CHAPTER 8

PRELIMINARY ENGINEERING

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8.1 General

This preliminary engineering study is concerned with the works undertaken for the preliminary design for the construction of A-Route, B-Route and C-Route, and deals only with the engineering aspects of the Project.

The purpose of the study is to undertake Preliminary Engineering to the degree of accuracy that will permit estimates of quantities for major construction items with an accuracy of $\pm$20% based on the final quantities. The principal construction work items include embankment, common excavation, aggregate subbase, portland cement concrete pavement, number and size of principal drainage structures, bridges, and others.

The preliminary engineering design for bridges also included determination of the approximate span lengths, types of superstructures, and types of foundations. Engineering investigations including topographical, soils and materials surveys were undertaken by the Team.

Based on the preliminary engineering design the construction cost was estimated together with other data and costs for the economic analysis. The economic analysis of the Project Roads was divided into A-1, A-2, B-1, B-2, C-1, C-2 and C-3 sections to determine the optimum priorities for stage construction. (See "Drawings - Typical Cross Sections").

8.2 Basic Data

8.2.1 Aerial-Photo Mosaics

The Study Team examined the aerial-photos available for the Study area, and found that the aerial-photo mosaics could be used as topographic maps for the detailed study of land use as well as for engineering purposes.

1) Purchase of Aerial-Photos

Aerial-photos of the Project area at a scale of 1/5,000 taken in 1978 were purchased from the Cultural Center of the Philippines. These photos, however, did not cover the portion west and south of Muntinlupa. To supplement, photos at a scale of 1/15,000 taken in 1976 were enlarged to a scale of 1/5,000.

2) Preparation of Aerial-Photo Mosaic

Aerial-photos with considerable widths along Paranaque-Sucat Road, Alabang-Zapote Road and Taguig-Las Pinas-Muntinlupa Loop Road were processed from the original aerial-photo mosaics and used for the following purposes:

- road inventory survey;
- investigation of various control points;

- making polygraphy[1/] and plan and profile maps;
- hydrological investigations, etc.

The engineering design work was conducted based on the aerial-photo mosaics processed to a scale of 1/2,500, and the final engineering drawings were reduced to a scale of 1/5,000, being accommodated in the "Drawings".

8.2.2 Topographical Survey

Profile leveling, soundings, cross section survey and alignment survey along the proposed road centerlines were conducted.

Leveling along the centerline of the proposed roads was carried out, and leveling monuments were established at 2000-meter intervals.

Profile leveling was established at 200-meter intervals along the centerline of the proposed road. This leveling included the taking of additional elevations at top and toe of slope, fishpond as well as at abrupt changes in terrian conditions.

Cross sections were taken at 200-meter intervals along the centerline of the proposed road and at abrupt changes in terrain conditions.

8.2.3 Soils and Materials Survey

The Project area is composed of lowlands and hilly regions at the skirts of Taal volcanic mountains. Lowlands in the Project area are composed of unconsolidated deposit in alluvium epoch of the Quarternary period. Hilly regions are composed of elastic rocks and tuff formation in Pliocene-Pleistocene epoch of the Tertiary-Quarternary period. According to the geological map information (Appendix Fig. 8.2-1), the Marikina fault line is located along the western shore of Laguna de Bay.

Accumulation of surface soils is shown in Appendix Fig. 8.2-2. The geologic formation for each Project route is described in Appendix Note 8.2.

1) Subsoil Survey

All the data collected from the MPWH were verified and examined to identify additional surveys to be undertaken to supplement the collected data. The location of the supplementary exploration and collected data are shown in Appendix Fig. 8.2-3 and the results are presented in Appendix Fig. 8.2-4 thru 8.2-8 and Appendix Tables 8.2-1 and 8.2-2. Favorable evaluation of fill material (earthwork) is discussed in Appendix Note 8.2-1 based on these test results.

1/ Polygraphy maps, which are made from polygraphy paper, were processed from aerial-photo mosaic of 1/2,500 and 1/5,000 scales to be used for engineering purposes.

2) Materials Source Survey

Location of all possible material sources near the Project Roads was collected and the quality and the available quantities were checked. The location of the material sources is shown in Appendix Fig. 8.2-9 and their description is presented in Appendix Table 8.2-3.

8.3 Design Standards

8.3.1 Geometric Design Standards

1) General

Highway geometric design standards in the Philippines were usually prepared to suit each highway project, based on past experience from similar projects and also on the "Highway Design" general standards as published by the MPWH and the IBRD in November 1979.

However, presently the MPWH is preparing the common highway design standards for use of all highway projects financed by the Asian Development Bank. Since these common highway design standards have not yet been finalized, the Study Team provided a temporary design standard for this Project.

The Study Team established a design standard suitable for this Project based on the combination of the "Highway Design" published by the MPWH and the IBRD and the Japanese geometric design standards.

The recommended standards in the study for the "Manila-Bataan Coastal Road and Its Related Roads (C-5 and C-6) Project" was also referred to.

2) Types of Roads

The Project Roads consist of improvement of existing roads, as in the case of the existing portions of Paranaque-Sucat Road, Zapote-Alabang Road, and the new construction for the Taguig-Las Pinas-Muntinlupa Loop Road.

A minimum design standard for the improvement of existing roads was proposed and a desirable design standard for the new construction section was also proposed. In view of the difficulty in land acquisition, however, the minimum right-of-way of 35 m was adopted by the MPWH for both the improvement and the new construction sections. Thus, only one type of geometric design standard was recommended for the Roads. (Refer to Table 8.3-1).

3) Elements of Geometric Design Standards

The elements of the design standards are discussed below.

a. Design Speed

A design speed of 60 KPH is considered reasonable for all Project Roads based on a consideration of the

TABLE 8.3-1 GEOMETRIC DESIGN STANDARDS

ITEM	Unit	Recommended Standards	Common Use Standard in Philippines	Japanese Standards
Road Class	–		Categories III	
Terrain	–	Flat	Flat	Flat
Design Speed	KPH	60	60	60
Min. R.O.W. Width	m	35	–	–
Lane Width	m	3.5, 3.25*	3.5	3.25
Median Width	m	1.5 with barrier	greater or equal to 3.00 (1.50 with barrier)	1.75
Inner Shoulder Width	m	0.25	–	0.25
Outer Shoulder Width	m	1.5, 0.50*	3.25 or 3.00 or 2.75	0.75
Crossfall of Carriageway	%	1.5 for cement concrete pavement 2.0 to 3.0 for bituminous concrete pavement	2.5	2.0
Crossfall of Shoulder	%	Same as above	5.0	–
Maximum Super-elevation Rate	%	8	8	10
Minimum Radius	m	120	120	150
Maximum Gradient	%	7	7	5
Sidewalk Width (minimum)	m	4.50, 3.00* (1.25)	1.25 (1.00)	1.5 (0.75)
Bus and Jeepney Lane	m	3.50, 3.25*	–	–

Note: 1. The figures with asterisk indicate values for use in the western part of A–Route.
2. The figures in brackets indicate values for bridge section.

minimum cross section possible to avoid excessive land and property acquisition.

b. Minimum Right-of-Way Width

Because of high land values, difficulty in right-of-way (ROW) acquisition and removal of affected buildings, a minimum possible right-of-way width is proposed for the improvement of the existing roads. The Roads will be constructed by stages in accordance with the traffic demand. However, the ultimate ROW width of these roads should be acquired from the beginning since land acquisition by stages is generally not practical and will prove to be costly in the long run.

For the entire length of the Project Road a 35-meter ROW width (minimum) was proposed as shown in Fig. 8.3-1[2/]. This width was determined based on a consideration of the minimum future practical functions of the road which will run through built-up areas.

c. Lane Width

The lane width depends on the desirable lateral clearance, the size of the widest vehicles expected to travel on the road and the design speed. The desirable lateral clearance, in case of a design speed of 60 KPH is estimated to be 50 cm (absolute minimum = 37.5 cm) for each size of the heavy vehicles with a standard width of 2.50 meters. Therefore, one lane width will require 3.50 meters (absolute minimum = 3.25 meters) which is presently being used by the government in urban areas.

Since the Japanese standard specifies the use of 3.25 meters for a design speed of less than 60 KPH, lane width of 3.25 meters as absolute minimum value was recommended for the western part of A-Route. If this is applied to the Project Road, another two additional lanes could be accommodated but with the reduction of the shoulder width from 1.50 meters to 0.50 meter and of the sidewalk width from 4.50 meters to 3.00 meters as shown in Fig. 8.3-1.

d. Median Width

The minimum median width of 1.50 meters for all the Roads was proposed to accommodate a space for a supporting pier for the pedestrian overpasses, guard rails, lighting column, traffic signs, drainage, etc.

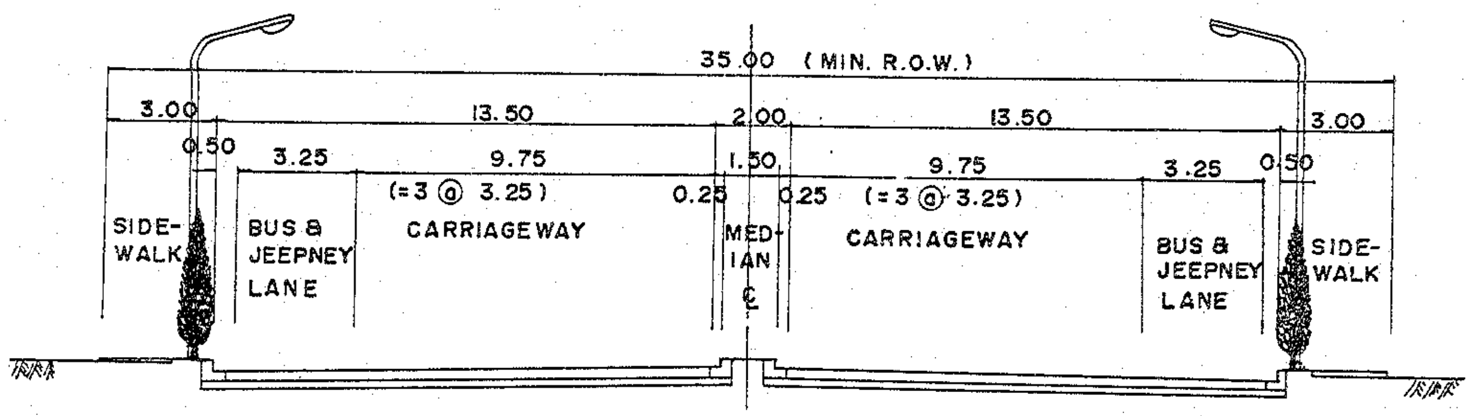
e. Shoulder Width

A shoulder on both sides of the road is proposed for vehicles to park in case of emergency or for stalled vehicles or for loading and unloading area and at the same time providing lateral clearance for through traffic.

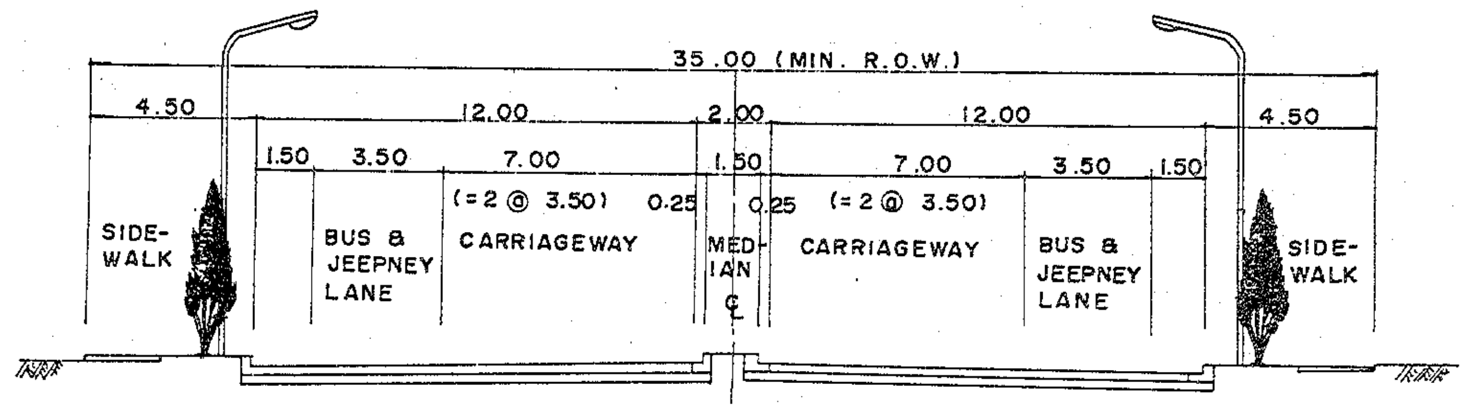
2/ A cross section of western part of A-Route is arranged with all elements as absolute minimum values based on requirements of future traffic volume.

