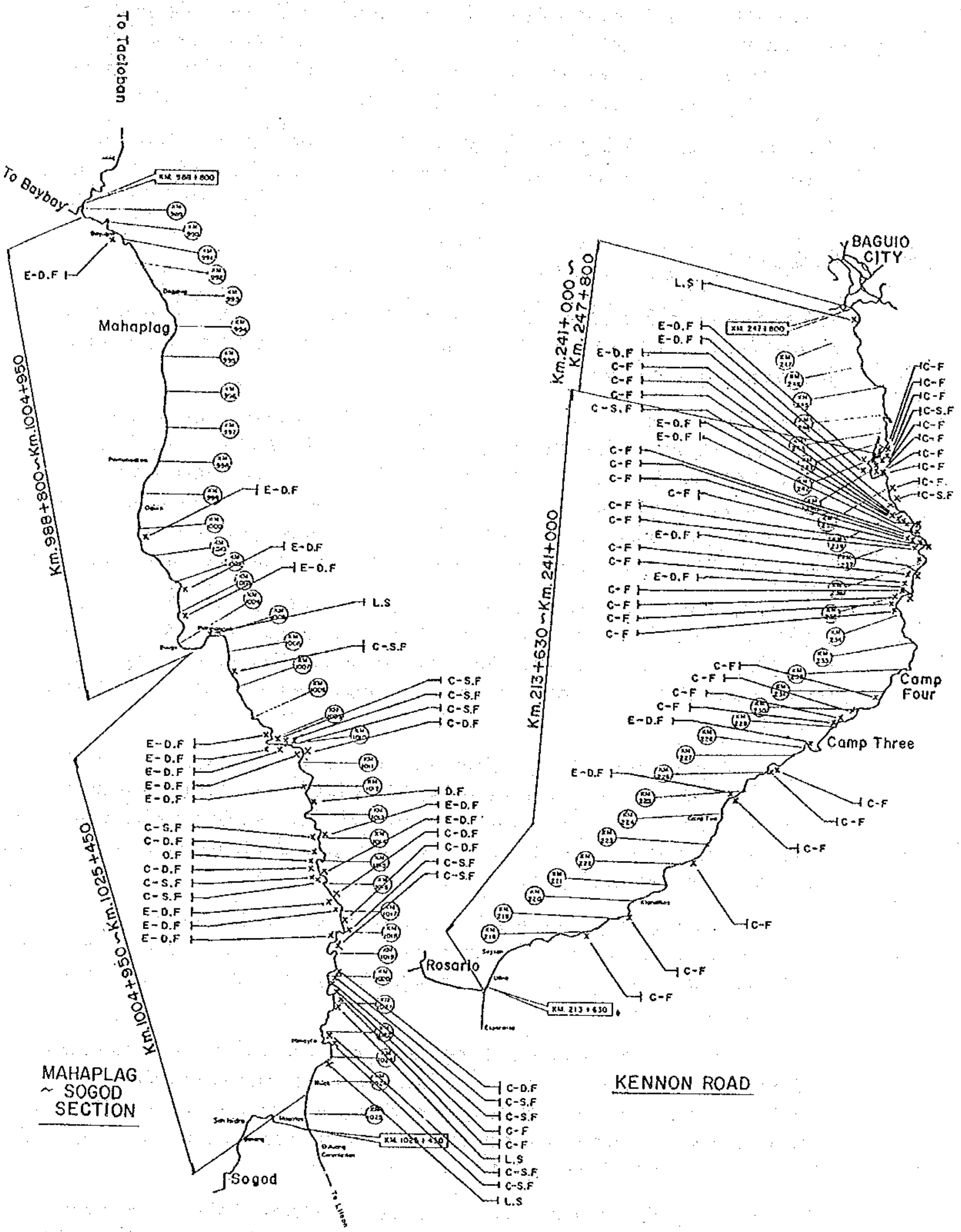


FIGURE 8.2-1 LOCATION OF DISASTER SPOTS IN MAHAPLAG-SOGOD SECTION AND IN KENNON ROAD

There are three landslide spots, all of which are classified as soil landslides. Since spring water was obsered at the lower part of the landslide mass at all these spots, the slides are assumed to have been caused by elevation of groundwater. The landslide at km. 1,004 + 950 still seems to be continuously moving. The pavement at this spot is damaged and the road surface has risen about 3 meters.

There is a torrent crossing the road at km. 1,014 + 500, but there is no cross drain. Therefore, water from the torrent is flowing across the road surface during heavy rain, this spot is classified as an overflow spot.

8.3 KENNON ROAD

The section has the third largest number of 48 spots with disaster potential which is almost wqual to Mahaplag-Sogod Section. Among them, there are 46 spots designated as disaster potential A or B.

Disasters must have occurred many times during the 47 years since its completion in 1937, however, no disaster records of old are remained. Two large scale disaster occurred in 1979 and 1980 each of which disrupted traffic for more than 4 months. These two were due to damming up to the Bued River caused by natural slope failure of the mountain on opposite side of the river. Besides this special case, disasters which interrupted traffic for one to three weeks occurred once or twice almost every year.

This roads extends 34.2 kms from Rosario along tha Manila North Road (km. 213 + 630) to Baguio (km. 247 + 860). Between Rosario and km. 214 + 000, the road meanders up the steep mountainside along the Bued River at a moderate gradient. Between km. 241 + 000 and Baguio, the route moves away from the Bued River and follows a steep route with a series of hairpin curves. (See Figure 8.2-1).

All disaster spots on the Kennon Road, except one landslide spot, are located in the first sub-section between Rosario and km 241 + 000. The small number of disasters in the second sub-section is due to the facts that there are no large-scale cut slopes or embankment slopes, and the route is away from the Bued River, which is the main cause of embankment slope failures.

As for the number of spot evaluated as A or B by type of disaster of the total of 46 spots, rock falls are dominant amounting to 31 spots, followed by 9 spots of embankment slope failure and 5 spots of cut slope failure. Hence, falls account for 70 percent of disasters on Kennon Road.

Cut slopes in this section are mainly composed of conglomerates, limestone, andesite and diorite. These rocks, though fairly hard are deeply craked so rock falls occur at many cut slopes. There are slopes with vertical gradients or overhangs. These slopes look very unstable even when they are made of hard rock with hardly any cracks, therefore, they were selected as the spots to be studied.

There is no big scale of cut slope failure except failures of the hillside on opposite bank of the Bued River at the km 226 + 350 which occurred in 1979 and 1980.

Embankment slope failures are due to scouring caused by the Bued River or concentrated surface water flow. A major embankment slope failure occurred at km. 227 + 500 in August 1983. Since spring water can be seen at the failure spot, it is jubged to have been caused by the seepage of groundwater from the mountain side into the embankment.

There is one landslide, a fairly large one, at km. 247 + 700, the entrance to Baguio City. According to a city engineer, the road at this spot has been sinking about 10 centimeters each year.

The Kennon Road was opened in 1937, and over 40 years have passed since then. Cut slopes along this road seem to have stabilized somewhat. In other words, the size of the disasters would not become larger over the years.

CHAPTER 9

TRAFFIC DEMAND FORECAST

9.1 PLANNING FRAMEWORK

9.1.1 Development Policies and Strategies

1) National Development

The focus of the present Philippine development programs from 1983 to 1987 will be the continuous pursuance of the national goals of sustainable economic growth, an equitable distribution of the fruits of development, and total human development. The NEDA 1983-87 Plan embodies the renewed commitment to the objectives, policies and measures which were set forth in the previous 5-Year Development Plans 1978-1982, the Mid-term Plan 1978-87 and the Long-term Development Plan up to year 2000 to resolve the netional problems on mess poverty, unemployment and underemployment, and social justice.

Although the major economic target set forth in the new Plan have been considerably scaled down to reflect the recent unexpected set-back in the domestic economy, the Plans are imbued with flexibility to respond to domestic needs. Thus, it is expected that the national economy will exhibit creditable performance in the future despite various internal and external pressures.

In response to the major challeges that confrout the economy, the Plan's substantive thrust follow the continuing development emphasis on self-reliance on basic needs, rural development and agrarian reform, expansion of industry including tourism, accelerated investment in economic and social infrastructure projects and other forms of social services and above all, social justice.

9

2) Regional Development

The fundamental objective of the regional development, which are patterned closely after and are supportive of the major national goals, is to effect equity of opportunity for each region to exploit its indigenous resource potentials for productive development endeavors. For tha plan period of 1983-87, two major goals were set, namely: 1) the improvement of the people's quality of life particularly in the least developed and lowincome areas by making available to them opportunities for gainful endeavor and the benefits of development; and 2) the enhancement of capability for full resource mobilization through resource allocation and government inducement schemes.

The regional strategies by sector and location of selected major on-going projects designed to make the sectoral system consistent with the national development efforts are shown in Appendix 9-1.

Particularly within the influence of the project area, three major development projects are presently on-going which are envisioned to contribute greatly to the economic development of these areas. Such development projects are as follows:

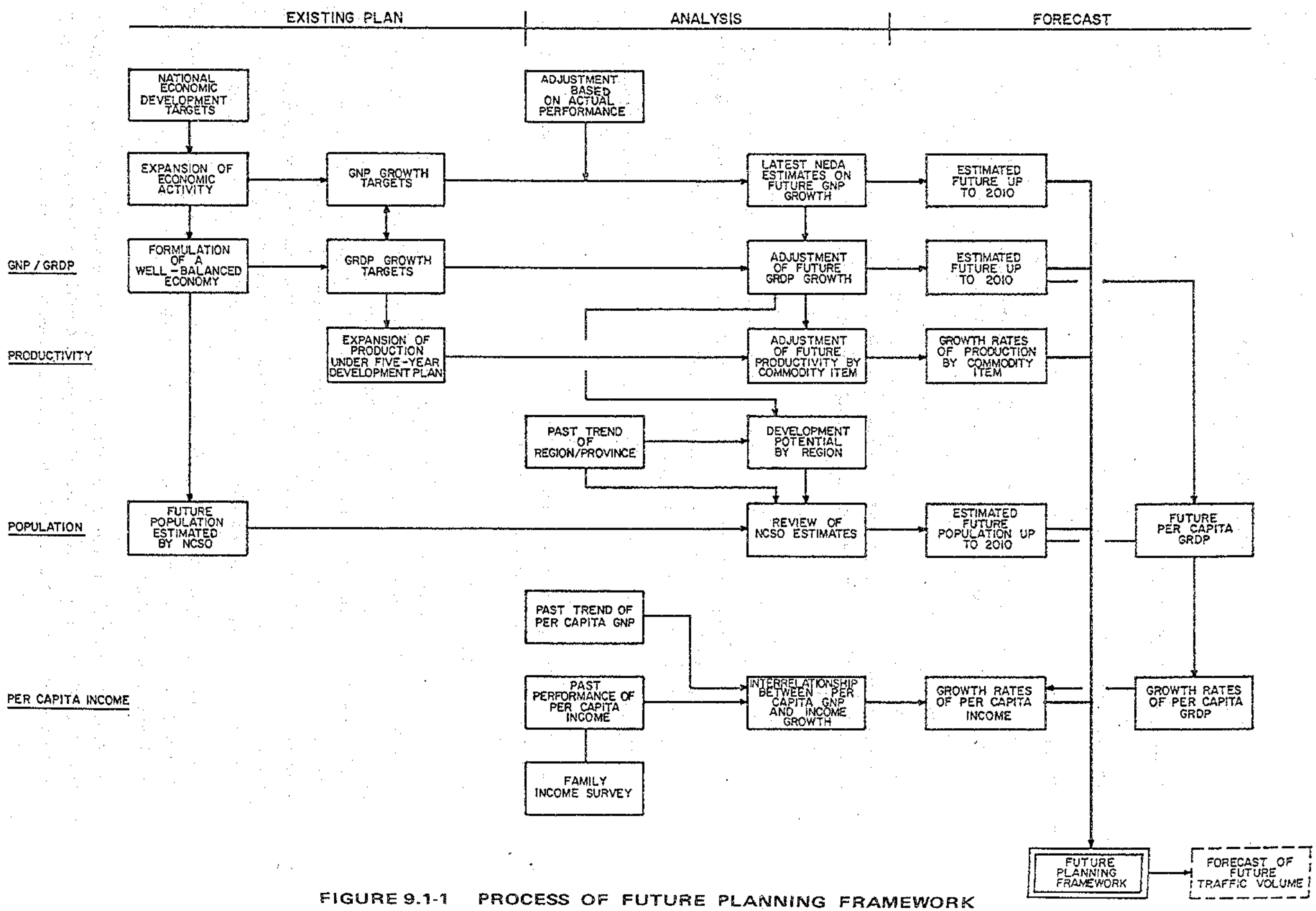


FIGURE 9.1-1 PROCESS OF FUTURE PLANNING FRAMEWORK

1) Cagayan Integrated Rural Development Project

The project includes agricultural development, provision of irrigation, electrification, construction of barangay roads and flood control facilities and other developmental projects within Cagayan Valley region.

2) Phil-Japan Friendship Highway-Ferry Service Project

The ferry service project that would serve as final link for the Maharlika Highway from Allacapan in Cagayan to Davao City, located in Liloan, Leyte.

3) Export Processing Zone

Export processing center in Region I, located in Baguio City, to cater for light and medium exportoriented industries.

9.1.2 Economic Framework

1) GNP and GRDP

Under the NEDA Five-Year Development Plan (1983-1987), the country's real Gross National Product (GNP) is expected to post a 6.5 percent annual growth in 1983-1987, resulting in a total GNP at current prices of 749 billion by 1987. This shows that despite the slow growth in 1981 and 1982 the country's economy is expected to attain a gradual recovery during 1983-1987. However, due to the impact of financial difficulties experienced in the later part of 1983 the above projection was scaled down by NEDA for 1984-1987 following the implementation of critical adjustment measures in order to strengthen the country's balance of payments. Such projections are as follows:

	Annual Growth of GNP (%)
1983 (estimate)	1.4
1984	1.4
1985	3.0
1986	4.0
1987	5.0
1988	6.5

Although the above figures are still preliminary pending the official updating of NEDA's 1983-1987 Plan, the Study Team decided to use such estimates in the analysis of future economic development.

The Study Team also assumes that the Philippines will achieve the constant economic growth of 6.5 percent after 1988. This conservative assumption is based on the expected economic recovery of the country during 1984-87 period, considering that the nationwide recession and inflationary tendency of the economy which has persisted in the early part of the 1980's has probably bottomed out. Likewise, the responsive development plans framed for the country will effectively adjust to such unfavorable economic trend leading to gradual national recovery toward productivity growth and national development.

As to the future economic development of the regions, the Gross Regional Domestic Product (GRDP) is assumed to follow the national economy's (GNP) future development performances. These estimates are reflected in TABLE 9.1-2.

2) Intensity of Regional Economic Growth

The intensity of future development potentials of each regions is reflective of the government pursuance of redressing the development imbalances among regions in terms of development targets and a more spetially diffused allocation of investments.

Based on the 5-year development plan 1983-87 (adjusted) and the NEDA compilation of major development projects as of 1983 the following regional rankings on development intensity is obtained.

TABLE 9.1-1 REGIONAL RANKINGS ON INTENSITY OF DEVELOPMENT POTENTIALS

Regions	GRDP		Development Projects		Ranking of Dev. Intensity
	Growth Rate	Rank	Number	Rank	
NCR	4.0	C	3	C	C
I	5.1	A	16	A	A
II	5.3	A	11	B	A
III	4.6	B	8	C	C
IV	4.7	B	26	A	A
V	5.2	A	17	A	A
VI	4.9	B	12	B	B
VII	5.1	A	6	C	B
VIII	5.4	A	10	B	A
IX	5.2	A	7	C	B
X	5.2	A	17	A	A
XI	5.2	A	7	C	B
XII	5.3	A	10	B	A
CRITERIA	A -	> 5.0		> 15	2A , AB
	B -	4.5 - 5.0		10 - 15	2B , AC
	C -	< 4.5		< 10	2C , CB

The above table shows that the high ranking regions are those which are presently least developed and low income regions while the low rankings are the relatively well developed and high income regions. This means that future developmental objectives are mainly focused on the low income regions such as Regions I, II, V and VIII.

TABLE 9.1-2 ESTIMATED GNP AND GRDP PROJECTIONS, 1983 – 2010

1. GROSS NATIONAL PRODUCT (GNP)

	GNP (Million Pesos at 1972 Price)					Annual Growth Rate (%)			
	1980	1983 1/	1990 1/	2000 1/	2010 1/	1980-1990	1983-1990	1990-2000	2000-2010
G N P	92,609	100,180	138,015	259,074	486,317	4.1	4.7	6.5	6.5

2. GROSS REGIONAL DOMESTIC PRODUCT (GRDP)

	GRDP (Million Pesos at Constant Prices at 1972)					Annual Growth Rate (%)			
	1980	1983 1/	1990 1/	2000 1/	2010 1/	1980-1990	1983-1990	1990-2000	2000-2010
N C R	29,959	31,567	41,459	71,841	124,059	3.3	4.0	5.6	5.6
Region I	3,315	3,796	5,383	10,519	20,523	5.0	5.1	6.9	6.9
Region II	2,437	2,815	4,029	8,077	16,000	5.1	5.3	7.2	7.1
Region III	7,500	8,866	12,188	22,746	42,407	5.0	4.6	6.4	6.4
Region IV	12,935	13,795	19,087	35,986	67,695	4.0	4.7	6.5	6.5
Region V	3,277	3,396	4,832	9,534	18,821	4.0	5.2	7.0	7.0
Region VI	7,331	8,335	11,662	22,412	42,893	4.7	4.9	6.7	6.7
Region VII	6,794	7,313	10,351	20,262	39,537	4.3	5.1	6.9	6.9
Region VIII	2,272	2,516	3,629	7,383	14,930	4.8	5.4	7.4	7.3
Region IX	3,248	3,406	4,872	9,715	19,307	4.1	5.2	7.1	7.1
Region X	4,267	4,588	6,542	12,902	25,435	4.4	5.2	7.0	7.0
Region XI	6,292	6,622	9,440	18,654	36,717	4.1	5.2	7.0	7.0
Region XII	3,079	3,165	4,541	9,042	17,993	4.0	5.3	7.1	7.1
Philippines	92,706	100,180	138,015	259,074	486,317	4.1	4.7	6.5	6.9

1/: NEDA Preliminary Estimates.

