No. 4

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR CONSTRUCTING
BRIDGES ALONG RURAL ROADS
(PHASE II)
IN
THE REPUBLIC OF THE PHILIPPINES

JUNE 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of the Philippines, the Government of Japan has decided to conduct a basic design study on the Project for Constructing Bridges along Rural Roads and the Japan International Cooperation Agency (JICA) sent to the Philippines a study team headed by Mr. Hiro-o Jin, Head of Research Division, Planning and Development Department, Honshuu-Shikoku Bridge Authority from February 15 to April 10, 1988.

The team had discussions on the Project with the officials concerned of the Government of the Philippines and conducted a field survey in the project area. After the team returned to Japan, further studies were made, a draft report was prepared and, for the explanation and discussion of it, a mission headed by Mr. Juro Chikaraishi, Second Basic Design Study Division, Grant Aid Planning and Survey Department, JICA was sent to the Philippines from June 15 to June 21, 1988. As a result, the present report has been prepared.

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

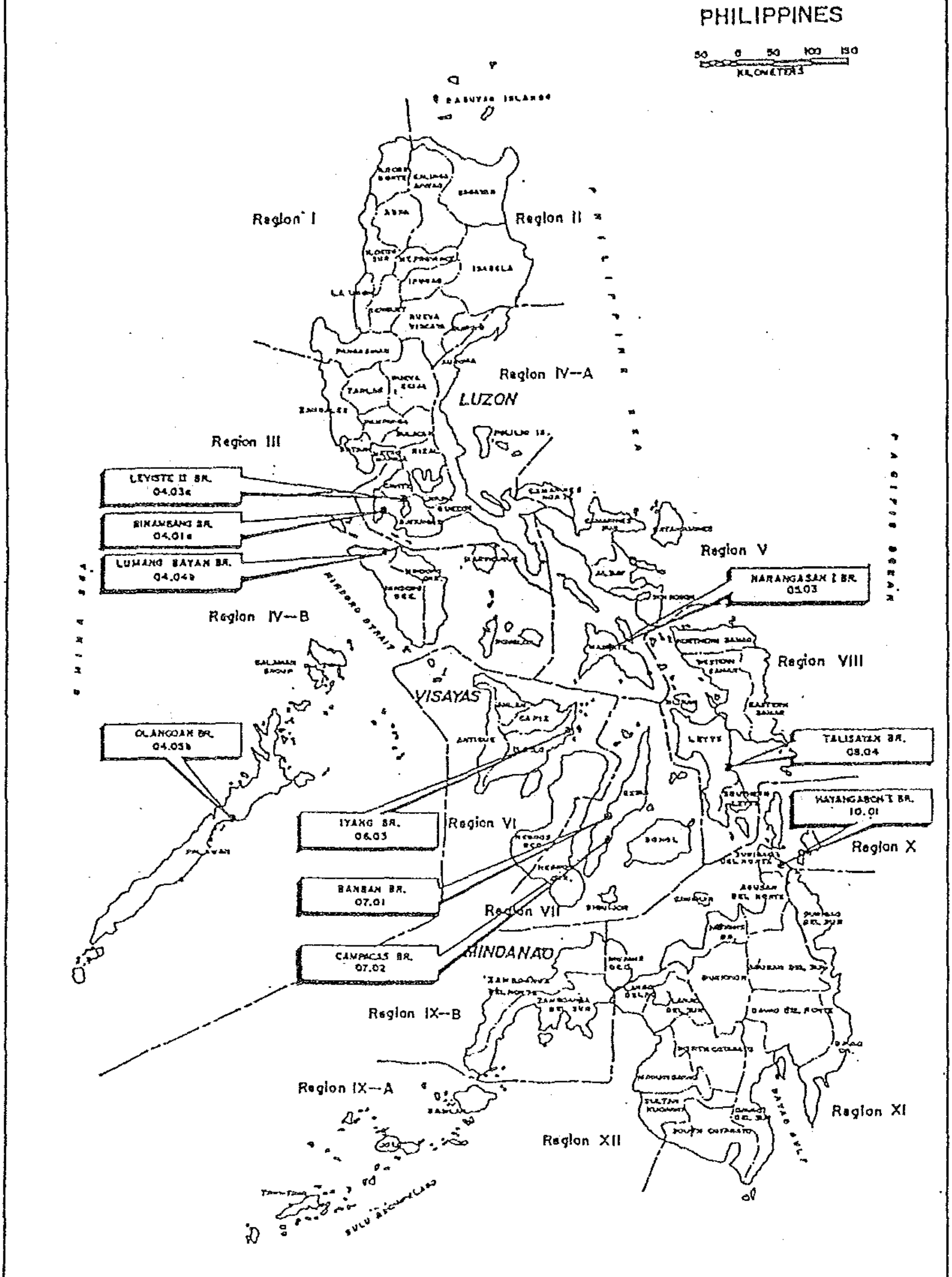
I wish to express my deep appreciation to the officials concerned of the Government of the Republic of the Philippines of their close cooperation extended to the team.

June, 1988

Kensuke Yanagiya

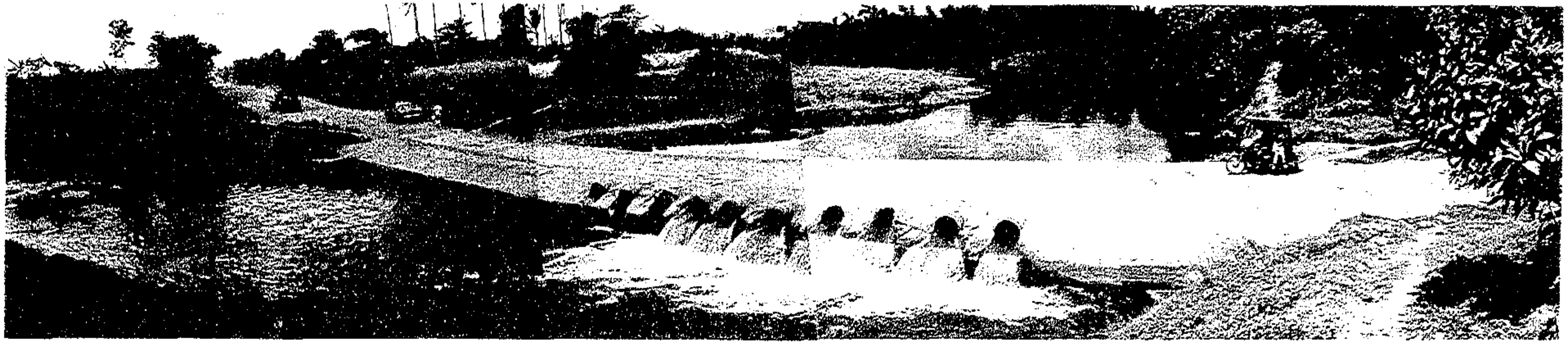
Kensuke Yanagiya
President
Japan International Cooperation Agency