FIG. 8.3–1 TYPICAL CROSS SECTION (ULTIMATE STAGE)

SCALE 1:200



WESTERN PART OF A–ROUTE



EASTERN PART OF A–ROUTE, B–ROUTE AND C–ROUTE

Outer shoulder width of 1.50 meters for all the Roads, except the western part of A-Route, was proposed.

The outer shoulder widths of bridges were minimized based on a consideration of reducing construction cost. The proposed outer shoulders are shown in Fig. 8.3-1.

Inner shoulder width of 0.25 meter for all the Roads was also proposed for minimum lateral clearance.

The reason for the adoption of a 1.50 meter outer shoulder is for the necessity of providing bus stops along the route. The recommended total width of the outer shoulder including the bus-jeepney lane of 5.0 meters is deemed adequate without affecting stops on the through lanes (See Fig. 8.3-2).

f. Crossfall of Carriageway and Shoulder

Crossfalls of 1.5% for cement concrete pavement and 2.0-3.0% for bituminous concrete pavement are the standards presently used by the MPWH. However, a crossfall of only 1.5% for all the Roads was proposed since all pavements will be cement concrete.

g. Maximum Superelevation Rate

A maximum superelevation rate of 8% was proposed in accordance with the Philippine standards.

h. Minimum Radius

A minimum radius of 120 meters was proposed based on a consideration of the design speed and maximum superelevation rate.

i. Maximum Gradient

Since topography of the Project area is predominantly flat, a gradient of 6% was adopted as the maximum value for actual use in this Project.

j. Sidewalk Width

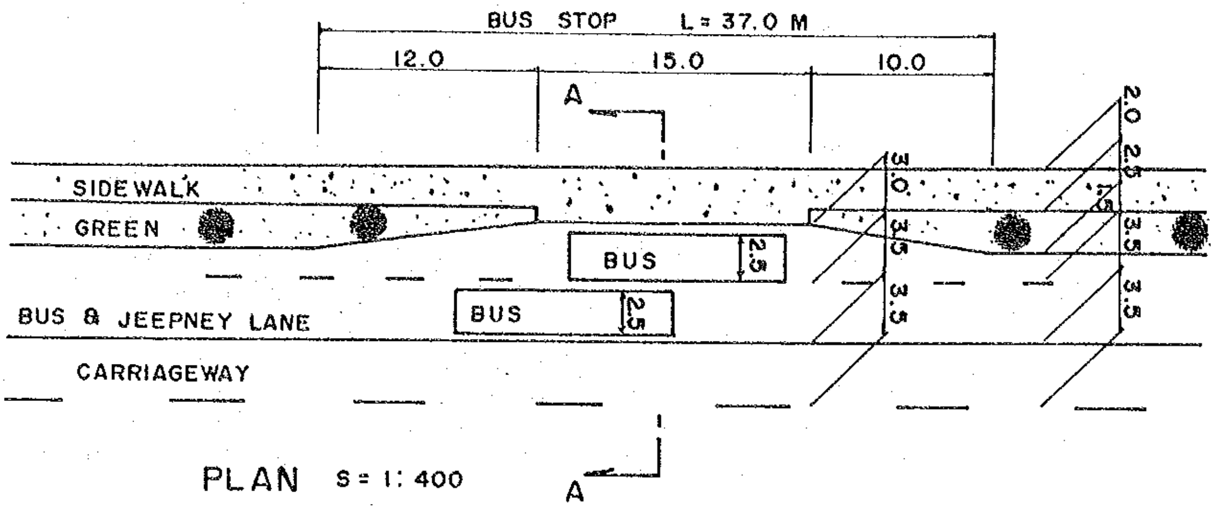
Minimum sidewalk of 1.25 meters or 1.50 meters is presently being used in the Philippines and Japan. However, this width does not include some facilities which may be provided within the sidewalks, such as traffic signs, green belt, guardrails, lighting column and others.

Thus, a minimum width of 4.50 meters and absolute minimum width of 3.00 meters were recommended to accommodate green belts from the view point of environmental aspect.

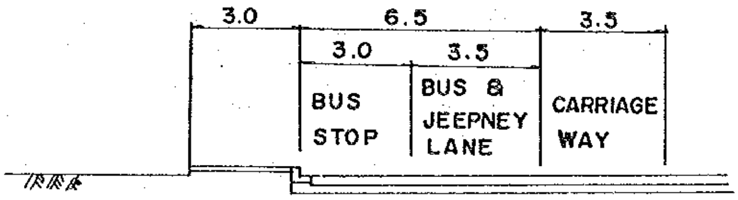
k. Bus and Jeepney Lanes

After due consideration of present practices in Manila, provision of bus and jeepney lanes will be necessary in order to provide through lanes flow to full capacity without interruption.

FIG. 8.3–2 PLANS OF BUS & JEEPNEY LANE

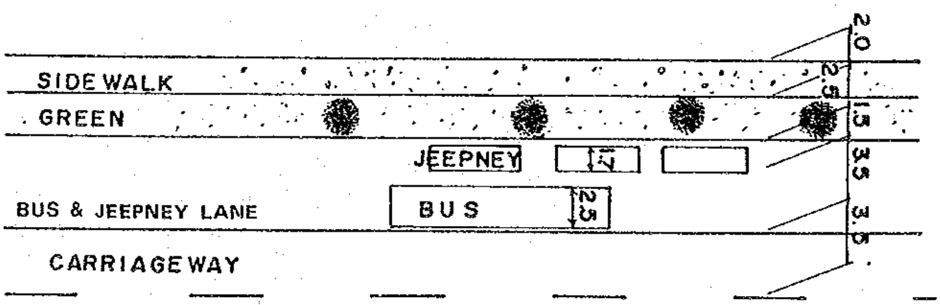


PLAN S = 1: 400



SECTION A - A
S = 1: 200

(1) DETAILS OF BUS & JEEPNEY LANE WITH BUS STOP



(2) DETAILS OF BUS & JEEPNEY LANE S = 1: 400

Thus, bus and jeepney lane of 3.50 meters (3.25 meters for western part of A-Route) together with the 1.50-meter outer shoulder will have a total width of 5.00 meters.

4) Proposed Typical Cross Sections

Based on the above discussion typical cross sections of the Project Roads were determined. Fig. 8.3-1 shows the cross sections of the Roads in their ultimate stage, consisting of two types: a 6-lane divided road with 2 auxiliary lanes for the western part of A-Route and a 4-lane divided road with 2 auxiliary lanes for B-Route, C-Route and the eastern part of A-Route.

For the bridge sections, the width of a bridge was determined taking into consideration the minimum construction cost. For the box culvert sections, however, the same cross sections as in the normal roadway were taken. Fig. 8.3-3 and Fig. 8.3-4 show the cross sections of bridges and box culverts for the above respective types.

C-Route and the western part of A-Route will be constructed by stages. Fig. 8.3-5 shows the cross sections of their initial stage construction. The timing of their implementation is described in Chapter 13.

8.3.2 Structural Design Standards

The Standard Specifications for Highway Bridges (125h Edition, 1977), adopted by the American Association of State Highway and Transportation Officials (AASHTO), were used as principal guideline for the structural design of bridges. In cases not covered by these standards, the standards adopted by the MPWH and/or the Japanese Government specifications were used.

The design live load of the AASHTO HS 20-44 was adopted.

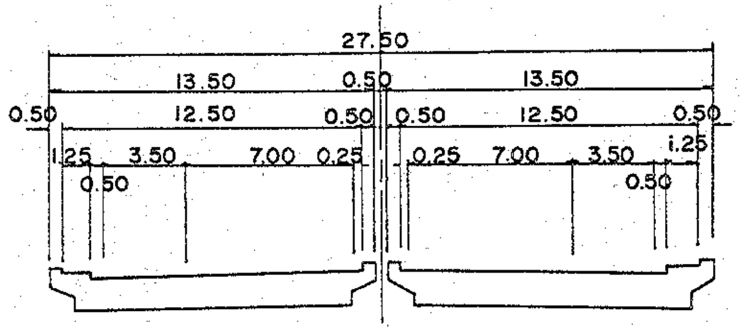
The seismic horizontal coefficient of 0.10 was used as a basic value in accordance with the practice of the MPWH Design Division. However, the use of another value was considered depending on the soil conditions at different locations. The seismic coefficients are proposed as follows:

- 0.15 : for soft ground conditions near/along Manila Bay and Laguna de Bay sides.
- 0.10 : for better ground conditions inside the Project Area.

FIG. 8.3–3 TYPICAL CROSS SECTION OF STRUCTURES
– B–ROUTE, C–ROUTE AND EASTERN PART OF A–ROUTE –

SCALE 1:300

SECTION OF BRIDGE



SECTION OF BOX CULVERT

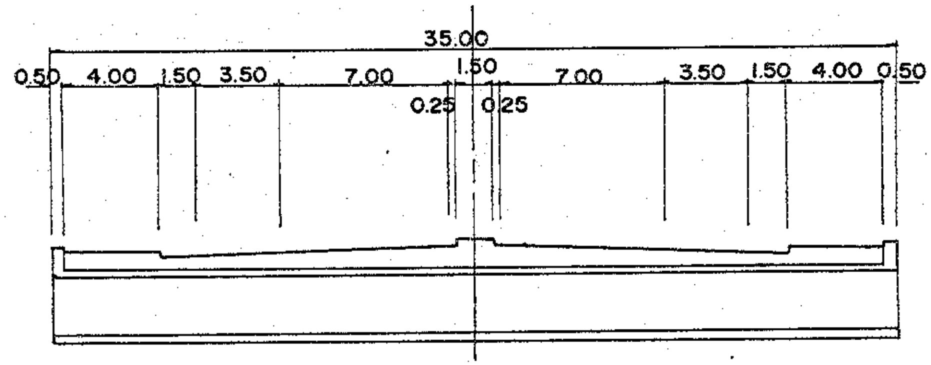
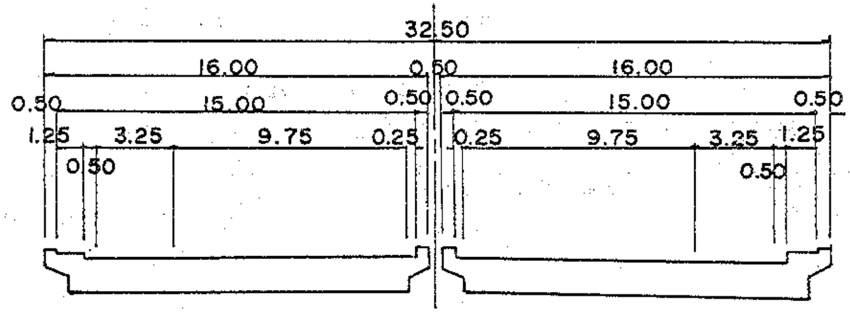