9.1.3 Population Forecast

1) National Level

The National Census and Statistics Office (NCSO) has completed in 1982 the forecast of national, regional, provincial and municipal population up to the year 2030. Since this forecast were used as the basis in the preparation of the Five-Year National and Regional Development Plan, such estimates were also adopted in the Study.

The government initiated family planning measures seem to have contributed a lot to lower population growth in the past. Hence, it is expected that the declining rates of population increases may continue in the future. The NCSO projections seem to follow this assumption. By the year 2010, the end of the planning period for the study, the national population growth is expected to continuously deccelerate. From an annual growth of 2.7% in the past ten-year period (1970-1980) it is expected to decline to 1.2% in the period 2000-2010.

The national population density, on the other hand, is expected to increase from 160.3 persons per square kilometer in 1980 to 261.4 persons per square kilometer in the year 2010.

Table 9.1-3 presents the national and regional future population trends.

2) Regional Level

By region, the same table shows that Region I has the least forecasted population growth among all regions having only a 0.9% future (1980-2010) annual growth followed by Regions VII, VIII, V, and XII with future growth rates ranging from 1.1% to 1.3%.

The three regions with highest forecasted population growth are Regions XI, X and the National Capital Region.

The future population in the project area by province is presented in Appendix 9-2.

9.1.4 Other Major Indices

Future planning framework defines the desired future profile of a region for planning purposes. The major components of such framework are described above; namely, national development policies and strategies, economic framework, and future population forecast. Future per capita income is discussed below.

The annual income of rural households in the Philippines in 1975 amounted to 5,543 pesos. Since there are 6.0 persons perhousehold, per capita income is assumed to be 920 pesos. The growth of per capita income corresponds to economic growth, and judging from past statistics per capita income growth gained about 50 to 60 percent of per capita gross national product (GNP) growth. In the study, assuming that the growth of personal income is directly influenced by regional productivity, future growth in personal income is forecasted for each region based on the growth of per capita gross regional domestic product (GRDP).

TABLE 9.1-3 FUTURE POPULATIONS 1980 – 2010

	Population					Annual Growth Rate (%)				
	1980	1983	1990	2000	2010	1980-1990	1983-1990	1990-2000	2000-2010	1980-2010
N C R	5,925,884	6,452,000	7,867,000	9,653,000	11,308,000	2.9	2.9	2.1	1.6	2.2
Region I	3,540,893	3,696,000	4,086,000	4,422,000	4,659,000	1.4	1.4	0.8	0.5	0.9
Region II	2,215,522	2,373,000	2,784,000	3,273,000	3,740,000	2.3	2.3	1.6	1.3	1.8
Region III	4,802,793	5,131,000	5,988,000	6,964,000	7,875,000	2.2	2.2	1.5	1.2	1.7
Region IV	6,118,620	6,623,000	7,969,000	9,468,000	10,822,000	2.7	2.7	1.7	1.3	1.9
Region V	3,476,982	3,655,000	4,105,000	4,421,000	4,664,000	1.7	1.7	0.7	0.5	1.0
Region VI	4,525,615	4,798,000	5,501,000	6,164,000	6,520,000	2.0	2.0	1.1	0.6	1.2
Region VII	3,787,374	4,002,000	4,552,000	5,114,000	5,586,000	1.9	1.9	1.2	0.9	1.3
Region VIII	2,799,534	2,956,000	3,358,000	3,763,000	4,054,000	1.8	1.8	1.2	0.7	1.2
Region IX	2,528,506	2,691,000	3,111,000	3,609,000	4,015,000	2.1	2.1	1.5	1.1	1.5
Region X	2,758,985	2,997,000	3,637,000	4,465,000	5,317,000	2.8	2.8	2.1	1.8	2.2
Region XI	3,346,803	3,663,000	4,522,000	5,608,000	6,675,000	3.1	3.1	2.2	1.8	2.3
Region XII	2,270,947	2,386,000	2,677,000	2,961,000	3,191,000	1.7	1.7	1.0	0.7	1.1
Philippines	48,098,460	51,423,000	60,157,000	69,885,000	78,426,000	2.3	2.3	1.5	1.2	1.6

9.2 TRAFFIC FORECAST

9.2.1 Methodology

1) Target year

The target year is established by taking into account the opening year of the project and the project life. With 1990, 2000 and 2010 as target years, future traffic volumes are forecasted based on current origin-destination data and future frameworks.

2) Outline

Figure 9.2-1 shows the traffic forecast procedures. An analysis of current traffic behaviors in each F/S section indicates the following points.

- Business purpose accounts for a high share of trip purposes of car passengers, and private purpose accounts for a high share of trip purposes of public transportation passengers. Cars tend to be used for higher value added trips than public transportation.
- Cars and public transportation show different traffic distribution patterns. The trip length of car is longer than the trip length of public transportation.
- There are large differences in the volumes and items of commodity flow through each F/S section.
- There are large differences in loading factors in each F/S section, reflecting the differences in the physical conditions of roads.

From the above, making separate traffic forecasts for cars and for public transportation is judged to be appropriate. As for truck traffic, it is judged appropriate to first forecast commodity flow by item and then convert these into truck trips using the loading factors. Forecasts are made for normal, induced and qenerated traffic, in accordance with the usual method.

a) Car Traffic

Car traffic is characterized by the high share of business purpose trips. In the Dalton Pass section, Mahaplag-Sogod section and Kennon Road, business purpose trips represent 49 percent, 53 percent and 38 percent, respectively, of all car trips. Business purpose trips are assumed to increase corresponding with the region's economic growth as measured by GROP.

Private purpose car trips, as represented by "visit relatives," reflects the trip-maker's intentions, and the frequency is in proportion to the trip-maker's ability to pay traffic costs. The forecast model recommended in MPWH's planning manualuses the trip-maker's ability to pay traffic costs as a factor, so the model is used for forecating private purpose trips in the Study (see Figure 9.2-2).

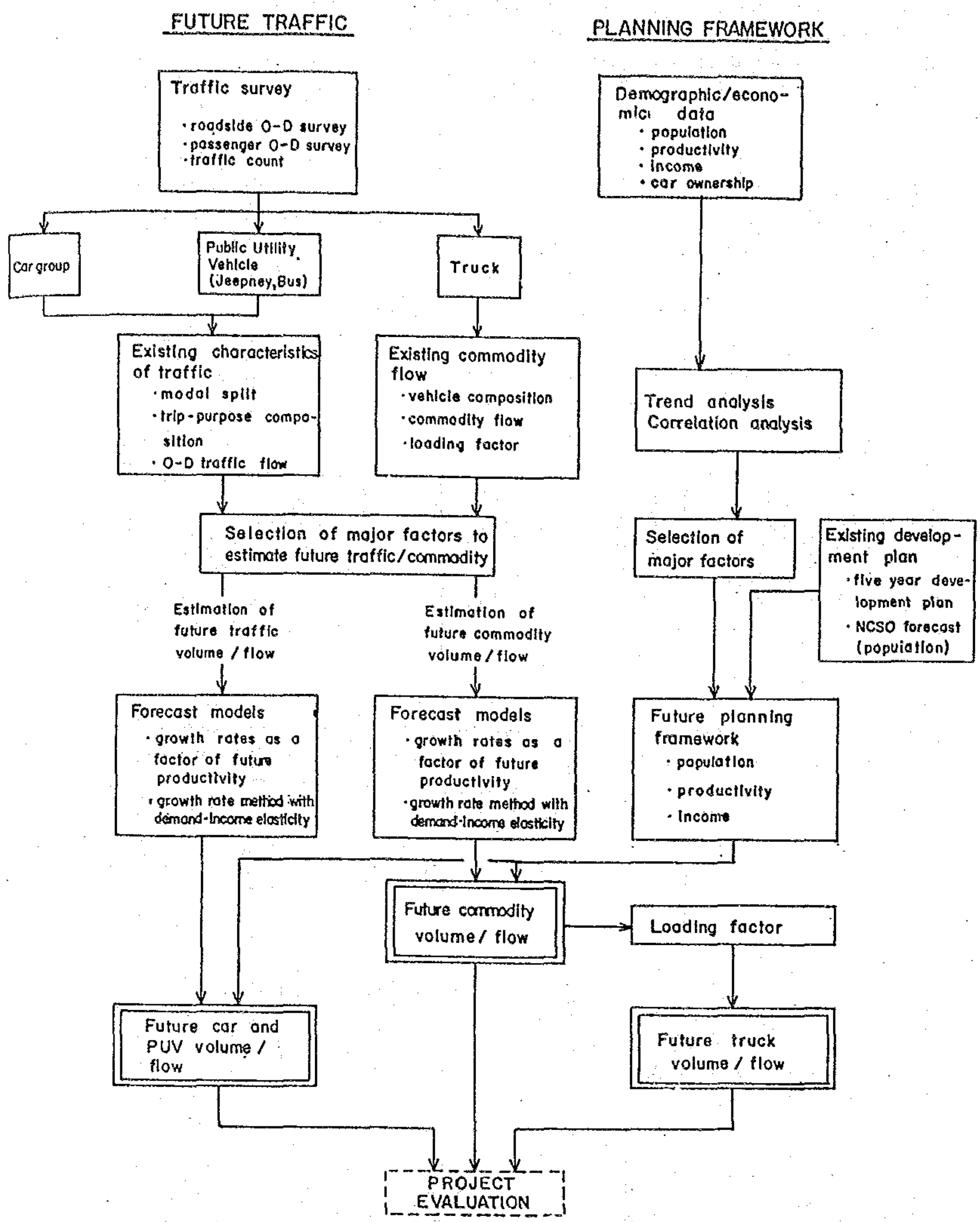


FIGURE 9.2-1 WORK PROCEDURE OF FUTURE TRAFFIC ESTIMATES

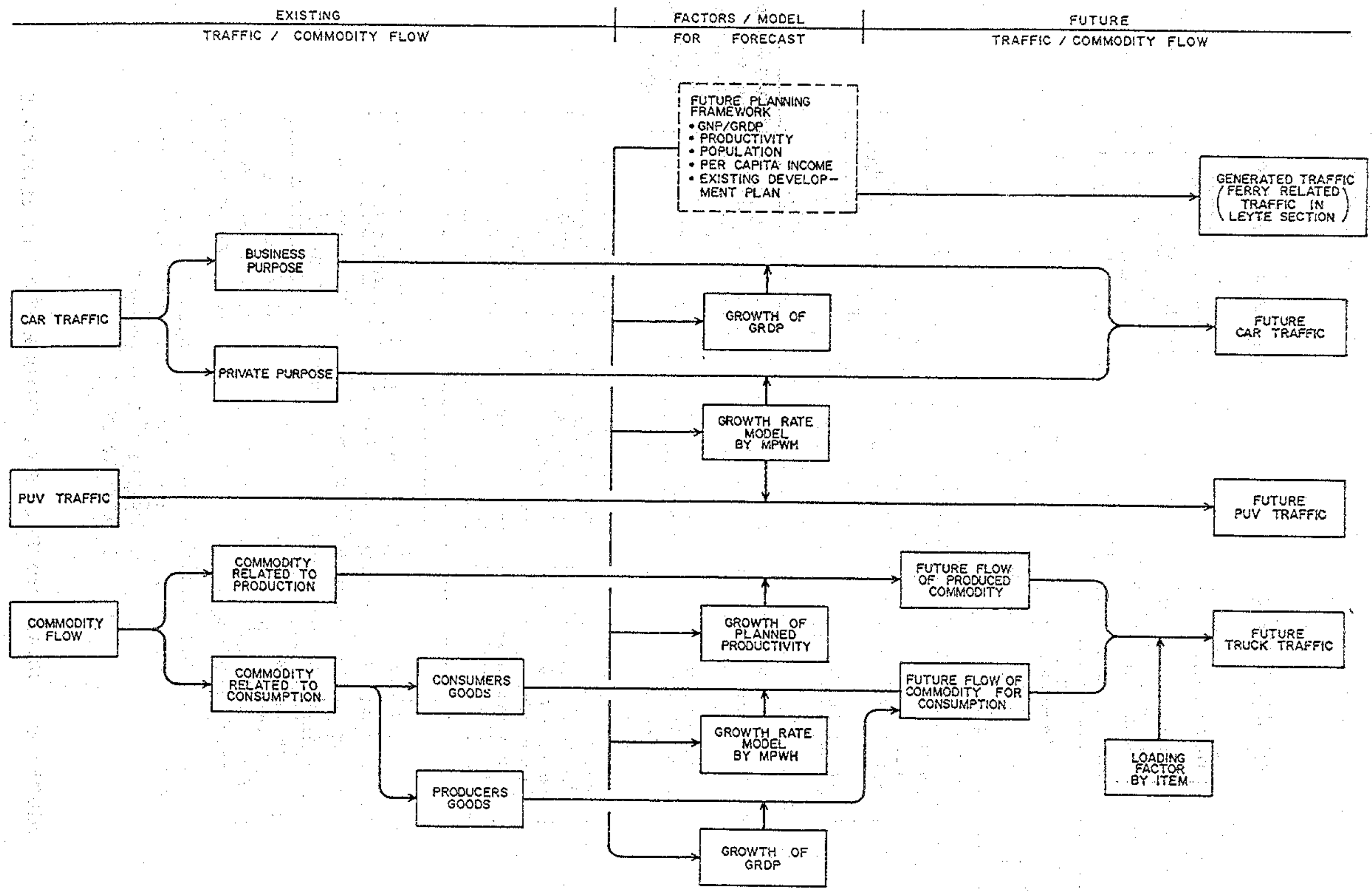


FIGURE 9.2-2 PROCEDURE OF FUTURE TRAFFIC FORECAST

b) Public Transportation

Most of public transportation trips are private purpose trips. In the Dalton Pass section, Mahapalg-Sogod section and Kennon Road, private purpose trips represent 82 percent, 75 percent and 81 percent, respectively, of all public transportation trips. Hence, for the same reason as given for car traffic above, MPWH's forecast model is used to forecast future public transportation traffic.

c) Trucks

Commodity flow by trucks is divided into those involving produced commodities and those involving commodities for consumption. Future volume of produced commodities is forecasted on the basis of the productivity growth targeted in the Five-Year Development Plan and Regional Development Plan.

Consumption commodities which can be divided into consumers goods, mainly processed food, and producers goods such as construction materials, gasoline and machinery. The former is assumed to correspond to personal income growth and the latter to GRDP as the indicator or regional economic productivity.

Future volumes of commodity flow are converted into truck traffic volumes using the loading factors established on the basis of F/S section surveys.

d) Induced Traffic

Induced traffic is the potential traffic that is actualized by a decline in traffic costs. The Study mainly concerns to road disaster prevention measures, which basically do not result in lower traffic cost, unlike road improvement palns.

As a result of actually having driven on the Dalton Pass section and Kennon Road, it is judged that traffic cost savings will not be enough to induce new traffic. On the other hand, the Mahaplag-Sogod section (Leyte) has inadequate side ditches and, due to steady year-round rainfall, the road surface is covered by mud which flows down from failured slopes. For this reason, side ditches and partial road surface impovements are planned in addition to slope protection for this section. Since this means that a fair amount of traffic cost savings can be expected, induced traffic forecasts are made for this section.

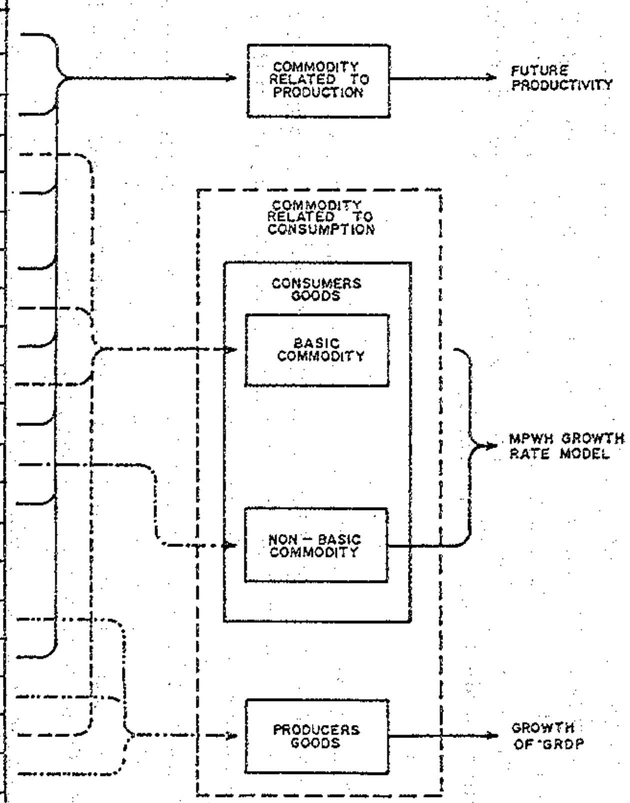
e) Generated Traffic

Existing projects closely connected to this project are the Cagayan Integrated Rural Development Project and the Pan-Philippine Highway Ferry Service Plan (see 9.1.1).

The aim of the Cagayan Integrated Rural Development Project is reflected in the high GRDP growth of 7.4 percent established for Region II as future framework. Forecasts of traffic through the Dalton Pass section rests on the premise that the objective of the development plan is successfully achieved.

The Ferry Service Plan is a plan to link Luzon, Samar, Leyte, and Mindanao to each other, with the Maharlika Highway as the axis. Traffic from Mindanao should have a major impact on the Mahaplag-Sogod section when the ferry service is opened. In the Study, the traffic forecast made under the Ferry Service Plan is referred to as generated traffic through the Mahaplag-Sogod section.

