4.2.3 Phasing of Bridges

The 37 BRidges are composed of 27 bridges as Group 1 and 10 bridges as Group 2.

(1) Phasing Criteria

The criteria employed in phasing bridges are as follows:

a) Criteria for Group 1 Bridges

- The Government of the Philippines can design the substructure and erect the steel girder easily.

- No difficulty in construction, especially erection of steel girders and construction of substructures, is anticipated.

b) Criteria for Group 2 Bridges

- Erection of steel girders may be difficult because of deep valleys or long spans.

- Cofferdams may be recommended to be used for the constructions of piers inside rivers.

- Geological surveys are required to decide the types of foundations.

- Detailed topographic surveys are required because of complicated terrain.

(2) Phasing of Bridges

In accordance with the criteria established, all selected bridges were classified into Groups 1 and 2.

The result of the technical study, especially those on design and construction requirements for the bridges, are presented in Table 4.2-2.

Table 4.2-3 summarizes the number of bridges and their length proposed for Group 1 and 2 by Region and Province. Table 4.2-4 also summarizes the type and number of bridges.

Table 4.2-5 and 4.2-6 show the list for Group 1 and 2, respectively.

TABLE 4.2-2 SELECTION AND GROUPING OF PROPOSED BRIDGES (1/6)

No.	Bridge No.	Name of Bridge	Traffic Volume (ADT)	Existing Bridge			Proposed Bridge		Design and Construction Requirements	Group
				Length (m)	Type and Condition	Load Limit (tons)	Length (m)	Type		
1	01.02	Maphilindo Bridge Pangasinan	4741	128.35	Bailey o Deteriorated lumber and bailey panels o Conc. Pier	5	32+32+32+32+32 =160	o Steel Plate Girder o Pile Foundation	o Detailed topographic survey and geological investigation is required o Hydrological analysis is required o Cofferdam for pier construction is required o Working temporary bridge may be needed. o Ordinary water (3m)	2
2	03.01	Pangulisanin Bridge Bataan	200	21.65	Bailey o Fair Steel	6	24.0	o H-Beam o Pile Foundation	o No difficulty in construction o Ordinary water (1.0m)	1
3	03.03*	Bacong Bridge Bataan	50	46.00	Bailey o Deterioreated Lumber and Bailey Panels	2	26+26=52	o Steel Plate Girder o Pile Foundation	o Detailed topographic survey and geological investigation is required. o Hydrological analysis is required.	2
4	03.04	Tigbe Bridge Bulacan	345	18.90	Bailey o Delapi-dated Timber Trestle	5	22.0	o H-Beam o Pile Foundation	o No difficulty in construction	1
5	03.06*	Balasing Bridge Bulacan	200	31.20	Bailey o Seriously Dilapidated	2	15+23=38	o H-Beam o Pile Foundation	o No Difficulty in construction o No water at position of the pier for construction	1
6	03.07	San Roque Bridge Bulacan	200	63.60	Timber o Seriously Dilapidated o Unpassable	—	18+18+18=54	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required o Cofferdam for pier construction is required o Deep water (2.0m) o Many houses will be affected o Right-of-Way shall be acquired	2
7	03.08	Pias Bridge Pampanga		8.00	Bailey (Collapsed)	—	23+23=46	o H-Beam o Pile Foundation	o No difficulty in construction	1

* Revised Request

TABLE 4.2-2 SELECTION AND GROUPING OF PROPOSED BRIDGES (2/6)