FIG. 8.3–4 TYPICAL CROSS SECTION OF STRUCTURES
– WESTERN PART OF A–ROUTE –

SCALE 1:300

SECTION OF BRIDGE



SECTION OF BOX CULVERT

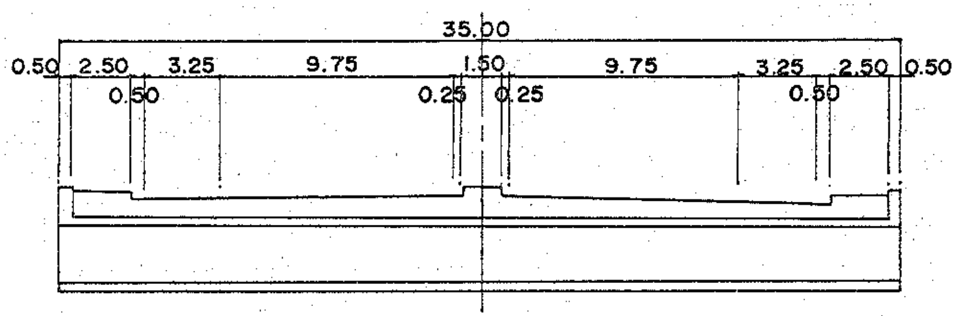
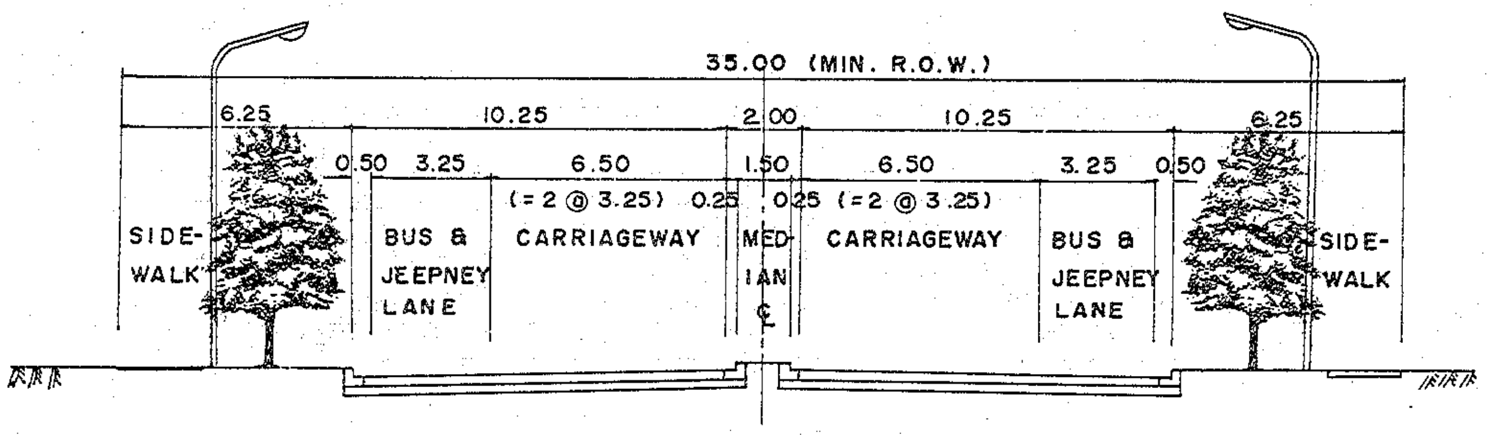
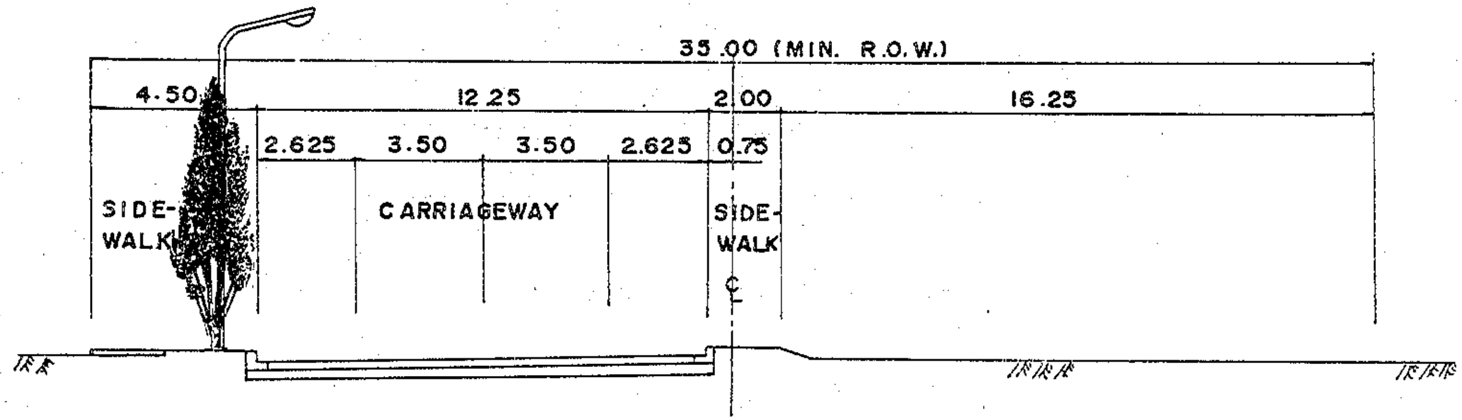


FIG. 8.3–5 TYPICAL CROSS SECTION (STAGE CONSTRUCTION)

SCALE 1 : 200



WESTERN PART OF A–ROUTE (FIRST STAGE)



C–ROUTE (FIRST STAGE)

8.4 Analysis of Road Capacity

The traffic capacity was analyzed using the projected traffic volumes described in Chapter 6. The concepts and methodology used for the highway capacity analysis were based on the "Highway Capacity Manual of Highway Research Board, U.S.A.". However, some adjustments were made to reflect local conditions based on the results of studies accomplished by "Highway Research Board, Japan" since similar conditions between the Philippines and Japan were observed in terms of sizes of vehicles and operating conditions.

Highway capacities for B-Route, C-Route, eastern part of A-Route, western part of A-Route and rampways at the uninterrupted flow level under ideal conditions are summarized as shown in Table 8.4-1.

The capacity analysis was used to determine the timing of grade separation structures by stages which are shown by alternative plan in Appendix Figs. 10.5-1 thru 10.5-3.

8.5 Preliminary Design of Roads

8.5.1 Alignment Study

1) Route Description

Based on the best route, (selected as outlined in Chapter 7), a detailed alignment study was made and the general description for each route is presented below:

a. A-Route

Generally, the topography along this route is flat with the western part lower than the eastern part. Regarding land use for the eastern part, commercial and residential areas are predominant in comparison with the western part where fishponds and saltbeds are predominant.

This route starts at Sucat Interchange along South Luzon Expressway and then follows the existing Paranaque-Sucat Road with very gentle horizontal alignment up to Sta. 6+400. The route crosses C-Route at Sta. 3+500.

From Sta. 6+400 the alignment diverts from the existing road until it intersects Quirino Avenue traversing fishponds and saltbeds, with one river crossing.

The horizontal alignment is very gentle with a minimum horizontal radius of 600 meters. (See "Drawings - Plans and Profiles")

b. B-Route

Topography along this route is relatively flat with its western part lower than the eastern part. Regarding land use along this route, commercial and industrial areas are predominant.

This route starts at Alabang Interchange along South Luzon Expressway and goes to Sta. 8+800 along the existing Zapote-Alabang Road with very gentle horizontal

TABLE 8.4–1 TRAFFIC CAPACITY ANALYSIS FOR STUDY ROADS

ITEM	DESIGN SPEED (KM/HR)	LANE WIDTH (M)	LATERAL CLEARANCE		HEAVY VEHICLE		COEFFICIENT OF ADJUSTMENT					BASIC CAPACITY (P.C.U./HR)	POSSIBLE CAPACITY (VEH/HR)	DESIGN LEVEL	ADJUSTMENT OF DESIGN LEVEL	DESIGN CAPACITY (VEH/HR)	PEAK FACTOR (%)	RATE OF DIRECTION (%)	DESIGN DAILY VOLUME (VEH/DAY) PER LANE	REMARKS
			Right	Left	% of H.V.	Passr Car Equive.	Lane Width.	Lateral Clear- ance	Heavy Veh.	Cond. of Sight	Total									
			(m)	(m)	Pt	Et	L	c	T	1		CB	C			CD	K	D	ADT	
4 LANE 2 WAY[1)]	60	3.50	1.50	0.25	10	2.0	1.00	0.95	0.91	0.9	0.778	2,500	1,950	2	0.9	1,760	10	60	14,600	
6 LANE 2 WAY[2)]	60	3.25	0.50	0.25	10	2.0	0.94	0.90	0.91	0.9	0.693	2,500	1,730	2	0.9	1,550	10	60	12,900	
2 LANE 2 WAY[3)]	60	3.50	2.625	2.625	10	2.0	1.00	0.96	0.91	0.9	0.786	2,500	1,970	2	0.9	1,770	10	60	17,700	
1 LANE 1 WAY (RAMP WAY)	40	3.50	3.00	0.50	10	2.0	1.00	0.95	0.91	0.9	0.778	2,500	1,950	2	0.9	1,760	10	60	14,600	
2 LANE 1 WAY (RAMP WAY)	40	3.50	1.00	0.50	10	2.0	1.00	0.90	0.91	0.9	0.737	2,500	1,840	2	0.9	1,660	10	60	13,800	

Note: 1) : B–ROUTE, C–ROUTE and eastern part of A–ROUTE
2) : Western part of A–ROUTE
3) : First stage of C–ROUTE

$$r = \frac{100}{100-Pt+Et\ Pt}$$

$$C = CB.\ L.\ c\ .\ 1.\ T$$

$$ADT\ (MULTIPLE\ LANES) = \frac{5000 \times CD}{K.D.}$$

WHERE
- T: COEFFICIENT OF ADJUSTMENT FOR HEAVY VEHICLES
- Pt: PERCENTAGE OF HEAVY VEHICLES
- Et: PASSENGER CAR EQUIVALENT OF HEAVY VEHICLES
- L: COEFFICIENT OF ADJUSTMENT FOR LANE WIDTH
- c : COEFFICIENT OF ADJUSTMENT FOR LATERAL CLEARANCE
- 1: COEFFICIENT OF ADJUSTMENT FOR CONDITION OF SIGHT
- K: PEAK FACTOR (%)
- D: RATE OF DIRECTION (%)
- CD: DESIGN CAPACITY (VEH/HOUR)
- CB: BASIC CAPACITY (PCU/HOUR)

alignment. At Sta. 4+400, the route crosses C-Route.

From Sta. 8+800, the alignment diverts from the existing road up to its terminal point which connects with Quirino Avenue.

Within this diversion, the route crosses an industrial area, river, and residential and commercial areas near its terminus point.

A minimum horizontal radius of 200 meters was adopted. (See "Drawings - Plans and Profiles".)

c. C-Route

The topographic conditions for the northern half of the route as classified as flat terrain and the southern half as rolling terrain. Regarding land use of this route, residential area is predominant in the northern half while arable land and open land are predominant in the southern half.

This route starts at Bicutan Interchange along South Luzon Expressway, then runs in a south-westward direction, thence, veers generally southward crossing A-Route at Sta. 4+000 where a diamond type of interchange is proposed in the future. It will also be crossing the proposed Paranaque Spillway at Sta. 2+900.

From Sta. 4+000, the route passes through open space between residential areas up to Sta. 7+800. The alignment crosses the eastern edge of Tropical Palace from Sta. 5+400 to Sta. 6+000.

A horizontal radius of 400 meters was adopted near Sta. 7+000 in order to be close to a suitable place for an interchange between B-Route and C-Route.

At Sta. 7+800, the route crosses over planned B-Route. A diamond type interchange was planned at this location to connect with B-Route.