COMMODITY TYPE	DIRECTION OF COMMODITY FLOW	MAIN COMMODITY	COMMODITY VOLUME (TON/DAY)	FACTOR FOR FORECAST
UNPROCESSED CEREALS	OUT BOUND 1/	PALAY	587	AGRICULTURAL PRODUCTIVITY
	IN BOUND 2/	–	0	–
OTHER UNPROCESSED AGRICULTURAL FOODSTUFF	OUT BOUND	MEAT	122	AGRICULTURAL PRODUCTIVITY
	IN BOUND	FISH, VEGETABLES	36	CONSUMPTION FOR BASIC COMMODITY
UNPROCESSED AGRICULTURAL CASH CROPS	OUT BOUND	TOBACCO	57	AGRICULTURAL PRODUCTIVITY
	IN BOUND	–	0	–
PROCESSED AGRICULTURAL PRODUCTS	OUT BOUND	MILLED RICE	1,039	AGRICULTURAL PRODUCTIVITY
	IN BOUND	VEGETABLE OIL, WHEAT FLOUR	185	CONSUMPTION FOR BASIC COMMODITY
MANUFACTURED FOODSTUFF	OUT BOUND	CANNED FOODS, GROCERIES	191	GRDP
	IN BOUND	CANNED FOODS, SOFT DRINKS	406	CONSUMPTION FOR BASIC COMMODITY
OTHER MANUFACTURED CONSUMERS GOODS	OUT BOUND	COTTAGE INDUSTRY PRODUCTS	11	GRDP
	IN BOUND	APPLIANCES	71	CONSUMPTION FOR NON-BASIC COMMODITY
FORESTRY AND MINING PRODUCTS	OUT BOUND	LOGS, LUMBER	3,867	LOGS AND LUMBER PRODUCTIVITY
	IN BOUND	–	0	–
MINERAL OIL PRODUCTS	OUT BOUND	–	2	–
	IN BOUND	GASOLINE	252	GRDP
BUILDING AND CONSTRUCTION MATERIALS	OUT BOUND	VENEER, PLYWOOD	173	LOGS AND LUMBER PRODUCTIVITY
	IN BOUND	CEMENT	743	GRDP
MANUFACTURED PRODUCERS GOODS	OUT BOUND	BOTTLES	294	CONSUMPTION FOR BASIC COMMODITY
	IN BOUND	FERTILIZER MACHINERY	174	GRDP
EMPTY TRUCK	OUT BOUND	–	103 3/	AVERAGE GROWTH RATE OF TRUCK TRAFFIC
	IN BOUND	–	336 3/	

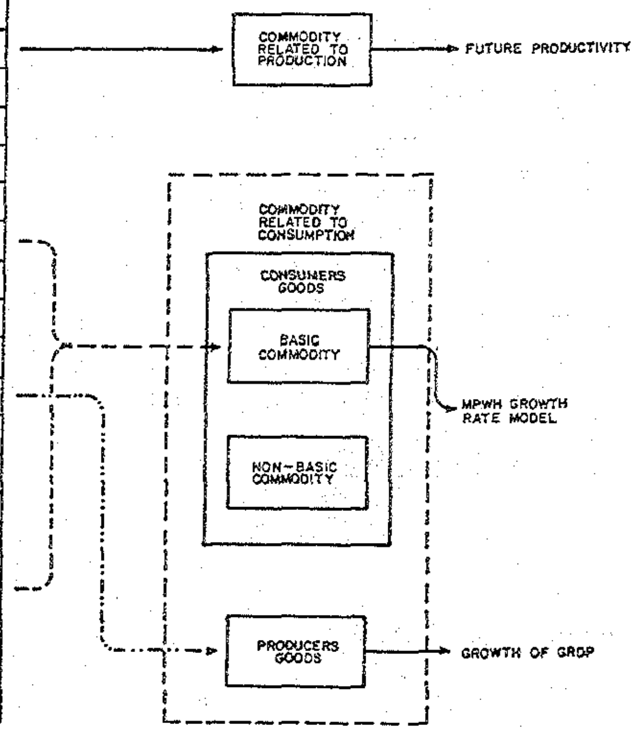


SOURCE : THE STUDY TEAM

NOTE 1/ : DIRECTION FROM CAGAYAN VALLEY
2/ : DIRECTION TO CAGAYAN VALLEY
3/ : VEHICLE / DAY

FIGURE 9.2-3 FACTORS TO FORECAST FUTURE COMMODITY VOLUME IN DALTON PASS SECTION

COMMODITY TYPE	DIRECTION OF COMMODITY FLOW	MAIN COMMODITY	COMMODITY VOLUME (TON/DAY)	FACTOR FOR FORECAST
UNPROCESSED CEREALS	OUT BOUND 1/	–	0	–
	IN BOUND 2/	–	0	–
OTHER UNPROCESSED AGRICULTURAL FOODSTUFF	OUT BOUND	–	0	–
	IN BOUND	–	0	–
UNPROCESSED AGRICULTURAL CASH CROPS	OUT BOUND	COCONUTS	24	AGRICULTURAL PRODUCTIVITY
	IN BOUND	–	0	–
PROCESSED AGRICULTURAL PRODUCTS	OUT BOUND	–	0	–
	IN BOUND	–	0	–
MANUFACTURED FOODSTUFF	OUT BOUND	–	0	–
	IN BOUND	CANNED FOODS, SOFT DRINKS	87	CONSUMPTION FOR BASIC COMMODITY
OTHER MANUFACTURED CONSUMERS GOODS	OUT BOUND	–	0	–
	IN BOUND	–	0	–
FORESTRY AND MINING PRODUCTS	OUT BOUND	–	0	–
	IN BOUND	LOGS, LUMBER	2	GRDP
MINERAL OIL PRODUCTS	OUT BOUND	–	0	–
	IN BOUND	–	0	–
BUILDING AND CONSTRUCTION MATERIALS	OUT BOUND	–	0	–
	IN BOUND	–	0	–
MANUFACTURED PRODUCERS GOODS	OUT BOUND	BOTTLES	31	CONSUMPTION FOR BASIC COMMODITY
	IN BOUND	–	0	–
EMPTY TRUCK	OUT BOUND	–	7 3/	AVERAGE GROWTH RATE OF TRUCK TRAFFIC
	IN BOUND	–	7 3/	



SOURCE: THE STUDY TEAM

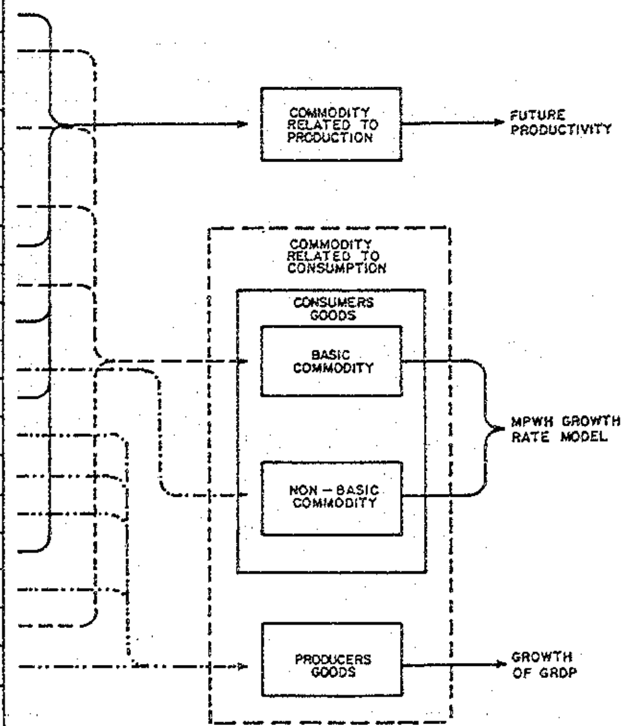
NOTE 1/ : DIRECTION FROM SOUTHERN LEYTE

2/ : DIRECTION TO SOUTHERN LEYTE

3/ : VEHICLE / DAY

FIGURE 9.2-4 FACTORS TO FORECAST FUTURE COMMODITY VOLUME IN MAHAPLAG-SOGOD SECTION (LEYTE)

COMMODITY TYPE	DIRECTION OF COMMODITY FLOW	MAIN COMMODITY	COMMODITY VOLUME (TON/DAY)	FACTOR FOR FORECAST
UNPROCESSED CEREALS	OUT BOUND[1/]	–	0	–
	IN BOUND[2/]	–	0	–
OTHER UNPROCESSED AGRICULTURAL FOODSTUFF	OUT BOUND	VEGETABLE	202	AGRICULTURAL PRODUCTIVITY
	IN BOUND	FISH	12	CONSUMPTION FOR BASIC COMMODITY
UNPROCESSED AGRICULTURAL CASH CROPS	OUT BOUND	–	0	–
	IN BOUND	COCONUTS, FOODSTUFF FOR ANIMALS	113	CONSUMPTION FOR BASIC COMMODITY
PROCESSED AGRICULTURAL PRODUCTS	OUT BOUND	–	0	–
	IN BOUND	MILLED RICE, REFINED SUGAR	63	CONSUMPTION FOR BASIC COMMODITY
MANUFACTURED FOODSTUFF	OUT BOUND	PRESERVED VEGETABLES	2	AGRICULTURAL PRODUCTIVITY
	IN BOUND	CANNED FOODS, SOFT DRINKS	126	CONSUMPTION FOR BASIC COMMODITY
OTHER MANUFACTURED CONSUMERS GOODS	OUT BOUND	COTTAGE INDUSTRY PRODUCTS	9	GRDP
	IN BOUND	APPLIANCES	14	CONSUMPTION FOR NON-BASIC COMMODITY
FORESTRY AND MINING PRODUCTS	OUT BOUND	COPPER	35	MINING PRODUCTIVITY
	IN BOUND	LOGS, LUMBER	30	GRDP
MINERAL OIL PRODUCTS	OUT BOUND	GASOLINE	6	GRDP
	IN BOUND	GASOLINE	20	GRDP
BUILDING AND CONSTRUCTION MATERIALS	OUT BOUND	VENEER, PLYWOOD	13	GRDP
	IN BOUND	CEMENT	231	GRDP
MANUFACTURED PRODUCERS GOODS	OUT BOUND	BOTTLES	62	CONSUMPTION FOR BASIC COMMODITY
	IN BOUND	MACHINERY	141	GRDP
EMPTY TRUCK	OUT BOUND	–	90[3/]	AVERAGE GROWTH RATE OF TRUCK TRAFFIC
	IN BOUND	–	17[3/]	



SOURCE : THE STUDY TEAM

NOTE 1/ : DIRECTION FROM BAGUIO
2/ : DIRECTION TO BAGUIO
3/ : VEHICLE / DAY

FIGURE 9.2-5 FACTORS TO FORECAST FUTURE COMMODITY VOLUME IN KENNON ROAD

3) Forecast Model

The Ministry of Public Works and Highways, in the "Highway Planning Manual," recommends the growth rate model as a method of forecasting future traffic volumes. Use of the growth rate model in rural road planning rather than urban road network planning is indicated. The model is expressed by the following formula:

$$\text{TGR (in percent)} = \left[\left(\frac{I \times E}{100} + 1 \right) CP - 1 \right] \times 100$$

Where:

TGR is the traffic (or commodity) growth rate per annum;

E is the transport demand (or goods consumption) income elasticity

I is the growth rate (in percent) for per capita income in constant prices; and

CP is the compound population growth rate per annum

Factors used in the model are population growth, per capita income growth and elasticity. Elasticity is defined as traffic demand-income elasticity when forecasting car or public transportation traffic and as goods consumption-income elasticity when forecasting commodity flow.

The planning manual indicated that 1.8 for cars and 1.1 for public transportation are appropriate as traffic demand income elasticity values, and that elasticity values should be adjusted to increases in fuel prices. In the Study, assuming that fuel prices will have a strong impact on cars, the elasticity value is reduced by 20 percent and established as 1.5.

The planning manual does not give any actual values for goods consumption-income elasticity. In the Study, the relationship between per capita income growth and goods consumption growth is analyzed from the results of the 1975 household income statistics, and the goods consumption-income elasticity factor is established as 0.8 for basic commodities and 1.4 for non-basic commodities.

TABLE 9.2-1 TRANSPORT DEMAND (OR GOODS CONSUMPTION INCOME ELASTICITY)

Vehicle Type (or Commodity Type)		Parameter-E
Car		1.5
PUV		1.1
Truck	Basic Commodity	0.8
	Non-Basic Commodity	1.4

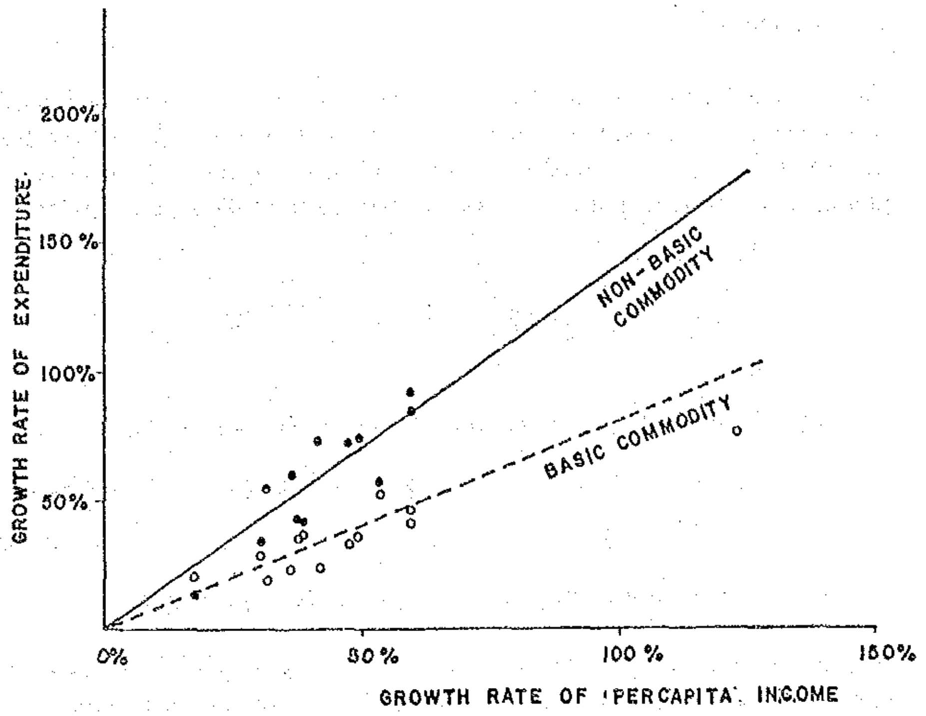


FIGURE 9.2-6 COMMODITY EXPENDITURE-INCOME ELASTICITY

9.2.2 Future Traffic Volume

1) Traffic Growth

Dalton Pass Section

The current traffic through the Dalton Pass section is 2,120 vehicles/day. The average annual growth will be 5.3 percent during 1983 to the year 2010 wherein future traffic will reach 8,500 vehicles/day in the year 2010. This volume is about the capacity of a two-lane road. Growth of normal traffic in all F/S sections during the 1990's and thereafter is expected to be slightly higher than in the 1980's. This is based on the fact that the overall trend of the Philippine economy is that the 1980s is the decade for transition from economic instability to stability and that the economy will remain stable after 1990 (See Tables 9.2-2 and 9.2-5).

Mahaplag - Sogod Section (Leyte)

Current traffic through the Mahaplag-Sogod section is 134 vehicles/day. Average annual growth during 1983 to the year 2010 will be a high 8.8 percent and traffic in the year 2010 will reach 1,300 vehicles/day. Traffic growth is expected to be espected to be especially high during the 1980s due to the opening of ferry service between Leyte and Mindanao. (See Table 9.2-3 and 9.2-5).

Kennon Road

The current traffic on the Kennon Road is 1,815 vehicles/day. Average annual growth during 1983 to the year 2010 will be 5.7 percent and traffic in the year 2010 will reach 8,100 vehicles/day, a volume equal to the Dalton Pass section. The capacity of the Kennon Road is rather small compared to the ordinary two-lane roads due to its narrow road width and steep vertical gradient and 8,100 vehicles/day is most likely the maximum traffic the road can handle. The traffic growth by type of vehicle during 1983 to the year 2010 will be, 6.2 percent, 5.8 percent and 4.7 percent for cars, trucks, and public transportation, respectively. (See Table 9.2-4 and 9.2-5)

2) Change in Model Split

Reflecting the high growth of car traffic, the modal share of cars in future splits will be greater. The shapest change will be seen in the Mahaplag-Sogod section (Leyte), where car share will expand from the current 45 percent to 65 percent in the year 2010.

Public transportation traffic, on the other hand, will decrease its shares in the future, both compared to total traffic and to passenger traffic. However, over 70 percent of passenger transport through the Dalton Pass section and Kennon Road will still rely on the public transportation in the year 2010.

3) Commodity Flow

Dalton Pass Section

Commodity flow through the Dalton Pass section is even at present an overwhelming 8,200 tons/day. Owing to the positive development efforts reflected by the Cagayan Integrated Rural Development Project, commodity flow in the year 2010 will be 3.2 times the current volume, or 26,400 tons/day, and truck traffic will reach 3,700 vehicle/day.

The share of timber to total commodity flow will decrease greatly from 47 percent in 1983 to 25 percent in the year 2010. On the other hand, the share of rice, the focal point of agricultural development efforts will grow from 22 percent to 30 percent. The volume of construction materials transported to the Cagayan Valley will be large because of development projects, and its share will rise from 11 to 18 percent.

Mahaplag-Sogod Section

The current commodity flow of 140 tons/day will increase to 1,020 tons/day in the year 2010. Average annual growth, at 7.5 percent, will be the highest of all F/S sections. Of the 1.020 tons/day of commodity flow in the year 2010, about half will be to or from Mindanao, using the ferry service. The remaining half will be to or from Southern Leyte.

Kennon Road

Commodity flow on the Kennon Road is currently 1,100 tons/day, out of which, 330 tons/day are from Baguio to Pangasinan or Metro Manila and 770 tons/day are in the opposite direction. Average annual growth will be 5.8 percent and commodity flow in the year 2010 will be 5,100 tons/day. The share of foodstuff will decrease, while the shares of copper, a valuable export item, and construction materials will increase.

4) Traffic Characteristic of Each F/S Section

The Dalton Pass section is stressed as a route for commodity flow and the Kennon Road as a corridor for passenger traffic. As shown in Figure 9.2-9, the characteristic functions of the two F/S sections are expected to strengthen over the years in stages. The Mahaplag-Sogod section will become an important link with Mindanao when the ferry service is opened.