LOCATION OF PHASE II BRIDGES



04.01a BINAMBANG BRIDGE

Km. 107 + 540
BALAYAN - BALIBAGO - CALATAGAN ROAD
CALOOCAN, BALAYAN, BATANGAS

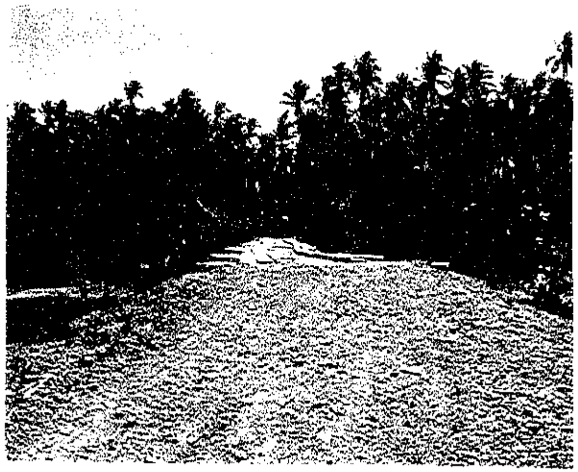


04.03a LEVISTE II BRIDGE

Km. 92+430
TALISAY-LAUREL-AGONCILLO ROAD
LAUREL, BATANGAS

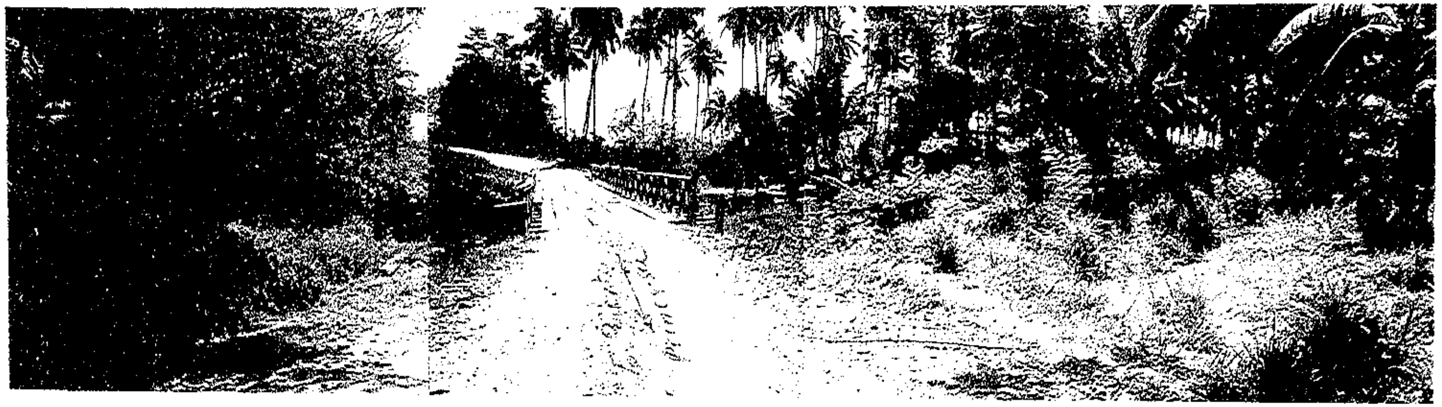
04.04b LUMANG BAYAN BRIDGE

KM. 34 + 954
MABURAO – NORTH PUERTO GALERA ROAD
ORELAN, ABRA DE ILONG MINDORO OCCIDENTAL



04.05b OLANGOAN BRIDGE

Km. 74 + 524
PUERTO PRINCESA NORTH ROAD
CONCEPCION, PUERTO PRINCESA CITY
PALAWAN

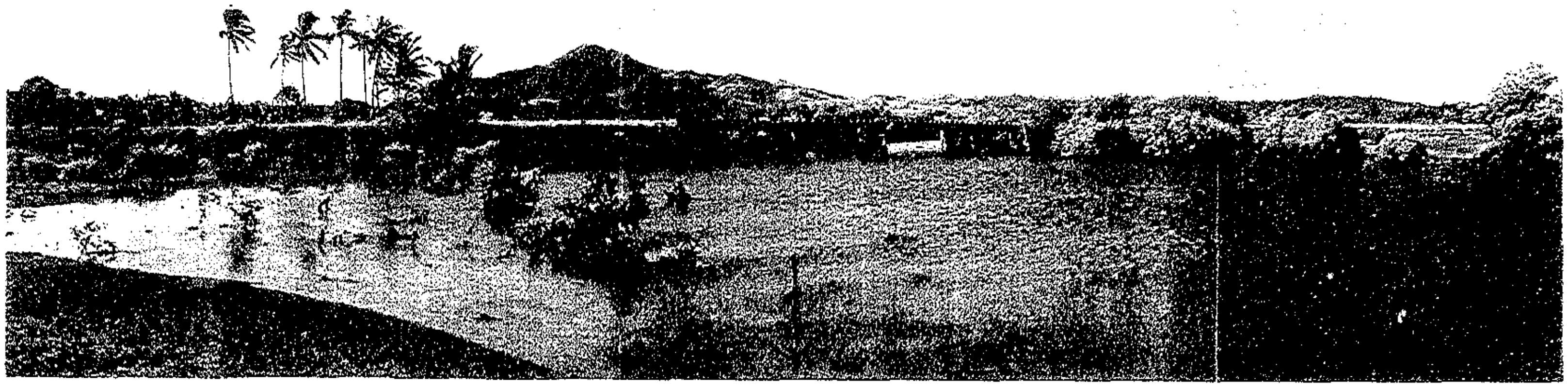


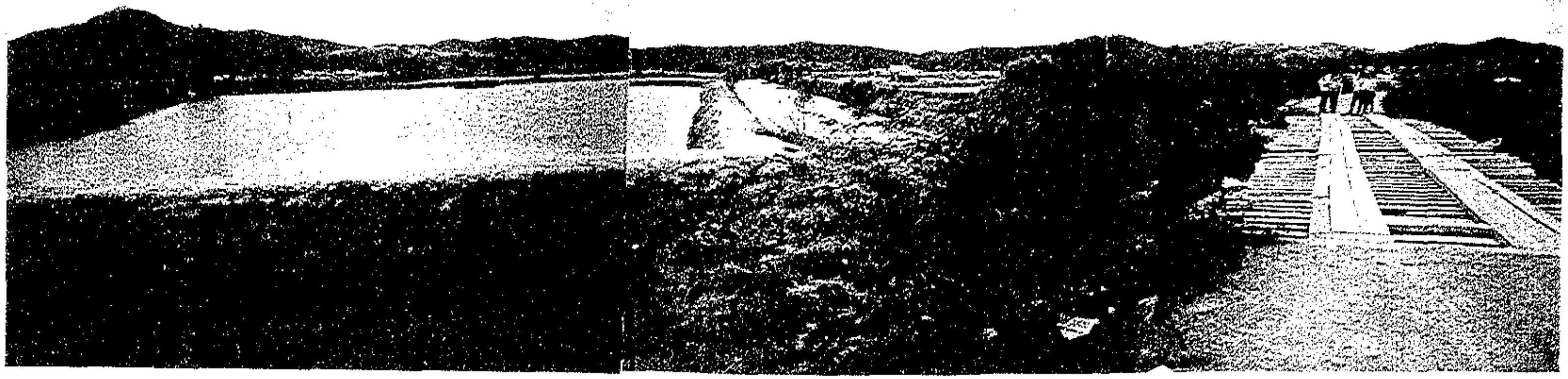
05.03 NARANGASAN I BRIDGE

Km. 31 + 145
JCT. TAWAD-BALUD ROAD
MILAGROS, MASBATE

06.03 IYANG BRIDGE

Km. 109 + 962
CONCEPCION - SAN DIONISIO NATIONAL ROAD
CONCEPCION , ILOILO



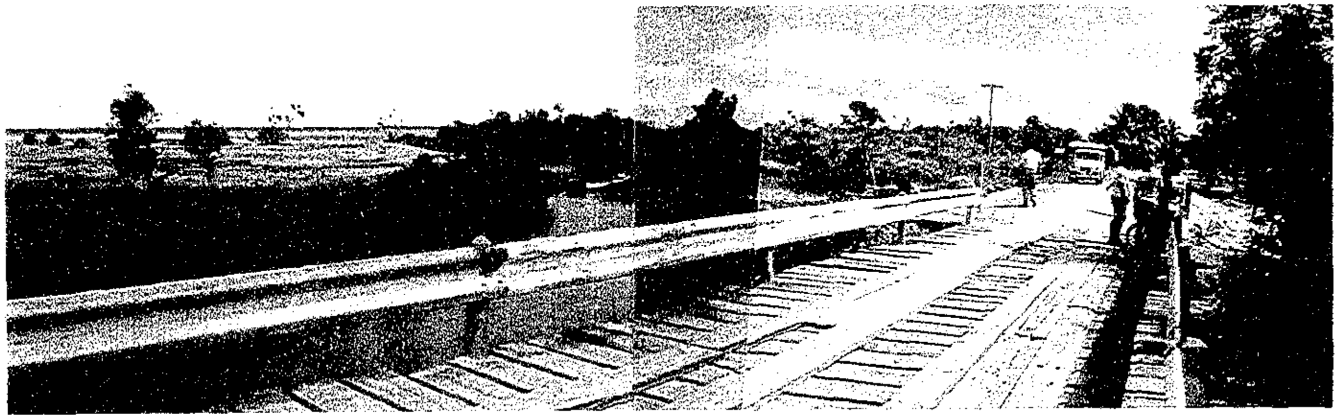


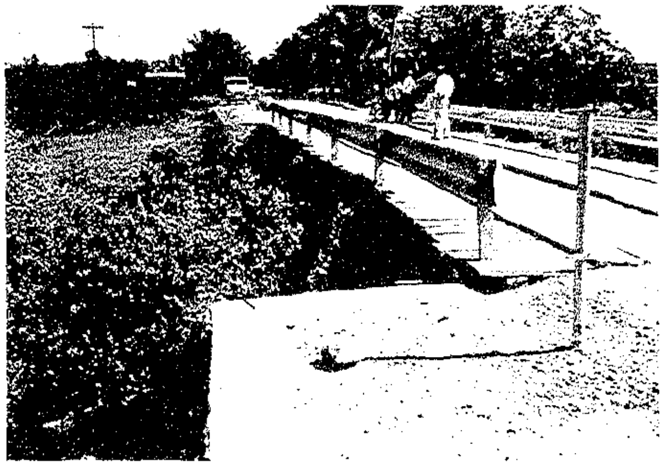
07.01 BANBAN BRIDGE

KM. 62 + 100

PINAMUNGAHAN - ALOGUINSAN - MANTALONGON ROAD

PINAMUNGAHAN, CEBU



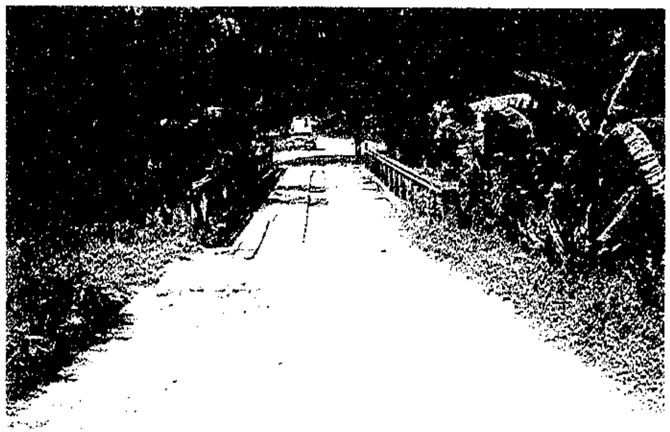


07.02 CAMPACAS BRIDGE

KM. 97 + 600

DALAGUETE — MANTALONGON ROAD

DALAGUETE CEBU

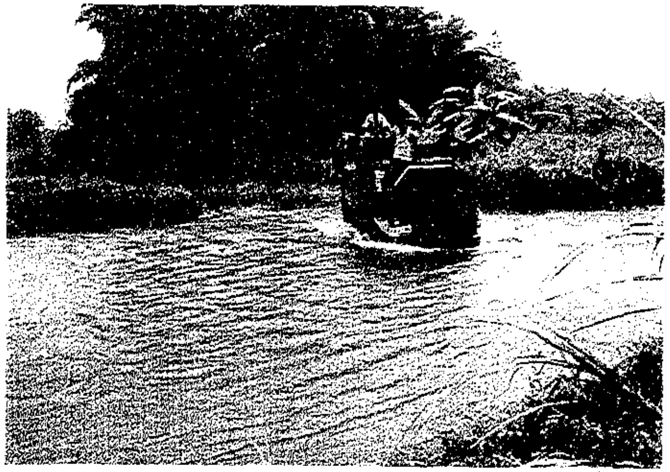


08.04 TALISAYAN RIVER CROSSING

Km. 66 + 800

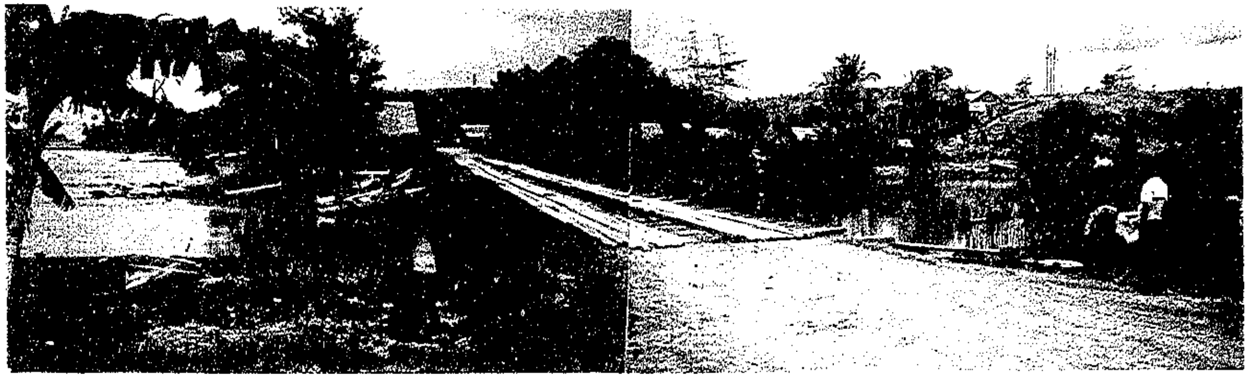
LA PAZ-JAVIER-BITO ROAD

TALISAYAN, JAVIER, LEYTE



10.01 HAYANGABON I BRIDGE

KM. 1202 + 586
SURIGAO – DAVAO COASTAL ROAD
HAYANGABON, CLAVER SURIGAO DEL NORTE



SUMMARY

In response to the request of the Government of the Philippines, the Government of Japan has decided to conduct the Basic Design Study on the Project for Constructing Bridges along Rural Roads (Phase II) (hereinafter referred to as "the Study") in the Republic of the Philippines, upon completion of the same study (Phase I). Subsequently, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Basic Design Study Team from February 15 to April 10, 1988. The Minutes of Discussions on this Study was exchanged on April 7, 1988.

The Study Team held a series of discussions and consultations on the Project with the officials concerned of the Government of the Philippines and conducted a site survey including topographic and geotechnical surveys. Information and materials to determine the scope and grade of the Project were collected.

Upon its return to Japan, the Study Team held further discussions with relevant agencies of the Government of Japan to examine the appropriateness of the Project as a grant aid project. Information and data gathered in the Philippines, problems anticipated in the construction and maintenance of the bridges and the expected effects of the Project were taken into consideration in preparing the Basic Design of the Project.

Upon the completion of a Draft Final Report, JICA dispatched a mission to explain and discuss it with the relevant officials of the Government of the Philippines from June 15 to 21, 1988. The Minutes of Discussions on the Study was exchanged on June 20, 1988. Through these discussions, the Basic Design Study Report (Phase II) was finally drawn up.

This report summarizes the output of the analysis and the basic design for Phase II Bridges.

I. Background and Objective of the Project

The Government of the Philippines aims to reinforce the physical foundation of the economy to support the overall development thrust of sustained economic growth, economic efficiency and recovery. It seeks to establish and improve essential transport facilities in rural areas to increase activities in these areas for greater production and to induce direct investment therein.

It has been pointed out that some of the bridges in rural areas are old and temporary wooden bridges which are often closed to traffic, especially during the rainy season. Missing or weak bridges diminish the usefulness of many existing roads. This situation has been regarded as one of the main constraints of development in rural areas.

The replacement of these old temporary and dilapidated bridges by permanent steel structures will ensure fast, safe and smooth land transportation, which will certainly contribute to the socio-economic development of these areas.

The implementation of the Project is proposed in line with the Highway Development Strategy as envisioned in the Medium-Term Philippine Development Plan 1987-1992.

II. Proposed Bridges

The Government of the Philippines proposed fifty-eight (58) bridges for Japan's Grant Aid Project, which were classified into the following three (3) categories from the engineering point of view in the course of the Phase I Study:

1) Phase I Bridges - The steel materials for bridge construction will be provided by the Japanese Government. The required level of engineering for the bridge construction is relatively easy for the Philippine side to design and construct by using those materials.

2) Phase II Bridges - All the materials and construction work will be provided by the Japanese Government. The required level of engineering for the bridge construction is relatively high and suitable for the Japanese side to design and construct their substructures and superstructures.

3) Others - No data is available, or immediate replacement is not necessary.

From the total of fifty-eight (58) bridges, 24 were selected as Phase I Bridges under Japan's Grant Aid Project, while twenty-one (21) were identified as Phase II Candidate Bridges and thirteen (13) were classified as others.

Among the twenty-one (21) Phase II Candidate Bridges, however, only ten (10) were selected as the subject bridges for the Phase II Study in accordance with the priority established taking into consideration the urgency of reconstruction, traffic demand and conditions of roads to be used for transporta-tion of construction materials and equipment. The selec-tion of ten (10) bridges was agreed on between both governments prior to the Study. Upon arrival of the Study Team in the Philippines, the Philippine Government requested that one (1) of the ten (10) bridges included in the list be changed, because it was included in other project. This was officially accepted by the Government of Japan.

The Basic Design Study (Phase II) was conducted for the ten (10) bridges officially approved.

III. Brief Description of Phase II Bridges

The main features of the Phase II Bridges are as follows:

. Total Number of Bridges : 10

. Total Length of Bridges : 517 m

. Length of Spans : 22 ~ 35 m

. Number of Spans	:	4 (4 one-span bridges) 8 (4 two-span bridges) 3 (1 three-span bridge) 4 (1 four-span bridges) 19
. Width of Bridges	:	Total Width 8.320 m Roadway 3.350 m x 2 lanes Sidewalk 0.420 m x 2 lanes
. Type of Superstructures	:	H-Beam Composite Girder Build-up Steel Girder
. Type of Substructures	:	T - type Abutment (Spread Footing or Pile Foundation) Column -type Pier (Spread Footing or Pile Foundation)
. Cofferdam	:	Steel Sheet Pile
. Approach Roads	:	Roadway 3.350 m x 2 lanes Shoulder 1.000 m x 2 lanes Portland Cement Concrete Pavement
. River Bank Protection	:	Grouted Riprap

IV. Scope of Both Governments

(1) Scope of the Government of Japan

Japan's Grant Aid will be extended to the construction of bridges, related structures and approach roads, including supply of steel materials, as follows:

1) Supply of Steel Materials

. H-Beams and Others	452.2 t
. Build-up Steel and Others	340.5 t
. Steel Sheet Piles and Others	168.8 t
. Steel Railings and Posts for Bridge Approaches	640.0 m

2) Construction of Structures

. Deck Slabs of Bridges	4384.9 m^2
. Abutments	20 abutments
. Piers	9 piers
. Concrete Piles	261 piles (2988.0 m)
. River Bank Protection	4642 m^2

3) Construction of Approach Roads 2.492 km

(2) Scope of the Government of the Philippines

The Government of the Philippines is responsible for undertaking the followings steps:

1) Acquiring the right-of-way and providing necessary land area for the construction works.

2) Demolishing obstacles including houses within the right-of-way that affect the implementation of the Project.

3) Making passable all roads and bridges leading to the Project sites for the transportation of materials and equipment provided under Japan's Grant Aid.

V. Project Cost

The Project cost to be borne by the Government of the Philippines is roughly estimated at 36 million yen (about 6 million pesos).

VI. Construction Schedule

The construction schedule is tentatively programmed as follows:

. Detailed Design : 3.5 months
. Tendering : 1.5 months
. Construction : 12 months

VII. Executing Agency

The executing agency of the Government of the Philippines for the Project is the Department of Public Works and Highways (DPWH). The Bureaus of Design, Construction, and Maintenance, and Regional Offices, of the DPWH are responsible for their corresponding activities.

The Project aims to provide transportation facilities for the smooth movement of people and commodities in rural areas, and to induce agricultural and industrial investment and development. Thus, the Project will contribute to the development goals of the Philippines, i.e., alleviating poverty, generating more productive employment, promoting equity and social justice and attaining sustainable economic growth.

Given that the expected effect of the Project for constructing bridges along rural roads will greatly benefit the people and society in rural areas, implementation of the Project under Japan's Grant Aid is quite appropriate.

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

In response to the request of the Government of the Philippines, the Government of Japan decided to conduct the Basic Design Study on the Project for Constructing Bridges Along Rural Roads (Phase I) (hereinafter referred to as the Phase I Study) and the Japan International Cooperation Agency (hereinafter referred to as JICA) dispatched the Basic Design Study Team to the Philippines in November 1987 for a field investigation. Subsequently, the Basic Design Study Report (Phase 1) was prepared in January 1988.

Following the Phase I Study, the Government of Japan decided to conduct the Basic Design Study on the Project for Constructing Bridges Along Rural Roads (Phase II) (hereinafter referred to as the Phase II Study) and JICA dispatched the Basic Design Study Team to the Philippines from February 15 to April 10, 1988.

The Study Team had a series of discussions with the officials concerned of the Government of the Philippines and conducted field investigation and topographic and geo-technical surveys together with its Philippine counter-parts. (Refer to Appendix 1). The Minutes of Discussions on the Phase II Study was signed on April7, 1988. (Refer to Appendix 1).

The Project involves the construction of new bridge structures and the replacement of old bridges along rural roads throughout the country. A total of fifty-eight (58) bridges were proposed by the Government of the Philippines. Based on the engineering point of view, the proposed fifty-eight (58) bridges were classified into three (3) categories: Phase I Bridges, Phase II Candidate Bridges and Others.

Among the twenty-one (21) Candidate Bridges, ten (10) bridges were selected as Phase II Bridges for Japan's Grant Aid in accordance with the priority established taking into consideration the urgency of reconstruction, traffic demand and conditions of roads to be used for transportation of construction materials and equipment. The selection of ten (10) bridges was agreed on between the Japanese and Philippine Governments prior to the commencement of the Phase II Study.

However, when the study team arrived in the Philippines, the Philippine Government requested to change one (1) of the ten (10) bridges in the list. The Japanese Government approved it and, the ten (10) bridges as the subject for the Basic Design Study (Phase II) were finalized.

Data and information collected in the field and the outcome of topographic and geotechnical surveys were further analyzed in Japan. As result of the study, a Draft Final Report was prepared and JICA dispatched a mission to explain and discuss it with the relevant officials of the Government of the Philippines from June 15 to 21, 1988. The Minute of Discussions on the Draft Final Report was signed June 20, 1988. (Refer to Appendix 2). Through these discussions, the Basic Design Study Report (Phase II) was finalized.

This report covers the result of the analysis and the basic design for Phase II Bridges.

CHAPTER 2

BACKGROUND OF THE PROJECT

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BACKGROUND OF THE PROJECT

The Project for Constructing Bridges along Rural Roads (Phase II) is a continuation of Phase I which has been completed on January, 1988. Therefore, the background of Phase II Study is the same as described in the Basic Design Study Report for Phase I, which is summarized below.

2.1 Present Condition of Highways and Bridges

2.1.1 Present Condition of Highways

Of the four (4) transport modes, namely road, rail, sea and air transport, road transport is dominant in the Philippines. The road network has been developed rapidly in the last two (2) decades, and carries 90 percent of passenger and 65 percent of freight traffic. Almost all intra-island transport depends on road transport. See Table 2.1-1.

TABLE 2.1-1 APPROXIMATE NATIONAL MODAL SPLIT, 1980
(DOMESTIC TRAFFIC ONLY)

Mode	Freight		Passenger	
	Ton-km (Billion)	Share (%)	Passenger-km (Billion)	Share (%)
Sea	12	(35)	4	(7)
Road	22	(65)	53	(90)
Rail	0.04	(-)	0.04	(1)
Air	(Negligible)	(-)	1.2	(2)

Source: NTPP

As shown in Table 1 of Appendix 8, the Philippines has a total road length of 161,709 km; of which 16% are classified as national roads, 18% as provincial roads, 3% as city roads, 8% as municipal roads and 55% as barangay roads.

Only 9,188.15 km (6%) of the roads are made of concrete surface, 12,049.78 km (7%) asphalted and the remaining 140,470.7 km of unpaved surface, consisting of gravel roads (81%) and earth surface (6%). Most concrete paved stretches are national roads for a total of 6132 km (or 67%). Provincial and city roads have approximately 1349 km (15%) of concrete pavement, while municipal roads have 1706.25 km (19%).

Relative to the projected 1985 population, the country has 3 km of road for every 1,000 persons. The regions with very high road lengths per thousand population are Regions I, II, IV-B, X, XI, and XII, while the regions with very low road lengths per thousand population are NCR and Southern Tagalog.

The present highway network is observed to have the following deficiencies:

(a) Less than 50% of the total network may be considered as all-weather roads. Only about 40% of the national road network is paved with concrete or asphalt.

(b) The condition of many roads, especially barangay (feeder) and provincial (secondary) roads and even some national road sections, is poor because of initial low design standards relative to traffic volume, sub-standard construction, inadequate maintenance and damage from over-loaded vehicles.

(c) Missing or weak bridges diminish the usefulness of many existing roads.

(d) In some remote areas, access roads connecting with arterial or rural roads are scarce.

2.1.2 Present Condition of Bridges

The Philippines has a total of 218,993.67 linear meters of bridge structures in 1985, of which 75% are permanent and 25% are temporary. The temporary bridges are Bailey with wooden trestles, timber, etc.

These bridges are dilapidated and dangerous and are often closed to traffic, especially during the rainy season. This situation has been regarded as one of the main constraints on development in rural areas.

The region with the shortest length of temporary bridges is NCR with 1.1%, followed by Regions III (4.6%), I (10.1%) and IV-A (11.5%). The region with the largest percentage of temporary to permanent bridge length is Region IV-B (49.1%), followed by Regions XI (43.1%), VIII (41.0%) and VI (34.7%), as shown in Table 2.1-2.

TABLE 2.1-2 EXISTING BRIDGES BY CLASSIFICATION AND STANDARD 1985 (ALONG NATIONAL ROADS ONLY)

	Permanent (L.M.)	Temporary (L.M.)	(%)	Total (L.M.)
Philippines	163,404.46	55,589.21	(25.4)	218,993.67
N C R	9,293.01	104.00	(1.1)	9,397.01
I	21,095.32	2,367.51	(10.1)	23,462.83
II	16,153.67	4,324.68	(21.1)	20,478.35
III	16,153.67	770.99	(4.6)	16,860.18
IV-A	11,021.75	1,430.01	(11.5)	12,451.76
IV-B	5,968.74	5,769.19	(49.1)	11,737.93
V	10,386.21	3,312.51	(24.1)	13,698.72
VI	14,391.52	7,634.22	(34.2)	22,025.74
VII	9,230.23	3,795.74	(29.1)	13,025.97
VIII	14,954.00	10,379.41	(41.0)	25,333.41
IX	6,808.48	1,796.01	(20.9)	8,604.49
X	13,810.03	5,391.98	(28.1)	19,202.01
XI	7,624.14	5,792.04	(43.1)	13,416.19
XII	6,578.17	2,720.92	(29.3)	9,299.09

Note :
Permanent Bridge - Concrete, steel and similar materials.
Temporary Bridge - Bailey, timber, coconut and similar materials.
% - Ratio of temporary bridge length to permanent.