From Sta. 7+800 to Sta. 10+000, the route crosses sparsely populated area and flat terrain.

From Sta. 10+000 to the terminus, the terrain conditions change from flat to rolling and the route crosses arable land and open land. At Sta. 16+000, the route passes planned diamond type interchange to connect the Road with the proposed Muntinlupa-Rosario route and the route to Carmona. From Sta. 16+000 to Sta. 18+000, the route passes through the boundary area between the Muntinlupa reservation area and Victoria Homes Subdivision.

At Sta. 20+000, the route crosses over South Luzon Expressway. A trumpet type interchange was planned at this location to connect C-Route with South Luzon Expressway.

The horizontal alignment between Sta. 7+800 and the terminus is very gentle because the route crosses sparsely populated area with few control points. (See "Drawings - Plans and Profiles").

2) Study of Vertical Alignment

An initial study for the vertical alignment was made simultaneously with the study for the horizontal alignment and following the study of the bridges and culverts, the vertical alignment mentioned above was adjusted.

Where the Project Road crosses a river, hydrological and hydraulic studies were made in order to determine the high water levels for waterway and drainage structures. High water levels determined were incorporated in the vertical alignment study.

Basic requirements controlling the engineering aspects of the vertical alignment study were as follows:

- In areas subject to flooding, the finished grade of the roadway will maintain adequate free board above the water surface;
- Flatter vertical gradients and a longer length of vertical curve will be adopted as much as possible for the interchange sections;
- The minimum vertical clearance for grade separation structure for major road crossings will be 4.88 m considering future overlay;
- The minimum vertical clearance for grade separation structures for minor road crossings will be 3.00 m; and
- A combination of horizontal and vertical alignments will be considered.

In addition to the basic requirements mentioned above, the following primary control points were considered for the determination of vertical alignment: (Refer to "Drawings - Plans and Profiles")

a. A-Route

- Clearance for South Luzon Expressway at Sta. 0+000 will be the same as that of the existing bridge;
- Finished grade of the improvement section of the existing road will be maintained; and
- Future grade separation structure (vertical clearance of more than 4.88 m) is planned at Sta. 6+950, A-Route and Imelda Avenue Extension intersection.

b. B-Route

- Finished grade line at the improvement section of the existing road will follow that of the existing road; and
- Vertical clearance for the Maliksi River at Sta. 9+250 is more than one meter above flood level.

c. C-Route

- Clearance for South Luzon Expressway at Sta. 0+000 will be the same as that of the existing bridge;
- Future grade separation structures are:

  Sta. 3+970, C-Route and A-Route (Clearance is more than 4.88 m)

  Sta. 5+310, C-Route and major access road (Clearance is more than 4.88 m)

  Sta. 6+400, C-Route and major access road (Clearance is more than 4.88 m)

  Sta. 7+800, C-Route and B-Route (Clearance is more than 4.88 m)

  Sta. 20+000, C-Route and South Luzon Expressway (Clearance is more than 4.88 m)

3) Plans and Profiles

The horizontal and vertical alignments for each Road are presented on the plan and profile sheets at 1:400 vertical scale and 1:5,000 horizontal scale and are compiled in the Drawings (See Plans and Profiles).

The elements of horizontal and vertical alignments, the stations, radii of horizontal curves, finished grade line, existing ground line, profile of bridges and culverts are included on these sheets together with other salient features.

8.5.2 Study of Intersection/Interchange

1) General

Interchanges and intersections are the vital connecting facilities for the roadway system. There should be an adequate number of them in order to attain utmost traffic efficiency.

Interchange and intersection designs are generally developed based on the integrated considerations of traffic requirements, safety for drivers, site conditions, design controls and standards established for the interchange ramp and turning roadways, surrounding conditions, and economy.

After site investigations and collection of basic data, the Study Team selected suitable types of interchange considering the above mentioned objectives.

There are several basic types of interchange and patterns of ramps for vehicle movements at a grade separation, and each type of interchange has some advantages and disadvantages. In general, the characteristics of an urban interchange vary with the type of roads involved. For instance, at a crossing of two arterial streets, simple and compact forms, such as diamond or partial cloverleaf arrangements involving at-grade ramp terminals are suitable, since speed is relatively slow and interrupted flow at these intersections is common. Diamond or partial cloverleaf layouts are also appropriate at intersections of a tollway with an arterial street.

2) Location of Intersection/Interchange

The location of proposed intersections/interchanges is listed as follows:

Intersection/-Interchange At	Number of Legs	Crossing Road
A-Route (Sucat)	4	South Luzon Expressway
A-Route	4	Imelda Avenue Extension
A-Route	4	Quirino Avenue
B-Route (Alabang)	5	South Luzon Expressway, Highway 1
B-Route	4	Quirino Avenue
C-Route (Bicutan)	4	South Luzon Expressway
C-Route	4	A-Route
C-Route	4	B-Route
C-Route	4	Muntinlupa-Rosario Road
C-Route	4	South Luzon Expressway
C-Route	4	Highway 1

3) Selection of Interchange Type

The factors considered in selecting the type of interchange are as follows:

- Type of connecting road and its design speed;
- Characteristics of future intersecting traffic;
- Terrain conditions;
- Existing structures, buildings and land use affecting the design of the interchange;
- Safety and efficiency of traffic; and
- Cost

The following three types of interchanges were considered based on the type of connecting road and existing site conditions for the Project Roads:

Type A - Crossing of two arterial streets
(New construction)

Type B - Improvement of existing interchange or intersection

Type C - Crossing of a tollway with an arterial street

Only one type of interchange was proposed for Type A.

Improvements of existing interchanges or intersections are quite difficult in view of large scale improvements usually present at these intersections.

Typical interchange Type C (only one location) will be selected when the crossing involves a tollway and an arterial street.

a. Type A Interchanges

Three types of interchanges - diamong type, cloverleaf and directional type are considered for Type A interchange. These types are compared as shown in Table 8.5-1.

Type A interchanges are planned as connections of arterial streets with a road having relatively low design speed (60 KPH). Stage construction should be considered.

Therefore, the economical aspect and stage construction are the most important factors.

TABLE 8.5–1 COMPARISON OF CHARACTERISTICS OF TYPE A INTERCHANGES

Item	Diamond Type	Cloverleaf Type	Directional Type
Construction Cost	Low	Medium	High due to many structures required
Land Acquisition Cost	Low	High	High
Traffic Capacity	Small with at grade intersection	Medium	Large
Traffic Movement	Fair	Fair	Good
Difficulty of Stage Construction	Easy	Difficult	Difficult

The Study Team recommended the diamond type for Type A interchange. (See "Drawings - Plans and Profiles").

b. Type B Interchange

Since interchanges at the proposed location of Type B interchange already exist, and are handling a large traffic volume, a large scale improvement is difficult as mentioned above.

Therefore, the Study Team recommended that the improvement of intersection including widening the existing bridge to improve traffic flow, will be planned for Type B interchange as shown in "Drawings".

c. Type C Interchange

Type C interchange is the typical connection between an arterial street and a tollway with toll plaza.

An intensive toll plaza is effective for economy and traffic control for this type of interchange. Therefore, the trumpet type of interchange was recommended as shown in the "Drawings".

4) Interchange and Intersection Planning

Based on method of selection for interchange type mentioned above, the Study Team carried out the selection of type for each interchange to complete the preliminary design. Capacity analysis of the at-grade intersection as part of an interchange, was also made. This analysis was also used for the design of signal controlled intersections. The calculations of the capacity of each intersection and the procedure adopted were in accordance with the recommendations of "Highway Research Board, Plans and Designs for At-Grade Intersections, Japan" which were based on experience in Japan with these problems. The basic elements are as follows:

- Traffic capacity per lane:

  Through lanes: = 2,250 veh (PCU)/green hour

- Right turn and left turn lanes:

  = 2,000 veh(PCU)/green hour

- Other elements:

  Peak Factor: = 7.7%

  Percent of heavy vehicles: = 10%

  Rate of direction at peak hour: = 60%

Each proposed intersection/interchange is discussed briefly as follows. Traffic flow and capacity analysis is presented in Appendix Fig. 8.5-1 thru Fig. 8.5-17.

a. Sucat Interchange

Type B interchange was planned for this location. Widening the existing bridge and approaches was determined from analysis of improved intersection capacity, and one way control was recommended for the service roads.

b. A-Route/Imelda Avenue Extension Interchange

Type A interchange was planned for this location.

c. A-Route/Quirino Avenue Interchange

Type A interchange was planned for this location. However, since the overpass structure will be constructed by CDCP and A-Route will connect with CDCP Tollway (R-1 Extension) through this structure, analysis of the Study Team was limited to two rampways between A-Route and Quirino Avenue.

d. Alabang Interchange

Type B interchange was planned for this location. Since the existing interchange is located under South Luzon Expressway, extensive improvement under the structure of the expressway is very difficult.

Improved traffic flow based on a consideration of higher traffic capacity with one way control was planned by small scale improvement. (See "Drawings")

e. B-Route/Quirino Avenue Interchange

Type A interchange was planned for this location. The planning approach was the same as the A-Route/Quirino Avenue Interchange.

f. Bicutan Interchange

Type B interchange was planned for this location. Widening the existing bridge and approaches was determined from analysis of the improved intersection capacity, and one way control was recommended for the service road.

In addition to the improvements mentioned above, a new viaduct section to connect C-Route with future C-5 Route was determined as shown in "Drawings". This viaduct section however is not included in the construction cost of C-Route because this section is considered to be part of the future C-5 Route.

g. C-Route/A-Route Interchange

Type A interchange was planned for this location.

h. C-Route/B-Route Interchange

Type A interchange was planned for this location.

i. C-Route/Muntinlupa-Rosario Road Interchange

Type A interchange was planned for this location. However, since an overpass structure will be constructed during the construction period for Muntinlupa-Rosario Road, the construction cost for the overpass structure was not included in the cost of C-Route.

j. C-Route/South Luzon Expressway Interchange

Type C interchange (trumpet type) was planned for this location as mentioned in Paragraph 2), c. of this section. (See "Drawings")

k. C-Route/Highway 1 Interchange

Type A interchange was planned for this location. The planning approach is the same as the A-Route/Quirino

Avenue Interchange.

8.5.3 Other Studies

1) Relocation of Utilities

a. General

The Study Team investigated existing utilities likely to be affected by the construction of the Project Roads, including:

- Power and communication lines
- Water supply/distribution lines
- Sanitary/storm sewers
- Street lighting
- Existing traffic signs

The Study Team inquired from and held meetings with agencies and other organizations about the existence of their utilities and their future development plans within or near the construction limits of the Project. It was difficult however to determine any relocation requirements within such a short period of time. The proposed methods for relocation of the main utilities are described in this paragraph and further discussions with the authorities concerned would be held during the detailed design stage.

Under the initiative of the MPWH, owners of public utilities are considering the provision of common duct along the Project Roads for their respective utilities. It is expected that the implementation thereof will occur during the construction. It could however be implemented before the start of construction.

b. Relocation of Street Lighting Columns

For the entire project length the lighting columns along the existing roads are on the edge of the road at some locations.

The new lighting columns along Zapote-Alabang Road should be provided at frequent intervals under the supervision of the MPWH, taking advantage of the road widening.

In the relocation work due consideration should be given to the planned Project Roads. The relocation work for the cables, feeder panels and lighting columns will have to be carried out in cooperation with the MPWH.

Almost all the existing lighting columns can be reused for new arterial streets. Additional new lighting columns however, will be required for the Project Roads in order to provide a uniform system for the network as a whole.

2) Lighting

The main objective of lighting facilities is to minimize traffic accidents which may occur resulting from low visibility. It will also make the Road more attractive and convenient for potential users. Considering future development in the surrounding areas of the Project Roads and the predicted volume of traffic, the Study Team recommended that A-Route and B-Route should also be provided with complete lighting facilities.