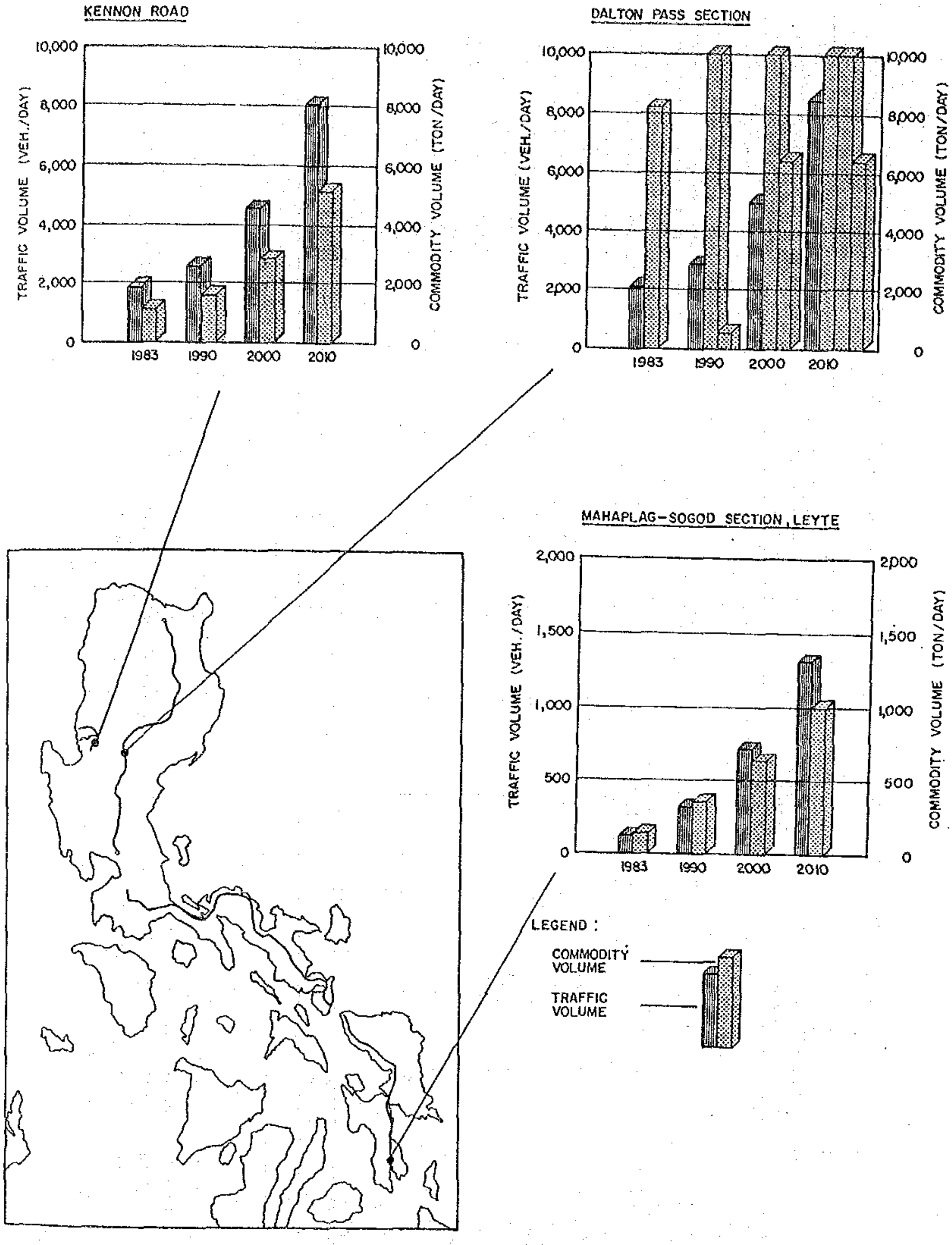


FIGURE 9.2-7 FUTURE TRAFFIC/COMMODITY VOLUME

TABLE 9.2-2 FUTURE TRAFFIC VOLUME ON DALTON PASS SECTION

		1983			1990			2000			2010		
		Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)
Car	Business Trip	-	-	270	-	-	421	-	-	842	-	-	1,678
	Private Trip	-	-	318	-	-	465	-	-	819	-	-	1,438
	Total	-	-	588	-	-	886	-	-	1,661	-	-	3,116
PUV		-	-	473	-	-	656	-	-	1,051	-	-	1,638
Truck	Type - 1	586	13.7	43	844	13.7	62	1,524	13.7	111	2,742	13.7	200
	Type - 2	155	4.9	32	203	4.9	41	310	4.9	63	471	4.9	96
	Type - 3	57	19.0	3	78	19.0	4	131	19.0	7	220	19.0	12
	Type - 4	1,224	19.1	64	1,738	19.1	91	3,058	19.1	160	5,377	19.1	282
	Type - 5	598	10.0	60	826	10.0	83	1,382	10.0	138	2,340	10.0	234
	Type - 6	81	3.2	25	116	3.2	36	208	3.2	65	371	3.2	116
	Type - 7	3,868	17.7	219	4,401	17.7	249	5,436	17.7	307	6,697	17.7	378
	Type - 8	254	7.3	35	387	7.3	53	772	7.3	106	1,533	7.3	210
	Type - 9	923	11.6	80	1,334	11.6	115	2,512	11.6	217	4,807	11.6	414
	Type - 10	468	8.2	57	652	8.2	80	1,104	8.2	135	1,884	8.2	230
	Unloaded	-	-	441	-	-	581	-	-	934	-	-	1,550
	Total	8,214	-	1,059	10,579	-	1,395	16,437	-	2,243	26,442	-	3,722
Total		-	-	2,120	-	-	2,937	-	-	4,955	-	-	8,476

NOTE:
- Type 1: Unprocessed Cereals
- Type 2: Other Unprocessed Agricultural Foodstuff
- Type 3: Unprocessed Agricultural Cash Crops
- Type 4: Processed Agricultural Products
- Type 5: Manufactured Foodstuff
- Type 6: Other Manufactured Consumer's Goods
- Type 7: Forestry and Mining Products
- Type 8: Mineral Oil Products
- Type 9: Building and Construction Materials
- Type 10: Manufactured Product's Goods

Source: The Team

TABLE 9.2-3 FUTURE TRAFFIC VOLUME ON MAHAPLAG-SOGOD SECTION OF MAHARLIKA HIGHWAY

		1983			1990			2000			2010		
		Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)
Car	Business Trip	-	-	34	-	-	57	-	-	115	-	-	233
	Private Trip	-	-	26	-	-	34	-	-	62	-	-	115
	Total	-	-	60	-	-	91	-	-	177	-	-	348
PUV		-	-	31	-	-	41	-	-	67	-	-	108
Truck	Type - 1	0	-	0	0	-	0	0	-	0	0	-	0
	Type - 2	0	-	0	0	-	0	0	-	0	0	-	0
	Type - 3	24	3.1	7	36	3.1	12	67	3.1	22	127	3.1	41
	Type - 4	0	-	0	0	-	0	0	-	0	0	-	0
	Type - 5	87	5.7	14	110	5.7	19	161	5.7	28	233	5.7	41
	Type - 6	0	-	0	0	-	0	0	-	0	0	-	0
	Type - 7	2	0.6	3	5	0.6	8	10	0.6	17	19	0.6	31
	Type - 8	0	-	0	0	-	0	0	-	0	0	-	0
	Type - 9	0	-	0	0	-	0	0	-	0	0	-	0
	Type - 10	31	6.3	5	41	6.3	7	60	6.3	10	87	6.3	14
	Unloaded	-	-	14	-	-	24	-	-	41	-	-	67
	Total	144	-	43	192	-	70	298	-	118	466	-	194
Total		-	-	134	-	-	202	-	-	362	-	-	650
Ferry boat related and traffic					144	-	93	307	-	319	504	-	606
Induced Traffic					19	-	20	30	-	37	46	-	65

NOTE:
Type 1: Unprocessed Cereals
Type 2: Other Processed Agricultural Foodstuff
Type 3: Unprocessed Agricultural Proudcts
Type 4: Processed Agricultural Products
Type 5: Manufactured Foodstuff
Type 6: Other Manufactured Consumer's Goods
Type 7: Forestry and Mining Products
Type 8: Mineral Oil Prodścts
Type 9: Building and Construction Materials
Type 10: Manufactured Product's Goods

Source: The Team

TABLE 9.2-4 FUTURE TRAFFIC VOLUME ON KENNON ROAD

		1983			1990			2000			2010		
		Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)	Commodity (Ton/Day)	Loading Factor	Traffic (Veh./Day)
Car	Business Trip	-	-	308	-	-	469	-	-	920	-	-	1,796
	Private Trip	-	-	566	-	-	819	-	-	1,503	-	-	2,623
	Total	-	-	874	-	-	1,288	-	-	2,423	-	-	4,419
PUV		-	-	633	-	-	870	-	-	1,426	-	-	2,212
Truck	Type - 1	0	-	0	0	-	0	0	-	0	0	-	0
	Type - 2	212	4.6	46	281	4.6	61	442	4.6	96	690	4.6	150
	Type - 3	114	9.4	12	155	9.4	16	238	9.4	25	342	9.4	36
	Type - 4	84	6.9	12	114	6.9	17	176	6.9	26	252	6.9	37
	Type - 5	127	4.4	29	173	4.4	39	266	4.4	60	383	4.4	87
	Type - 6	22	1.5	15	33	1.5	22	63	1.5	42	115	1.5	77
	Type - 7	65	5.4	12	113	5.4	21	286	5.4	53	745	5.4	138
	Type - 8	26	3.7	7	40	3.7	11	78	3.7	21	151	3.7	41
	Type - 9	245	8.1	30	371	8.1	46	726	8.1	90	1,416	8.1	175
	Type - 10	205	5.4	38	300	5.4	56	552	5.4	102	1,007	5.4	186
	Unloaded	-	-	107	-	-	154	-	-	274	-	-	493
	Total	1,100	-	308	1,580	-	443	2,827	-	789	5,101	-	1,420
Total		-	-	1,815	-	-	2,601	-	-	4,638	-	-	8.051

NOTE:
Type 1: Unprocessed Cereals
Type 2: Other Unprocessed Agricultural Foodstuff
Type 3: Unprocessed Agricultural Cash Crops
Type 4: Processed Agricultural Products
Type 5: Manufactured Foodstuff
Type 6: Other Manufactured Consumer's Goods
Type 7: Forestry and Mining Products
Type 8: Mineral Oil Products
Type 9: Building and Construction Materials
Type 10: Manufactured Product's Goods

Source: The Team

TABLE 9.2-5 FUTURE TRAFFIC GROWTH BY F/S SECTION

		Dalton Pass Section			Mahaplag-Sogod Section			Kennon Road		
		1990/1983	2000/1990	2010/2000	1990/1983	2000/1990	2010/2000	1990/1983	2000/1990	2010/2000
Car	Business Trip	1.56	2.00	1.99	1.68	2.02	2.03	1.52	1.96	1.95
	Private Trip	1.46	1.76	1.76	1.31	1.82	1.85	1.45	1.84	1.75
	Sub- Total	1.51	1.87	1.88	1.52	1.95	1.97	1.47	1.88	1.82
PUV		1.39	1.60	1.56	1.32	1.63	1.61	1.37	1.64	1.55
Truck	Type - 1	1.44	1.81	1.80	-	-	-	-	-	-
	Type - 2	1.31	1.53	1.52	-	-	-	1.33	1.57	1.56
	Type - 3	1.37	1.68	1.68	1.71	1.83	1.86	1.33	1.56	1.44
	Type - 4	1.42	1.76	1.76	-	-	-	1.42	1.53	1.42
	Type - 5	1.38	1.67	1.69	1.36	1.47	1.46	1.34	1.54	1.45
	Type - 6	1.43	1.79	1.78	-	-	-	1.47	1.91	1.83
	Type - 7	1.14	1.24	1.23	2.67	2.13	1.82	1.75	2.52	2.60
	Type - 8	1.52	1.99	1.99	-	-	-	1.57	1.91	1.95
	Type - 9	1.45	1.88	1.91	-	-	-	1.53	1.96	1.94
	Type - 10	1.39	1.69	1.71	1.40	1.43	1.40	1.47	1.82	1.82
	Sub-Total	1.32	1.61	1.66	1.63	1.69	1.64	1.44	1.78	1.80
Total		1.39	1.69	1.71	1.51	1.79	1.80	1.43	1.78	1.74

NOTE:
Type 1: Unprocessed Cereals
Type 2: Other Unprocessed Agricultural Foodstuff
Type 3: Unprocessed Agricultural Cash Crops
Type 4: Processed Agricultural Products
Type 5: Manufactured Foodstuff
Type 6: Other Manufactured Consumer's Goods
Type 7: Forestry and Mining Products
Type 8: Mineral Oil Products
Type 9: Building and Construction Materials
Type 10: Manufactured Product's Goods

Source: The Team

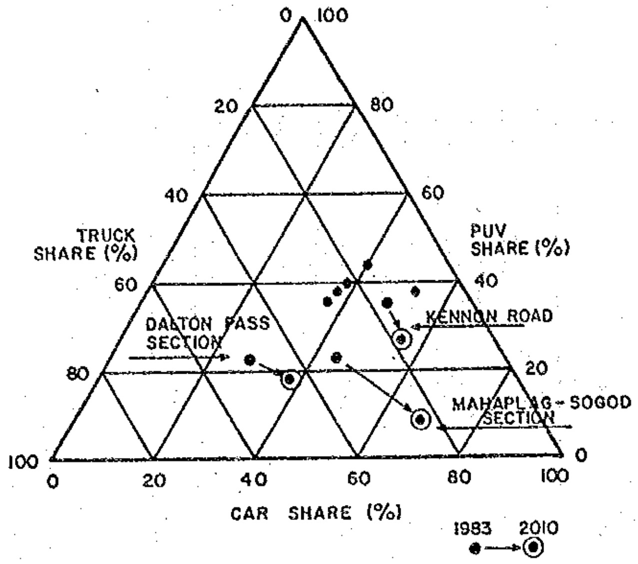


FIGURE 9.2-8 MODAL SHARE BY SECTION

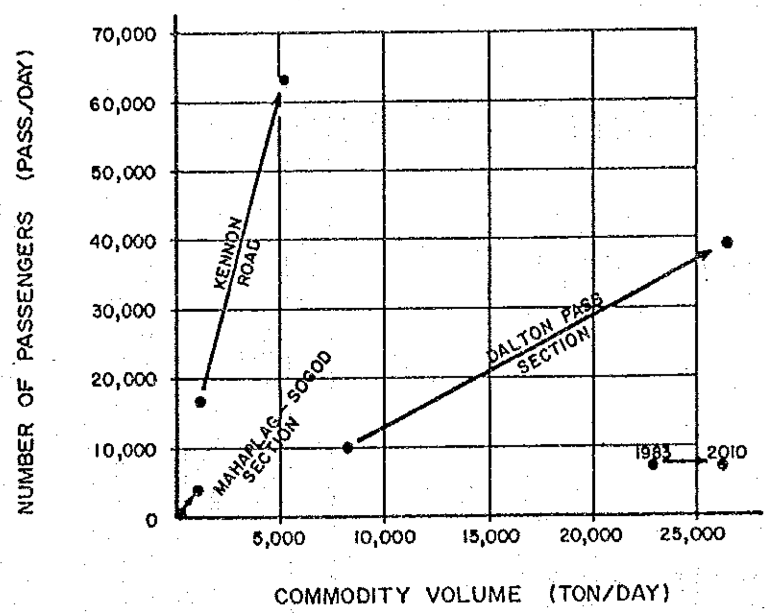


FIGURE 9.2-9 FUNCTIONAL CHARACTERISTICS OF EACH F/S SECTION

CHAPTER 10

PRELIMINARY DESIGN

10.1 DESIGN POLICY

10.1.1 Spots Subject to Design

Countermeasures are designed for those spots evaluated as disaster potential A or B plus several additional spots selected through supplemental field reconnaissances. The reason for excluding disaster potential C spots is given in 10.1.2.

Countermeasures are designed for 73 spots in the Dalton Pass section, 46 on Kennon Road and 40 in the Mahaplag-Sogod section, for a total of 159. Table 10.1-1 lists these spots by type of disaster.

TABLE 10.1-1 NUMBER OF DESIGNED SPOTS

Type of Disaster	Section			Total
	Dalton Pass	Mahaplag - Sogod	Kennon Road	
Cut Slope Failure	39	18	5	63
Embankment Slope Failure	13	14	9	36
Fall	6	2	31	39
Landslide	-	3	1	4
Debris Flow	14	1	-	15
Others	1	1	-	2
Total	73	40	46	159

10.1.2 Level and Scope of Improvement

1) Level of Improvement

The level of improvement for road disaster prevention may vary depending on the class or importance of the road. In general, however, the countermeasure is designed based on a certain design criteria, regardless of the class or importance of the road. Hence, the difference of the level of improvement is dependent, not on design criteria to be adopted but rather on selection criteria of spots to be improved.

Taking into account the traffic volume, the level of the road facilities, past investment amount for restoration of the disasters, etc., on the subject roads, it was judged sufficient to improve only the spots evaluated as A or B.

Disaster spots A, B and C are correspond to H, M and S, respectively, in the evaluation criteria presented in Table 5.3-1 in chapter 5. As shown in the table, disaster potential A and B indicate direct impacts on the roads and thus necessitate immedaite countermeasure. On the other hand, disaster potential C does not. Therefore, it is more realistic and rational to improve first the spots with disaster potential A and B and then, if budget allows, the spots with disaster potential C.

2) Level of Improvement on Dalton Pass Tunnel Section

"The Feasibility Study on Dalton Pass Tunnel Project" conducted in 1982 by JICA proposed a 15 km section between km 202 + 000 and km 217 + 000 as an alternative route to be newly constructed which includes the 2 km tunnel section. Thus, in the Study, the countermeasures to be effective only until completion of the proposed tunnel were suggested for this section. However, there is no design method which can reflect the lifespan of the countermeasure. Therefore, a lower grade countermeasure than believed optimum was applied. For instance, countermeasures for cut slope failures were dealt with as follows;

- Re-cutting was applied to soil slopes only; rock slopes which are steeper gradient than the standard are not recut, as long as no abnormal deformation was observed.