NCR - National Capital Region

Listed below are comments and observations on the existing temporary bridges made by DPWH district, city and maintenance engineers:

. Temporary timber trestle bridge is always damaged by flood resulting in frequent repairs of timber parts.

. Maintenance cost of the long span temporary bridge is excessive.

. Repair work is very expensive and has to be done very frequently.

. Existing bridge is out of alignment.

. Capacity of existing bridge may not conform with the live loads passing over the bridge.
(Load limits of existing bridges are 3 to 10 tons.)

. Heavy equipment and other heavy cargo trucks cannot cross the bridge safely.

. Truck loads hauling agricultural products, such as rice, copra, forest and aqua-cultural products, exceed the capacity of the bridge.

. Inconvenient for the traveling public, especially in transporting agricultural products from farm to market.

. Accidents ocurred to some motorists when fording the river.

. Traffic jams created from water or flooding.

2.2 Outline of Related Development Plans

2.2.1 National Development Plan

The Philippine Government published in January 1987 the "Medium-Term Philippine Development Plan 1987-1992". The plan analyses the cause of the minus economic growth starting in late 1983 and the present conditions, and sets the new goals of the government. The principal goal is the restoration of the economy which will lead to the alleviation of poverty and increase in employment opportunities. (Present unemployment rate : 11.8%; part-time employment rate : 35.2%). The major economic indexes of the Philippines are shown in Table 5 of Appendix 8. The composition of expenditures is shown in Table 6 of Appendix 8.

The main points of the Plan are as follows:

(1) National Development Goals

The following four (4) goals are addressed. Their accomplishment fully depends on economic growth and the Plan emphasizes that cooperation between the public and private sectors is indispensable.

a) Alleviation of poverty.
b) Generation of more productive employment.
c) Promotion of equity and social justice.
d) Attainment of sustainable economic growth.

(2) Economic Indexes for National Development Goal

As a target for economic growth, an average growth rate of GNP of 6.8% per annum is expected for the six years from 1987 to 1992. An inflation rate of 7.6% per annum and a GNP per capita at 16,870 pesos ($827 @, $1=20.4 pesos) in 1992 are also forecast. Refer to Table 2.2-1.

TABLE 2.2-1 GROSS NATIONAL PRODUCT AND PER CAPITA GNP, 1986-92

	Estimate	Targets						Annual Averag
	1986	1987	1988	1989	1990	1991	1992	1987-9
Gross National Product (in billion pesos, at constant 1972 prices)	89.4	95.3	101.9	108.6	116.2	124.3	132.7	113.2
Growth rate (%)	1.1	6.5	6.9	6.7	7.0	6.9	6.7	6.8
Gross National Product (in billion pesos, at current prices)	619.6	697.3	811.8	927.3	1,075.7	1,253.2	1,438.0	1,033.9
Inflation Rate (%)	2.0	5.2	8.7	7.0	8.3	8.9	7.4	7.6
Per Capita GNP (in pesos, at constant 1972 prices)	1,597	1,661	1,734	1,808	1,891	1,977	2.064	1,856
Growth rate (%)	-1.3	4.0	4.4	4.3	4.6	4.5	4.4	4.4
Per Capita GNP (in pesos, at current prices)	11,063	12,157	13,825	15,430	17,497	19,934	22,378	16,870

Sources: NEDA AND NCSO

2.2.2 Highway Development Plan

The Medium-term Philippine Development Plan 1987-1992 sets out the following policies and strategies for the highway sector, as follows.

In line with the stress on the development of the rural-agricultural sector, increased emphasis will be given to the rehabilitation, improvement and expansion of the feeder and secondary network, which consists mainly of farm-to-market roads. The program seeks to convert these roads into all-weather transport facilities. These roads will be underscored particularly in economically depressed areas with low road densities to spur production. Feeder and secondary roads will also be improved in corridors of main highways which have just been or are programmed to be improved; this will provide for a more efficient network to collect and distribute traffic to and from the hinterlands.

Rehabilitation and improvement of major roads will be selectively carried out, particularly in sections, as in Mindanao and Visayas, that can no longer economically serve the present and immediate future traffic volume, and where transport costs are so excessively high that they restrain production and marketing.

Temporary or weak bridges will be replaced with permanent structures. Measures will be introduced to stabilize road slopes and embankments and to strengthen pavements to minimize road disasters and closures. This will be complemented by schemes, both structural and nonstructural, to reduce the rate of accidents and to improve road traffic safety.

Road maintenance activities will be reinforced in order to defer the huge investments in roads, lengthen their useful lives, reduce transport operating costs and minimize public inconvenience. For this purpose, the inspection, monitoring and accounting system for maintenance will be strengthened.

The physical targets 1986-92 in the Highway Development Program are shown in Table 2.2-2.

TABLE 2.2-2 HIGHWAY DEVELOPMENT PROGRAM
PHYSICAL TARGETS 1986-92

	Program	Targets						1987-92	
	1986	1987	1988	1989	1990	1991	1992	Total	% of Total
Roads (in km)	6,475	9,319	10,000	10,538	11,708	12,704	13,711	68,078	100.0
Feeder Roads (inc. barangay roads)	4,702	6,876	9,458	7,610	8,551	9,255	9,963	49,713	73.0
Secondary Roads (inc. national roads)	1,263	1,403	1,545	1,712	1,856	2,052	2,270	10,838	15.9
Major Roads	510	1,040	1,097	1,214	1,301	1,397	1,478	7,527	11.1
Bridges (in lineal meters)	4,899	5,059	5,624	6,219	6,860	7,683	8,465	39,920	

(a). Restoration, rehabilitation, improvement and construction.
Sources of basic data: DPWH, DLG

CHAPTER 3

GENERAL CONDITIONS OF THE PROJECT AREA

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GENERAL CONDITIONS OF THE PROJECT AREA

3.1 Project Area

The ten (10) bridges proposed for the Project (Phase II) are located along secondary national and provincial roads in rural areas throughout the country.

The number of Phase II Bridges proposed in each region are shown in Table 3.1-1.

The location of each bridge is listed in Table 4.2-1 and shown on the location map.

TABLE 3.1-1 DISTRIBUTION OF PHASE II BRIDGES

	Region	No. of Proposed Bridges	Location of Proposed Bridges
I	Ilocos	-	
II	Cagayan Valley	-	
III	Central Luzon	-	
IVA	Southern Tagalog	2	Batangas
IVB	Southern Tagalog	2	Mindoro Occ., Palawan
V	Bicol	1	Masbate
VI	Western Visayas	1	Iloilo
VII	Central Visayas	2	Cebu
VIII	Eastern Visayas	1	Leyte
IX	Western Mindanao	-	
X	Northern Mindanao	1	Surigao del Norte
XI	Southern Mindanao	-	
XII	Central Mindanao	-	
	Total:	10	

3.2 Socio-Economic Conditions

(1) Land and Population

The Philippines consists of 7,100 islands that were formed by repeated organic movement and volcanic activities. The islands are divided into the three main groups of Luzon, Visayas and Mindanao. Luzon is the largest island and is located furthest north. Mindanao, the second largest island, is located furthest south. Visayas, composed of Samar, Leyte and other islands, is situated between Luzon and Mindanao.

The area of the major islands is shown below.

Island	Area (km^2)
Luzon	104,687
Mindanao	94,630
Samar	13,079
Negros	12,704
Palawan	11,784
Others	43,541
Total	280,415

In 1980, the total population of the Philippines was about 48 million with an average density of 160.3 persons per square kilometer. The unbalanced population distribution is pronounced, with NCR (National Capital Region) having a population density of 9,317 and the other regions having population densities ranging from 60 to 260. Refer to Appendix 8, Table 1.

(2) Nature

The Philippines is located in the tropics. The climate is affected by its geographical location and the different wind system that prevails over the area. The condition of the climate has been described in terms of the characteristics of the distribution of rainfall received in a locality during different months of the year. There are four climate types in the Philippines.

Over 50% of the rainfall is associated with tropical cyclones. The frequency of tropical cyclones in the Philippine Area of Responsibility (PAR) averages 20 times a year, while the frequency crossing in the Philippines averages 8.8 times a year.

The average annual rainfall in the Philippines is 2416.3 mm. The largest average annual rainfall are 4316 mm and 4360 mm at Borongan in Samar and Hinatuan in Surigao del Sur, respectively, both of which face the Pacific Ocean. The highest daily rainfall was 979.4 mm recorded in Baguio City on October 17, 1967. In Samar and Leyte Islands, the highest daily rainfall of 387.9 mm was recorded in Catbalogan City, whereas in Mindanao Island, it was 564.7 mm in Surigao City.

(3) Society

In the Philippines, wide variations of economic performance in different regions is observed. In 1985, the Gross National Product (GNP) registered 90.4 billion pesos, with contributions of 27.0 billion pesos (30%) by NCR (National Capital Regions) and 12.9 billion pesos (14%) by Region IV (Southern Tagalog).

The regional poverty incidence in 1985 ranged from 44% of the families in NCR to 73% in Regions V (Bicol) and VI (Western Visayas). (Refer to Appendix 7, and Tables 2 and 3.)

(4) Economy

By industrial sector, the service sector consistently dominated the country's economy throughout the years from 1970 to 1985, contributing 38% to 42% to the national economy. Industry was next with contributions from 30% to 37%. Agriculture had the lowest contribution, ranging from 25% to 29% during the same period.

The economy of the country is basically agricultural and the total arable land of the Philippines is 1,333,258 hectares. In 1986, total agricultural crop production came to 28.5 million metric tons planted on 12.2 million hectares and valued at 77.9 million pesos. Of total production, about 80% was contributed by food crops made up of palay, corn and fruits, and only 20% by commercial crops led by coconuts and sugarcane.

The largest crop producing region of the country is Region XI (Southern Mindanao), contributing about 18% of the country's total crop production. The next largest crop producing regions are Central Mindanao (R-XII) and Western Visayas (R-VI), each contributing 12%. Refer to Appendix 7, Table 4.

(5) Infrastructure

As for infrastructure, transportation is described in Chapter 2 BACKGROUND OF THE PROJECT. Appendix 7, Table 7 shows road length by region, road classification and road surface type.

CHAPTER 4

DESCRIPTION OF THE PROJECT

CHAPTER 4

DESCRIPTION OF THE PROJECT

4.1 Objectives of the Project

As described in Chapter 2, some of the bridges along rural roads and even some on national roads are too old and weak to carry the present traffic load. Most of these bridges are temporary wooden or simple Bailey type without concrete deck slabs. These bridges are often closed to traffic, especially during the rainy season, and consequently people living in their influence areas are sometimes isolated.

The replacement of these old and dilapidated timber bridges and temporary steel truss bridges by permanent steel structures or reconstruction will bring about significant savings in transport costs and travel times. It will ensure smooth transportation and contribute greatly to the socio-economic development of the project areas.

In line with the Highway Development Program and in awareness of the conditions described above, priority is given to replacement of dilapidated and temporary bridges which diminish the efficiency of the highway network.

Under the Highway Development Program, both the Phase I and Phase II bridge construction Projects will be implemented in conformity with the following objectives:

(a) To provide basic transport facilities in rural areas, and

(b) To enhance development and facilitate the effective delivery of socio-economic extension services to the communities served.

4.2 Review of Requested Contents of the Project

(1) Phase II Candidate Bridges

In the Basic Design Study of Phase I, twenty-one (21) bridges were selected as the Phase II Candidate Bridges. Refer to Appendix 3.

The physical conditions of the Phase II Candidate Bridges, compared with the Phase I Bridges, require a relatively high level of engineering for bridge construction. Therefore, it was decided that the Japanese side should design and construct the sub-structure and superstructures, considering the following technical reasons:

- . Detailed topographic surveys are required to design bridges and approach roads because of complicated terrain.
- . Detailed geotechnical surveys are required to corroborate bearing layers because undulant bearing layers are expected.
- . Hydrological analysis are required to decide bridge span lengths because the sites are flood prone areas.
- . Erection of steel girders may be difficult because of deep valleys or long spans.
- . Cofferdams are required to construct piers inside rivers.

These technical evaluations on bridges are based on data presented by DPWH in the Basic Design Study of Phase I. Refer to Appendix 3.

(2) Selection of Phase II Bridges

Ten (10) bridges out of the above twenty-one (21) were decided as the subject for Phase II Bridges in accordance with the priority. Such priority as agreed on by both governments was established taking into consideration the urgency of reconstruction, traffic demand and conditions of roads for transportation of construction materials and equipment.

However, the Philippine government proposed by an official document that a bridge described below needs to be substituted by another at the first session with the Study Team. According to the document, the bridge had already been pledged by another implementation program of the DPWH. The Japanese Government agreed to this change.

. Original bridge: Bridge No. : 02.02
Bridge Name: Dumadata Bridge
Location : Cabarroguis, Quirino, Region II

. New bridge : Bridge No. : 07.01
Bridge Name: Banban Bridge
Location : Pinamungaban, Cebu, Region VI

The list of ten (10) bridges were finally selected as the subject bridges for the Basic Design Study (Phase II) is shown in Table 4.2-1.

(3) Requested Contents

The Phase II Bridges are to be designed and constructed by the Japanese side, and their major construction works are as follows:

. Detailed design of bridges, approach roads and river bank protection.

. Construction of bridges

. Construction of approach roads

. Construction of river bank protection

TABLE 4.2-1 PHASE II BRIDGES

Bridge No.	Bridge Name	Location
04.01a	Binambang	Km 107 + 540 Balayan-Balibago-Calatagan Road Balayan, Batangas
04.03a	Leviste II	Km 92 + 430 Talisay-Laurel-Agoncillo Road Laurel, Batangas
04.04b	Lumang Bayan	Km 34 + 954 Mamburao-North Puerto Galera Road Orelan, Abra de Ilog Mindoro Occidental
04.05b	Olangoan I	Km 74 + 524 Puerto Princesa North Road Concepcion, Puerto Princesa City Palawan
05.03	Narangasan I	Km 31 + 145 Jct. Tawad-Balud Road Milagros, Masbate
06.03	Iyang	Km 109 + 962 Concepcion-San Dionisio National Road Concepcion, Iloilo
07.01	Banban	Km 61 + 100 Toledo-Pinamungaban National Road, Cebu
07.02	Campacas	Km 97 + 600 Dalaguete-Mantalongon Road Dalaguete, Cebu
08.04	Talisayan	Km 66 + 400 La Paz-Javier-Bito Raod Talisayan, Javier, Leyte
10.01	Hayangabon I	Km 1202 + 586 Surigao-Davao Coastal Road Hayangabon, Claver, Surigao del Norte

4.3 Scope of Japan's Grant Aid

As stated in the Minutes of Discussion for the Project dated April 7, 1988, the scope of Japan's Grant Aid for the Project covers the followings: Refer to Appendix 3.

1) Construction of superstructures

   . Supplying and delivering of steel materials and erecting steel girders.
   . Constructing concrete slab deck and handrails.

2) Construction of substructures

   . Construction of abutments and piers (including piles).
   . Construction of temporay cofferdams.

3) Construction of approach roads
   (Approach roads are limited to connecting new bridges and present roads with smooth alignment.)

4) Construction of river bank protection
   (Bank protection is limited to protecting abutments from scouring.)

Detailed description and estimated quantities of major construction works for Phase II Bridges are mentioned in Section 6.2.

While the Government of the Philippines will undertake the followings;

1) To ensure the exemption of custom duties of the materials and equipment provided under Japan's Grant Aid.

2) To acquire the right-of-way and to provide necessary land area for the construction works.

3) To demolish obstacles including houses within the right-of-way that effects the implementation of the Project.

4) To make passable all roads and bridges leading to the project sites for the transportation of materials and equipment provided under Japan's Grant Aid.

CHAPTER 5

BASIC DESIGN

CHAPTER 5

BASIC DESIGN

5.1 Design Policy

The basic design of the Phase II Bridges was planned based on the data collected from field investigation topographic and geotechnical surveys conducted by the Study Team. The general views of these bridges were prepared as shown in the separate volume of the Basic Design Study (Phase II).

In preparing the general views, the following design policies were adopted:

1) Location of bridges shall be determined after the Study Team considers DPWH proposals.

2) Maximum utilization of steel materials for super-structures.
Steel girders shall be fabricated in such sizes and heights so as to transport them safely and conveniently.

3) Maximum utilization of local materials for sub-structures.
Footings of abutments shall be embedded below existing ground and of piers below river beds. Steel sheet piles may be employed as cofferdams while constructing substructures in the river if necessary.

4) Adoption of concrete pavement for approach roads considering the construction convenience.