The provision of lighting facilities in this Project is limited to the following locations.

- Entire lengths of A-Route and B-Route
- Interchanges, including rampways and crossing structures for C-Route
- Bridge and its approaches for C-Route
- Vicinity of and inside the toll plaza.

3) Traffic Signs

a. General

Regulatory signs, warning signs and guide signs are essential to ensure traffic safety and they should be in accordance with Government Standards, taking into account those factors controlling the effectiveness of signs which include legibility (ease in reading the message), target value (factors which draw attention to the sign, such as size and contrast with background), and the priority value (location with respect to other signs).

b. Guide Signs

Guide signs convey information to assist drivers, such as destinations with directions and distances, service facilities, and route confirmation information. These signs will play a very important role in informing the driver in advance of the correct traffic lane for making an exit or entry at interchanges and of the location of toll gates. Gantry type signs may be required at certain locations.

4) Toll Plaza

For the preliminary design of the toll gate for C-Route/ South Luzon Expressway, a study of the necessary construction and furnishing equipment required for the facilities was made.

Toll gate construction consists of the work items shown below:

- Toll gate structure including columns and roof structure;
- Refuge island construction;
- Toll booth construction;

- Equipment installation in short booths; and
- Equipment installation in long booths.

8.6 Pavement Design

8.6.1 Selection of Type of Pavement

The two types of pavement, rigid and flexible, have their own advantages and disadvantages. The type of pavement for the Project Roads was determined by studying the comprehensive factors which are related to the Roads as presented in Table 8.6-1.

The Study Team recommended the rigid concrete pavement type for the Roads based on a consideration of the long term investment and the present conditions in the country. The flexible concrete pavement was recommended for the bridge slab surfacing. More detailed study for the selection of pavement type, however, should be included in the detailed engineering for the Project Roads.

The rigid pavement thickness design was determined based on the method discussed in Subsection 8.6.2, and description of the thickness design of flexible pavement is presented in Appendix Note 8.6.

8.6.2 Design of Rigid Pavement

The design method for the pavement structure for the Roads was based on the "AASHTO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURES, 1972". The values analyzed were checked using the method shown in TRRL ROAD NOTE 29, U.K.

1) Average Daily Traffic

A 20-year design period from 1987 to 2007 was used for the rigid pavement design. The average daily traffic volume for each section for the selected years is shown in Table 8.6-2.

2) Equivalent 18-kip Single Axle Loads

The number of equivalent 18-kip single axle load applications per day in the design lane was obtained by multiplying the traffic volume per lane by the 18-kip equivalence factors for all heavy vehicles and the results are listed in Table 8.6-3.

3) Composite Kc-Value

The composite Kc-value on the top of sub-base was estimated from the sub-base thickness, the sub-base stiffness (E) and the modulus of sub-grade reaction (K).

TABLE 8.6-1 COMPARATIVE STUDY OF PAVEMENTS

Item	Rigid Pavement	Flexibile Pavement
1. Construction * Cost	222 ₱/m^2 (Portland Cement: t=25cm Sandy gravel Subbase: t=25cm)	267 ₱/m^2 (Asphalt Concrete: t=5cm Bituminous Treated Base : t=20cm Sandy gravel sub- base : t=40cm) - - - - - - - - - - 193.9 ₱/m^2 (Asphalt Concrete t=5cm Aggregate Base: t=50cm Sandy Gravel Subbase: t=40cm) - - - - - - - - - - 425.9 ₱/m^2 (With overlay on surface course every 5 years)
2. Maintenance Cost	Low	High
3. Running Condition	Fair	Good
4. Supply of Materials	Possible to prepare all materials in the Philippines	Necessary to import bituminous material from abroad
5. Present Situation of Pavement Construction	Most national roads were constructed by rigid pavement.	Flexible pavement was used for only a part of roads or maintenance.
6. Resistence to Oil from Vehicles	Strong	Weak
7. Difficulty of Maintenance	Difficult	Easy

* Note: Construction costs of pavement by type are compared in Appendix Note 8.6.

TABLE 8.6-2 AVERAGE DAILY TRAFFIC BY ROUTE

For the A-Route

Description	1987 (Opening year)	1997 (10 years hence)	2007 (20 years hence)
Average Daily Traffic (veh/day)	43,030	70,916	91,452
Design Traffic Volume (veh/direction/lane/day)	7,172	11,819	15,242
Heavy Vehicle (veh/direction/lane/day)	909	1,508	1,930

For the B-Route

Description	1987 (Opening year)	1997 (10 years hence)	2007 (20 years hence)
Average Daily Traffic (veh/day)	36,497	60,714	66,602
Design Traffic Volume (veh/direction/lane/day)	9,124	15,179	16,650
Heavy Vehicle (veh/direction/lane/day)	1,393	2,245	2,338

For the C-Route

Description	1987 (Opening year)	1997 (10 years hence)	2007 (20 years hence)
Average Daily Traffic (veh/day)	23,452	41,122	61,807
Design Traffic Volume (veh/direction/lane/day)	5,863	10,281	15,452
Heavy Vehicle (veh/direction/lane/day)	665	1,275	1,617

TABLE 8.6-3 EQUIVALENT 18-KIP SINGLE AXLE LOAD FREQUENCY

For the A-Route

Designation	1987	1997	2007
Equivalent 18-kip Single Axle Load Frequency	-	5,884,900	8,671,500

For the B-Route

Description	1987	1997	2007
Equivalent 18-kip Single Axle Load Frequency	-	7,472,100	9,520,000

For the C-Route

Description	1987	1997	2007
Equivalent 18-kip Single Axle Load Frequency	-	4,420,600	6,718,000

Note: The equivalent factors are 0.03 ∿3.45 for trucks and 0.34 for buses, depending upon the serviceability index and the thickness of concrete slab.

The values of the above-mentioned parameters are as follows:

- Sub-base thickness = 8 inches
- Sub-base stiffness (Granular) E = 15,000 psi
- Modulus of sub-grade reaction K = 315 psi (Fair sub-grade)

Using Fig. D.4-1 in the AASHTO INTERIM GUIDE, the composite Kc-value was determined to be 340 psi.

4) Working Stress in Concrete

Working stress of 490 psi was used to determine the thickness of the concrete slab.

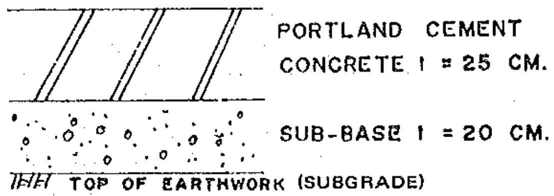
5) Serviceability Index

The terminal serviceability index of 2.5 was adopted for the design of this Project since the road sections are defined as a major highway road.

6) Determination of Pavement Slab Thickness

The thickness of concrete pavement slab was determined based on the use of design chart shown in Fig. D.4-2 of the AASHTO INTERIM GUIDE. From this chart, the thickness of concrete pavement slabs was obtained by entering all values mentioned above.

The pavement structures resulting from this procedure is as follows:



8.7 Preliminary Design of Bridges and Drainage Structures

8.7.1 General

The basic purpose of the preliminary design is to estimate the construction cost of all the Project Roads, which can be used for the Feasibility Study. The size and type of structures were determined based on the design standards mentioned in Subsection 8.3.2 and existing data for structures of a similar nature based on field investigations. In order to provide a basis for preliminary design, the following surveys were undertaken:

- Topographical survey and soundings at bridge sites: longitudinal and cross sections, and river cross section;

- Supplemental sub-surface soils survey: standard penetration test, laboratory test and their analyses; and
- Hydrological study: highest flood level, planned cross section of waterways, intensity and frequency of heavy rainfall in the catchment areas.

8.7.2 Site Investigations

From the structural points of view the Project routes can also be classified into two categories:

- Improvement of existing roads:

  A-Route: Paranaque-Sucat Road, and

  B-Route: Zapote-Alabang Road

- New construction road:

  C-Route: Taguig-Las Pinas-Muntinlupa Loop Road

The site investigations for these routes were conducted during the period from June to September 1981, to obtain the necessary structural data for preliminary engineering.

1) A-Route and B-Route

The existing bridges and box culverts crossing the rivers/waterways were investigated; their types and dimensions were determined and are tabulated in the form of an inventory in Appendix Table 8.7-1.

The measured dimensions were compared with the required waterway opening calculated hydraulically to determine the necessity for improving the existing structure in question.

Flood marks near the drainage structures were carefully investigated in order to determine the high water level.

The existing grade separation structures on A-Route at Sucat with South Luzon Expressway was carefully investigated in terms of type, dimensions, clearances, etc., since this structure will have to be widened to meet future traffic demand.

2) C-Route

Before and after the selection of the best route from the alternatives, the following points were surveyed using the aerial-photographs.

- Optimum location of waterways/streams that will be provided with drainage structures and necessity for relocating waterways/streams, based on identification of the existing hydrological conditions;
- Actual measurement of the widths of existing cross roads and their intersecting angles with the proposed route to determine the size of the proposed grade separation structures; and

- Careful survey of the existing grade separation structure at Bicutan with South Luzon Expressway in terms of type, dimensions, clearances, etc., as this structure will have to be widened to meet future traffic demand.

8.7.3 Desirable Types of Structures

Based on the survey results of topography, subsurface soils and drainage conditions, existing design data and the proposed alignment, types of superstructures and box culverts were selected. The following points were found generally suitable considering the economical and technical aspects:

- Long span bridges more than 30 meters in length to be built on soft ground shall be of steel composite girder type construction which can reduce the dead load of the structures;
- Intermediate long span bridges 15 to 30 meters in length shall be prestressed concrete structures (mainly of composite I-beam girders);
- Short span bridges 7 to 15 meters in length shall be prestressed/precast concrete or reinforced concrete structures according to the topography, etc.;
- Structures less than 7 meters long shall be reinforced concrete box culverts, which will be mono-opening type or multi-opening type depending on the site and planned cross section of the waterway;
- For grade separation structures with existing roads prestressed/precast concrete and/or steel composite girder structures shall be adopted from the points of construction and/or erection requirements; and
- In widening the existing roads, the type and length of the existing structures at Bicutan and Sucat Interchanges shall be maintained as much as possible taking into full consideration the design criteria of the roads and waterways.

8.7.4 Preliminary Design of Bridges

1) General

Locations of proposed structures (bridges, grade separations, box culverts and pedestrian overpasses) for each route are shown in Appendix Fig. 8.7-1, and the proposed bridges are listed in Appendix Table 8.7-2.

The following points were taken into consideration in determining the type of structures.

- Required minimum span length of the structure passing over a road or crossing a river, terrain conditions and planned cross section of the waterway;

- Optimum number of spans and total length of the bridge to minimize its construction cost;
- Technical and economical advantages in the construction of substructures and erection of superstructures;
- Aesthetic view and harmony with the environment; and
- Easy maintenance of the structure after construction.

2) Superstructure

Based on the points mentioned above, the type of structures, span lengths and characteristics have been determined as shown in Table 8.7-1.

Types of superstructures across small and medium size rivers can generally be determined by their respective span lengths. In this Project, span lengths are almost within the range from 15 to 25 m.

In this country, standardized P.C. Composite I-Girders (AASHTO STANDARD P.C. I-BEAM SECTIONS) are made available, which can accommodate the above span lengths. Therefore, use of these girders was considered when estimating the construction cost of the superstructures as well as determining their types. The dimensions of the standard beam sections are shown in Appendix Table 8.7-3.

Grade separation structures which pass over existing roads or the expressway will have longer spans. For this Project, these structures were found to have a span length of as long as 40 m over the existing roads including a clearance for channelization of the intersection and 35 m over the expressway. In addition, the construction of the grade separation structures will have to be executed under the normal traffic control. In such a case, the stage construction using P.C. girders will be technically difficult. From the various aspects including safety, steel girders were adopted for the types of such structures having a span length of 35 to 40 meters. To widen the structures of the Bicutan and Sucat Interchanges, the structure types were determined based on the following conditions:

- Secure required clearance (Height: more than 4.88 meters);
- Separation of new and existing structures with joints from the point of view of structural stability; and
- Use of materials similar to the existing structure from the aesthetic point of view.