No.	Bridge No.	Name of Bridge	Traffic Volume (ADT)	Existing Bridge			Proposed Bridge		Design and Construction Requirements	Group
				Length (m)	Type and Condition	Load Limit (tons)	Length (m)	Type		
8	03.10*	Dolores Bridge Pampanga	95	24.65	o Washed out	5	24+24=48	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required. o Cofferdam for pair construction is required. o Deep water (2m)	2
9	03.11	Pulo Bridge Pampanga	35	11.85	Timber o Dilapidated Timber Trestle	3	23.0	o H-Beam o Pile Foundation	o No difficulty in construction. o Houses will be affected o Sta. Catalina Bridge leading to bridge site shall be required	1
10	03.13	Mangkuyog Bridge Nueva Ecija	300	No Existing Bridge			24+24+24+24=96	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required o Hydrological analysis shall be conducted to decide bridge length	2
11	03.17	Sula Bridge Tarlac	70	No Existing Bridge			20+20+20=60	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required o Hydrological analysis is required	2
12	03.18	Sindol Bridge Zambales	53	24.10	Timber o Seriously Dilapidated o Unpassable	—	15+15=30	o H-Beam o Pile Foundation	o No difficulty in construction o Near fish pond	1
13	04.01a	San Juan Bridge Cavite	200	19.20	Bailey o Collapsed o Unpassable	—	23.0	o H-Beam o Pile Foundation	o No difficulty in construction o Right-of Way shall be acquired o Daang Bakal Bridge leading to bridge site shall be reinforced	1
14	04.02a	Tabon-Batong Br. Cavite	200	13.80	Bailey o Dilapidated Timber Trestle	3	22.0	o H-Beam o Pile Foundation	o No difficulty in construction o Houses will be affected o Near fishpond o Tabon-Gahak Bridge leading to bridge site shall be reinforced	1

* Revised Request

TABLE 4.2-2 SELECTION AND GROUPING OF PROPOSED BRIDGES (3/6)

No.	Bridge No.	Name of Bridge	Traffic Volume (ADT)	Existing Bridge Length (m)	Existing Bridge Type and Condition	Existing Bridge Load Limit (tons)	Proposed Bridge Length (m)	Proposed Bridge Type	Design and Construction Requirements	Group
15	04.04a	Caglate Bridge Quezon	100	18.42	Bailey o Dilapidated Lumber and Bailey Panels	5	23.0	o H-Beam o Pile Foundation	o No difficulty in construction o 12 bridges leading to construction site shall be repaired	1
16	04.06a	Buenavista Bridge Quezon	95	17.26	- do -	3	24.0	o H-Beam o Pile Foundation	o No difficulty in construction o 4 dilapidated bridges shall be repaired	1
17	04.07a	Camagong Bridge Quezon	100	15.36	- do -	3	22+22=44	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required o Hydrological analysis is required o 8 dilapidated bridge shall be repaired o River protection is required	2
18	04.09a	Isabang Bridge Quezon	150	15.00	Spillway	5	24+24=48	o H-Beam o Pile Foundation	o No difficulty in construction	1
19	04.10a	Pansipit Bridge Batangas	—	No Existing Bridge			22+22=44	o H-Beam o Pile Foundation	o No difficulty in construction o Cofferdam for pier construction may be required	1
20	04.11a	San Diego Bridge Batangas	200	18.60	Bailey o Deteriorated Lumber and Bailey Panels	5	15+15=30	o H-Beam o Pile Foundation	o No difficulty in construction o Cofferdam for pier construction may be required o Water (1.0m)	1
21	04.13a	Bagong-Pook Bridge Batangas	120	26.80	Timber o Dilapidated Timber o Concrete Pier	5	24	o H-Beam o Pile Foundation	o No difficulty in construction o Palico Bridge (30m) leading to bridge site shall be repaired	1

TABLE 4.2-2 SELECTION AND GROUPING OF PROPOSED BRIDGES (4/6)

No.	Bridge No.	Name of Bridge	Traffic Volume (ADT)	Existing Bridge			Proposed Bridge		Design and Construction Requirements	Group
				Length (m)	Type and Condition	Load Limit (tons)	Length (m)	Type		
22	04.16a	Pingit Bridge Aurora	30		No Existing Bridge		21+21=42	o H-Beam o Pile Foundation	o No difficulty in construction o Cofferdam for pier construction may be required o Water (1.5m)	1
23	04.17a	Salay Bridge Aurora	90	23.42	Timber o Dilapidated Lumber o Conc. Pier	1	15+15=30	o H-Beam o Pile Foundation	o No difficulty in construction o Palayan II Bridge is dilapidated	1
24	04.18a	Mijares Bridge Aurora	100		Timber o Overflow when Flood Water o Deteriorated Lumber	1	23.0	o H-Beam o Pile Foundation	o No difficulty in construction	1
25	04.19a	Palayan Bridge Laguna	63	18.40	Bailey o Deteriorated Lumber and Bailey Panels	3	24.0	o H-Beam (Skewed 60) o Pile Foundation	o No difficulty in construction	1
26	04.20a	Paragusan Bridge Laguna	100	40.00	Bailey o Deteriorated Lumber Bailey Panels o Unsuitable Lumber Trestle	3	15+30=45	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required o Construction of high pier (14m) o Study on detour road during construction	2
27	04.21a	Tarak Bridge Laguna	100	22.00	Bailey	3	24	o H-Beam o Pile Foundation	o No difficulty in construction	1
28	04.22a	Sto. Nino Bridge Rizal	50	18.00	Bailey o Deteriorated Lumber and Bailey Panels	3	23	o H-Beam o Pile Foundation	o No difficulty in construction	1