5) River protection shall be provided in order to avoid damage to abutments by river flows.

6) Detour roads shall be provided during construction as required.

The detailed design of the structures described above will be conducted by the Japanese consultant. Designs would be drawn in accordance with design criteria adopted for the Phase I Bridges established between the DPWH and the Study Team as discussed in this chapter.

5.2 Site Survey

5.2.1 Field Investigation

Prior to implementing the hydrological analysis, topographic survey and geotechnical survey, the Study Team conducted field investigation for the purpose of ascertaining existing conditions at the sites and of establishing survey procedures. The items investigated were as follows:

. Examining present condition of bridges.

. Confirming topographic and geographic features.

. Ascertaining the DPWH views concerning the locations of bridges to be replaced and discussing the locations from the engineering point of view.

. Determining whether detour roads are required during bridge construction and whether there are existing detour roads.

. Investigating conditions of roads and ports to be utilized to transport equipment and materials for construction.

. Determining whether any existing houses close to the bridges need to be demolished.

. Collecting climatic data of the sites, particularly the timing of dry and rainy seasons.

. Conducting interviews to determine the highest water levels when flooded at the bridge sites.

. Investigating the existence of any obstacles which may obstruct the construction.

. Investigating other special factors.

The basic information of the field investigation is shown in Table 5.2-1.

TABLE 5.2-1 (1/2) BASIC INFORMATIONS ON PROPOSED BRIDGES

No. of Bridge	Name of and Location of Bridge	Condition of Existing Bridge	Proposed Location of New Bridge	Detour during Construction	Demolition of Existing Bridge	Condition of Access Road	Remarks
04.01a	BINAMBANG BRIDGE · Km 107+540 Balayan- Balibago Calatagan Road Balayan, Batangas	· Spillway · Overflow even during dry season	· Upstream because of road alignment	· Existing spillway can be used	· Not necessary	· Good condition · 107Km from Manila	· Rainy season; June to November
04.03a	LEVISTE II BRIDGE · Km 92+430 Talisay—Laurel — Agoncillo Road Laurel, Bbatangas	· Washed-out	· Along the existing road alignment	· Necessary · Construct at upstream	· No existing bridge	· Good condition · 92Km from Manila	· Rainy season; June to November
04.04b	LUMANG BAYAN BRIDGE · Km 34+954 Mamburao-North Puerto Galera Road Orelan, Abra de Ilog Mindoro Occ.	· Fair bailey · Dilapidated timber trestle · Load limit 5 tons	· Downstream because of power line	· Existing bridge can be utilized with minor repair as detour	· Not necessary	· Many weak bridges (Load Limit 3 - 5 tons) from Hambrerao · Sometimes unpassable during rainy season	· Relocaylon of two poles of power line by Occidental Mindoro Electric Company · Rainy season; June to December
04.05b	OLANGOAN I BRIDGE · Km 74+524, Puerto Princesa North Road Concepcion, Puerto Princesa City Palawan	· Fair bailey steel · Timber trestle · Load limit 5 tons	· Upstream to improve road alignment	· Existing bridge can be utilized with minor repair as detour	· Not necessary	· Several weak bridges (Load Limit 3 - 5 tons) from Aniiawan	· Existence of salt water · Rainy season; May to November
05.03	NARANGASAN I BRIDGE · Km 31+145 JCT Tawad- Balud Road, Milagros Masbate	· Fair bailey steel · Dilapidated timber trestle · Load limit 1 tons	· Same as existing bridge, but a little downstream in order not to encroach existing fences	· New construction of detour is required at the downstream site	· Necessary before construction of new bridge	· Passable condition from Masbate · Three weak bridges from Masbate	· Bridge opening due to flood · Salt water Instrusion · Rainy season; July to January

TABLE 5.2-1 (2/2) BASIC INFORMATIONS ON PROPOSED BRIDGES

No. of Bridge	Name of and Location of Bridge	Condition of Existing Bridge	Proposed Location of New Bridge	Detour during Construction	Demolition of Existing Bridge	Condition of Access Road	Remarks
06.03	IYANG BRIDGE · Km 109+962 Concepcion-San Dionisio National Road Concepcion Iloilo	· Timber · Dilapidated trestle · Load limit 3-5 tons	· Same location of existing bridge	· Not necessary · Existing bypass can be used as detour	· Necessary before construction of new bridge	· Good condition	· Sea water intrusion · Protection of embankment approach · Rainy season; June to December
07.01	BANBAN BRIDGE · Km 62+100 Toledo – Pinamungaban National Road Cebu	· Dilapidated timber · Load limit 5 tons	· Same location of existing bridge	· Detour is required at upstream	· Necessary before construction of new bridge	· Three weak bridge (Load Limit 5 tons)	· Rainy season; June to December
07.02	CAMPACAS BRIDGE · Km 97+600 Dalaguete- Mantalongon Road Dalaguete, Cebu	· Fair bailey steel · Dilapidated timber trestle · Load limit 5 tons	· Same location of existing bridge	· North side road can be used as detour, but improvement by the District Engineer is needed	· Necessary before construction of new bridge	· 98Km from Cebu City · 13Km from Dalaguete is very bad condition with 12% gradient.	· Hydraulic opening is required · Suspending of two potable water Pipes · Rainy season; June to December
08.04	TALISAYAN BRIDGE · Km 66+400 La Paz- Javier-Bito Road Talisayan- Javier Leyte	· No existing bridge	· Direct alignment from the south approach · Crossing two rivers	· Depend on construction · Construction of pier should be undertaken during dry season.	· No existing structure	· 59Km from Tacloban is good paved road, but remaining 10Km is bad including four timber bridges.	· About 150m on each side subject to flood · Protection of abutment, embankment and river are required. · Rainy season; July to February
10.01	HAYANGABON I BRIDGE · Km 1202+586 Surigao- Davao Coastal Road Hayangabon, Claver, Surigao del Norte	· Dilapidated timber · Load limit 5 tons	· Same location of existing bridge	· Detour is required at downstream	· Necessary before construction of new bridge · Existing nipa house may be affected	· 11 bridges (Load Limit 3- 5 tons) from Surigao · Repair of bridge is required.	· Structure should be protected by marine environment · Suspension of one water line · Always bad weather condition · Rainy season; October to July

5.2.2 Hydrological Analysis

The hydrological analysis was conducted to estimate the magnitude of design discharge and to decide the area of river openings required for discharge during flooding. The output of the analysis is presented in Appendix 4 and the detailed analysis is compiled in the separate report.

(1) Rainfall Intensity

In the Philippines, the climate in a particular area depends on the distribution of rainfall in time and topography. Thus, the rain-fall pattern traditionally dictates the climatic classification of an area. The different provinces throughout the country fall under any of four types of climate. The ten bridges are located in various provinces, falls under one of the climatic classifications indicated in Table 5.2-1.

The most important version of rainfall useful in run-off estimation is the rainfall intensity or the rainfall depth at different durations. Thus, for each of the bridge sites, appropriate data were adopted. Refer to Table 5.2-2.

TABLE 5.2-2 RAINFALL DATA OF THE BRIDGE SITES

Bridge No.	Name of Bridge	Location (Province)	Type of Climate	Rainfall Intensity Data Reference	Source of Dimensionless U.H
04.01a	Binambang	Batangas	I	Calapan, Or. Mindoro	Mean for Luzon and Visayas
04.03a	Leviste II	Batangas	I	Tanauan, Batangas	- ditto -
04.04b	Lumang Bayan	Occ. Mindoro	I	Calapan, Or. Mindoro	- ditto -
04.05b	Olangoan	Palawan	III	Zamboanga City	- ditto -
05.03	Narangasan I	Masbate	III	Masbate, Masbate	- ditto -
06.03	Iyang	Iloilo	I	Iloilo City	- ditto -
07.01	Banban	Cebu	III	Cebu Airport	- ditto -
07.02	Campacas	Cebu	III	Cebu Airport	- ditto -
08.04	Talisayan	Leyte	II	Tacloban City	- ditto -
10.02	Hayangabon I	Surigao del Norte	II	Surigao City	Mean for Mindanao

(2) Design Storm

The Unit Hydrograph Method is one of the most accepted methods in discharge computation for large catchment areas, particularly bridge river basins. The derivation of the Synthetic Unit Hydrograph is accomplished by using the Modified Snyder Formula for lag time as follows:

$$Lg = C\left(\frac{L \cdot Lc}{\sqrt{S}}\right)^{n} \times 0.69667$$

where: Lg = lag time in hours

L = total length of waterway from bridge point to furthest water source, in km

Lc = distance along stream from bridge point to perpendicular line passing through basin centroid, in km

S = equivalent slope of main stream

C = lag time coefficient ranging from 0.70 to 2.2 depending on basin characteristics

n = 0.38

After the Synthetic Unit Hydrograph has been derived, the design storm is determined by incorporating rainfall increment, infiltration loss and excess rainfall. The design storm is then computed into storm discharge by the process of convolution given by the following equation:

$$q_t = \sum_{i=0}^{t} Pi\ [U_{t-i+1}]$$

where: q_t = storm of flood discharge at increment

Pi = ordinate of design storm at i^{th} time

U = ordinate of computed Synthetic Unit Hydrograph

(3) Hydrological Analysis on Waterway Opening

The hydrological design component of this Study is concerned with the determination of the flood level that might occur in the river due to a given flood and of the minimum waterway opening under the bridges. A storm frequency of 1 to 50 years was adopted in accordance with the Design Guideline of the Philippines.

The flood level is determined by the Rating Curve Computation, which is based on the Manning Formula, as follows:

$$q = \frac{1}{n} AR^{2/3} S^{1/2}$$

where: q = discharge, m^3/S

n = Manning's roughness coefficient

A = cross sectional area, m^2

R = hydraulic radius (equals $\frac{\text{cross sectional area}}{\text{wetted perimeter}}$)

S = hydrographic gradient

The results of the hydrographic analysis are given in Table 5.2-3.

TABLE 5.2-3 REQUIRED OPENING AREA OF RIVERS AND BRIDGE LENGTH

Bridge No.	Name of Bridge	D.A. (M^2)	Q(Design) (M^3.S)	Required Opening Area (M^2)	Bridge Length (M)	Water Depth (M)	Velocity (M/S)	M.F.L. (Computed (Elev.)	M.F.L. (Interview) (Elev.)
04.01a	Binambang	91.38	441.70	93.4	70	3.00	4.73(ovf)	13.73	15.01
04.03a	Leviste II	3.50	107.97	33.6	24	2.00	2.01	17.10	18.00
04.04b	Lumang Bayan	149.02	580.00	269.2	105	3.00	2.15	20.91	21.47
04.05b	Olangoan	222.70	815.00	182.0	35	2.50	4.47	17.14	17.45
05.03	Narangasan I	36.75	468.50	155.0	48	3.00	3.02	57.65	59.00
06.03	Iyang	7.15	162.51	39.0	46	2.50	4.17	18.93	19.33
07.01	Banban	60.02	228.73	34.9	25	3.00	6.55	20.80	21.12
07.02	Campacas	28.64	272.00	59.0	24	4.50	4.61	393.05	393.01
08.04	Talisayan	33.37	279.00	56.9	96	1.50	4.02	297.90	298.24
10.01	Hayangabon I	10.43	523.23	92.2	44	2.50	5.87	19.47	19.50

Note :
DA ; Drainage Area
Q (Design) ; Design Discharge
V (Ave) ; Average Velocity Under the Bridge
M.F.L. (Computed) ; Maximum Flood Level (50-year frequency) as Computed.
M.F.L. (Interview) ; Maximum Flood Level based on field interview.

5.2.3 Topographic Survey

The topographic survey was conducted to obtain the topographic data necessary for the detailed design of the bridges, access roads and river bank protection, comprising the following works.

The survey quantity list and the description of bench marks (BM) are presented in Appendix 5, while the detailed survey results are compiled separately.

1) Centerline Survey

All bench marks (BM) were established with an assumed elevation, properly monumented with concrete monuments (20 cm x 20 cm x 60 cm).
The length of centerline survey was more than 100 m along roads and 50 m along rivers, in front of and behind the bridges.

2) Profile Survey

The elevation of every 20 meters and at changeable inclination points on the proposed centerline were surveyed.

3) Cross Section Survey

Along roads	:	20 meters intervals, 50 meters in width.	
Along rivers	:	20 meters intervals, 60 meters in width.	
Accuracy	:	Traversing	1/10,000
		Leveling	5 cm + 3 cm $\sqrt{S}$ S = level route

4) Reporting

. Location Maps : 1/50,000
. Topographic Maps : 1/200
. Profile Maps : 1/200, 1/100
. Cross Sections : 1/200
. Field Survey Notes
. Photographs
. BM Point Survey Description

5.2.4 Geotechnical Survey

The geotechnical survey was performed to confirm the geological condition of foundations of all 10 bridges for the detailed design, consisting of the following works.

The survey quantity list, boring profile and the description are presented in Appendix 6, while the detailed survey results are reported separately.

1) Drilling

A bore hole was drilled on the proposed location of each foundation of all bridges.

2) Standard Penetration Test

This test was conducted at intervals of one meter and at the change of soil strata.

3) Sampling

The undisturbed samples were collected for the corresponding laboratory tests.

4) Laboratory Test

The following laboratory tests were conducted for soil layer samples, according to the AASHTO Test:

. natural water content test (for all bridges)

For the Banban Bridge, the following additional tests were conducted to analyze settlement and embankment failure because of the deep soft ground:

. HA (hydrometer grain size analysis)
. LL (liquid limit test)
. PL (plastic limit test)
. CU (unconfined compression test)
. UW (unit weight)

5.3 Types of Bridges

5.3.1 Description on Bridge Site Conditions

The most appropriate type of bridge at a proposed site shall be decided taking into consideration the topographical, geological and hydrological conditions as well as the construction condition, available materials and equipment, and the economic condition.

In this Section, the hydrological and geological conditions of each bridge are discussed to determine the most appropriate type of bridge. Table 5.3-1-A summarizes the brief description on those conditions.

(1) 04.01a Binambang Bridge

Hydrological Condition

The Binambang River is a wide and relatively shallow waterway. An existing 10~610 mmø RCPC overflow structure serves as the main carriageway across the channel. The existing structure which is called a spillway is often inundated by floodwater causing traffic cut-off during the wet season, sometimes even during the dry season.

2 spans bridge with 35 m span length was proposed for the hydrological analysis. Analysis shows that, when there is complete replacement of the existing structure, the maximum flood level (MFL) equals EL 13.99 m with an average velocity (v) of 2.73 m/s. If not, MFL is 13.73 m with AV of 4.73 m/s. These valves may be considered reasonable in bridge design. Because of the high flood level, a high embankment will be required.

Geological Condition

Upper layer of alluvial deposit consists of clay with sand (N; 10~19, thickness; 2.5~6.5m), and lower layer is fine sand with gravel (N; 30~48, thickness; 2.5~3.0m). Sand of diluvial deposit is tightened (N>50).

The fine sand layer can be expected as a bearing stratum for piles of both abutments. But, the pier, can be designed as a spread foundation typed because of the existence of rock at the proposed pier location. In this case, it is necessary to search for a distribution area of rock fragment during excavation.

(2) 04.03a Leviste II Bridge

Hydrological Condition

The Leviste River is a small waterway on the downslope of the Tagaytay Ridge towards Taal Lake. Since there is no existing structure, vehicles cross the river by fording during the flood season, causing cutting of the approaches and widening of the channel across the existing roadway. The river sections then becomes narrow and small upstream wide and deep across the roadway and narrow and shallow downstream.

With this condition, two options where analyzed. Option 1 proposed 3 spans of 20 m in span length and resulted in an MFL of EL 17.10 m with V of 2.01 m/s. Option 2 proposed 1 span of 25 m in span length with MFL of EL 17.20 m and V of 2.73 m/s. With the two sets of results, option 1 is considered safer and more appropriate for the actual characteristics of the existing channel across the center line of roadway. A high embankment is inevitable because of the high flood level.

Geological Condition

Upper layer of alluvial deposit consists of gravel and sand with boulder gravel and includes Andesite and Basalt of maximum diameter ø1.0 m (N>50, N; 17, Clayey sand). Lower layer is homogeneous gravel and sand with silt (N; 5~28, thickness; 3.0~6.0 m). Diluvial deposit is tightened (N>50).

Upper layer of sand and gravel can not be expected as a bearing stratum. Because the grain sizes of large gravels are not homogeneous in horizontal and vertical directions. Therefore, sand of diluvial deposit is proposed as a bearing layer of the pile foundation. But pile cannot penetrate gravel of upper layer and should be excavated by manpower.

(3) 04.04b Lumang Bayan Bridge

Hydrological Condition

The Lumang Bagan Bridge is only 40 m in width during dry season, but its waterway width during flood is difficult to estimate because of a flood area.

As 3-span bridge with span length of 35 m is proposed after comparison of several schemes, which became the basis of the hydrological analysis. The result shows MFL of EL 20.91 m and V of 2.15 m/sec. These results are both permissible, since MFL (computed) is less than MFL (interview) and the velocity is not excessive. For design safety, however, the higher flood level was finally adopted.

Geological Condition

Alluvial deposit consists of sand with silt (N; 5~31, thickness; 7.0~8.0 m), while Diluvial deposit consists of gravel with boulder and clay (N>50).