From the above, P.C. Composite I-Girders (span length: 2 @ 25 m) were proposed for the widening of the structure of the Bicutan Interchange, while for the Sucat, steel composite H-girders were proposed.

3) Substructure

Types of abutments and piers of substructures were determined in accordance with the size of superstructures,

TABLE 8.7-1 COMPARATIVE STUDY OF SUPERSTRUCTURE

		APPLIED SPAN LENGTH (M) 20 40 60	RUNNING COMFORT	SIDE ELEVATION	AVAILABILITY OF MATERIALS	RELIABILITY OF QUALITY	CONSTRUCTION PERIOD	EASE OF CONSTRUCTION	MAINTENANCE	SPECIAL TYPE			ECONOMY (INCLUDING STRUCTURE)
										CURVED BRIDGE	HIGH PIER BRIDGE	VARIABLE WIDTH BRIDGE	
RC	SIMPLE GIRDER		B	B	A	B	B	B	A	O			B
	HOLLOW SLAB		B	A	A	B	B	B	A	O		O	A
PSC	T - SLAB		B	A	B	B	A	A	A				B
	SIMPLE I GIRDER		B	B	B	B	A	A	A			O	A
	CONTINUOUS BOX GIRDER		A	A	B	B	B	C	A				B
METAL	SIMPLE GIRDER		B	B	C	A	A	A	C	O	O	O	C
	CONTINUOUS BOX GIRDER		A	A	C	A	A	A	C	O	O		C

NOTE: A = Excellent, B = Normal, C = Inferior and, O = Suitable (Special type only) subsoil conditions and required substructure height. Based on the results of previous feasibility studies and other data available, the substructures to be used were roughly evaluated from the viewpoint of economy and construction method as summarized in Table 8.7-2.

a. Abutment

The required heights of the abutments for the proposed structures were in the range from 5 to 10 meters. Therefore, the reversed T-type was selected from the economical aspect.

b. Bridge Pier

The pile-bent type was used for some piers from the hydrological and sub-soil conditions, but the wall type for most of the others. For widening the existing bridges, the same types of pier as the existing ones were adopted from the aesthetic point of view.

4) Foundations

The type of foundation is determined mainly by subsurface soil conditions, difficulty of construction, and scale of the substructure. Based on the soil data, types of foundation are roughly classified according to economy, construction method, and technical aspect as summarized in Table 8.7-3.

The diversion sections of the existing Paranaque-Sucat and Zapote-Alabang Roads which are located near Manila Bay have bearing layers at 5 to 10 meters below the ground surface, and the size of the proposed superstructures for these sections are small. Standard P.C. piles (square: 45 x 45 cm) were proposed for the foundation of these structures. For the remaining sections of the two existing roads, the spread type foundation was proposed.

The Taguig-Las Pinas-Muntinlupa Loop Road has bearing layers at 2 to 5 meters below the ground surface. The spread type foundation was proposed for this route.

5) Design of Pedestrian Overpass

Provision of pedestrian bridges was proposed for the pedestrian traffic across the Project Roads with heavy vehicular traffic as shown in Appendix Table 8.7-4.

The design of this structure should be for the ultimate stage roadway width, and a structure of P.C. I-beams (AASHTO) for main girders and P.C. precasts for floor beam was proposed as standard.

The effective walk width of the bridges is 3.0 meters and the width of a stairway of 2.0 meters.

8.7.5 Standard Design of Box Culverts and Retaining Walls

The design standards of box culverts and retaining walls have been established by the MPWH and were adopted for this Study.

TABLE 8.7-2 TYPES OF SUBSTRUCTURES

T Y P E		N O T E S
Abutment	Gravity	For heights ranging from 2 to 6 meters
	Reversed - T	For heights ranging from 4 to 10 meters
	Buttress	For heights more than 10 meters
P i e r	Wall	For river and long span, etc.
	Column	For street and intersection, etc.

TABLE 8.7-3 TYPES OF FOUNDATIONS

T Y P E			N O T E S
Shallow	Spread Foundation		For a depth of 5 to 6 meters from ground surface
Deep	Pile Foundation		
		Precast Prefabricated Pile	PSC-Pile: Depth is 10 to 20 meters Steel Pile: Depth is 20 to 60 meters Cast-in-place-Pile: Depth is 20 to 30 meters
		Caisson	
		Composite	Caisson with piles

1) Box Culverts

Box culverts were proposed for rivers, swamps, creeks and fishponds/saltbeds.

Type of culverts was determined by the required span lengths as follows:

Span Lengths	T y p e
Less than 1.5 m	R.C. pipe culvert
1.5 to 3.0 m	R.C. mono-opening box culvert
3.0 to 7.0 m	R.C. multi-opening box culvert

Box culverts proposed for this Study are listed in Appendix Table 8.7-5.

2) Retaining Walls

Retaining walls are classified as gravity-type and reinforced concrete reversed-T type, and the latter usually is adopted when the wall height is more than 3.0 m mainly from economical viewpoint.

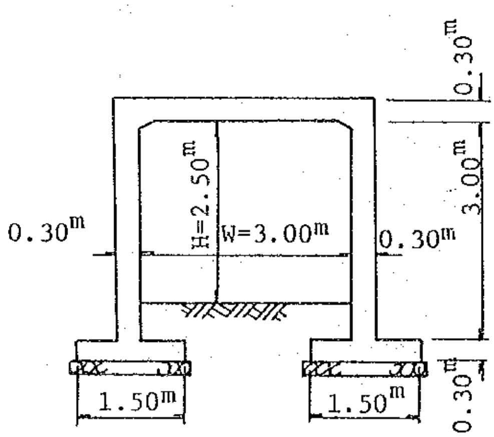
Relationship of cost of retaining walls by type are shown in Appendix Fig. 8.7-2.

8.7.6 Pedestrian and Farm Animal Underpass

In the vicinity of the southern portion of C-Route, west and south of Muntinlupa, farm animal herds can be seen grassing. To prevent the accidents of vehicles with those animals, it is necessary to provide crossing structures under the Project Road. They will be used for pedestrian traffic as well.

The dimensions of the structure of 3.00 m width and 2.50 m vertical clearance will be sufficient for the pedestrian and cattle traffic. The location of structures should be studied during the detailed engineering stage of the Project Road taking into consideration the present and future ecology of the cattles. Fig. 8.7-1 shows the standard cross section of the structures which were used for the Manila South Expressway Extension.

FIG. 8.7-1 CROSS SECTION OF CROSSING STRUCTURE FOR PEDESTRAIN AND FARM ANIMAL TRAFFIC



(Source: MPWH)

8.8 Hydrology

8.8.1 General

This Study was carried out to furnish the data, from a hydrological and hydraulic point of view, for the design of the bridges and other drainage structures, and to determine the minimum height of embankment at river basins so that the profiles of the roads could be planned. The location of rivers and streams related to the Project area is shown in Appendix Fig. 8.8-1.

8.8.2 Site Investigation

The site investigations were carried out to identify the extent of the watershed area and the coefficient of run-off for the basins of rivers and streams, and to determine the lowest allowable finish grade in the embankment sections in the areas near the Manila Bay coast where the ground might be inundated during floods.

Based on the existing hydrological data collected, the Study Team made careful site reconnaissance surveys to identify the effects of floods.

1) General Geography and Topography

The Project site is situated at the skirts of Taal volcanic mountains, and its terrain is almost hilly except for the lowlands near Manila Bay. The lowlands which are 0 to 2 meters above the mean sea level, adjacent to Manila Bay, accommodate fishponds and saltbeds utilizing the tidal seawater. They are about one kilometer wide parallel to the coast of the bay.

In the east-west direction, the terrain of the Project area becomes gradually higher from Manila Bay, consisting of hilly terrain having about 30 m height at about 1.5 kilometers from Laguna Lake, and from there, the ground slopes down to Laguna Lake with a steep grade.

The hilly areas are indented through erosion by rainwater that streams from the Taal mountains with Mt. Sungay as principal peak, and the plateau formation divides the watershed of the Manila Bay water system and the Laguna Lake water system. (The mean tide values of Manila Bay is appended in Appendix Fig. 8.8-2).

2) Precipitation

Statistical data show that about 16 to 20% of 132 typhoons that have entered the Philippine territory during the past 32 years have passed within a radius of 120 kilometers from Manila, with half of them occurring within the period from June to September.

Southwest monsoons and typhoons bring a great magnitude of precipitation and its maximum falls from June to September as illustrated in Fig. 8.8-1.

FIG. 8.8-1 NORMAL RAINFALL AND RAINFALL DAY IN MANILA

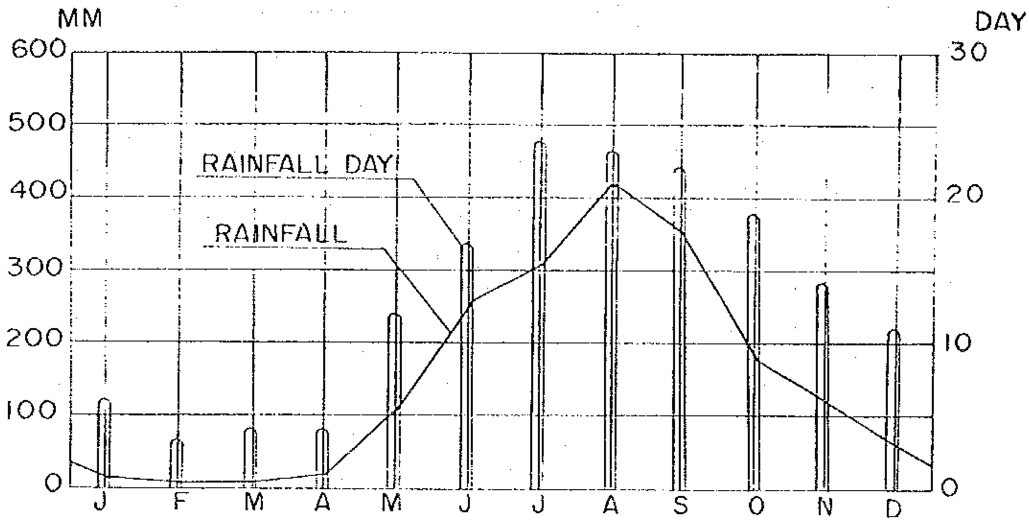


TABLE 8.8-1 NORMAL RAINFALL (mm)
(1951-1970)

Month	MIA	Port Area
January	15.5	13.3
February	4.9	6.3
March	4.3	10.1
April	16.8	21.3
May	104.5	122.9
June	255.6	236.9
July	306.2	354.3
August	420.4	473.9
September	348.7	401.0
October	172.7	181.9
November	120.5	114.2
December	57.8	58.1
Annual Total	1,827.9	2,044.2

Table 8.8-1 shows the result of observation of average monthly rainfalls at the Manila International Airport area and the port area during the 20-year period from 1951 to 1970.

8.8.3 Rainfall

The "Rainfall Intensity Duration Curves for Manila Area" were analyzed as shown in Appendix Fig. 8.8-3. Since the Project area is under almost the same rainfall conditions as in Manila, the said duration curves were used for the hydraulic analysis.

8.8.4 Run-Off Estimation Method

1) Calculation Formula

The rational formula was used in the calculation of flood discharges for the following reasons:

- Catchment areas to be handled are not so large;
- Peak discharges are used for determination of cross-sections of waterways;
- Verification of the results is difficult if the other methods are used; and
- The formula is widely used in the Philippines and easy to calculate.