  In general, some slope protection or other is applied for soft rock slopes. In this section , however, no slope protection was applied for soft rock slopes when they were observed to be hardly weathered.

  For those slopes requiring structural protection, structural protections of a grade lower than believed optimum were applied. For example, slopes where cast-in-place concrete cribs are thought to be suitable were given sprayed concrete cribs, slopes where sprayed concrete cribs are thought to be suitable were given concrete spraying of 15 cm thickness and so forth.

3) Scope of Improvement

In accordance with the Scope of Work of the Study, countermeasures which require more than working on road facilities, such as large-scale riparian and sabo work, are beyond the scope of the Study. There are three spots requiring such countermeasures.

- At Spot No. II-11 (km 221 + 200) in the Dalton Pass Section, a large-scale debris flow occurred during typhoon Aring, causing a great number of casualties and also damaging road facilities. The debris flow was created by a torrent having a wide basin, and its total prevention requires major hillside works and the construction of a series of large sabo dams. However, as mentioned earlier, such countermeasures as these are not proposed in the Study. As a substitute plan, elevation of the road was raised so that materials carried in by the small scale debris flow can be deposited outside the road. This simple countermeasure may prevent traffic interruptions caused every year by small-scale debris flow onto road surface, but it cannot prevent large-scale debris flows such as the one created during typhoon Aring. However, this is thought to be the maximum possible measure without extending into nonroad facility work.

- At Spot No. IK-10 (km 226 + 600) on the Kennon Road, a large-scale failure of the hillside on the opposite bank of the Bued River, which runs beside the road, dammed the river and damaged road facilities, necessitating more than four months for the restoration. The hillside in question is still in danger of collapsing again, and to prevent this major hillside and riparian works are required. However, these countermeasures are not proposed because they are beyond the scope of the Study.

- The piers of the bridge located near the toll gate on Kennon Road is in a dangerous condition due to scouring of the Bued River and impact from stones of large diameters brought down by floods. Required to correct this situation are a large scale hillside works as well as construction of a series of sabo dams on the adjacent hillside devastated by copper mining. In the Study, however, the temporary measure of foot protection to piers is applied.

10.1.3 Basic Policy in Countermeasure Selection

In selecting countermeasures, it is essential to select the appropriate methods based on the causes and types of disasters assumed by investigations of the topography, geology, surface water, subsurface water and other conditions of the subject disaster spot, taking into full consideration such factors as work conditions, work cost, maintenance problems, environmental protection.

After considering various kinds of factors as mentioned above the following basic policies are adhered to in selecting countermeasures in the Study.

- Active introduction of new techniques and work methods (especially concerning slope protection work)
- Selection of countermeasures and work methods that minimize traffic interruption during work
- Selection of countermeasures that harmonize with the environment
- Selection of countermeasures that minimize maintenance problems

1) Active introduction of new techniques and work methods (especially concerning slope protection work)

Many of the cut slope failures subject to design are caused by the weathering of the slope surface and its erosion and scouring resulting from surface water flow, but no slope protection work has been applied to almost all of the slopes. Of the work methods currently used in the Philippines, vegetation, stone pitching and cast-in-place concrete crib work are spplicable for slope protection. These methods, however, are costly and time-consuming when applied to full-scale protection of large slopes. A quicker and less costly method is available in, for example, concrete spraying, which is as yet unused in the Philippines. The initial cost of adopting this method is not very high, since all that is required are simple equipment such as compressors and spray guns. Although vegetation work can be done by hand, the adoption of seed mud spraying which is also as yet unused in the Philippines will considerably shorten the work period. The same equipment used in concrete spraying can be used in seed mud spraying.

The total area requiring slope protection in the sections subject to the Study is about 340,000 square meters. Considering also the fact that there are many slopes requiring immediate protection work in sections not subject to the Study, taking this opportunity to introduce new slope protection techniques and methods such as concrete spraying, seed mud spraying, etc. to the Philippines is believed to be extremely meaningful.

2) Selection of countermeasures and work methods that minimize traffic interruption during work

Allowing traffic to flow without obstruction and maintaining its safety during work is an important consideration in selecting countermeasures. In general, re-cuttings produce a large amount of excavated materials, and so seriously affect traffic. Therefore, whenever possible, application of re-cutting should be avoided. In the Study, for example, a slope protection method such as sprayed concrete crib combined with rock bolts were selected even for slopes with gradients of slightly steeper than standard, which ordinarily would be corrected by re-cutting.

Since, as mentioned previously, the major cause of cut slope failure was weathering of slope surface and its erosion and scouring due to surface water, even if re-cutting is applied, slope protection work is required to prevent weathering, erosion and scouring. Therefore, it is more economical in many cases to apply a slightly stronger slope protection which can somewhat heighten slope stability than usual, instead of re-cutting. Many of the existing slopes have irregular surfaces caused by erosion and scouring, and in order to protect these slopes with concrete pitching, stone pitching or cast-in-place concrete cribs, substantial cutting is required to correct the irregularities and make slope surface smooth. However, since sprayed concrete cribs can be applied to irregular surfaces, there is no need for cutting work. Hence, in the Study, sprayed concrete crib work is applied to many spots. This method is as yet unknown in the Philippines, and it will be necessary to newly introduce its techniques and work methods.

However, there are still some slopes which will require recutting or removal of unstable materials on the slope. In cases where slopes are low, recutting will be done by providing a protection fence at the center of the carriageway so as to have one-way traffic. However, majority of the slopes in the study are so high that the protection fence is not safe to traffic since falling rocks and other materials may go over the fence. In such cases, a temporary structure covering the carriageway such as a rock shed may be necessary to assure perfact traffic safety, but this will cost even more than the countermeasure work itself. Hence, in the Study, as the next best method, re-cutting and removing of unstable materials at night and regulating traffic to certain hours were adopted. The cost required for effecting this method is included in the work items concerned.

3) Selection of countermeasures that harmonize with the environment

Structural protection does not always harmonize with the surrounding natural scenery. Slope protection by vegetation, on the other hand, provides green to the slopes and creates a pleasing sight in harmony with nature. In the Study, therefore, slope protection with vegetation was given priority as much as possible, except in those slopes where soil and rock properties and other factors indicate that vegetation will not take root.

4) Selection of countermeasures that minimize maintenance problems

Generally, there are 2 types of countermeasures: one is to prevent the occurrence of disaster by slope protection works, and the other is to prevent from spreading of damage by catch works although failure may occur. The first type requires a large initial cost and lesser maintenance cost, while the second type is vice-versa.

Countermeasure was selected considering both initial and maintenance costs. The first type of countermeasure was applied mainly to cut slope failure, because cut slope failures caused mainly by erosion, scouring and weathering are extending year by year, requiring higher maintenance cost if suitable slope protection is not provided. On the other hand, the second type of countermeasure was mainly applied to rock falls.

Slopes susceptible to rock falls are usually composed of hard rocks which are hardly weathered, eroded and scoured, so application of the second type of countermeasure may not cause a gradual enlargening of the disaster scale accompanying problem in maintenance.

10.2 LAND AND GEO-TECHNICAL SURVEYS

10.2.1 Land Survey

The following surveys were made:

- Centerline and profile surveys of sections subject to the study for the purpose of identifying their road alignments
- Cross-leveling and preparation of topographical maps of potential disaster spots for the purpose of designing countermeasures
- Preparations of topographical maps of sections thought to require route relocation

The extents to which the surveys were made are given in Table 10.2.1

TABLE 10.2-1 VOLUME OF SURVEYS

ITEM	Section			
	Dalton Pass	Kennon Road	Mahaplag -Sogod	Total
Traverse and Profile Surveys	20 km	24 km	23 km	67 km
Cross-sectional survey and topography	10 spots (37 sections)	35 spots (99 sections)	25 spots (85 sections)	70 spots
Topography for study of shifting the route	-	1 section	1 section	2 sections

Centerline and profile surveys were conducted only in those sections where disaster spots subject to design exist and on which road alignment data or maps are lacking. Table 10.2-2 shows the lengths of the surveys conducted compared to the total lengths of sections concerned.

TABLE 10.2-2 LENGTH OF CONDUCTED SURVEYS

Section	Total Length (km)	Length of Conducted Surveys (km)	Remarks
Dalton Pass	77.500	20.00	Using map of F/S on Dalton Pass Tunnel Project
Kennon Road	34.240	24.000	Only in sections where disaster spots exist
Mahaplag-Sogod	36.650	23.00	- do -

The accuracy of the centerline surveys is 1/10,000 and that of the profile surveys, ±6cm /S (S = horizontal length to be surveyed in kilometers). Based on their results, alignment maps with scales of 1/200 vertical and 1/2,000 horizontal were prepared. When conducting the profile surveys, temporary benchmarks were provided at each disaster spot or spot nearby. A total of 61 benchmarks were provided.

Cross-levelings of disaster spots were conducted every 50 meters as a rule and every 20 meters where the topography is complicated. The accuracy is ±6cm /S . Based on crossleveling results and field observations, topographical maps with five-meter contour lines were prepared. The scales of cross-leveling maps and topographical maps are 1/200 and 1/400, respectively.

Cross-leveling and topographical maps were made only for large-scale or typical disaster spots. Countermeasures for the remaining spots are designed on the basis either of existing maps or on rough measurements and sketches made at the time of field surveys. Table 10.2-3 shows the number of spots surveyed compared to total number of disaster spots.

TABLE 10.2-3 NUMBER OF DESIGNED SPOTS AND SURVEYED SPOTS

Section	Total Number of Disaster Spots	Number of Surveyed Spots	Number of Sketched Spots	Number of Spots utilizing available data*
Dalton Pass	73	10	34	29
Kennon Road	46	35	11	-
Mahaplag - Sogod	46	25	14	-
Total	159	70	59	29

*Data available in the Feasibility Study on Dalton Pass Tunnel Project were utilized.

Spots thought to require route relocations are the two sections; one is at spot No. IK-39, IK-40, IK-41 and IK-42 on the Kennon Road, where there are successions of high cut slopes, and the other is at spot No. VIII-81 of the Mahapalg-Sogod section, where there is a large-scale cut slope failure. Cross-levelings were conducted over a wider area in these two sections, and based on the results topographical maps with five-meter contour lines, which allows planning of route relocation, were prepard. The scales of the cross-leveling and topographical maps are 1:200 and 1:1,000, repectively.

10.2.2 Geo-technical Survey

Ordinarily, the following surveys are conducted to investigate the characteristics of disaster;

i) Field surveys so investigate and record the current state of disaster spot, namely its topography, geologic formation, rock properties, slope protection, spring water, shape of slope failure, etc.

ii) Soundings, borings and seismic surveys for the purpose of estimating sliding plane of failure or landslide, or to check groundwater conditions and so on.

iii) The use of field intrumentations such as a landslide gauge where landslides have occurred, to measure its movement.

Countermeasures are designed by putting together the results of all the above surveys.

In the Study, the above surveys were conducted as the following measures

i) To investigate the current states of disaster spots, tables to check factors thought to cause disasters were prepared and filled in, and sketches and photographs were attached. The check tables thus prepared are given separately.

ii) Estimations of sliding planes and investigations of groundwater conditions were limited to spots with large-scale cut slope failures or landslides. Borings and seismic surveys by blasting were conducted at one spot on the Kennon Road and two spots in the Mahaplag-Sogod section. Table 10.2-4 gives the spots surveyed and the extents to which the survey were conducted.

TABLE 10.2-4 QUANTITIES OF GEO-TECHNICAL SURVEY CONDUCTED FOR INVESTIGATION OF SLIDING PLANE AND GROUND-WATER

Spots	Km Post	Kind of Disaster	Quantities Conducted		Remarks
			Boring	Seismic Survey	
IK -48	247 + 00	Landslide	2 Holes 57 m.	3 Lines 400 m	Kennon Road
VIII - 81	1010 + 40	Cut Slope Failure	2 Holes 70 km.	3 Lines 700 m	Mahaplag - Sogod
VIII - 71	1005 + 100	Landslide	2 Holes 25 m.	-	Mahaplag - Sogod
Total			5 Holes 152 m.	6 Lines. 1100m.	

Concerning borings, standard penetration tests were conducted in areas composed of earth and of soft rock, in areas composed of rock, corings were made and groundwater levels were observed. The results were presented as geological cross-sectional maps, which are given in the APPENDIX Volume.

iii) Since most of the cut slope failure found in the sections subject to the study are caused by erosion or scouring, therefore, boring tests were not conducted ar these spots.

Instead, seismic surveys by hammering were conducted on typical cut slopes composed of rock, in order to investigate the relationship between the velocity of seismic wave, P wave, and stable slope gradient. Spots surveyed are 10 on the Kennon Road and 8 in the Mahaplag-Sogod section, or 18 spots all together. The survey results were used in determining stable slope gradients. The survey was not conducted in the Dalton Pass section under the study because the same survey has already been conducted during the feasibility study on the Dalton Pass Tunnel Project; the results of this survey can be used in the study.

Since JICA donated a landslide gauge to the MPWH, measurement of movement of landslide were planned. However, the results of measurement could not be used for the Study, because of time constraint.

10.3 SELECTION OF COUNTERMEASURES

10.3.1 General

There are countermeasures commonly applied corresponding to the type or the cause of disasters. The countermeasures which can be effectively used for the road disaster in the Philippines were listed up based on examples of various countries.

The most appropriate countermeasure to the cause of disaster assumed based on investigations of topography, geology, surface water, subsurface water and other conditions was selected among the countermeasures listed up.

In the selection of countermeasures natural conditions related to the road disasters in the Philippines, especially severe weather involving extremely high rainfall intensity, were taken fully into consideration. However, there are somewhat misgivings about design criteria and durability of countermeasures, especially, slope protection works. Although, all slope protection works applied in the Study are practically used in Japan, they are not used in the philippines as yet. Therefore, their durabilities under such a severe natural condition as the Philippines are not proved yet. Pilot application of slope protection works is desirable to check design criteria and their durabilities.

10.3.2 Cut Slope Failure

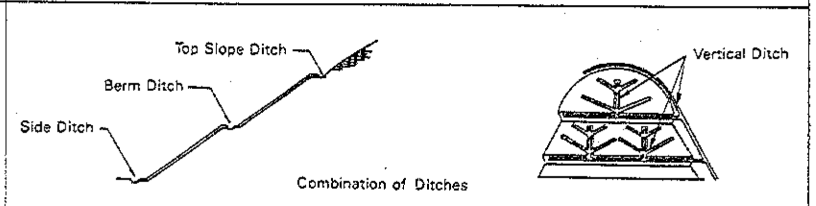
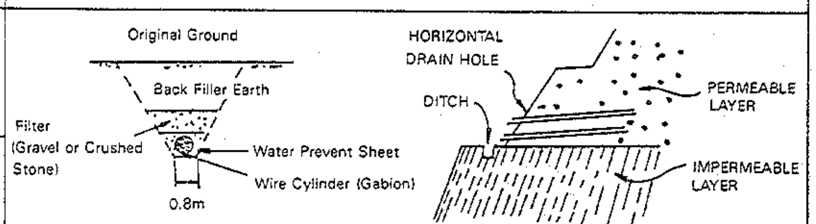
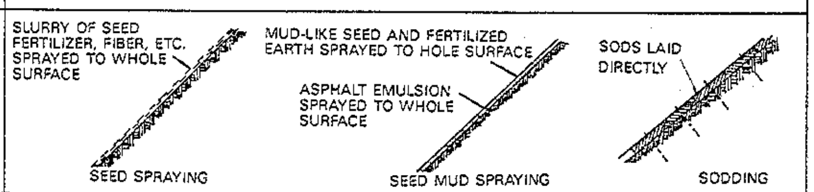
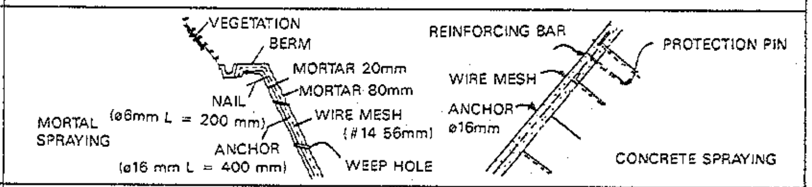
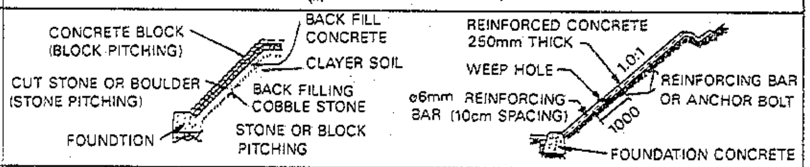
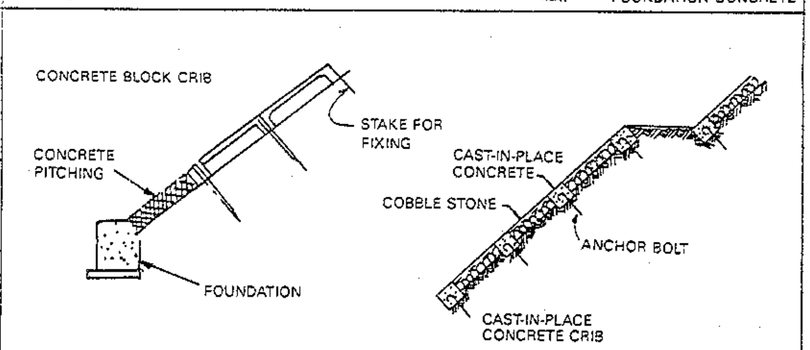
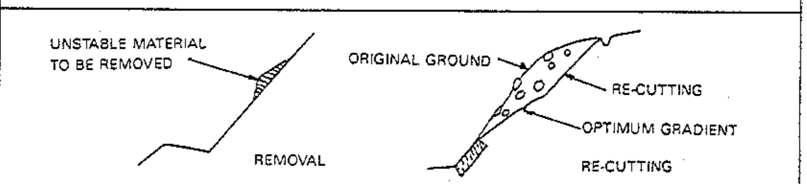
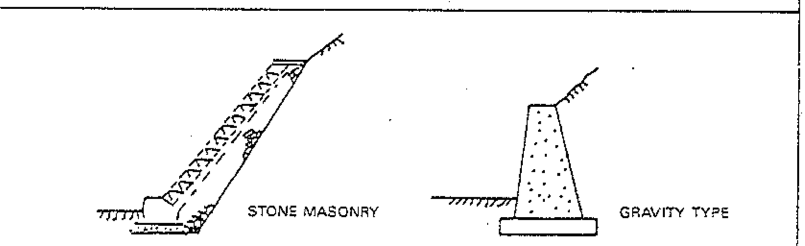
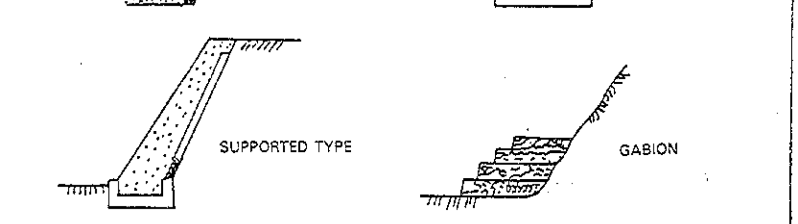
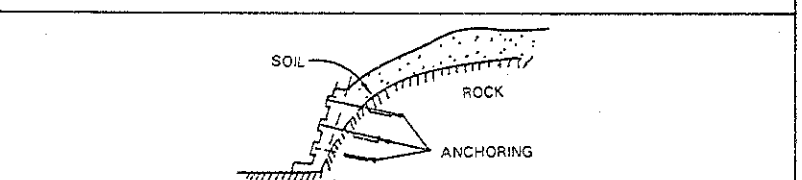
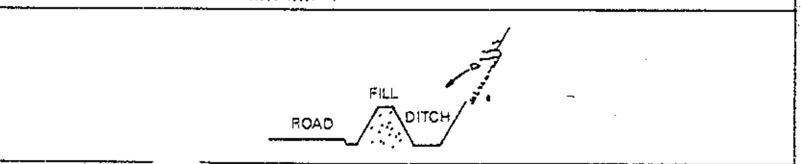
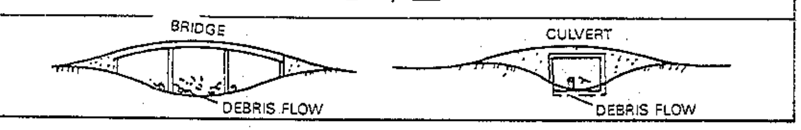
Table 10.3-1 gives the main countermeasures which can be applied to cut slope failures.