The diluvial deposite can bear the foundation of structure by pile. The sand and gravel layer is with coral reef and thickness of the layer is not homogeneous. Therefore, the length of pile may be designed with a little allowance.

(4) 04.05 Olangoan I Bridge

Hydrological Condition

The Olangoan River has an intermediate width of about 30 m and a deep riverbed. It also has a large drainage area which causes a large run-off. Therefore, one-span bridge without pier is preferable.

An analysis of the natural channel condition (disregarding any proposed structure) shows that the natural flood level at the bridge point is MFL of EL. 18.64 m with a velocity of 4.47 m/s. Because of the high velocity, the river protection is recommended to be firmly constructed.

Geological Condition

Alluvial deposit consists of clayey soil with silt (N; 13~23, thickness; 2.0~6.0m) and diluvial deposit consists of sand and gravel (N; 45~50, thickness; 4.0~8.7m). Bed rock is Paleozoic slate.

Short pile should be adopted for shallow bearing layer of the diluvial deposit. The bridge site is located at the foot of the mountain and alluvial deposit is shallow and therefore underground water is predicted to spring out during excavation for abutment.

(5) 05.03 Narangasan I Bridge

Hydrologic Condition

The Narangasan River is a deep and well defined waterway with about 30 m in width, but floods are anticipated during the rainy season. Therefore, the use of steel sheet pile is recommended for construction of pier inside waterway.

A proposal of 2-span bridge with a span length of 24 m was used in the hydraulic computation and the result shows MFL of EL 57.65 m and V of 3.02m/s. MFL (interview) of El. 59.00 m, which is greater than that computed, was thus adopted for the final design.

Geological Condition

Upper layer of alluvial deposit consists of fine sand with clay (N; 3~12, thickness; 4.5~5.5m) and lower layer consists of fine sand with clay (N; 16~34, thickness; 1.5~11.0m). Diluvial deposit is hard mudstone and standard penetration test cannot be examined. Thickness of this layer is not uniform and thickness of clay of upper layer is shallow at the pier.

N-value of diluvial deposit is low, therefore can not be expected as bearing layer, but alluvial layer of lower part can be expected. Thickness of mud-stone layer of alluvial deposit is not uniform, therefore the pile length should be decided with an allowance.

(6) 06.03 Iyang Bridge

Hydrological Condition

The Iyang river, located in an estuary, is bounded by earth dikes on both riverbanks. The river is smooth and well defined channel causing uniform, steady flow, but steel sheet piles are required for the construction of pier inside the river because of deep water.

The hydrological analysis was conducted assuming a 2-span bridge with a span length of 23 m and gave MFL of EL 18.93 m and V of 4.17 m/s. But, MFL of 19.33 m was obtained from interview survey, therefore the velocity may be a little slower.

Geological Condition

Upper layer of alluvial deposit consists of clayey soil (N; 17~22, thickness; 4.0~5.0 m), and lower layer consists of sand with gravel (N; 20~35, thickness; 2.0~5.0 m). Bed rock is tertiary tuffcious shale which is tightened, and its upper portion is weathered soft rock, lower is hard rock.

Thickness of bed rock layer is thin and is not uniform, therefore foundation of structures are not of the same type. A1 abutment is pile foundation, while pier and A2 abutment are spread foundation.

(7) 07.01 Banban Bridge

Hydrological Condition

The Banban River is a waterway located in a shallow estuary and bounded by fishpond dikes. Upstream of earth dikes which serve as the river channel boundary are shallow and prone to flood inundation. Because of an angle of river flow direction, an skew bridge is recommended.

A hydrological analysis, resuming 1-span bridge with 25 m span, indicates MFL of EL20.80 m with V of 6.55 m/s. This velocity is considerably high so that a firm river protection should be constructed.

Geological Condition

The bridge is located at the lagoon where a very soft ground layer exists. Upper layer of alluvial deposit consists of organic clay (Natural Water Content Wn; 60~120%, Compressive Strength qu; 0.009~0.12 kg/cm^2, N; 1~6, depth; 20.0 m). Lower layer of alluvial deposit consists of clay. (N; 6~10, N.W.C; 60~80%, depth; 20.0~24.0 m). Diluvial deposit consists of sand with gravel and coral including large gravel (N>50).

In the basic design of foundation for this bridge, the following points were taken into consideration. See Section 5.6.3.

- Embankment with a height less than 2 m may be stable, considering the existing embankment height of 1.0~1.5 m.
- Embankment with a height more than 3.0 m located behind the bridge abutments may not be stable.
- Analysis on embankment settlement shows 26.1 cm at the road center and 38.0 cm at the shoulder.
- The construction speed of embankment shall be less than 5 cm in height per day.
- Pile net method is recommended to strengthen weak foundation and stabilize embankment in order to avoid differential settlement of road surface. Coconut tree and bamboo can be utilized as pile and net, respectively.
- Pile foundation is recommended to penetrate into diluvial deposit.

(8) 07.02 Campacas Bridge

Hydrological Condition

The Campacas River is a waterway located in the mountain, and characterized by high and steep slope and high velocity flow. Because of this condition, the temporary staging shall be constructed for erection of steel girders.

For a hydrological analysis, 1-span bridge with 24 m span was considered. MFL of EL 393.05 m and V of 4.61 m/s were obtained. Because of a high velocity, river protection shall be carefully constructed.

Geological Condition

The proposed bridge is located in the flood plain composed of terrace deposit. Bed rock is mudstone and sand stone layer of the tertiary deposit. Upper layer is clay (N; 11~38, thickness; 5.0~7.0 m) and soft rock (weathered mudstone, N; 30~50).

At the left side of the river, the bounding between sand with gravel and soft rock inclines to a road, which indicates possible slope failure. The excavation work for abutment foundation shall be carefully carried out.

(9) 08.04 Talisayan Bridge

Hydrological Condition

The Talisayan River is a waterway characterized by a shallow and very wide flood plain. During ordinary conditions, the water flows through a small and narrow channel. During flood periods, however, water inundates a wide stretch of grassland which has an undefined bank boundary. In this condition, a long bridge is desirable to serve as the thoroughfare.

Two options, 4-span bridge with 24 m span length and 3-span bridge with 25 m, were proposed for the hydrological analysis. The latter shows a high water velocity, therefore the former with MFL of EL297.90 m and V of 4.02 m was adopted.

Geological Condition

Upper layer of alluvial deposit consists of sand and gravel with an average diameter of 20~30 cm (N>50, thickness; 5.0 m), while lower layer is homogeneous fine sand (N; 7~25, thickness; 5.0~9.0 m). Diluvial deposit consists of gravel with silt and includes granite breccia. (diameter; 10~20 cm)

Grading of the gravel layer shows a little sand and is not uniform. Coefficient of permeability of this layer is high and underground water tends to spring out during excavation. Sand with gravel of upper layer can not be expected as bearing stratum for pile foundation, therefore, pile should be penetrated into diluvial deposit.

(10) 10.01 Hayangabon I Bridge

Hydrological Condition

The Hayangabon I Bridge is located near the seashore. The rainfall catchment area of the river is so wide and the river bed is so deep that the design discharge considered is quite large.

The hydrology of the river was analyzed assuming 2-span bridge with 22 m span length. The result shows MFL of 19.47 m and V of 5.87 m/s which requires a firm river protection.

Geological Condition

Aluvial deposit consists of clay with sand (N; 10~24, thickness; 1.3~2.3 m)

Bed rock is soft diabase, the upper layer (depth 1.3~9.0 m) of which is weathered. Since clay layer at the upper portion is thin, the bridge foundation shall be spread on bed rock.

Table 5.3-1 (1) TOPOGRAPHIC, GEOLOGICAL AND HYDROLOGICAL CONDITIONS

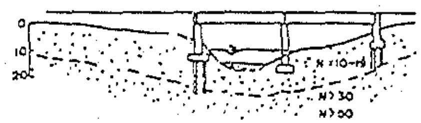
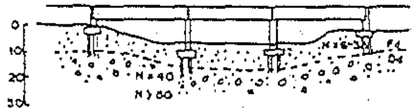
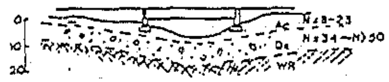
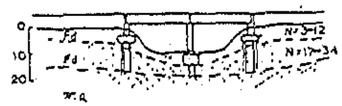
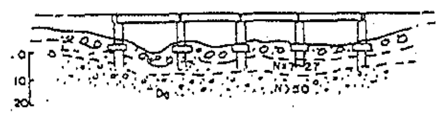
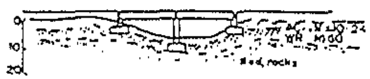
Bridge No.	Name	Location of Bridge Site	Geological Profile	Topographical Condition	Geological Condition	Hydrological Condition
1. 04.01a	Binambang Bridge	. Km. 107 + 540 Balayan-Balibaga Calatagan Road Balayan, Batangas . End of fan		. Bridge site is terrace which consists of fan deposits. . River has a gentle gradient and is wounded.	. Fan deposits consist of argillaceous materials which are alternated with gravel, sand and clay. . Diluvial deposits are weakly cemented.	. Flood area . Velocity is relatively low. . Flood elevation is high resulting in high embankment.
2. 04.03a	Leviste II Bridge	. Km. 92 + 430 Talisay-Laurel-Agoncillo Road . Laurel, Batangas . End of fan		. River has a sharp gradient. . Bridge is located at the end of fan. . Terrace exists at both river sides.	. Gravel boulders exist on the top of fan deposits which are andesite or basalt. . Top of fan deposits is detritus. . Diluvial deposits were stiffed density. . Pile foundation	. High velocity of water from mountain during flood . High embankment is required because high flood elevation.
3. 04.04b	Lumang Bayan	. Km. 34 + 954 Mamburao-North Puerto Galera Road Orelan, Abra de Ilong Mindoro Occidental . Near the coast		. River has a gentle gradient. . Bridge is located near the coast.	. Flood plain deposits consist of gravel and fine sand. . Diluvial deposits consist of gravel, boulder and sand. . Pile foundation	. Flood area . Influenced by sea water. . High embankment is required.
4. 04.05b	Olangoan I Bridge	. Km. 74 + 524 Puerto Princesa North Road Concepcion, Puerto Princesa City, Palawan. . Coastal plain (flat)		. River has a gentle gradient and is located near the coast. . River bed is mounded. . Bridge site is coastal.	. AC formation is clayeous soil. . D.S. formation is sand and gravel . W.R. formation is weathered bed rocks composed of shale.	. Influenced by sea water. . Firm river protection is required.
5. 05.03	Narangasan I Bridge	. Km. 31 + 145 JCI Taward-Balud Road, Milagros Masbate . Flood plain		. River has a gentle gradient. . Low terrace is developed at both river sides.	. Top of flood plain deposits consist of clay and fine sand. . Weathered bed rocks consist of diluvial mudstone.	. Influenced by sea water. . Steel sheet piles are required because of deep water.

Table 5.3-1 (2) TOPOGRAPHICAL, GEOLOGICAL AND HYDROLOGICAL CONDITIONS

Bridge No.	Name	Location of Bridge Site	Geological Profile	Topographical Condition	Geological Condition	Hydrological Condition
6. 06.03	Iyang Bridge	. Km. 109 + 962 Concepcion-San Dionisio National Road Concepcion Iloilo . Coast side		. River has a very gentle gradient and is mounded. (delta or lagoon) . Bridge site is made of low terrace.	. Alluvial low plain consists of the clay. . Weathered rock and hard rock are tufferous shake. (tertiary pliocene) A1; Pile, Others; Spread footing	. Influenced by sea water . Steel sheet piles are required because of deep water.
7. 07.01	Banban Bridge	. Km. 62 + 100 Cebu Toledo-Piramungahan National Road Cebu . Coast side (low land)		. River has a very gentle gradient and is mounded. . Bridge site is a low land with lagoon deposits. . Special counter-measure for softground . Pile length of 25m	. Alluvial deposits consist of lagoon Sediment materials (Peat, silt and clay) . Diluvial deposits consist of gravel, boulder and sand.	. Influenced by sea water . Skew bridge . Firm river protection is required.
8. 07.02	Campacas Bridge	. Km. 97 + 600 . Dalaguete-Mantalongon Road Dalaguete, Cebu . Terrace, plain (mountainous site)		. River has a very gentle sharp gradient and is mounded. . Bridge site is made of terrace.	. Alluvial deposits consist of weathered mudstone fragments. . Bed rock is mudstone. . Pile foundation	. Staging for steel girder erection shall be constructed. . Firm river protection is required.
9. 08.04	Talisayan River Crossing	. Km. 66 + 800 La Paz - Javier - Boto Road Talisayan Javier Leyte . Flood plain		. Bridge site is flood plain . Two rivers are confluenced and both rivers are mounded.	. Top of flood plain deposits are gravel, sand with cobbles and pebbles. . Alluvial sand is fine sand wih medium dense . Pile foundation	. Wide flood area . Steel sheet piles are required. . High embankment.
10. 10.01	Hayangabon I Bridge	. Km. 1202 + 586 Surigao-Davao Coastal Road, Hayangabon, Claver, Surigao del Norte. . Coast side		. Bridge site is alluvial flood plain. . River has an gentle gradient and is mounded.	. Alluvial flood plain deposits consist of clay . Bed rock is diabase . Spread booting	. Influenced by sea water. . Firm river protection is required.

5.3.2 Bridge Length and Span Length

(1) Bridge length

The location of abutments and piers which are to be constructed in the river areas should be planned not to obstruct the flow of flood water when the level of water is lower than the designed maximum.

In principle, abutments which control bridge length are planned to be located behind the intersection point of the river bank slope and the maximum flow level.

Therefore, in this Study, the hydrological analysis was conducted initially, and the bridge lengths were decided based on the results of the hydrological analysis described below. The outline of the hydrological analysis was earlier described in Section 5.2.2. The hydralogical data for the analysis is shown in Appendix 4.

1) To determine the drainage basin of the river and to compute its design discharge at a frequency of once every 50 years.

2) To compute the maximum flow level by incorporating design discharge and present water opening, and to examine the possibility of the maximum flow level, compared to the maximum flow level determined during field investigation. As a result, the higher level will be adopted as the design maximum flow level.

3) Abutments are planned to be located behind the intersection point of the design maximum flow level and the slope of river bank.

4) However, since the four (4) bridges listed below are planned in areas of flat topography where floods easily occur, the bridge length computed by this method is unreasonably long. For that reason, the design bridge length was determined based on the size of the required water opening, given the existing cross-sectional topography of the river and the topographical conditions on both sides of the bridges.

04.01a	Binambang Bridge
04.03a	Leviste II Bridge
04.04b	Lumang Bayan Bridge
08.04	Talisayan Bridge

(2) Span length

Span length was determined on the basis that piers should not obstruct flood water and streaming floats, considering the conditions of water flow and topography.

The Japanese Design Guideline specifies the approximate span length as follows:

$Q \geq 500\ m^3/sec \qquad L = 30 + 0.005\ Q$

$Q \leq 500\ m^3/sec \qquad L = 20 + 0.005\ Q$

where: Q = design flood discharge, m^3/sec
L = span length, m

The span length of the bridges computed by the formula of the specification are shown in Table 5.3-2.

The design span length is also shown in Table 5.3-2. Design span lengths were finally decided based not only on river conditions such as river alignment, topography and floats, but also on other factors such as geological and construction conditions.

TABLE 5.3-2 DESIGN SPAN LENGTH

Bridge No.	Bridge Name	Span (m) (Computed)	Design span (m)
04.01a	Binambang	22.2	35 x 2 span
04.03a	Leviste II	-	24 x 1 span
04.04b	Lumang Bayan	32.9	35 x 3 span
04.05b	Olanguan	-	35 x 1 span
05.03	Narangasan I	22.3	24 x 2 span
06.03	Iyang	20.8	23 x 2 span
07.01	Banban	-	25 x 1 span
07.02	Campacas	-	24 x 1 span
08.04	Talisayan	21.4	24 x 4 span
10.01	Hayangabon I	22.6/32.6	22 x 2 span

5.3.3 Types of Superstructures

The span length for the bridges are proposed based on the hydrological controls taking into consideration topographical, geological and construction conditions, and the span lengths are divided into the following two (2) cases:

Case 1 : Span length = 22 - 25 m
Case 2 : Span length = 35 m

As in Phase I Bridges, the H-beam composite girder type was adopted for bridge superstructures with case 1 span lengths. On the other hand, the plate girder (non-composite type) was finally adopted for bridge superstructures with case 2 span length. The reasons for the selection of superstructure type can be explained as follows:

(1) Case 1 : H-beam girder for 22 - 25 m bridge span

For bridges with span lengths less than 25m, the following three (3) types were judged to be more economical for steel bridges based on experience in Japan:

1) H-beam composite girder
2) Plate girder (non-composite build-up girder)
3) Composite plate girder (composite build-up girder)

Composite plate girder, in which slab concrete is utilized to take part of the resistant capacity of the girder based on the structural synthesis of slab concrete and plate girder, was determined as an unsuitable superstructure type for the Philippines because of problems in concrete quality, handling manner and maintenance. On the other hand, the composite structure type was adopted for H-beam girder because it has some allowance in its sectional stress but less in its deflection. As a result of the comparison between H-beam girder and plate girder (non-composite) in Table 5.3-3, the former was adopted.