TABLE 4.2-2 SELECTION AND GROUPING OF PROPOSED BRIDGES (5/6)

No.	Bridge No.	Name of Bridge	Traffic Volume (ADT)	Existing Bridge Length (m)	Existing Bridge Type and Condition	Existing Bridge Load Limit (tons)	Proposed Bridge Length (m)	Proposed Bridge Type	Design and Construction Requirements	Group
29	04.23a	Del Pilar Bridge Rizal	50	18.50	Bailey o Deteriorated Lumber and Bailey Panels	3	24	o H-Beam o Pile Foundation	o No difficulty in construction o Right-of-Way shall be acquired	1
30	04.03b	Maruyagon Bridge Palawan	88	18.00	Timber Dilapidated Timber Trestle	2	24	o H-Beam o Pile Foundation	o No difficulty in construction o 7 bridges leading to bridge site are dilapidated	1
31	04.04b	Dakoton Bridge Palawan	88	30.00	Bailey o Dilapidated Timber Trestle o Deteriorated Lumber and Bailey Panels	3	18+18=36	o H-Beam o Pile Foundation	o No difficulty in construction o Small cofferdam is required o Ordinary water depth (0.5m) o 11 bridges leading to bridge site are dilapidated	1
32	04.06b	Madalag Bridge Romblon	310	19.00	Bailey o Deteriorated Lumber and Bailey Panels	5	24	o H-Beam o Pile Foundation	o No difficulty in construction	1
33	04.07b	Tan-Agan Bridge Romblon	485	19.00	- do -	5	18+18=36	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required o Cofferdam for pier construction is required o Ordinary water depth (3.0m) o 3 bridges leading to bridge site are dilapidated	2
34	04.08b	Panique Bridge Romblon	490	21.34	Bailey o Deteriorated Lumber and Bailey Panels o Conc. Pier	5	18+18=36	o H-Beam o Pile Foundation	o No difficulty in construction o Cofferdam for pier construction may be required o Ordinary water depth (1.0m)	1
35	04.09b	Maralig Bridge Marinduque	30	18.86	Bailey o Deteriorated Lumber and Bailey Panels	4	15+15=30	o H-Beam o Pile Foundation	o No difficulty in construction o Ordinary water depth (0.5m)	1

TABLE 4.2-2 SELECTION AND GROUPING OF PROPOSED BRIDGES (6/6)

No.	Bridge No.	Name of Bridge	Traffic Volume (ADT)	Existing Bridge			Proposed Bridge		Design and Construction Requirements	Group
				Length (m)	Type and Condition	Load Limit (tons)	Length (m)	Type		
36	04.10b* -1	Daykitin Bridge Marinduque	110	17.00	Spillway	5	24	o H-Beam o Pile Foundation	o No difficulty in construction	1
37	04.10b* -2	Ihatub Bridge Marinduque	160	19.65	Spillway	5	23+23=46	o H-Beam o Pile Foundation	o Topographic survey and geological investigation is required o Hydrological analysis is required	2