In cases of large-scale cut slope failures where applying countermeasures directly onto the slope is technically difficult or extremely costly, catch work or avoiding problem work is usually applied. Catch work means the construction of a ditch, fill or retaining wall between the toe of slope and the road to prevent failured materials from extending to the road. In other words, the purpose of this countermeasure is not to prevent cut slope failure from occurring, but to prevent the failure from affecting the road.

As mentioned in 10.1.2, however, many of the cut slope failures seen in the sections subject to the Study are caused by either weathering or erosion and scouring due to surface water. Therefore, appropriate slope protection is necessary in order to prevent the scale of failure from growing over the years and the removal of failured materials from becoming a major maintenance problem. For this reason, together with the fact that there are few sections with enough room to allow the construction of catch work between the toe of slope and road shoulder, catch work was not applied to cut slope failures in the Study.

Avoiding problem work means shifting the route to avoid the disaster potential spot. This was considered for spots IK-39, IK-40, IK-41 and IK-42 in the Kennon Road where there are successions of high cut slopes and for the spot VIII-81 in the Mahaplag-Sogod Section where there is a large-scale slope failure, but because it was not found to be economical, it was not applied in the Study. (See Appendix 5-2)

TABLE 10.3-1 COUNTERMEASURES FOR CUT SLOPE FAILURE

Classification		Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Top slope Ditch	To collect surface water running directly on slope surface and thus prevent erosion and scouring of slope surface.	Required for almost all cases of slope protection, especially for slope with broad area or water concentration. Usually applied together with other countermeasures.	
		Berm Ditch			
		Side Ditch			
		Vertical Ditch			
	Subsurface Drainage	Subsurface Drainer	To drain groundwater, spring water and seepage water and lower pore with pressure and thus stabilize stability of slope.	Effective to drain water near ground surface. Generally used in combination with surface drainage.	
		Horizontal Drain Hole		Effective for slope where ground-water level is higher than plane of failure.	
Protection Work	Vegetation	Seed Spraying	To firmly bind materials of slope surface and thus prevent slope from erosion, scouring and weathering.	Mainly applied to slopes composed of soil or strongly weathered rock. When applied, gradient is preferred to be less than 0.8:1. It improves aesthetics view of the environment.	
		Seed Mud Spraying			
		Sodding			
	Spraying	Mortar Spraying	To cover whole surface of slope with mortar or concrete sprayed by concrete gun and thus prevent slope from erosion, scouring and weathering.	Mainly applied to slope of. . Easily weatherable rock with no spring water or not wet. . Weathered rock which may be stripped off. . Soil not suited for vegetation.	
		Concrete Spraying			
	Pitching	Stone or Block Pitching	To cover slope with stone, or concrete block or cast-in-concrete and thus prevent slope from erosion, scouring, weathering and slight surface failure.	Applied to slope gentler than 45°. Stone pitching is widely adopted.	
		Concrete Pitching			
	Crib	Concrete Block Crib	To prevent slope from erosion, scouring, weathering and slight surface failure. — Resisting force against earth pressure may not be expected.	Applied to slope gentler than 45°. Effective for slope with spring water.	
		Cast-in-place Concrete Crib			
		Sprayed concrete crib	Resisting force against earth pressure may be expected depending on size and space of crib.	Applied to slope steeper than 45°. Effective for weathered rock and large slope with spring water. — *1 / *2	
Earth Work		Removal	To stabilize slope by completely or partially removing unstable materials on slope.	Basic method. Reliable when perfectly enforced. Applied together with drainage, vegetation and other protection works. Application is sometimes limited because of traffic interruption.	
		Re-cutting	To stabilize slope by cutting to optimum gradient.		
Structural Work	Retaining Wall	Stone Masonry Retaining Wall	To protect slope from small size failure, especially, near toe of slope.	Effective only for small earth pressure. Applied to slope with gradient steeper than 45° and with firm soil. Height less than 7 m.	
		Gravity Type Retaining Wall	To directly restraint slope failure or used as a foundation of other works.	Strong bearing ground is required. Height less than 5 m.	
		Supported Type Retaining Wall	To directly restraint slope failure and prevent erosion, scouring and weathering.	Applicable for soil with loose solidification. It can be constructed in limited area. Height less than 8 m.	
		Gabion Retaining Wall	To protect slope from small size failure, especially near toe of slope.	Effective for slope with seepage or spring water.	
	Anchoring	Rock Bolt	To directly restraint slope failure. Usually applied together with concrete pitching crib, etc.	Mainly applied to slope with strongly weathered rock or rock with many cracks and joints. Rock bolt is for small tension against anchoring, while p.c. is for high.	
		P.C. Anchor			
Catch Work		Catch Fill and Ditch	To prevent spread of damage providing ditch and fill or wall to catch failured materials. Occurance of failure can not be prevented.	Applied when other countermeasures are difficult or costly. Wide space for deposite is required between road edge and toe of slope.	
		Catch Wall			
Avoiding Problem Work		Route Relocation	To avoid problem by relocating route or pass over disaster site with bridge.	Applied when other countermeasure are difficult or costly.	
		Bridge			

Note: *1. Irregularity of slope surface shall be corrected. Form is required.

*2. Irregularity of slope surface is not necessary to correct. Form is required. Concreting is done by spraying with gun.

Removing unstable soil and rock mass on slopes is called removal work. No matter what other countermeasures are applied, it is always necessary to first remove unstable soil and rock on the slope, and hence this was applied frequently in the Study.

Re-cutting is applied to correct slopes whose gradients are too steep and unstable. This is one of the most basic measures to heighten stability of the slopes but, when applied to very large slopes, it requires a large amount of excavation and so interrupts traffic flow, while work is going on. Therefore, as discussed in 10.1 recutting was avoided whenever possible in the Study. Instead of the re-cutting, as a countermeasures to ensure stability of slope, protection works which can resist earth pressure to a certain extent and structural works such as retaining walls were applied. However, re-cutting could not be avoided in many soil slopes.

Protection work by vegetation is to plant vegetation on a slope to prevent its erosion and scouring. The vegetation prevents rainfall from falling directly onto the slope and its roots binds the slope surface. Since this requires relatively low cost and greens the slopes, it was appiled whenever possible as a favorable protection work. Vegetation cannot grow on the following types of slopes, therefore, protection by structure is applied to such cases;

- Slopes with gradients steeper than 0.8 : 1
- Slopes of hard rock, slopes of soft rock with slight weathering or with few cracks and slopes of highly acid soil
- Slopes with a large amount of spring water

There are two main type of construction methods of slope protection by vegetation; method by hand and method by equipment. Although the method by hand such as sodding and planting of some kind of surub is used in the Philippines, the method by equipment, especially seed mud spraying, was applied as a main slope protection work by vegetation from the view point of prompt and economical construction as stated in 10.1.3. Seed mud spraying is to spray mixture of seeds, soil, fertilizer and water onto the slope by pump or spray gun.

Protection work by structure such as spraying, pitching and crib is applied for the slope where vegetation cannot grow, or when the stability of slope cannot be assured for a long period of time with vegetation. Concrete pitching and crib work can also be used as control work to resist big earth pressure when applied with rock bolt and p.c. anchor.

Spraying consists of mortar and concrete spraying but, mortar spraying was not adopted because it is not acceptable as a permanent structure under the high temperature and rainfall intensity in the Philippines. Concrete spraying was positively adopted because of its strength against earth pressure, quicker construction and it is more economical than other protection works by structures, notwithstanding the advantage that irregularity of surface of the slope does not need to be corrected.

Pitching is classified into stone pitching, block pitching and concrete pitching depending on materials to be used. Although these works can be performed in the Philippines, these would require a higher cost than concrete spraying and calls for correction on the irregularity of slopes. Therefore, these works were not recommended.

Crib work is a method of protecting slope surface with concrete cribs, which consists of pre-cast concrete block cribs and cast-in-place concrete cribs. In pre-cast crib work, concrete blocks manufactured at a plant are put together at the work site. Since pre-cast concrete blocks are not manufactured in the Philippines, only cast-in-place concrete crib work is applied in the Study. The dimensions of cast-in-place concrete cribs are determined in accordance with the degree of slope weathering, crack conditions, slope gradient and other factors. Where the cross point of cribs are fixed to the slope with rock bolts or PC anchors, the crib can be applied to control work, since it provides resistance to failure pressure. From environmental considerations, it is desirable that the space of cribs be filled with soil and planted with vegetation to green the slope, however, stone pitching is advised on slopes with spring water and concrete pitching for highly weathered slopes.

As mentioned earlier common type of cast in place concrete crib work is generally conducted after correction of the irregularity of the slope surface. However, sprayed concrete crib work, which allows working on irregular surfaces, is being more frequently used recently. The sprayed concrete crib work, is done so that a flexible wire net from is placed along the irregular surface of the slope, reinforcement bar are placed inside the from and concreting is done inside the from by spraying. This work can be accomplished in a shorter period of time since there is no need to correct irreqularity of the slope surface and concreting can be done with concrete spraying. Further, this can resist earth pressure when this is adopted with rock bolt and p.c. anchor. Because of these advantages, this is used in many cases in the Study.

Structural work includes retaining walls and anchoring. Retaining walls are primarily applied to the lower portion of a slope where gradient is steep to resist earth pressure. Main types of retaining walls include stone masonry, gravity type, supported type, and gabion retaining walls. In the study, stone masonry and supported type retaining wall were applied to cut slope failures.

The causes of cut slope failure by water may be divided into two: first, erosion and scouring due to surface water running down on slope surface; and second, sliding of the slope due to decrease of shearing strength and increase of pore water pressure because of elevation of groundwater. Cause of failures in the study is mostly on the first case. Thus, drainage work (especially surface drainage) is considered vital for slope protection. The following drainage ditches are planned and adopted:

- Top Slope Ditch. This type of ditch is planned at the top of the slope when running water from adjacent area is expected. The water accumulated from the ditch is directed outside the slope but when this is not possible, drained to vertical ditches constructed in the slopes.

- Berm Ditch. For wider and higher slopes a considerable amount of surface water flows down the slope surface causeing erosion and scouring. To prevent this, the berm ditch is proposed on the berm of the slopes, however, existing slopes are seldom provided berms. For slopes where re-cutting was planned berm ditches are proposed on all berms considering the high rainfall intensity in the Philippines.

- Vertical Ditch. Deep scouring due to surface water was often observed for concave-shaped cut slopes. In these cases, vertical ditches are provided. This type of ditches are also used to drain water collected from top slope ditch and berm ditch. At the bottom of the ditch a catch basin is desgned and connected to the existing drainage system. When there are no existing side ditches, new side ditches were designed and connected with available cross drain structures.

A large amount of seepage water was observed at the spot of a large scale of cut slope failure at km. 1010 + 450 in Mahaplag-Sogod Section. Horizontal drain holes were applied at this spot to drain groundwater.

10.3.3 Embankment Slope Failure

Table 10.3-2 gives the main countermeasures which can be applied to embankment slope failure. There are many failured slopes that remain without any remedial measures. For such slopes, re-filling work was proposed to obtain standard gradient of embankment sope. However, where this was not possible due to constraint of topographical condition, the retaining wall at the toe of the slope, pitching or crib work on the slopes were adopted.

The retaining wall applied was stone masonry, gravity type, supported type and gabion. Careful selection was made considering characteristics of these works. For example a gabion retaining wall was adopted for the slope where no firm foundation exists and a big amount of seepage water exists.

Stone pitching was applied as a typical method of pitching for the slopes lesser than 45°. Crib work was used with p.c. anchor for steep slopes to resist earth pressure.

Seed spraying is adopted for all slopes except those covered by retaining wall or pitching.

Almost all slopes observed are deteriorated by scouring due to concentration of surface water on roadway. Drainage system was planned with the following considerations:

- Side Ditch. Water on the road surface is generally concentrated at the inner side of curved roads with longitudinal gradient and thus creating huge scouring. This failure was created either because there were no side ditches or capacity of ditches were insufficient. The side ditch was planned at many spots.

- Berm Ditch. Berm ditches are not provided on the existing embankments. In this study berm ditch was designed for all slopes where re-filling was planned.

- Vertical Ditch. Vertical ditch was planned at points where concertrated surface water flows down on embankment slope or to guide the flow of water that is collected from berm ditches.

Pipe and box culvers were planned at sites where cross drain structures are insufficient, based on the study existing drainage system.

Serveral cases of embankment failures due to groundwater were observed. Therefore, when re-filling was applied, horizontal drain layer was planned to drain seepage water.

There are several slopes scoured by the river stream. In this case, stone pitching and stone masonry is applied to protect the bank and foot protection is provided for scouring of foundation.

10.3.4 Fall

Table 10.3.3 gives the main countermeasures which can be applied to falls. The removal work aims to remove unstable material from the slope. On the other hand, fixing work aims to fix unstable materials at site. Removal work is one of the basic methods and should be adopted prior to execution of protection work and anchored wire net. In the Study therefore, removal work was frequently used while the fixing work was not applied.

Re-cutting work was applied for over-hanging slopes, especially those along Kennon Road.

The fall generally occurs from slopes composed of hard rocks with developed cracks or joints, even though there is no erosion, scouring and weathering. For these slopes catchwork was adopted. The catchwork is classified into: catch fill and ditch, catch wall, catch fence, catch wire net and anchored wire net. Rock shed may be included as catchwork. The rock shed is applied only for large scale fall. This was not applied in the study. Other catchworks are more economical than slope protection works. However, catch fill and ditches and catch wall were not adopted because these require wide space for deposits between road edges and toe of slopes. Thus anchor wire net was used in many cases and catch fence for only one spot.

For the slopes composed of meterials that are easily eroded, scoured and weathered, slope protection works shall be applied rather than catch works. Therefore, seed spraying, concrete spraying and free frame were adopted to such slopes. For the slopes with falls due to surface water, as mentioned in cut slope failures, surface drainage work such as top slope ditches, berm ditches and vertical ditches were applied. However, these are not applied for slopes with hard rock which may not be eroded and scoured due to water.

10.3.5 Landslide

Table 10.3-4 gives tha main countermeasures which can be applied to landslides.

Sub-surface drainage aims to drain groundwater in order to prevent lowering shearing stress and raising water pore pressure. These works consist of closed conduit, horizontal drain hole and deep well.

Close conduit drains groundwater near the surface. However, this was not applied in the Study because groundwater exists in deep portions in all landslide to be subjected.

Horizontal drain hole is mode by horizontal boring up to the ground water holding layer and ground water is drained through the hole drilled.

Deep well is a method of draining groundwater through horizontal boring which is connected to the deep well, constructed in the landslide area. This is applied for large scale landslide with large volume of groundwater.

In the Study, the horizontal drain holes were applied to the landslides, except one in Kennon Road in which the level of groundwater is not so high according to result of boring survey. However, judging from the scale of landslide and volume of groundwater, deep well is deemed not necessary.

Earth removal work is generally accepted as a reliable and effective method. This is widely used for small and medium size landslides. In the Study, this method was planned as a major countermeasure for landslides. Excavated surface was protected by seed mud spraying.

Counterweight fill aims to control movement of landslide force by the weight of the fill. This method is simple and therefore widely applied to slopes where there is space for the filling at the toe of embankment. There are some spots where this particular method was applied in the Study.

Piling was applied for IK-48 in Kennon Road because there is no space where removal work or counterweight fill is applied.

Surface drainage will prevent surface water seepage into the sliding mass. However, this method is not applied in the Study.