TABLE 5.3-3 COMPARISON OF H-BEAM GIRDER AND PLATE GIRDER
(for 22 - 25 m bridge span length)

Evaluation Item	H-Beam Girder	Plate Girder	Evaluation (advantage)
Adoptable Span	Less than 25 m	Less than 40 m	--
Girder Depth	Approx. 90 cm	Approx. 130 m	H-beam
Difficulty of Transportation, Erection	Easy	Little difficult	H-beam
Cost	Lower (more material, cheaper fabrication cost)	Higher (less material, higher fabrication cost)	H-beam

Figure 5.3-1 shows a comparison of steel weights, except for accessories such as shoes, expansion joints, handrails and drainage boxes.

(2) Case 2: Plate girder (non-composite) for 35 m span bridge

For bridges with span length of 35 m, the following two (2) types are widely used as more economical steel bridges based on experience in Japan:

1) Plate girder (non-composite build-up plate girder)

2) Composite plate girder (composite build-up plate girder)

As described above, since the composite type is regarded as an unsuitable structure for the Philippines, the plate girder type was adopted despite its being relatively uneconomical. A comparison between plate girder and composite plate girder is presented in Table 5.3-4.

TABLE 5.3-4 COMPARISON OF PLATE GIRDER AND COMPOSITE PLATE GIRDER

Evaluation Item	Plate Girder	Composite Plate Girder	Evaluation (advantage)
Slab Concrete	Required quality, ~ck = 270 kg/cm^2	Required quality, ~ck = 300 kg/cm^2	Plate Girder ~ck = 270kg/cm^2 is common in R.P
Girder Depth	Over 180 cm	Approx. 180 cm	Composite pl. girder
Deflection	More	Less	Composite pl. girder
Maintenance	Easier to repair	More difficult to repair	Plate girder
Cost	Higher	Lower	Composite pl. girder

The girder depth adopted for the design was reduced to its deflectional limit of 160 cm, because the lower the girder depth the lower the approach road embankment and the shorter the approach road.

5.3.4 Proposed Bridge Types

The most appropriate type of bridge for each proposed site was finally selected as shown in Table 5.3-5, taking into consideration physical conditions mentioned above.

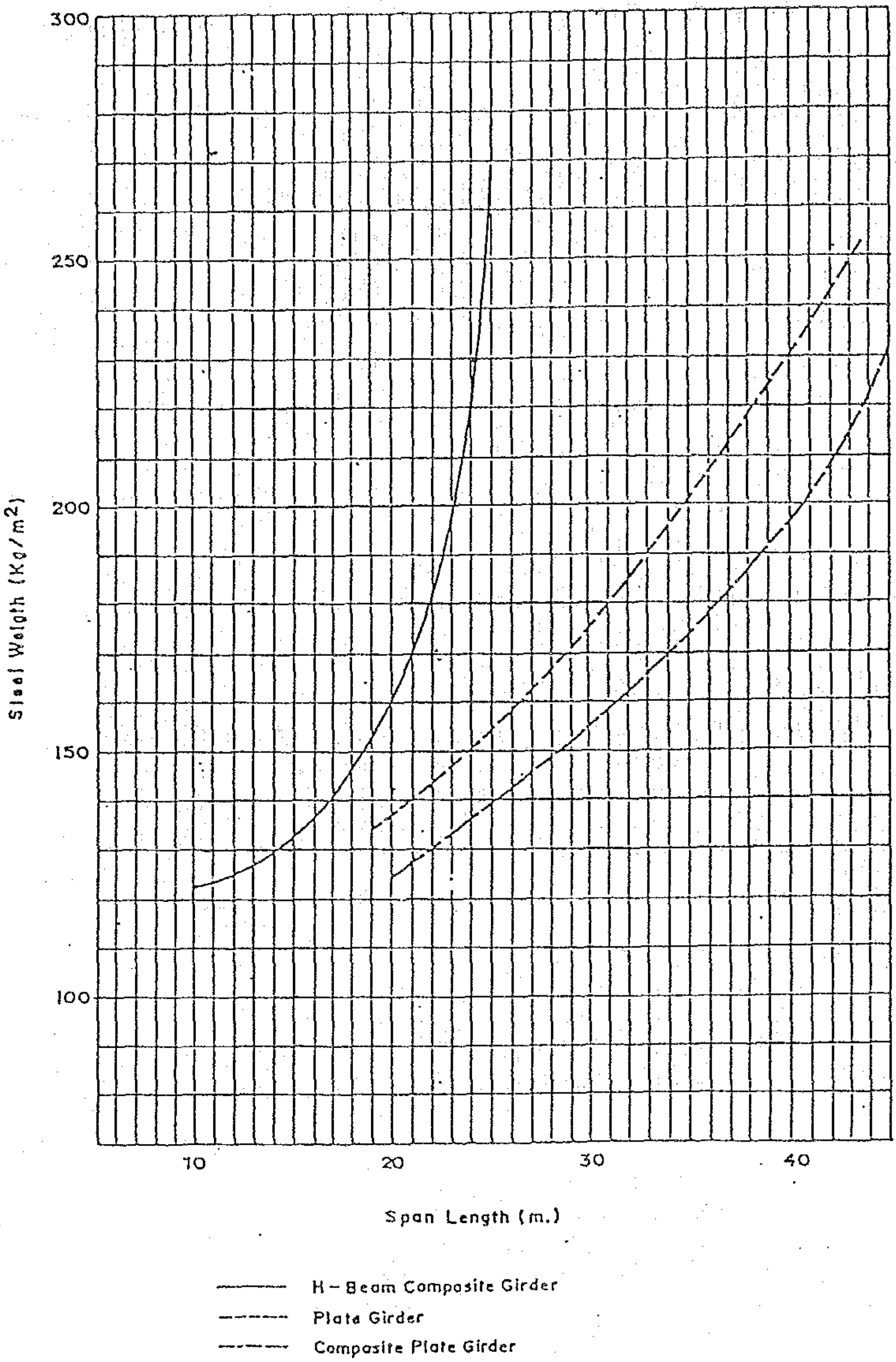
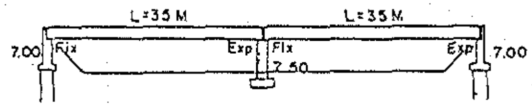
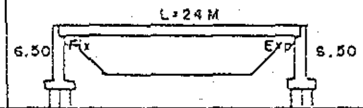
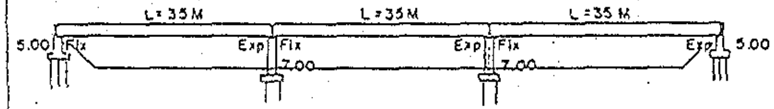
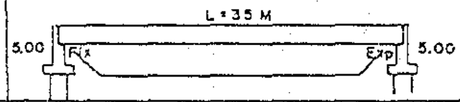
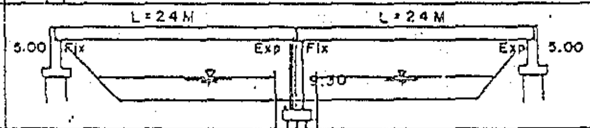
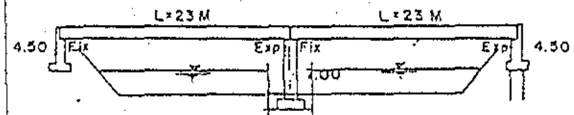
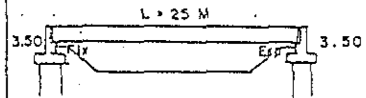
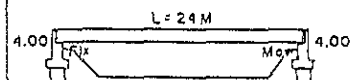
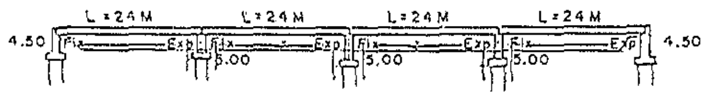
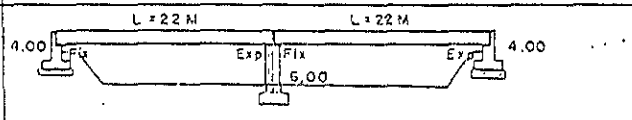


FIGURE 5.3-1 STEEL WEIGHT

TABLE 5.3-5 SUMMARY OF PHASE II BRIDGES

BRIDGE NO.	NAME OF BRIDGE	TYPE OF BRIDGE	SUPERSTRUCTURE	SUBSTRUCTURE	REMARKS
04.01a	BINAMBANG		BUILT-UP BEAM L = 35 M + 35 M	ABUT. A & B ON PILE FOUNDATION RC PILE ABUT. A = 400 x 400 x 9.00 M RC PILE ABUT. B = 400 x 400 x 9.00 M PIER ON SPREAD FOUNDATION	
04.03a	LEVISTE		H-BEAM L = 24 M.	ABUT. A & B ON PILE FOUNDATION RC PILE ABUT. A = 400 x 400 x 11.00 M RC PILE ABUT. B = 400 x 400 x 11.00 M	
04.04b	LUMANG BAYAN		BUILT-UP BEAM L = 35 M + 35 M + 35 M	ABUT. A & B ON PILE FOUNDATION RC PILE ABUT. A = 400 x 400 x 7.00 M RC PILE ABUT. B = 400 x 400 x 8.00 M PIER 1 & 2 ON PILE FOUNDATION RC PILE PIER 1 & 2 = 400 x 400 x 8.00 M	WEATHERING STEEL BRIDGE
04.05b	OLANGOAN		BUILT-UP BEAM L = 35 M	ABUT. A ON PILE FOUNDATION ABUT. B ON PILE FOUNDATION RC PILE ABUT. A = 400 x 400 x 7.00 M RC PILE ABUT. B = 400 x 400 x 9.00 M	WEATHERING STEEL BRIDGE
05.03	NARANGASAN		H-BEAM L = 24 M + 24 M	ABUT. A & B ON PILE FOUNDATION RC PILE ABUT. A = 400 x 400 x 19.00 M RC PILE ABUT. B = 400 x 400 x 16.00 M PIER 1 ON PILE FOUNDATION RC PILE PIER 1 = 400 x 400 x 6.00 M	WEATHERING STEEL BRIDGE SHEET PILE COFFERDAM
06.03	IYANG		H-BEAM L = 23 M + 23 M	ABUT. B ON PILE FOUNDATION RC PILE ABUT. A = 400 x 400 x 7.00 M ABUT. A ON SPRAD FOUNDATION PIER 1 ON SPREAD FOUNDATION	WEATHERING STEEL BRIDGE SHEET PILE COFFERDAM
07.01	BANBAN		H-BEAM L = 25 M	ABUT. A & B ON PILE FOUNDATION RC PILE ABUT. A & B = 400 x 400 x 25.00 M	WEATHERING STEEL BRIDGE SKEW 60°
07.02	CAMPACAS		H-BEAM L = 24 M	ABUT. A & B ON PILE FOUNDATION RC PILE ABUT. A & B = 400 x 400 x 11.00 M	
08.04	TALISAYAN		H-BEAM L = 24 M + 24 M + 24 M + 24 M	ABUT. A & B ON PILE FOUNDATION RC PILE ABUT. A = 400 x 400 x 14.00 M RC PILE ABUT. B = 400 x 400 x 11.00 M PIER 1 & 2 & 3 & 4 ON PILE FOUNDATION RC PILE PIER 1 = 400 x 400 x 12.00 M RC PILE PIER 2 = 400 x 400 x 13.00 M RC PILE PIER 3 = 400 x 400 x 11.00 M	SHEET PILE COFFERDAM
10.01	HAYANGABON I		H-BEAM L = 22 M + 22 M	ABUT. A & B ON SPREAD FOUNDATION PIER 1 ON SPREAD FOUNDATION	WEATHERING STEEL BRIDGE

5.4 Design of Superstructures

5.4.1 Design Criteria

The design criteria for superstructures, as adopted for the Phase I Bridges, are as follows:

- Design Specification : AASHTO Standard Specifications for Highway Bridges (13th Edition, 1983)

  : Specification for Highway Bridges, Japan Road Association, 1980

- Live Load : AASHTO HS-20-44 (MS18) for Roadways

  : 2.873 KN/M^2 for Sidewalks

- Temperature Change : rise + 10^0, fall - 10^0

- Concrete Slab : (3L + 11) x 1.05, L = span Length

- Max. Length of Member : 8.5 m

5.4.2 Types of Superstructures

The discussion on selection of types of superstructures is presented in Section 5.3.2, and the two (2) types below were adopted.

- Span length 22 m ~ 25 m : H-beam composite girder

- Span length 35 m : Plate girder (build up)

Given the fabrication of steel girders in Japan and the construction method in the Philippines, the maximum length of the girder members was decided to be less than 8.5 m.

Figure 5.4-1 shows a general view of H-beam composite girder and Figure 5.4-2 shows a typical section of superstructures.

Considering the location of bridges, weathering steel which provides atomospheric corrosion resistance was planned to be used for the following bridges. These bridges are located near seasides.

TABLE 5.4-1 BRIDGES FOR WEATHERING STEEL

Bridge No.	Name
04.04b	Lumang Bayan
04.05b	Olangsan I
05.03	Narangasan I
06.03	Iyang
07.01	Banban
10.01	Hayangabon I

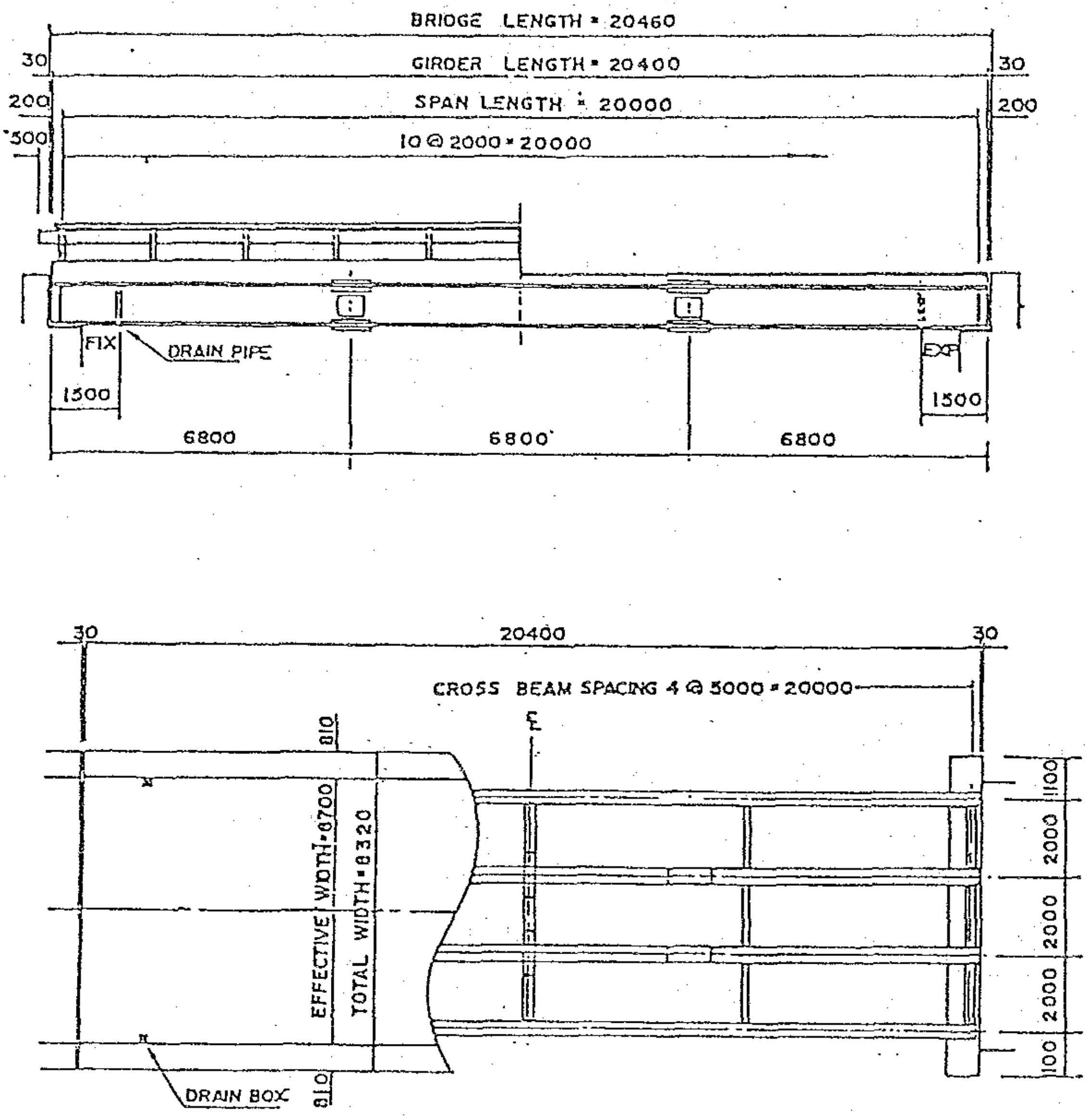
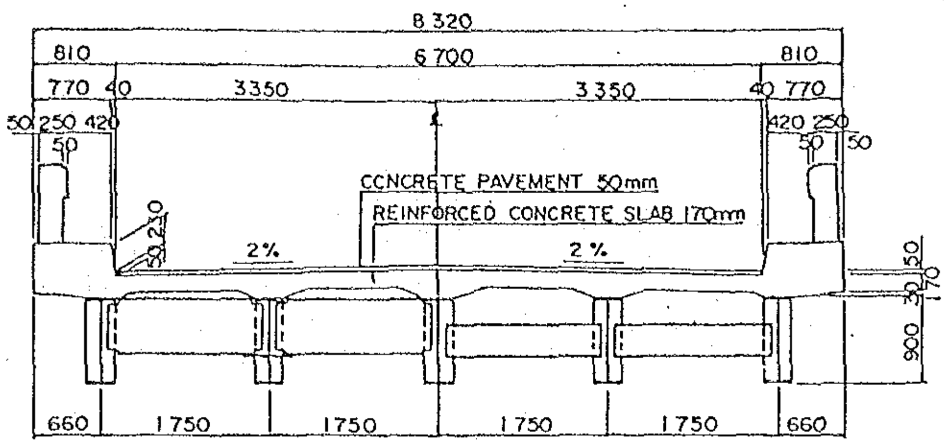
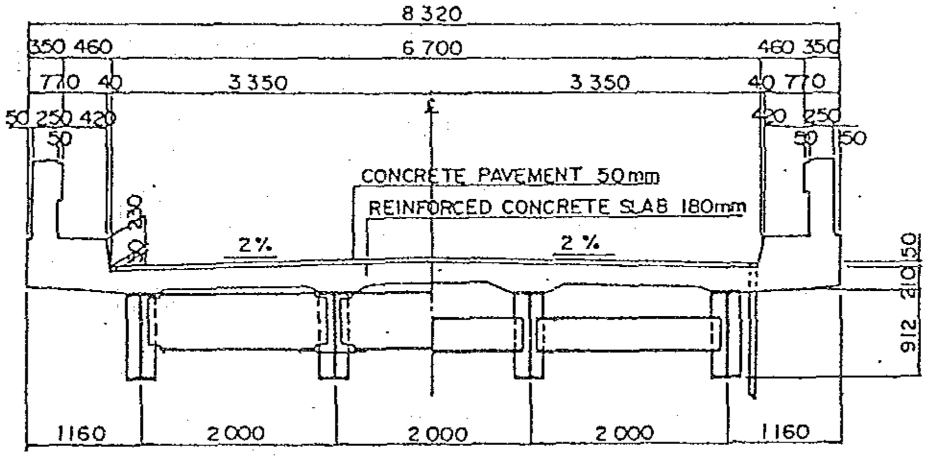