* Revised Request

TABLE 4.2-3 SUMMARY OF SELECTED BRIDGES

Region	Province	Group-1				Group-2				TOTAL			
		Number of Bridge		Bridge Length (m)		Number of Bridge		Bridge Length (m)		Number of Bridge		Bridge Length (m)	
		Request	Selected	Request	Selected	Request	Selected	Request	Selected	Request	Selected	Request	Selected
I	Pangasinan	(0)	0	(0)	0	(2)	1	(245)	160	(2)	1	(245)	160
III	Bataan	(2)	1	(48)	24	(1)	1	(46)	52	(3)	2	(94)	76
	Bulacan	(2)	2	(39)	60	(2)	1	(116)	54	(4)	3	(155)	114
	Pampanga	(2)	2	(30)	69	(2)	1	(210)	48	(4)	3	(240)	117
	Nueva Ecija	(2)	0	(48)	0	(0)	1	(0)	96	(2)	1	(48)	96
	Tarlac	(0)	0	(0)	0	(4)	1	(447)	60	(4)	1	(447)	60
	Zambales	(0)	1	(0)	30	(2)	0	(94)	0	(2)	1	(94)	30
IV-A	Cavite	(2)	2	(43)	45	(1)	0	(66)	0	(3)	2	(109)	45
	Quezon	(5)	3	(95)	95	(1)	1	(50)	44	(6)	4	(145)	139
	Batangas	(1)	3	(20)	98	(4)	0	(206)	0	(5)	3	(226)	98
	Aurora	(2)	3	(40)	95	(2)	0	(140)	0	(4)	3	(180)	95
	Laguna	(2)	2	(42)	48	(1)	1	(44)	45	(3)	3	(86)	93
	Rizal	(2)	2	(40)	47	(0)	0	(0)	0	(2)	2	(40)	47
IV-B	Palawan	(3)	2	(60)	60	(1)	0	(35)	0	(4)	2	(95)	60
	Romblon	(3)	2	(65)	60	(1)	1	(30)	36	(4)	3	(95)	96
	Marinduque	(4)	2	(38)	54	(0)	1	(0)	46	(4)	3	(38)	100
	Oriental Mindoro	(0)	0	(0)	0	(1)	0	(60)	0	(1)	0	(60)	0
	TOTAL	(32)	27	(608)	785	(25)	10	(1,789)	641	(57)	37	(2,397)	1,426

TABLE 4.2-4 TYPE OF SELECTED BRIDGES

Group 1

	No. of Bridges	Aggregate Length (m)
o Single Span (H-Beam)		
24	9	216
23	5	115
22	2	44
o Two Soans (H-Beam)		
2×24=48	1	48
2×23=46	1	46
2×22=44	1	44
15+23=38	1	38
2×21=42	1	42
2×18=36	2	72
2×15=30	4	120
Total	27	785

Group 2

o Continuous span (H-Beam)		
4×24= 96	1	96
2×24= 48	1	48
2×23= 46	1	46
2×22= 44	1	44
3×20= 60	1	60
2×18= 36	1	36
3×18= 54	1	54
o Continuous span (Build-up Sections)		
5×32=160	1	160
2×26= 52	1	52
o Continuous span (Hand Build-up Beam)		
15+30= 45	1	45
Total	10	641

NOTE :

Phase I : 24 bridges with 735m
Phase II : 10 bridges with 517m

TABLE 4.2-5 LIST OF BRIDGES FOR GROUP I (1/3)

NO	BRIDGE NO	NAME OF BRIDGE	LOCATION
1	03.01	Pangulisanin Bridge	Km. 149 + 910 Cabacaban Road Cabcaben, Mariveles, Bataan
2	03.04	Tigbe Bridge	Km. 77 + 520 Tigbe Barangay Road Norzagaray, Bulacan
3	03.06	Balasing Bridge	Km. 39 + 850 Balasing-Tigbe Brgy. Road Bulacan
4	03.08	Pias Bridge	Km. 90 + 470 Porac-Pias-Ebos Road Porac, Pampanga
5	03.11	Pulo Bridge	Km. 85 + 925 Sta. Catalina-Pulong Bayu Road Lubao, Pampanga
6	03.18	Sindol Bridge	Km. 172 + 350 Barangay-Sindol Road San Felipe, Zambales
7	04.01a	San Juan Bridge	Km. 25 + 500 Cavite-Zapote Road San Juan, Cavite
8	04.02a	Tabon-Batong Bridge	Km. 22 + 500 Cavite-Zapote Road Kawit, Cavite
9	04.04a	Caglate Bridge	Km. 027 + 180 Quezon-Alabat Perez Road Alabat, Quezon
10	04.06a	Buenavista Bridge	Km. 016 + 250 Quezon-Alabat-Perez Road Alabat, Quezon
11	04.09a	Isabang Bridge	Km. 127 + 399 MSR-Isabang-Rocohan-Domoit Lucena Diversion Road Lucena City, Quezon