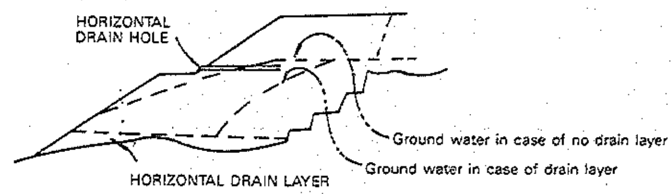
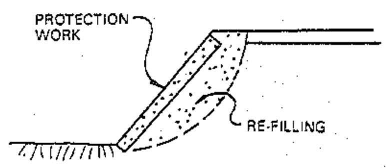
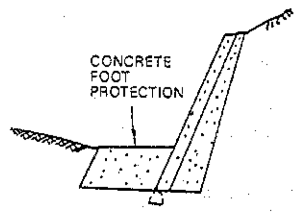
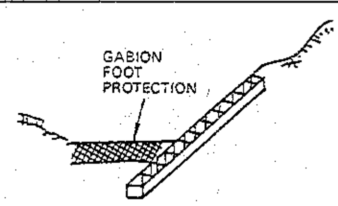
10.3.6 Debris Flow

Table 10.3-5 gives tha main countermeasures which can be applied to debris flow.

In some cases, avoiding problem work through bridges and culvert proves to be more economical than method to directly prevent occurrence of debris flow. For II-11, along the Dalton Pass section where large size debris flow exists, avoiding problem work through a bridge was studied but not adopted because of the extensive width of debris flow which requires a long-span bridge. Thus preliminary countermeasures as mentioned in 10.1.3 was planned. For the other spots with rather small sized debris flow, a small sabo dam or waterway was adopted because this proves to be more economical than the culvert to avoid flow.

Since the torrent subject to debris flow is generally small sized, a small sabo dam with waterway of 20 to 30 m. length upstream from where the torrent crosses the road, was deemed sufficient to prevent damage to roads caused by debris flow. Waterway was designed using stone pitching and planned with concrete consolidetion or small sized concrete sabo dam.

TABLE 10.3-2 COUNTERMEASURES FOR EMBANKMENT SLOPE FAILURE

Classification		Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Berm Ditch	Same as Countermeasures for Cut Slope Failure		Same as Countermeasures for Cut Slope Failure
		Side Ditch			
		Vertical Ditch			
	Subsurface Drainage	Subsurface Drainer	To drain groundwater, spring water and seepage water and lower pore water pressure and thus stabilize stability of slope.	Effective to drain shallow surface water.	
		Horizontal Drain Hole		Mainly applied to high embankment which is already or may be saturated. Effective for slope where groundwater level is higher than plane of failure.	
		Horizontal Drain Layer			
Protection Work	Vegetation	Seed Spraying	To firmly bind materials of slope surface and thus prevent slope from erosion, scouring and weathering.	Should be applied to any slope. It also improves aesthetics view on environmental aspect.	Same as Countermeasures for Cut Slope Failure
		Seed Mud Spraying			
		Sodding.			
	Pitching	Stone or Block Pitching	To prevent erosion and scouring slight resisting force to protect surface failure may be expected.	Mainly applied to slope gentler than 45° of high embankment susceptible to scouring.	
	Crib	Concrete Block Crib	To prevent erosion, scouring and slight surface failure. Resisting force against earth pressure may not be expected for block crib, but expected for cast-in-place crib.	Applied to slope with broad area or steeper than 45° where vegetation can not be appied or not effective.	
		Cast-in-place Concrete with form			
Earth Work		Re-Filling	To fill washed-out and broken-off portion of slope with earth and then, usually cover surface with protection in order to prevent further failure.	Applied to collapsed slope. Usually applied with other measures such as vegetation or pitching.	
				For scouring due to river stream, concrete crib is also used.	
Structural Work	Retaining* Wall	Stone Masonry Retaining Wall	Same as Countermeasures for Cut Slope Failure		Same as Countermeasures for Cut Slope Failure
		Gravity Type Retaining Wall			
		Supported Type Retaining Wall			
		Gabion Retaining Wall			
	Foot Protection	Concrete Foot Protection	To protect foot of retaining wall or other protection work.	Applied to foot which may be scoured by river stream.	 
		Gabion Foot Protection			

* Retaining wall is sometimes called as revetment, when it is used to protect scouring of slope due to river stream.

TABLE 10.3-3 COUNTERMEASURES FOR FALL

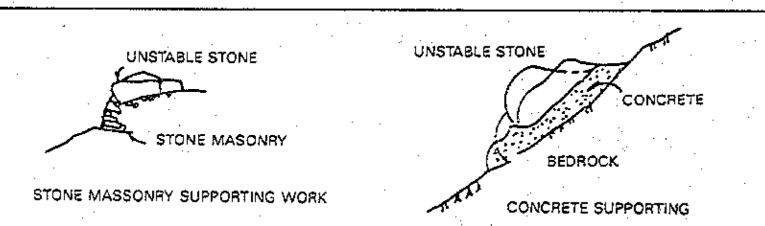
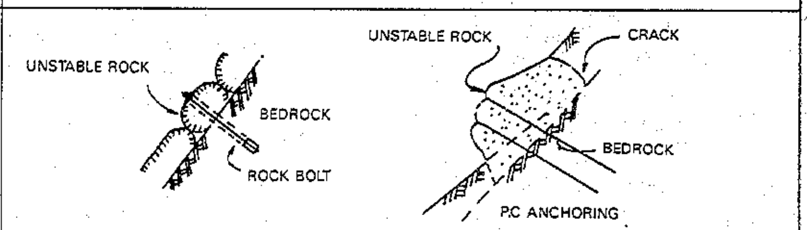
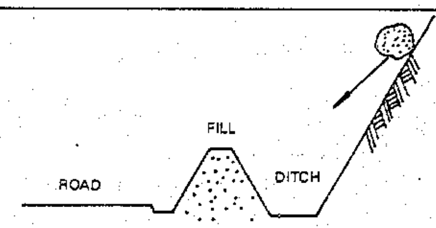
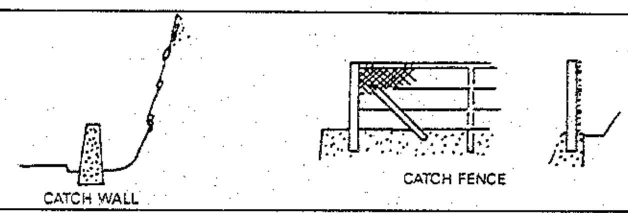
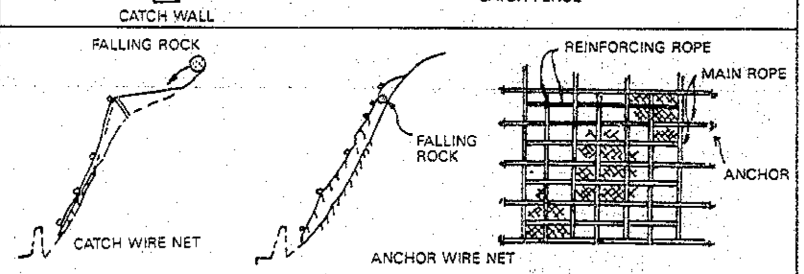
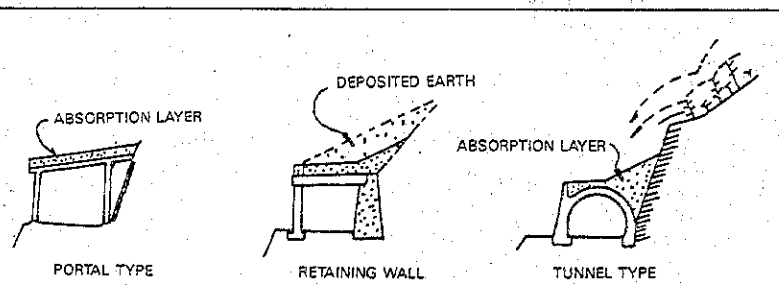
Classification		Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Top Slope Ditch			
		Berm Ditch			
		Vertical Ditch			
	Vegetation	Seed Spraying			
		Seed Mud Spraying			
		Sodding			
Protection Work	Spraying	Mortar Spraying	Same as Countermeasures for Cut Slope Failure		Same as Countermeasures for Cut Slope Failure
		Concrete Spraying			
	Pitching	Stone or Block Pitching	It also aims to prevent rocks from separating and detaching from ground or bedrock.		
		Concrete Pitching			
	Crib	Concrete Block Crib			
		Cast-in-Place Concrete Crib with form			
		Sprayed concrete crib			
Earth Work		Removal	Same as Countermeasures for Cut Slope Failure		Same as Countermeasures for Cut Slope Failure
		Re-cutting			
Fixing Work	Supporting	Stone Supporting	To fix unstable rock supporting with stone or concrete.	Mainly applied to big and supportless rock difficult to remove. Base of supporting shall be firmly shored.	
		Concrete Supporting			
	Anchoring	Rock Bolt	To fix unstable rock anchoring to bedrock with rock or p.c. wire.	Mainly applied to big, hard and supportless rock difficult to remove. Anchoring shall be made into firm bedrock. Rock bolt for relatively small rock, while p.c. for boulders.	
		P.C. Anchor			
Catch Work		Catch Fill and Ditch	To prevent spread of damage by providing fill and ditch, wall or fence to catch falling materials. Occurrance of fall can not be prevented.	Wide space for deposite is required between road edge and toe of slope.	
		Catch Wall		A little wide space for deposite is required between road edge and toe of slope. Space for wall or fence is narrower than for fill and ditch.	
		Catch Fence			
		Catch Wire Net	To prevent spread of damage covering slope by net with pocket to catch falling rocks.	Applied where no space for deposite. Unsuitable to soil and rock slope which are easily weathered.	
		Anchor Wire Net	To provide resisting force to fall directly by covering slope with net but inefficient to prevent erosion and scouring.		
Rock Shed		Concrete Rock Shed	To avoid damage by covering whole width of road with shed.	Mainly applied to a large scale of fall. Applied only when other countermeasures are difficult and costly.	
		Steel Rock Shed			

TABLE 10.3-4 COUNTERMEASURES FOR LANDSLIDE

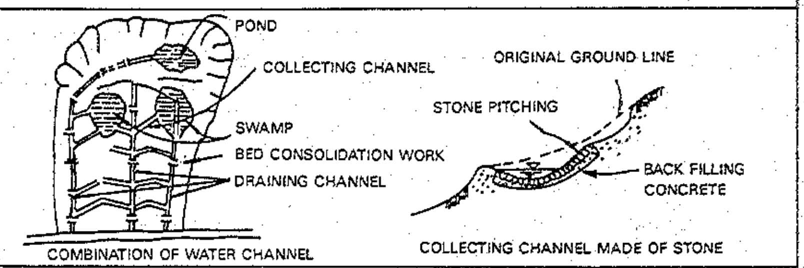
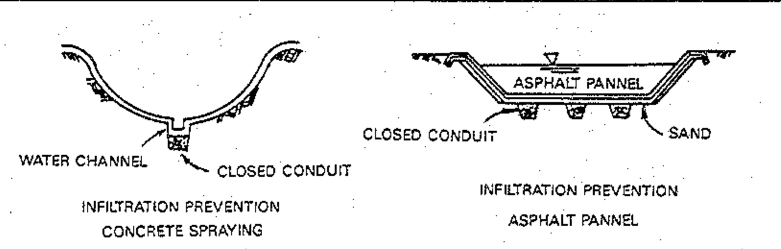
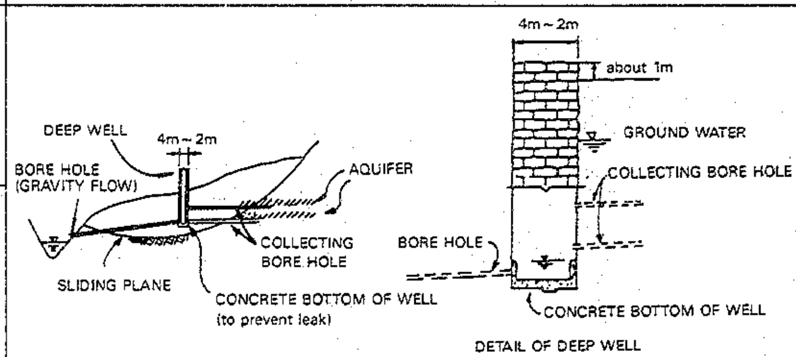
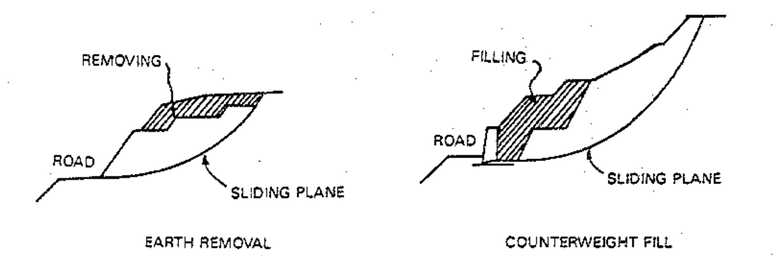
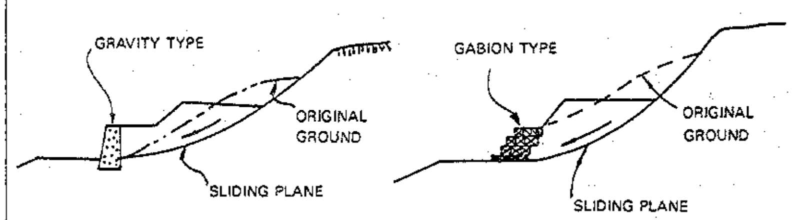
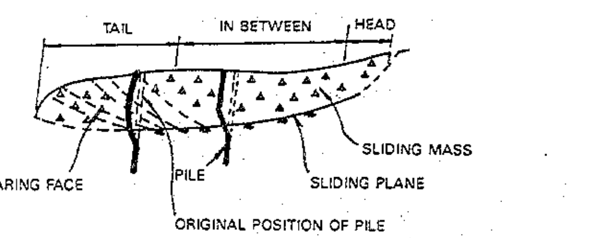
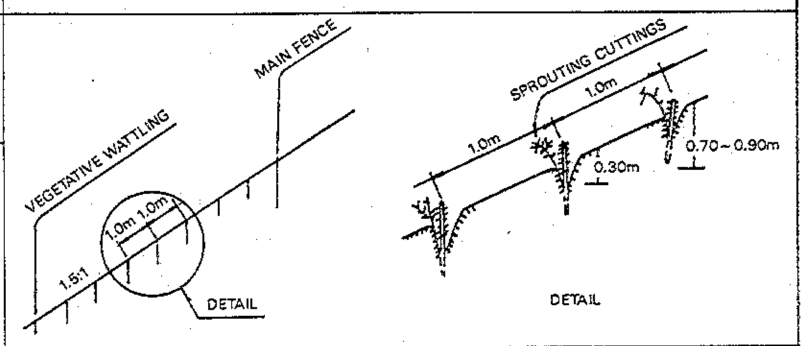
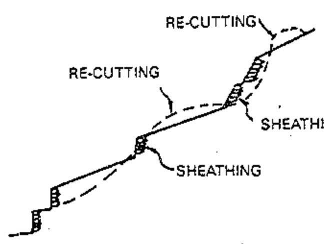
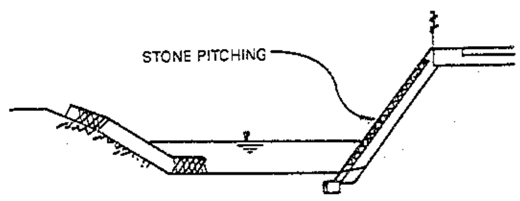
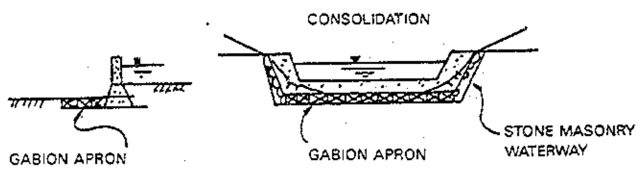
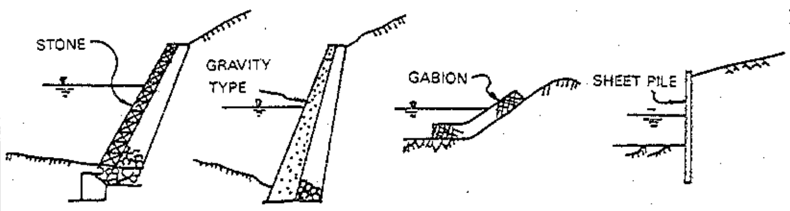
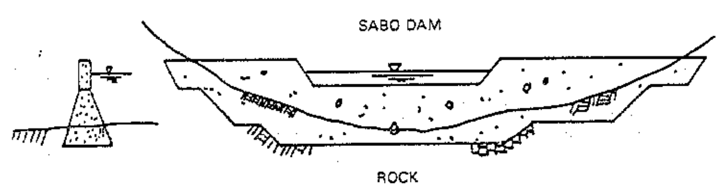
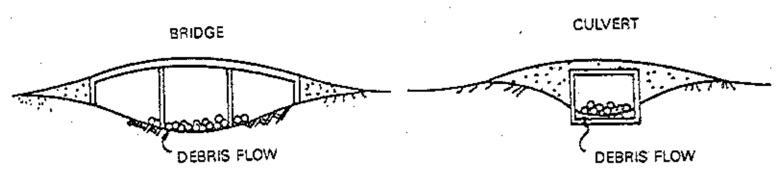
Classification		Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Water Channel	To quickly collect and discharge precipitated rain inside landslide area in order to prevent seepage water.	Applied to all cases. Water channel consists of collecting channel and draining. Effective channel network is required.	
		Infiltration Prevention	To cover cracks with cement, clay or other materials in order to prevent seepage of water into cracked portion inside landslide area.	Applied to call cases. Effective for cracked portion where seepage water easily infiltrates and on swamp or water route.	
	Subsurface Drainage	Subsurface Drainer	To drain groundwater and thus lower its level and pore water pressure.	Effective where groundwater level is higher than sliding plane.	
		Horizontal Drain Hole			
		Deep Well		Applied when drain hole is too long or crowdedly placed near bedrock.	
Protection Work	Vegetation	Seed Spraying	To prevent seepage of surface water into slide mass and also to protect slope from erosion and scouring.	Applied to all cases, whenever applicable. Applied to bare area.	Same as Countermeasures for Cut Slope Failure
		Seed Mud Spraying			
		Sodding			
Earth Work		Earth Removal	To stabilize slope by removing a partial or whole earth of sliding mass, usually head portion of sliding mass.	Reliable and effective method. Applied to many cases.	
		Counterweight. Fill	To control movement force of landslide by weight and shearing strength of fill. Filling of earth shall be executed at tail portion of landslide.	Wide area is required at toe of slide for construction. Groundwater shall be completely discharged.	
Structural Work	Retaining Wall	Gravity Type Retaining Wall	To control movement force of landslide, increasing resisting force by shear strength and weight of fill and wall. Anchoring is sometimes used to increase resisting force of wall against thrust of landslide.	Mainly applied to small scale landslide or secondary failure at tail portion of a large scale landslide. Gabion wall is mainly used as counterweight for tail portion of landslide.	
		Gabion Retaining Wall			
	Piling	Precast Concrete Pile	To control movement force of landslide by bending movement and shearing strength of pile. Anchoring is sometimes used to increase resisting force of pile against thrust of landslide.	Mainly applied to landslide where sliding plane is deep.	Conceptional Diagram of Pile Action 
		Cast-in-Place Concrete Pile			
		Steel Pile			