FIGURE 5.4-1 TYPICAL GENERAL VIEW OF BRIDGE



H - BEAM COMPOSITE GIRDER (SPAN: 25m)



H - BEAM COMPOSITE GIRDER (SPAN: 22m, 23m, 24m)

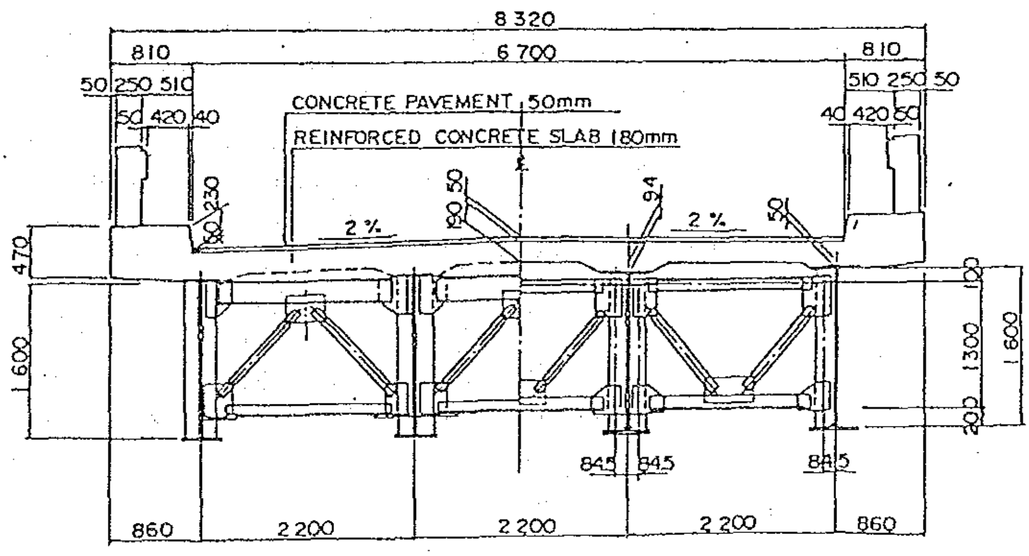


PLATE GIRDER (BUILD UP BEAM) (SPAN: 35m)

FIGURE 5.4-2 TYPICAL CROSS SECTION OF SUPERSTRUCTURES

5.5 Design of Substructures

5.5.1 Design Criteria

The design criteria for substructures, as adopted for the Phase I Bridges, are as follows:

- Design Specification : AASHTO Standard Specifications for Highway Bridges (13th Edition, 1983)

- Earthquake Load : C = 0.12 with Reference to Relevant AASHTO Provisions

- Concrete Strength at 28 days:

For superstructures	$f'c = 270\ kg/cm^2$
For substructures	$f'c = 210\ kg/cm^2$
For railings	$f'c = 270\ kg/cm^2$

- Reinforcing Steel : $fy = 2100\ kg/cm^2$

5.5.2 Types of Substructures

The types of substructures adopted for the Phase I Bridges are T-type abutments and wall type piers. However, since the rivers cross the Phase II Bridges at oblique angles, column piers were adopted to avoid disturbing the stream lines. Refer to Table 5.5-1.

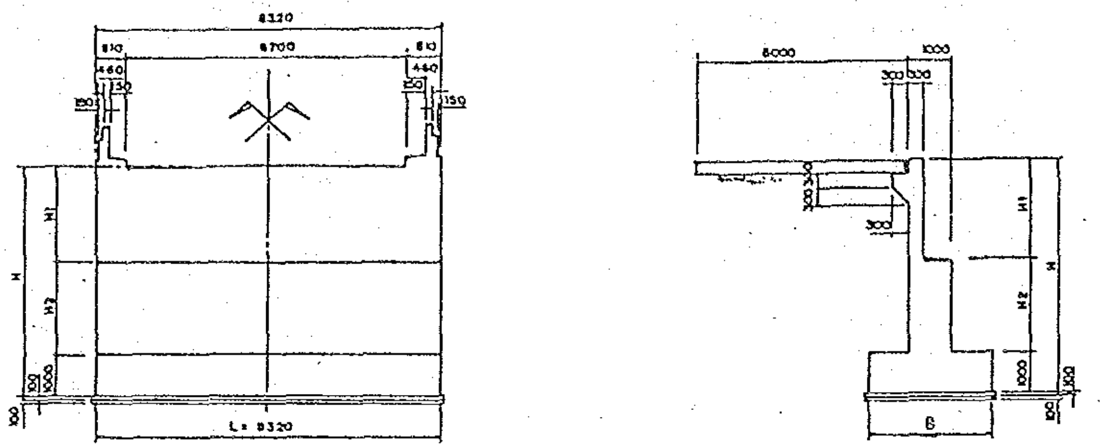
T-type abutments on pile foundations are strongly recommended to have at least two (2) lines of piles in order to avoid tilting of the abutments and scouring of the embankments behind the abutments.

The recommended standard types of abutments and piers, both for spread footings and pile foundations, are shown in Figures 5.5-1 and 5.5-2, respectively.

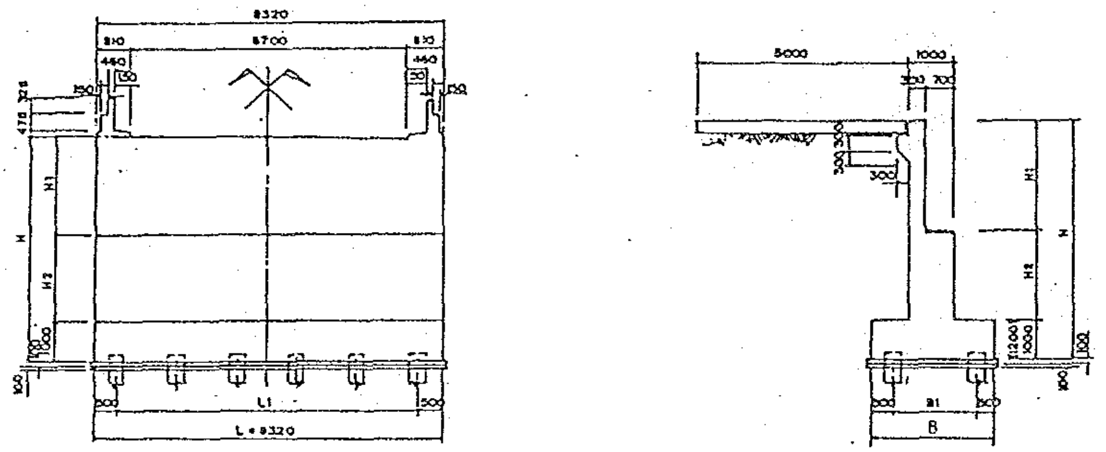
TABLE 5.5-1 STREAM ANGLE AND PIER TYPE

Bridge No.	Bridge Name	Stream a/ Angle	Type of Pier
04.01a	Binambang	40^{0}	Column pier
04.03a	Leviste II	90^{0}	- None -
04.04b	Lumang Bayan	30^{0}	Column pier
04.05b	Olangoan	90^{0}	- None -
05.03	Narangasan I	70^{0}	Column pier
06.03	Iyang	30^{0}	Column pier
07.01	Banban	40^{0}	- None -
07.02	Campacas	90^{0}	- None -
08.04	Talisayan	30^{0}	Column pier
10.01	Hayangabon	70^{0}	Column pier

a/ Oblique angle between stream line and bridge

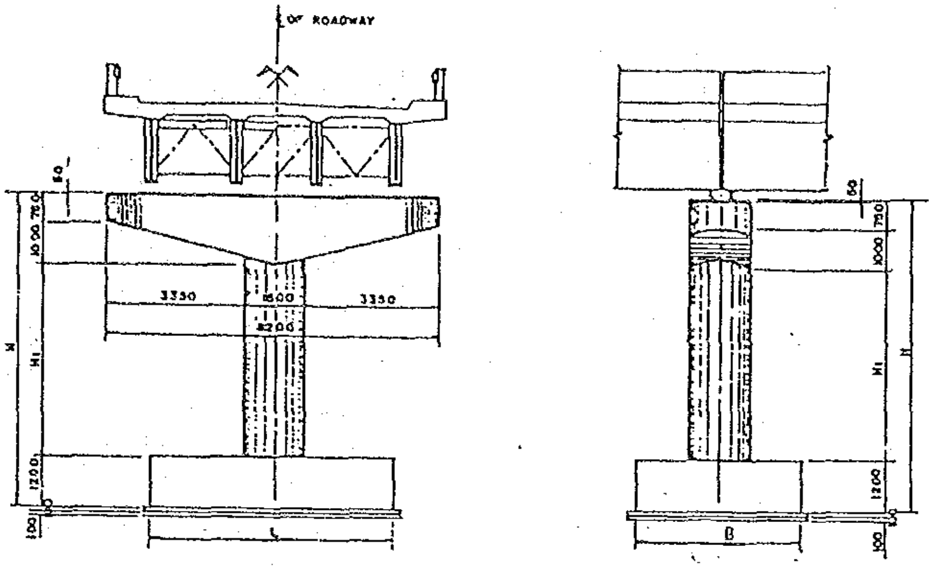


ABUTMENT ON SPREAD FOUNDATION

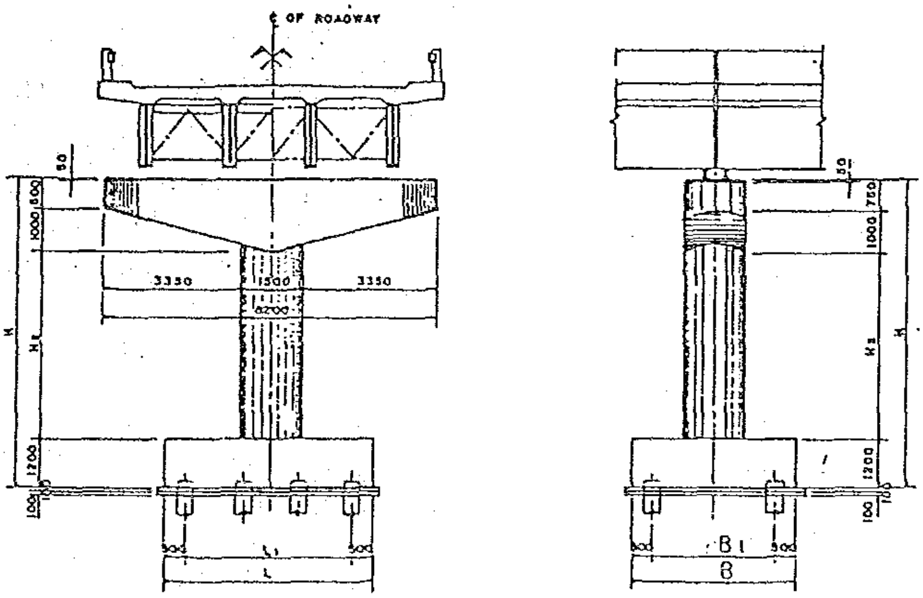


ABUTMENT ON PILE FOUNDATION

FIGURE 5.5-1 TYPICAL ABUTMENT

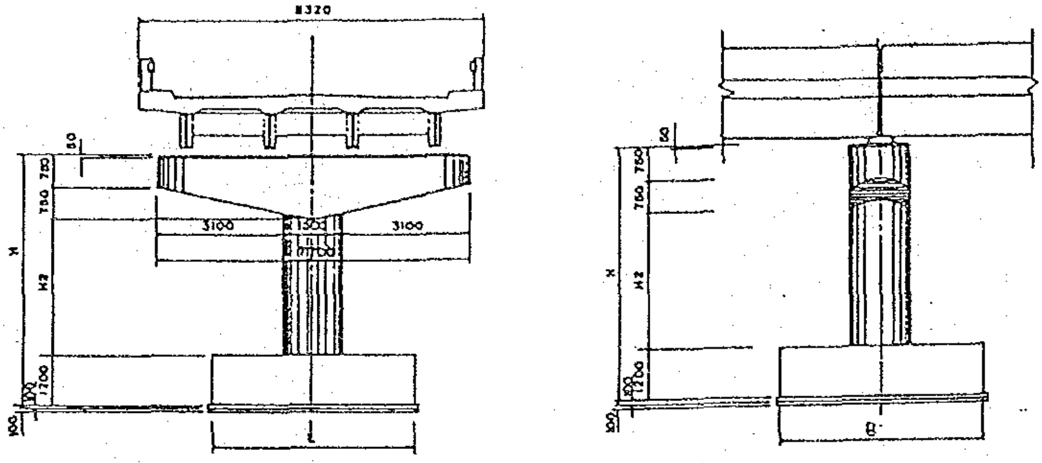


PIER ON SPREAD FOUNDATION

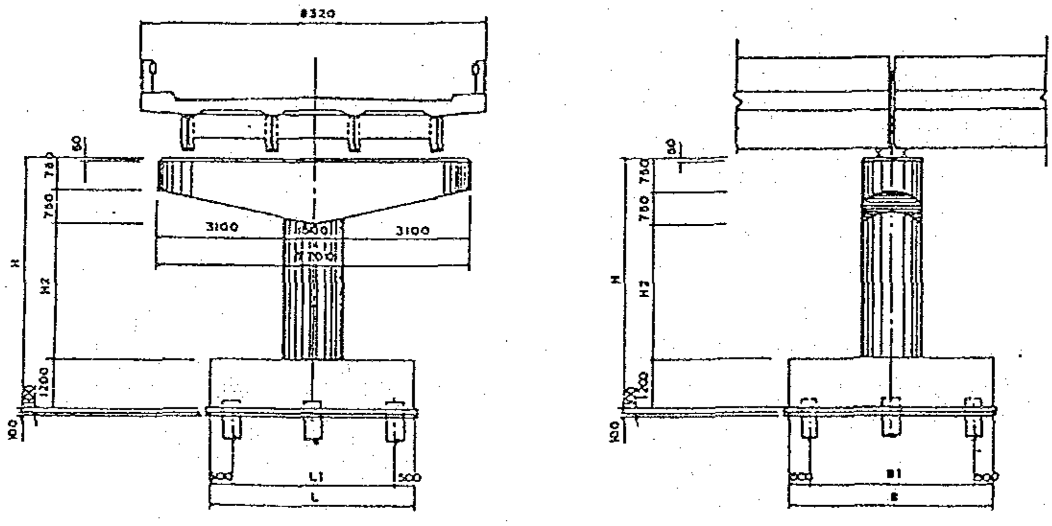


PIER ON PILE FOUNDATION

FIGURE 5.5-2(1/2) TYPICAL PIER (SPAN ≦ 35 m)



PIER ON SPREAD FOUNDATION



PIER ON PILE FOUNDATION

FIGURE 5.5-2(2/2) TYPICAL PIER (SPAN≦25m)

5.6 Design of Approach Roads

5.6.1 Design Criteria

The design standard for secondary class national road specified in the Highway Design Guideline of the Philippines was adopted for the design of the approach roads. Its geometric standard is shown in Table 5.6-1 and was also adopted for the Phase I Bridges.