TABLE 4.2-5 LIST OF BRIDGES FOR GROUP 1 (2/3)

NO	BRIDGE NO	NAME OF BRIDGE	LOCATION
12	04.10a	Pansipit Bridge	Km. 131 + 140 San Nicolas-Agoncillo and Vice Versa Brgy. Pansipit, Batangas
13	04.11a	San Diego Bridge	Km. 103 + 109.75 Nasugbu-Tagaytay Road Lian, Batangas
14	04.13a	Bagong Pook Bridge	Km. 95 + 90 Nasugbu-Tagaytay Road Bagong Pook, Lian Batangas
15	04.16a	Pingit Bridge	Km. 234 + 809 Baler-Baler Port Road Baler, Aurora
16	04.17a	Salay Bridge	Km. 238 + 108 Dipaculao-Aurora Road Brgy. Salay, Dipaculao Aurora
17	04.18a	Mijares Bridge	Km. 247 + 435 Baler-Casiguran Road Brgy. Mijares, Dipaculao Aurora
18	04.19a	Palayan Bridge	Km. 89 + 700 Calauan-Nagcarlan Road Nagcarlan, Laguna
19	04.21a	Tarak Bridge	Km. 85 + 144 San Pablo-Sta. Monica-Sta. Veronica Road Sta. Veronica, San Pablo City, Laguna
20	04.22a	Sto. Nino Bridge	Km. 0 + 550 Jct. City Road - Pinagbatan Road Brgy. Sto. Nino, Cainta, Rizal
21	04.23a	Del Pilar Bridge	Km. 0 + 100 Jct. Sumulong Highway - Del Pilar Jct. Road Del Pilar Ext., Antipolo, Rizal

TABLE 4.2-5 LIST OF BRIDGES FOR GROUP I (3/3)

NO	BRIDGE NO	NAME OF BRIDGE	LOCATION
22	04.03b	Maruyugon Bridge	Km. 50 + 320.50 Puerto Princesa North Road Brgy. Maruyugan, Puerto Princesa City, Palawan
23	04.04b	Dakoton Bridge	Km. 62 + 761.50 Puerto Princesa North Road Brgy. Babuyan, Puerto Princesa City, Palawan
24	04.06b	Madalag Bridge	Km. 34 + 900 Looc-Alcantara Road Madalag, Alcantara, Romblon
25	04.08b	Panique Bridge	Km. 8 + 000 San Andres-Odiongan Road Panique, Odiongan, Romblon
26	04.09b	Maranlig Bridge	Km. 56 + 637.80 Torrijos-Sibuyao Road Maranlig-Torrijos, Marinduque
27	04.10b-1	Daykitin Bridge	Km. 94 + 233 Buenavista-Gasan Road Daykitin, Buenavista Marinduque

TABLE 4.2-6 LIST OF BRIDGES FOR GROUP 2 (1/1)

NO	BRIDGE NO	NAME OF BRIDGE	LOCATION
1	01.02	Maphilindo Bridge	Km. 220 + 900 Biec-Lomboy Road Binmaley, Pangasinan
2	03.03	Bacong Bridge	Km. 105 + 360 Luacan-Bacong Road Bacong, Bataan
3	03.07	San Roque Bridge	Km. 57 + 284 San Roque Barangay Road Hagonoy, Bulacan
4	03.10	Dolores Bridge	Km. 076 + 870 Dolores-Del Rosario Road Dolores, Bacolor, Pampanga
5	03.13	Mangkuyog Bridge	Km. 169 + 000 Camachile-Bantug Road Nueva Ecija
6	03.17	Sula Bridge	Km. 150 + 000 Tarlac-Sula Road Sula, Tarlac, Tarlac
7	04.07a	Camagong Bridge	Km. 023 + 700 Quezon-Alabat Perez Road Alabat, Quezon
8	04.20a	Paragusan Bridge	Km. 91 + 084 San Pablo-San Isidro Road San Isidro, San Pablo City Laguna
9	04.07b	Tan-Agan Brdige	Km. 11 + 100 Odiongan-San Andres Road Tan-Agan, San Andres Romblon
10	04.10b-2	Ihatub Bridge	Km. 116 + 832.85 Boac-Gasan Road Ihatub, Boac, Marinduque