The rational formula is expressed as follows:

$$Q = \frac{1}{3.6} \cdot f \cdot r \cdot A$$

where: Q = peak discharge in cubic meters per second

f = coefficient of run-off

r = rainfall intensity for a duration equal to the time of concentration in millimeters per hour

A = drainage area in square kilometers

2) Time of Concentration

The time of concentration was determined from the fact that the Project site is an area where residential land use is developing.

The time of concentration was estimated by: (inlet time) + (flow time), where the values of the inlet times were adopted from the American Association of Civil Engineers and the values of the flow times calculated from Kraven's formula.

The relationship between stream velocity and slope of streambeds was assumed as in Table 8.8-2.

TABLE 8.8-2 RELATIONSHIP BETWEEN VELOCITY AND SLOPE

H/L	Over 1/100	1/100 to 1/200	Below 1/200
V (m/s)	3.5 m/sec	3.0 m/sec	2.1 m/sec

Where: H = height of waterway in meters
L = length of waterway in meters
V = velocity of stream in meters per second

3) Coefficient of Run-Off

The coefficient of run-off varies with slope, shape, soil type, vegetation, initial soil saturation, water table conditions, etc.

The Project site is a hilly area having a comparatively steep slopes (1/120 to 1/200) and it is supposed that the whole area will develop to a residential area. Geologically, tuff of the Pliocene and the Pleistocene epochs scatters in the Project area, having little holding capacity of water. Most of the precipitation during rainy seasons is supposed to run out. Based on the above discussion, the coefficient of run-off was estimated in the range of 0.8 to 0.9.

4) Drainage Areas

Each drainage area was computed on the maps with scales of 1/25,000 or 1/50,000, and the drainage area map is appended in Appendix Fig. 8.8-4.

8.8.5 Hydraulic Design Principles

1) General

The waterways in the Project area will bring about backwater effects after the road construction, thus increasing the water level upstream of the drainage opening. This phenomenon can cause the flood water to be diverted somewhere and in the process it may cause serious damage. At the same time pondings, which require smaller hydraulic openings must also be considered.

The height of the hydraulic structures greatly influences the vertical alignment of the road. High velocity of flow will sometimes cause scouring at and/or near the structure.

Generally to avoid adverse effects to flood control and irrigation, design should be made in such a way that the existing drainage patterns be disrupted as little as possible.

2) Hydraulic Design of Bridge

The hydraulic computations for the bridge design were made to determine the bridge length and clearance and the maximum water level under the structure. For the computation of the bridges proposed in the lowland area, the trend of the past floods was reviewed.

3) Hydraulic Design of Culvert

The culverts were designed to determine the type and size of structure that will most economically accommodate the flow of the stream, with attention paid to the permissible level of the headwater pool at the upstream side of the structure.

4) Discharge Capacity

Based on the policies discussed above the discharge capacities and shapes of channels required to deal with the major and medium size waterways were calculated by incorporating the available study data. The Manning's formula was used to calculate the mean velocity and discharge capacity of each waterflow as shown below:

a. Calculation Formula

$$Q = V \cdot A = 1/n \cdot A \cdot R^{2/3} \cdot I^{1/2}$$

where: Q = discharge in cubic meters per second

A = area of cross-sectional flow in square meters

V = mean velocity in meters per second

R = hydraulic mean depth in meters

I = slope of the channel

n = Manning's roughness coefficient (Typical values which were adopted for this study are shown in TABLE 8.8-3).

TABLE 8.8-3 VALUES OF MANNING'S ROUGHNESS COEFFICIENT

Type of Lining	Value of n
Natural river with slope protection	0.03
Artificial channels:	
Earth ditches with vegetation	0.035
Concrete pipe culvert	0.013
Side ditches, cast-in-place concrete	0.014

Source: Feasibility Study for Manila-Bataan Coastal Road and Its Related Roads (C-5 & C-6) Project, March 1980

b. Allowable Maximum Mean Velocity

To prevent the erosion of the channel lining the maximum mean velocities by lining materials were determined below and the respective values are shown in Table 8.8-4. However, for the flooding which is tentative, the following maximum velocities were considered:

Box culvert	:	less than 4.5 m/sec
Bridge:		
Clayey soil bed	:	less than 1.0 m/sec
Soft rock	:	less than 2.0 m/sec
Cobble stone cover	:	less than 3.0 m/sec

TABLE 8.8-4 ALLOWABLE MAXIMUM AVERAGE VELOCITIES BY MATERIALS OF CHANNEL BED

Material of Channel Lining	Velocity (m/sec)	Material of Channel Lining	Velocity (m/sec)
Sandy soil	0.45	Thick lining concrete	3.00
Sandy Loam	0.60	Thin lining concrete	1.50
Loam	0.70	Asphalt	1.00
Clayey loam	0.90	Cobble stone (thickness <30 cm)	1.50
Clay	1.00	Cobble stone (thickness >30 cm)	2.00
Clay with sand	1.20	Cobble stone grouted	2.50
Soft rock	2.00	Precast concrete pipe	2.50
Medium soft rock	2.50	Steel pipe	5.00
Hard rock	3.00		

Source: Hydraulic Calculation Examples, Sankaido Publishing Co. Japan

c. Erosion Protection

The allowable maximum mean velocities of the existing waterways are desirable to be below 0.7 m/sec for the waterbed consisting of loam, 1.0 m/sec for the bed of clay and 2.0 m/sec for the bed of soft rock.

The bed gradients of the existing waterways in the hilly areas are as steep as 1/100 to 1/250 and their beds are subject to marked erosion. There is a need to provide protection measures in the vicinity of the proposed road. The length of such protection measures should be about 3 times the road width for the bridge and 2 times for the culvert on their respective banks.

8.8.6 Determination of Hydrological Requirements for Structure Design

1) Hydrological Design Criteria

For this analysis, the rational formula was used based upon the design storm frequency curves. The design storm frequency of 50 years was adopted for the bridge which has a drainage area of 1.5 km^2, the frequency of 25 years for the box culvert which has a drainage area of less than 1.5 km^2, and the frequency of 5 years for the drainage of road surface and face of slope.

The freeboard above the design flood level was determined according to the design flood discharge as in Table 8.8-5.

TABLE 8.8-5 RECOMMENDED FREEBOARD

Design Flood Discharge (m^3/sec)	Freeboard (m)
Smaller than 200	0.6
200 - 500	0.8
500 - 2,000	1.0
2,000 - 5,000	1.2

Source: Feasibility Study for Manila-Bataan Coastal Road and Its Related Roads (C-5 & C-6) Project, March 1980.

2) Hydraulic Calculations

Based upon the policies, formulas and relevant values, the design discharge of each waterway on the Project Roads was calculated to determine the opening size of the drainage structures. The location of these structures is shown in Appendix Fig. 8.8-4.

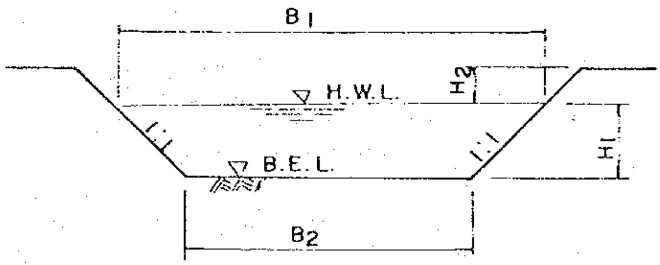
a. Cross Sections of Waterway for the Bridge

Based on the catchment areas, mean velocity (less than 3 m/sec), etc. discussed hereinbefore, dimensions of cross-sections of water ways for the bridge were determined as shown in Table 8.8-6.

TABLE 8.8-6 ADOPTED CROSS-SECTIONS OF WATERWAYS FOR BRIDGES

Route	Bridge Number	Dimensions (m)				High Water Level (H.W.L.)	Bottom Elevation (B.E.)	Design Discharge $Qp(M^3/sec)$
		B_1	B_2	H_1	H_2			
A	Br-2	34.0	26.0	4.0	0.8	3.00	-1.00	370
B	Br-1	20.0	12.0	4.0	0.6	7.90	3.90	180
	Br-2	20.0	12.0	4.0	0.6	13.50	9.50	190
	Br-3	48.0	34.0	7.0	1.0	5.00	-2.00	860
C	Br-4	20.0	12.0	4.0	0.6	9.00	5.00	180
	Br-6	17.0	10.0	3.5	0.6	8.50	5.00	160
	Br-8	20.0	12.0	4.0	0.6	13.00	9.00	200
	Br-11	20.0	12.0	4.0	0.6	25.50	21.50	190
	Br-13	15.0	8.0	3.5	0.6	61.50	58.00	120

Note:



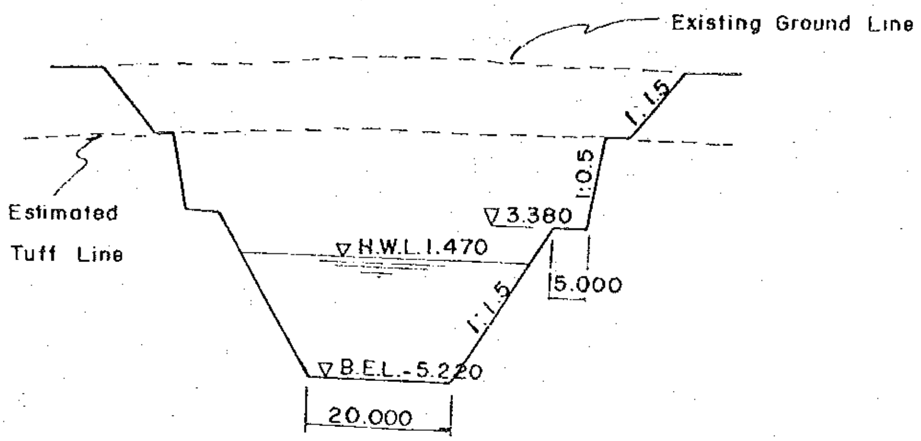
However, in this Project, there are two waterways that only accommodate tidal water and drain from their adjacent areas. As their existing cross-sections are sufficient for their bridges, their H.W.L.'s and B.E.'s were determined according to the past trend as below:

Route	Bridge Number	H.W.L.	B.E.
A	Br-4	2.57	-2.00
B	Br-4	2.30	-1.50

The design cross-sections of the proposed Paranaque Spillway and the proposed Cavite Friar Land Irrigation Canal are shown in Fig. 8.8-2 and Fig. 8.8-3, respectively.

FIG. 8.8-2 CROSS SECTION OF PROPOSED PARANAQUE SPILLWAY

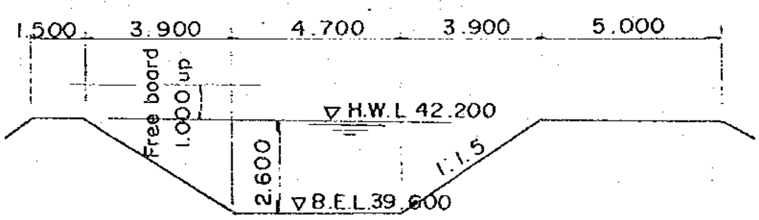
- BR-3 ON ROUTE C -



Source: Paranaque Spillway Project, around 4 + 0.00

FIG. 8.8-3 CROSS SECTION OF CAVITE FRIAR LANDS IRRIGATION CANAL

- BR-12 ON ROUTE C -



Source: Laguna de Bay Development Project Irrigation Component, National Irrigation Administration

b. Cross Sections of Waterways for Box Culverts

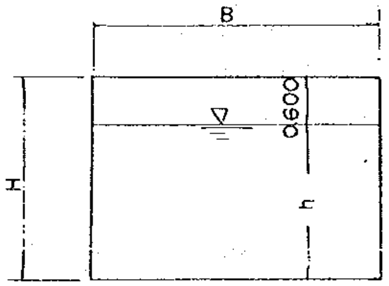
From the standard cross sections of the box culverts established by the MPWH, the dimensions accommodating the required discharges are shown in Table 8.8-7. Considering catchment area, time of concentration, discharge, bed slope, etc., the required cross sections of box culverts for this Project Roads are summarized in Table 8.8-8.