TABLE 5.6-1 MINIMUM GEOMETRIC STANDARD

	Flat	Rolling	Mountainous
1. Design Speed (km/hr)	60	50	40
2. Pavement Width (m)	6.70	6.70	6.70
3. Shoulder Width (m)	1.00	1.00	1.00
4. Minimum Radius (m)	120	80	50
5. Maximum Superelevation (%)	8	8	8
6. Maximum Grade (%)	3	5	10
7. Minimum Length of Vertical Curve (m)	60	60	60
8. Minimum Radius for Crest Vertical Curve (m)	1500	1200	1000
9. Minimum Radius for Sag Vertical Curve (m)	1500	1000	800

5.6.2 Typical Roadway Sections

Figure 5.6-1 shows typical roadway sections of the approach roads.

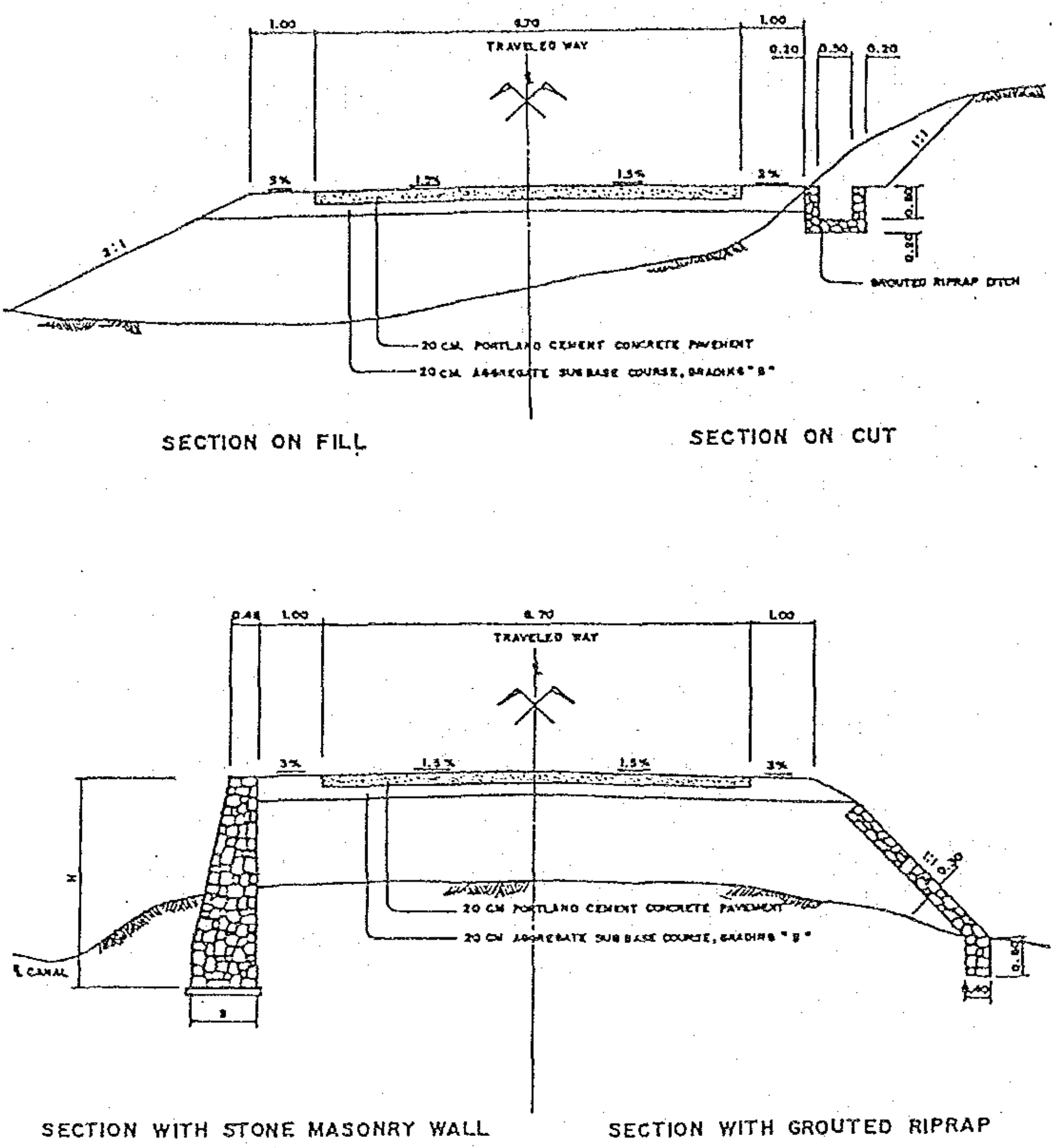


FIGURE 5.6-1 TYPICAL ROADWAY SECTION

5.6.3 Analysis on Soft Ground

As a result of geotechnical survey, it was ascertained that the subsoil of the Banban Bridge Site in Cebu is soft ground.

The problems on soft ground for the construction of bridges are insufficient bearing capacity of the subsoil, settlement of embankments due to consolidation and slope failure of embankments. As a countermeasure for insufficient bearing capacity, reinforced concrete piles with a length of 24 m which are made in Philippines are planned to be used. To stabilize the embankment, the following special countermeasures are planned because of the short period that the embankment must be implemented.

(1) Soil Property Constants and Embankment Section Model

Laboratory tests were conducted to determine the soil property constants like unit weight, moisture content, liquid limit, plastic limit and unconfined compressive strength, which are required to analyze soft ground stability.

The embankment section model and soil property constants of each layer are shown in Figure 5.6-2. These were used in the analysis.

The symbols in Figure mean the followings;

qu : unconfined compressive strength
Wn : natural water contents
rt : unit weight
A : activity index

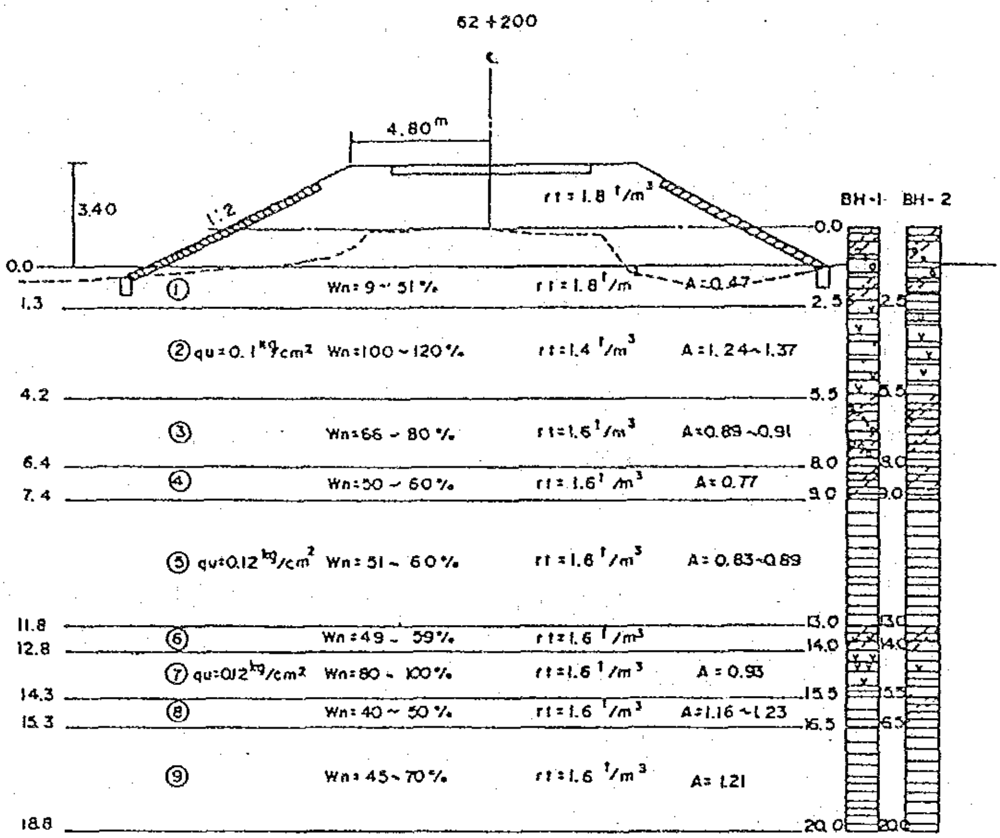


FIGURE 5.6-2 EMBANKMENT SECTION MODEL

(2) Consolidation Settlement Analysis

Consolidation settlement and settlement time can be computed using the following formulas:

$$Sc = \frac{e_0 - e_1}{e_0 + 1} \times H$$

where: Sc = consolidation settlement (cm)
$_0$ = initial void ratio
$_1$ = consolidated void ratio
H = depth of each soft layer (cm)

$$t = \frac{T \cdot d^2}{Cu}$$

where: t = settlement time
T = coefficient of time
d = drain distance
Cu = coefficient of consolidation

The consolidation settlement analysis is presented in Appendix 7. The analysis resulted in a complete settlement of 38.4 cm at shoulders and 26.1 cm at road center. Assuming a thickness of 5 cm of embankment is executed daily, 80% of complete settlement will be completed in 30 days.

Based on the results of the analysis, a countermeasure may be provided against settlement, although not severely critical.

(3) Slope Stability Analysis

Slope stability can be computed using the following formula:

$$Fs = \frac{(C\ l + W \cos\theta \tan\phi u)}{W \sin\theta}$$

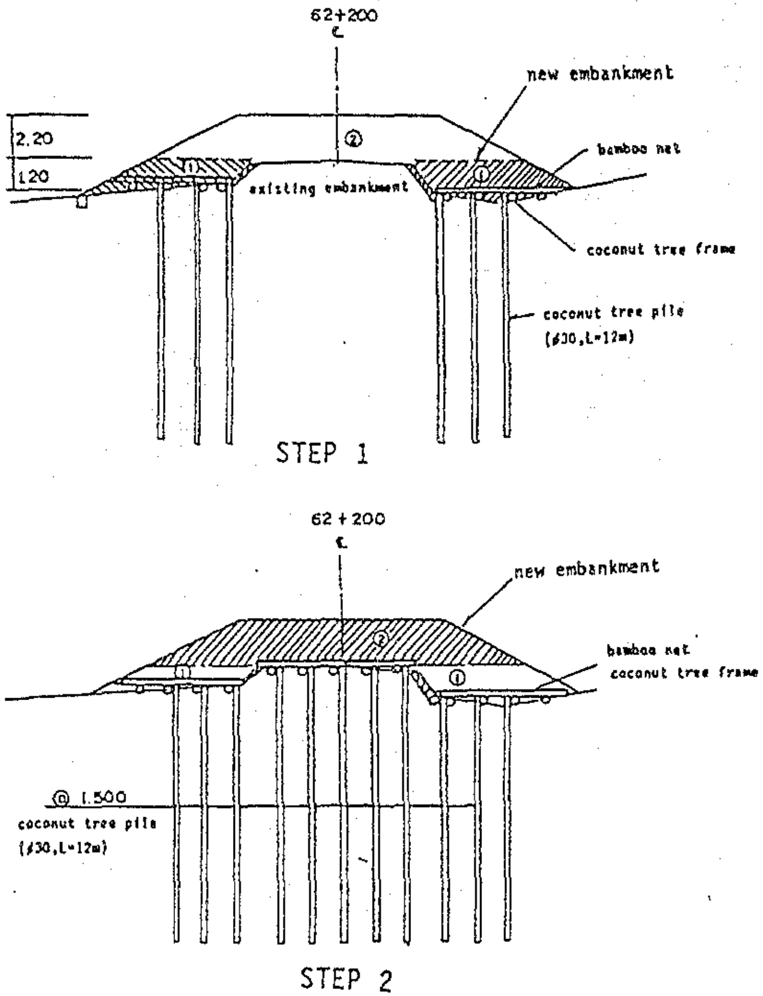
where: Fs = safety factor
C = cohesion of slip circle (t/m^2)
L = length of slip circle (m)
w = weight of sliced block (t)
θ = angle between vertical line and perpendicular line to slip circle (deg)

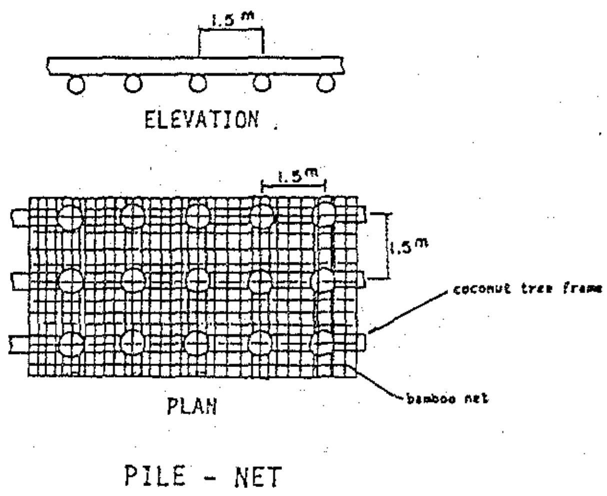
ϕn = angle of internal friction of soil (t/m^2)

The result of the analysis is presented in Appendix 7. The analysis showed the most unstable slip circle crossing at 7.40 m depth of the ground with a 0.925 safety factor. Since this indicates that the slope has a considerably high possibility of failures, it was decided to plan a countermeasure.

(4) Countermeasure

As a countermeasure, the pre-loading, sheet and pile-net methods were proposed. The pile-net method was adopted because of the necessity of speedy execution, procurement of local material and concrete pavement on the embankment. Bamboo nets and coconut trees will be used for the pile-net method which is illustrated in Figure 5.6-3.





Procedure of Execution

i) Drive coconut tree piles and stall wooden frames and bamboo nets on both side of existing embankment.
Execute Embankment on the bamboo nets up to existing embankment. (Riprap should be removed prior to embankment is executed where riprap is existing.)

ii) Drive coconut tree piles and stall wooden frames and bamboo nets on top of existing embankment. Execute embankment up to proposed grade.

FIGURE 5.6-3 COUNTERMEASURE ON SOFT GROUND (PILE-NET METHOD)

5.7 Design of Pavement Structures

5.7.1 Design Criteria

. Design Specification: AASHTO Guide for Design of Pavement Structure 1986, AASHTO

. Serviceability of PCC Pavement: initial 4.5
terminal 2.5

. Pavement Layer Characteristics:
modulus of subbase: 8000 psi
modulus of elasticity of PCC: 328×10^6 psi

. PCC Modulus of Rupture: 580 psi

. Drainage Coefficient: 0.9

. Load Transfer Coefficient: 4

. Loss of Support: 1

5.7.2 Types of Pavement

Since the length of roads to be constructed under the Project is short, Portland Cement Concrete (PCC) pavement is recommended, as shown in Figure 5.7-1.

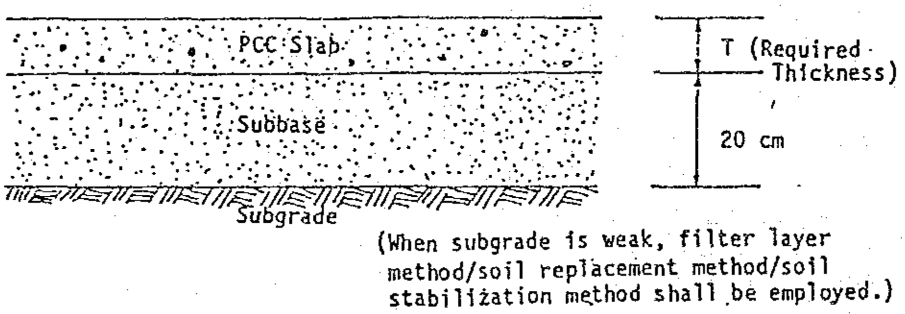


FIGURE 5.7-1 TYPICAL CROSS SECTION OF PCC PAVEMENT

The required thickness of PCC slab shall be designed to carry the expected number of traffic volumes and loadings. Table 5.7-1 summarizes the recommendation based on the outputs of the Feasibility Study of the Road Improvement on the Pan-Phillipine Highway conducted by JICA on September 1987.

TABLE 5.7-1 RECOMMENDED THICKNESS BY PCC SLAB

Traffic Loading Class (x10^6) \ CBR		2	3	4	6	8	10	15	20	PCC Thickness Performance Period
Light Traffic Loading	L-1 (0.005)									More Than 25 Years
	L-2 (0.01)	Apply Min. Thickness 20 cm.								
	L-3 (0.03)									
Heavy Traffic Loading	A (0.1)	23								15 Years
	B (0.2)	25								
	C (0.4)	28			25					
	D (0.7)				28					
	E (1.0)	30								
Extra Heavy Traffic Loading	F-d (1.5-3.5)	30 or 33 or 35[1/]								5 - 12 years

NOTE: Traffic loading class is expressed in number of ESAL (18-kip equivalent single axle loads)