4.3 Scope of Japan's Grant Aid

The scope of Japan's Grant Aid for the Project covers the following:

4.3.1 For Group 1 Bridges (27 Bridges)

Steel materials supply

1) Steel Girders
2) Cross Beams
3) Shoes
4) Drainage Boxes
5) Torgue Wrenches
6) Steel Railings and Posts for Bridge Approaches

Delivery of steel materials from Japan to designated ports of entry in the Philippines.

4.3.2 For Group 2 Bridges (10 Bridges)

1) Construction of Superstructures and Substructures
2) Construction of Approach Roads
3) Construction of Bank River Protection

Detailed descriptions and estimated quantities of major construction work for Group 2 Bridges are discribed in Chapter 5.

CHAPTER 5

BASIC DESIGN

CHAPTER 5

BASIC DESIGN

5.1 Design Policy

The selected bridges of Phase III are divided into two groups: Groups 1 and 2. The basic planning of Group 1 Bridges was conducted based on data furnished by the DPWH of the Government of the Philippines. On the other hand Group 2 Bridges were planned based on the data collected from field investigation and topographic and geotechnical surveys conducted by the Study Team.

The flow chart of implementation schedule of the Basic design study is shown in Table 5.1-1.

The general views of these bridges were prepared as shown in the separate volume of the Basic Design Study (Phase III).

5.1.1 Group 1 Bridges

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

1) Maximum utilization of steel materials for superstructures.

2) Maximum utilization of local materials for substructures.

3) Labor intensive construction method to be employed whenever applicable.

4) River protection to be provided in order to avoid damage to abutments due to river flow.

5) Footing of piers to be embedded below riverbed.

6) Steel girders to be fabricated in sizes and lengths for safe and convenient transport.

The detailed design of substructures, bridge approaches and other structures necessary to complete the Project is the responsibility of the DPWH.

Both designs are in accordance with the design criteria established between the DPWH and the Study Team as discussed in this chapter.

5.1.2 Group 2 Bridges

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

1) Location of proposed ten a(10) bridges to be execute to site investigation, study of technical examination by Study Team and then discussed with DPWH.

2) Maximum utilization of steel materials for superstructures.

   Steel girders to be fabricated in sizes and lengths for safe and convenient transport.

3) Maximum utilization of local materials for substructures.

   Footings of abutments to be embedded below existing ground and of ,piers below riverbeds. Steel sheet piles to be employed as cofferdams while constructing substructures in the river necessary.