TABLE 10.3-5 COUNTERMEASURES FOR DEBRIS FLOW

	Classification	Type of Work	Purpose	Application	Illustration
Hillside Work	Drainage	Water Channel	To collect surface water on hillside and thus prevent slope from erosion and scouring.	Applied to many cases. Used with other counter-measures.	Same as Countermeasures for Landslide
		Subsurface			Same as Countermeasures for Cut Slope Failure.
	Vegetation		To firmly bind materials of slope surface and thus prevent slope from erosion and scouring.	Vegetation is usually applied in combination with protection work such as terracing with stone, net muddling, etc.	
	Afforestation		To cover hillside with tree and shrub and thus prevent slope from erosion and scouring and sometimes to reduce velocity of surface water.	Applied to bare hillside.	
	Re-cutting		To stabilize slope by cutting unstable portion of hillside and reforming irregularity of surface of slope.	Applied to hillside with irregularity Used with vegetation, sheathing and others.	
	Sheathing		To retain unstable earth with stone or concrete wall or wicker etc.	Applied to a little steep slop where earth shall be retained. Mainly used with other hillside work.	
Torrent Work	Water Way	Stone Pitching Water Way	To smoothly lead flow of water and thus control turbulent flow and prevent scouring of stream bed and bank. Also to prevent overflow of flood to adjacent area.	Applied to stream bank composed of erodable soil or to stream bed with steep gradient. Usually used together with consolidation or sabo dam.	
		Concrete Pitching Water Way			
	Consolidation	Stone Consolidation	To control flow of water providing head of water to make gradient of stream bed gentler and to prevent turbulent flow and thus prevent scouring of stream bed and bank. Sometimes only to protect stream bed.	Applied to swift stream, meeting point of flow or stream bed susceptible to scouring. Usually used together with revetment, water way and sabo dam. Concrete consolidation is widely used.	
		Concrete Consolidation			
		Crib Consolidation			
	Revetment	Stone Masonry Revetment	To protect stream bank or hillside from waterclash due to curved flow of stream.	Applied to curved portion of stream.	
		Gravity Type Revetment			
		Gabion Revetment			
		Sheet Pile Revetment			
	Foot Protection	Concrete Foot Protection	To protect foots of revetment and water way from scouring.	Applied to foots of revetment and water way.	Same as Countermeasures for Embankment Slope Failure
		Gabion Foot Protection			
Sabo Works	Sabo Dam	Stone Dam	To control flow of debris and to catch and collect debris and sand, providing space for deposited materials and making gradient stream bed gentler and thus avoid spread of damage and, at the same time, prevent scouring of stream bed and bank.	Mainly applied to large scale of debris flow. Constructed at portion such as narrow stream width, hard bedrock or after meeting of flow.	
		Concrete			
		Concrete Dam			
		Steel Dam			
	Avoiding Problem Work	Bridge	To avoid damage. Debris flows passes under bridge or inside of culvert.	Applied when other counter-measures are difficult and costly.	
		Culvert			

* Structural details of revetment may be same as those of retaining wall.

10.4 PRELIMINARY DESIGN

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

To avoid duplication of the description, in this chapter, only concrete procedures or solution without mentioning general matters, to design appropriate countermeasure selected based on characteristics of each disaster spot subjected in the Study were discussed.

Typical drawings of most countermeasure works designed in the Study are shown in Volume IV "Drawings"

10.4.1 Surface Drainage

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

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

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

Where:

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

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

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

. Ten minutes is used uniformly as the average time of concentration.
The cross-sections of ditches are obtained by the Manning Formula:

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

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

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

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

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

10.4.2 Subsurface Drainage

1) Closed Conduit

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

Mainly closed conduits with gabion as shown in Figure 10.4-1 were applied in the Study.

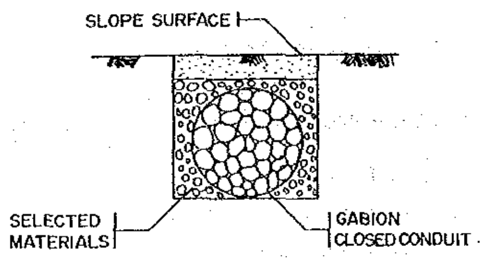


FIGURE 10.4-1 CLOSED CONDUIT

2) Horizontal Drain Hole

Horizontal drain holes with the following specifications were selected as countermeasure against subject landslide:

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

An illustration of horizontal drain hole is shown in Figure 10.4-2.

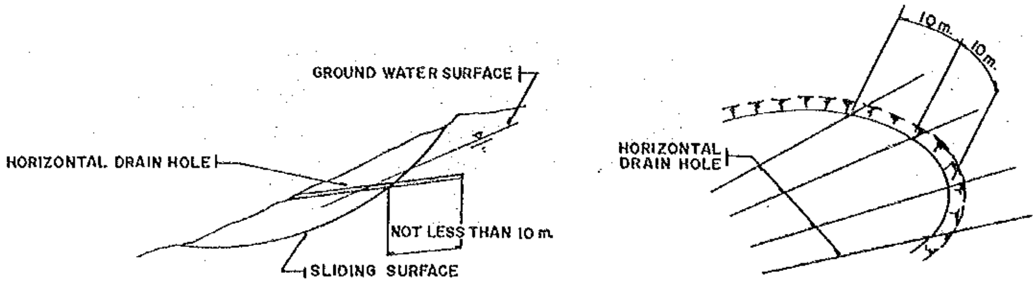


FIGURE 10.4-2 HORIZONTAL DRAIN HOLE

10.4.3 Removal Work for Cut Slope Failure and Fall

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

The quantity of removal work required was estimated as follows:

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

10.4.4 Re-cutting

Unstable slopes with steep gradients must be re-cut to achieve a stable gradient. The stable gradient of a slope is difficult to determine by stability calculation, because the characteristics of natural ground are complicated and inhomogeneous. It is the general practice to determine the stable gradient based on standard gradients established empirically. As an example, the standard gradients are shown in Chapter 5 of Volume V.

Cut slopes are usually provided with berms. The purpose of berm are: a) moderates the average gradient of the slope, thus providing greater stability and b) reduces the speed of surface water running down the slope, thus preventing erosion and scouring. In general, berms of 1.0 to 2.0 m widths are constructed at 5.0 to 10.0 m intervals of height. When a slope consists of different layers, it is desirable to provide berms at the borders of the different layers.

In the Study, re-cutting was designed by the following standards.

TABLE 10.4-1 STANDARD OF RE-CUTTING

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

As shown in Table 10.4-1, the berm was not proposed for the rock slope since erosion and scouring is not likely to occur. On the other hand, in slopes of soil and soft rock, 2-meter berms were provided, taking into consideration high rainfall intensity.

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

The quantity of re-cut material was quantified based on the cross sections surveyed and classified into earth, soft rock and hard rock.

10.4.5 Seed Mud Spraying

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

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

An illustration of seed mud spraying is shown in Figure 10.4-3.

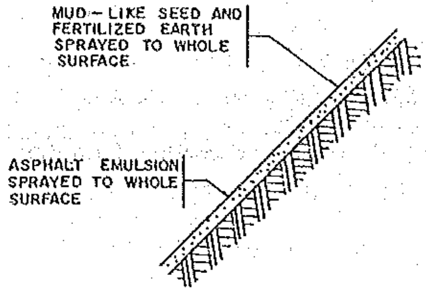


FIGURE 10.4-3 SEED MUD SPRAYING

10.4.6 Concrete Spraying

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

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

- The concrete mixture is 1:3:2 (cement, sand and gravel), and the ratio of water to cement is 45 percent.
- Concrete spraying of 15 cm thickness with reinforced steel net is applied to slopes of drastically weathered rock, slopes with loose rock masses of fairly large sizes, and slopes which are expected to have large volumes of surface water flow. At other slopes, concrete spraying of 10 cm thickness with wire net is applied.
- Weep holes are provided every 2 sqaure meters, which is the maximum standard interval.

An illustration of concrete spraying is shown in Figure 10.4-4.

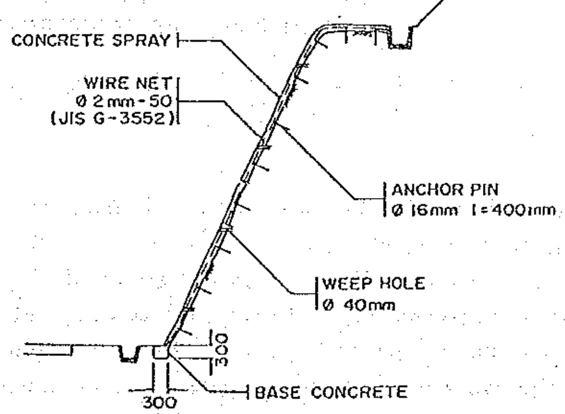


FIGURE 10.4-4 CONCRETE SPRAYING

10.4.7 Stone Pitching Revetment and Foot Protection

Stone pitching is applied as revetment work on subject embankment slopes along rivers and streams. The standard structure applied in the Study is as follows:

- The stay is 35 cm thick and made of pitched boulders, the space between the boulders being filled with concrete.
- A concrete back-filling of 10 cm thickness is provided.
- In order to improve drainage at the back, a 20 cm backfilling made of unscreened gravel is provided.
- A weep hole with a diameter of 50 mm is provided every 2 square meters.
- The base is made of concrete. When used as revetment, foot protection is designed in the front part of the base. The foot protection is a gabion type.

An illustration of a stone pitching revetment and a foot protection is shown in Figure 10.4-5.

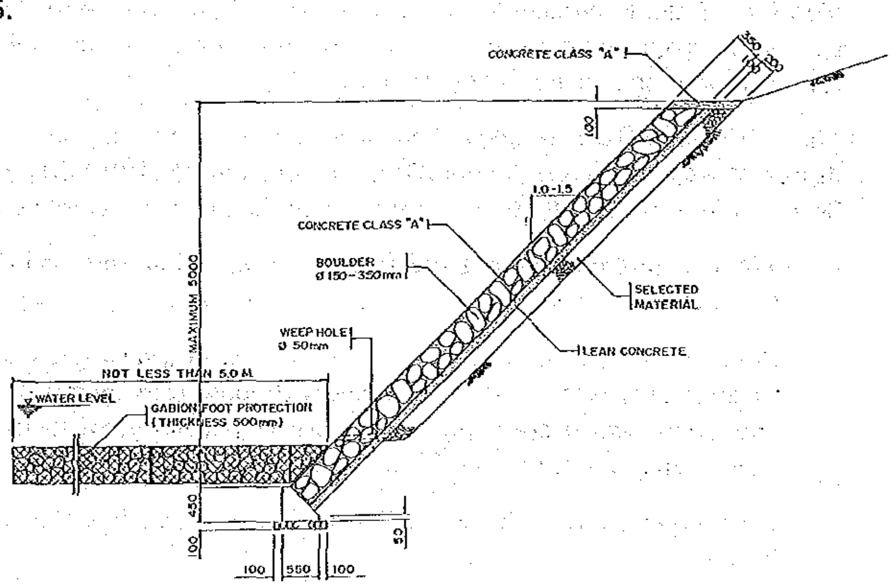


FIGURE 10.4-5 STONE PITCHING REVETMENT AND CABION FOOT PROTECTION

10.4.8 Crib

Cribs applied in the Study consist of cast-in-place concrete cribs and sprayed concrete cribs. The ordinary type of cast-in-place concrete cribs were applied mainly to embankment slopes. For embankment slopes of about 45 degree gradients, 30 cm crib which is reinforced with steel bars of 10 mm ϕ was applied. The space between the cribs is 2.0 m and wherein space between cribs was protected with vegetation. For steep slopes, cribs were used in combination with PC anchors to resist earth pressure. In this case, a 50 cm crib, which is reinforced with steel bars of 16 mm ϕ was applied. The space between the cribs is 2.5 m and wherein space between cribs was protected with concrete.

Sprayed concrete cribs were adopted for cut slope. The size of the crib is 30 cm., with 2.0 m spacing. The crosspoint of crib is anchored with reinforcing bar of 16 mm ϕ and 75 cm in length. When this is used in order to resist failure, rock bolt was used instead of reinforcing bar. The space between cribs was protected by vegetation, stone pitching or concrete pitching depending on slope gradient, degree of weathering and condition of spring water.

An illustration of crib is shown in Figure 10.4-6.

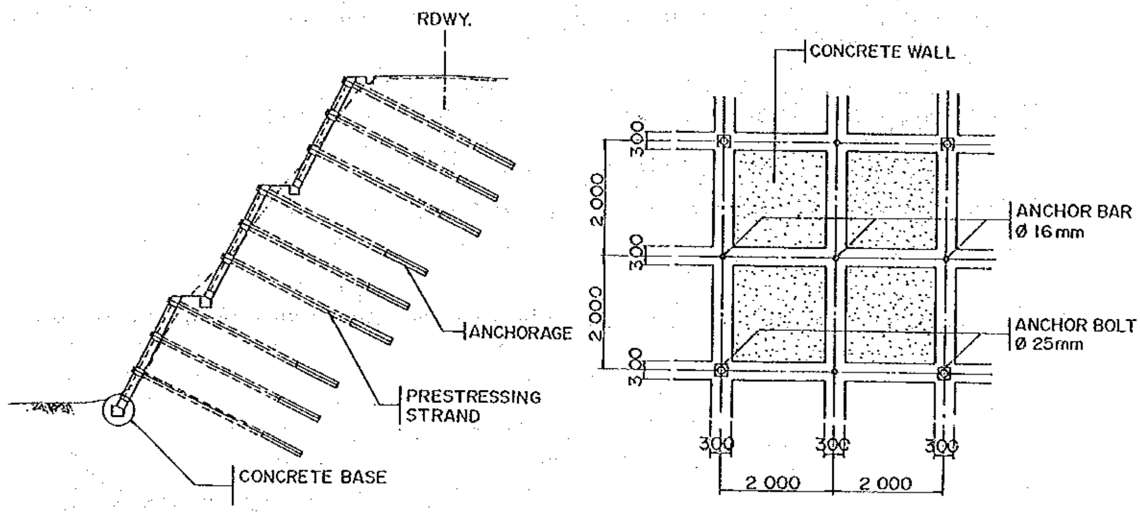


FIGURE 10.4-6 CAST-IN-PLACE CONCRETE CRIB

10.4.9 Retaining Wall

The types of retaining wall adopted in this study are stone masonry, gravity type, supported type and gabion retaining walls. They are illustrated in Figure 10.4-7.

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

The structural dimension shown in this drawing is designed in accordance with height of wall based on the past experiences in Japan.

For gravity type and supported type retaining wall, typical drawings were also prepared with design condition as shown in Table 10.4-7.

TABLE 10.4-2 DESIGN CONDITION

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

e = eccentric distance

B = width of retaining wall

Gabion retaining wall was also designed based on conditions stated in Table 10.4-2.

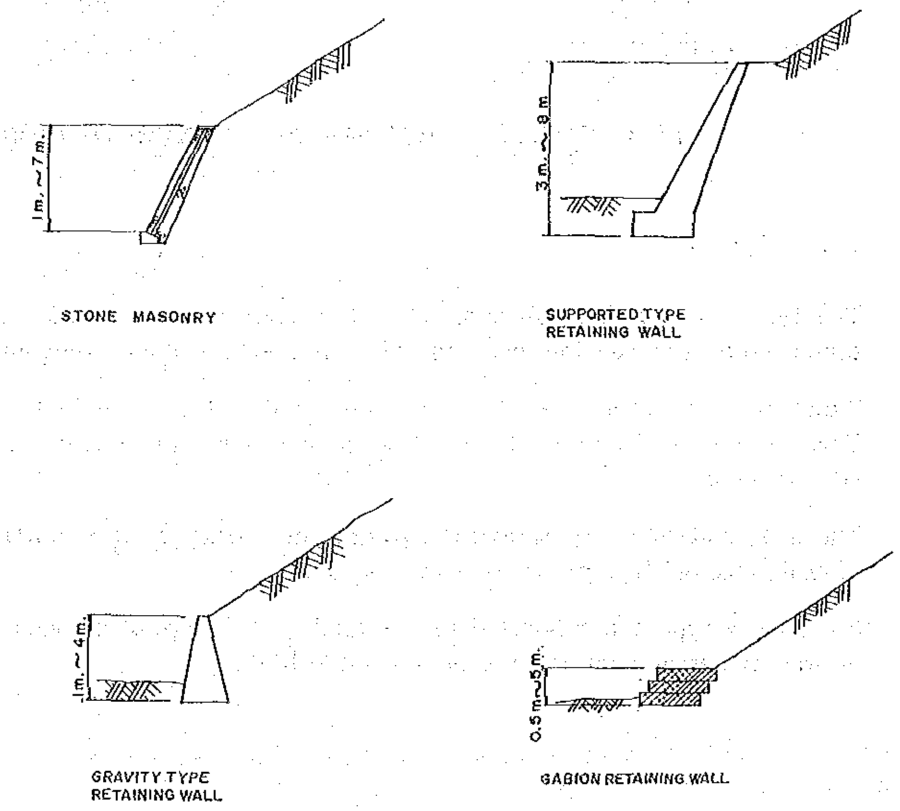


FIGURE 10.4-7 RETAINING WALLS