TABLE 8.8–7 DIMENSIONS OF BOX CULVERTS

(Unit: Meters)

B x H	h	A	P	R	$R^{2/3}$	$A.R^{2/3}$
1.52 x 1.52	0.92	1.459	3.44	0.424	0.564	0.823
1.52 x 1.83	1.23	1.870	3.98	0.470	0.605	1.131
1.83 x 1.83	1.23	2.251	4.29	0.525	0.651	1.465
1.83 x 2.13	1.53	2.800	4.89	0.573	0.690	1.932
2.44 x 2.13	1.53	3.733	5.50	0.697	0.773	2.886
2.44 x 2.44	1.84	4.490	6.12	0.734	0.814	3.655
3.05 x 2.44	1.84	5.612	6.73	0.834	0.886	4.972
3.05 x 3.05	2.45	7.473	7.95	0.940	0.960	7.174

Note:



$$Q = V \cdot A = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2} \cdot A$$

$n = 0.014$

$A = B \cdot h$ $R = \frac{A}{P}$

$P = B + 2h$

TABLE 8.8–8 ADOPTED SECTIONS OF BOX CULVERT

Route	Box Culvert Number	Dimensions (m)			Design Discharge Qp (M^3/Sec)
		B:Width	H:Height	x 1 (Mono) x 2 or 3(Multi)	
B	C - 1	3.05	2.44	x 1	23
	C - 2	3.05	2.44	x 3	99
	C - 3	2.44	2.13	x 1	15
	C - 4	3.05	3.05	x 2	66
	C - 5	3.05	3.05	x 1	33
	C - 6	2.44	2.44	x 1	17
C	C - 1	3.05	2.44	x 1	25
	C - 2	3.05	2.44	x 1	25
	C - 3	3.05	3.05	x 1	33
	C - 4	3.05	2.44	x 2	50
	C - 5	2.44	2.13	x 1	15
	C - 6	3.05	3.05	x 1	33
	C - 7	3.05	3.05	x 2	66
	C - 8	2.44	2.13	x 2	29
	C - 9	3.05	2.44	x 2	50
	C - 10	2.44	2.13	x 1	15
	C - 11	3.05	2.44	x 2	50
	C - 12	2.44	2.13	x 1	15
	C - 13	2.44	2.13	x 1	15
	C - 14	2.44	2.13	x 1	15
	C - 15	2.44	2.13	x 2	29
	C - 16	3.05	2.44	x 2	50
	C - 17	3.05	2.44	x 2	50
	C - 18	3.05	3.05	x 2	66

3) Study Results and Recommendations

The existing drainage facilities (bridges and culverts) on A- and B-Routes are found short of their flow capacity. Therefore, these structures should be improved in this Project.

The H.W.L. of the Las Pinas River which is situated near Manila Bay is set at +2.57 according to the past flood level marks, and the design height of the road to be improved is raised accordingly. The embankment slope below H.W.L. of the improved road section should preferably be provided with protection.

As C-Route is a new road running through hilly areas, the required structures should be provided to match the ground line of the existing waterways. For the structures especially provided on the waterway having a steep grade, due attention should be given to its channel bed gradient in order to prevent scouring and erosion.

CHAPTER 9

ENVIRONMETAL IMPACT OF THE PROJECT ROADS

Chapter 9 ENVIRONMENTAL IMPACT OF THE PROJECT ROADS

9.1 General

The environmental study for the Project Roads was described in a separate volume, "Environmental Impact Statement" which analyzed the environmental and social impacts of the Project Roads in accordance with the guidelines of the National Environmental Protection Council (NEPC) in order to obtain the approval and issuance of Environmental Clearance Certificate for the implementation of this Project.

9.2 Existing Environmental Conditions

9.2.1 Water Quality of Rivers

The amount of dissolved oxygen in Paranaque and Zapote Rivers which cross the Project Roads was observed by the National Pollution Control Commission (NPCC) to be less than the standard.

9.2.2 Atmosphere

The two main sources of air pollution in Metro Manila are emission from motor vehicles and industrial plants. The effect of automobile exhaust in the atmosphere is serious, because this country has no regulation for improvement of the automobile that can mitigate air pollution through motorized traffic. The air quality data in Metro Manila observed from 1975 thru 1979 by the NPCC show that the observed levels of air pollution are still below the maximum allowable standard set for each of the various pollutants.

9.2.3 Noise

The average noise levels at sampling points in Manila indicate that the noise levels exceed the ambient quality standards most of the time of the day.

9.2.4 Vegetation

The northern part of the Project area has been developed mainly for residential purpose. Vegetation exists on the southern part where the terrain is hilly and urbanization has not been in progress. Open spaces are covered mainly with seed grass and other short grass. Mango trees, banana and some other kinds are found. There is no specific vegetation to be preserved along the Project Roads.

9.2.5 Fish

Fishponds are found along the coast of Manila Bay. Owners cultivate milkfish, tilapia and catfish. One of the Project Roads will affect several fishponds.

9.2.6 Wildlife

Birds are the most conspicuous wildlife in the area. They nest, feed and breed their young in open spaces. The most common species are sparrows and timpapalis which are not listed as birds to be preserved.

9.3 Probable Environmental Impacts by the Project Roads

9.3.1 Natural and Physical Environments

1) Water

The Roads will cross existing rivers and streams by means of bridges and culverts. The river flows tend to get muddy during the construction of their foundations. The suspended solids in the water may flow and settle on aquatic plants and disturb aquatic life. However, these adverse effects are anticipated to occur only during the construction period and their duration is therefore limited.

2) Air Quality

The prediction values of high Nitrogen Dioxide, NO_2 and Carbon Monoxide, CO show that they are almost half of the standard values. Thus, it is forecast that the construction of the Roads will not significantly affect the air quality of the area.

3) Noise

The predicted noise levels at the western sections of Paranaque-Sucat Road and Zapote-Alabang Road show values a little higher than the standard, which are both tolerable, considering the present traffic conditions on the major roads in Metro Manila.

4) Vibration

The predicted value for the maximum vibration level is estimated to be 61 dB. It is generally known that people sleeping are disturbed when the vibration level is more than 65 dB. Thus, it is forecast that the Roads will not significantly affect the vibration level of the area.

9.3.2 Socio-Economic Environment

1) Land Use

It is expected that land use potential along the Roads will be greatly enhanced, and the vicinity of the Roads will be converted to highly developed residential, commercial and industrial land use because of better mobility.

2) Transportation

The Roads will greatly enhance and strengthen the function of the road network system south of Metro Manila. Accordingly, transport mobility and accessibility of the area will be improved because of reduction of travel time and traffic cost.

3) Economy

The implementation of the Roads is expected to promote economic activities in the surrounding areas. The total number of employed persons in the immediate influenced area is estimated to be 670 thousand by 1990 and 930 thousand by the year 2000.

4) Life Style

It has been observed that in the vicinity of the northern section of the proposed loop road, communities are developed in the form of subdivisions, where neighborhood cohesiveness exists. The implementation of the new road will adversely affect such cohesiveness. The adjacent areas of the two existing roads are envisaged to be converted to commercial uses. With a wider roadway, both sides will result into two weaker neighborhoods, each of which will grow separately as one commercial area with different characteristics.

In the area where only narrow roads and footpaths are usually provided, the newly constructed wide road will affect the daily activities of the community people, as they have to cross the new road at pedestrian crossings only. On the other hand, however, the new major road provides them with better access.

For those whose land and/or properties are to be acquired for the road right-of-way, the effect on their life style will be considerable because they are mostly middle income people.

5) Aesthetic Environment

Provision of open space in the form of a roadway will contribute to the beautification of the area where poor quality houses are built up. The southern section of the loop road will run through the hilly terrain area, where cut and fill earthwork might be required. It is desirable that ample road right-of-way should be acquired to accommodate embankment slopes that would be provided with landscaping.

9.4 Favorable Environmental Impacts

- The Project Roads will contribute to the improvement of traffic movement in the Project area and south of Metro Manila Area as a whole.
- The smoother and faster flow of traffic in the area will result in considerable reduction of losses in terms of accidents, man-hours, fuel consumption, engine depreciation, etc.
- It will offer to the local people the opportunity of acquiring road construction techniques.
- The Roads will greatly enhance and strengthen the function of the road network system in the National Capital Region (NCR).
- Provision of the Roads will improve traffic service within the surrounding area, and reduce traffic congestion south of NCR. Accordingly, transport mobility and accessibility of the corridor along the Roads will be improved because of reduction of travel time and traffic cost.
- Land use potential in the surrounding area of the Roads will be greatly enhanced. The corridor of the Roads will be highly developed for residential, commercial and industrial land uses.
- The land value in the surrounding area of the Roads will be enhanced due to the improvement in accessibility.
- Provision of open space in the form of a wide roadway will, to a certain extent, relieve people of high tension of living in a densely built up area and will also serve as a buffer during disasters such as fires.
- At first, existing community cohesion will be reduced by the provision of the Roads. However, immediate growth of a new community in the areas will be promoted and establishment of new community will hasten the realization of a comfortable and adequate living area.

9.5 Adverse Effects and Their Mitigating Measures

- Some congestion, dust, noise, etc. caused by the demolition of buildings can be expected. Obstruction to the existing traffic, noise and vibration of equipment can be reduced by adequate construction management and by application of proper construction methods and use of proper equipment.
- The river waters are likely to get muddy during construction of bridge foundations, although the duration of time involved is limited. The water can be kept as clean as possible by adopting suitable construction procedures.
- The re-alignment of the western section of Paranaque-Sucat Road to Quirino Avenue will run through fishponds/saltbeds. Opening with adequate size will be provided to let the seawater flow freely.

The vicinity of the said re-alignment is envisaged to be built up, thus threatening to pollute the tidal water to fishponds/saltbeds. Provision of appropriate sewerage or other measures can prevent such water pollution.

- To reduce the inevitable noise level at the roadside, shielding fence as a buffer wall can be introduced. Control of speeds and regulated entry of heavy vehicles will give immediate relief.

9.6 Recommendations

9.6.1 Air Quality

In order to improve the air quality, it is necessary to consider the comprehensive measures including regulations for vehicles, improvement of roads and traffic control. On the other hand, it is essential to promote air quality survey and its analysis as well as establishment of a method of forecasting.

9.6.2 Noise

Automobile noise is mainly emitted from engines, air intakes and exhaust pipes, cooling fans, drive trains, tires and so on. Actually, however, various factors, such as traffic volume, type of automobile vehicles, speed, structure of roads, etc. are completely integrated to create automobile noise problems at roadsides, aside from the noise created by automobiles themselves.

Accordingly, in order to minimize these problems effectively, it is necessary that measures such as regulation of noise emitted from vehicles themselves, the improvement of automobile structure, the improvement of operating conditions of vehicles, the control of traffic volume and improvement of road structure should be introduced in addition to other measures at roadsides.

The existing regulation which specifies the construction of houses with a minimum setback of three meters will not be sufficient for the noise problem. In case where houses and buildings are built along these roads, the owners can lessen the problem by introducing shielding fence as a buffer wall and setting back their residence about ten meters from the roadside, where it is advisable to provide rows of trees and bushes in front of the houses. In the case of stores and commercial/business buildings, provision of spacious parking lots in front of them is also advisable.

9.6.3 Vibration

Problems of traffic vibration in the areas along the roads are caused by the combination of various factors, such as, vehicle weight, running conditions and road conditions (evenness of road surface, pavement structure, roadbed conditions, etc.)

In order to minimize the vibration problems effectively, it is necessary that measures, such as the control of traffic volume on the existing roads and the improvement of road structure should be introduced in addition to other measures at roadsides.