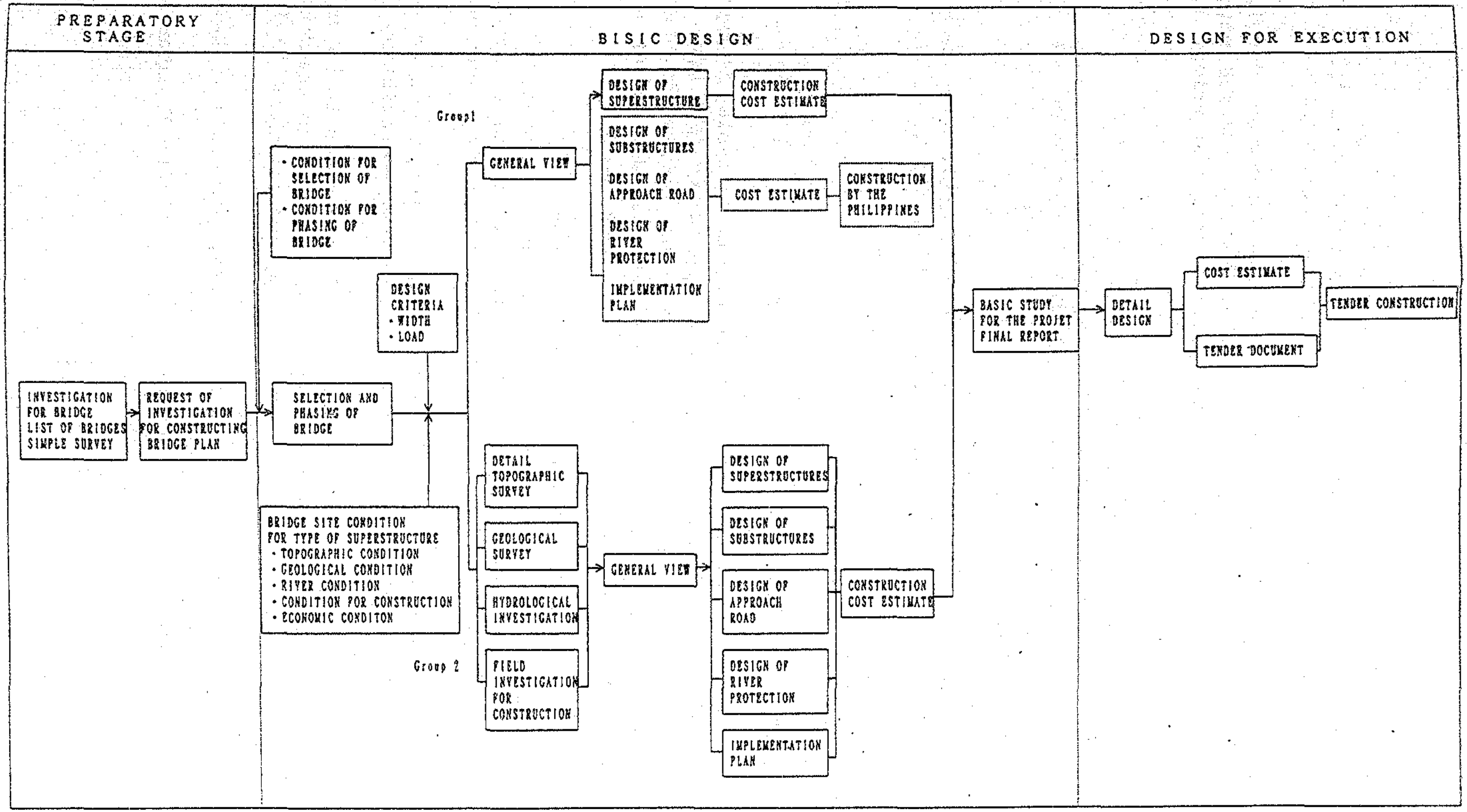
4) Adoption of concrete pavement or asphalt concrete pavement considering soil conditions of foundation.

5) River protection toe 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 will be drawn in accordance with the design criteria adopted for the Phase II Bridges (Preceding Project) established between the DPWH and the Study Team as discussed in the chapter.

TABLE 5. 1-1 FLOWCHART OF ALL STAGES IN THE PROJECT FOR CONSTRUCTING BRIDGES ALONG RURAL ROAD (PHASE III)



5.2 Site Survey

5.2.1 Group 1 Bridges

The measurement survey and the soil investigation will be carried out by DPWH. The Study Team will investigate the following items in order to determine the bridge length and others factors:

- Examining present condition of bridge.
- Site location of bridges
- Determining whether detour roads are required during bridge construction
- Condition of access roads
- Grasp of traffic condition
- Condition of gological profile and topographical condition
- Hydrological condition (M.F.L., water depth, etc.)
- Others

5.2.2 Group 2 Bridges

(1) Field Investigation

Prior to implementing the hydrological analysis, topographic survey and geotechnical survey, the Study Team conducted a 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 DPWH views concerning locations of bridges to be replaced and discussing locations from 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 bridges need to be demolished.
- Collecting climatic data of sites, particularly timing of dry and rainy seasons.
- Conducting interviews to determine highest water levels when flooded at bridge sites.

- Investigating existence of any obstacles which may obstruct construction.
- Investigating other special factors.

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

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

No.	BRIDGE No.	NAME & LOCATTION OF BRIDGE	PRESENT CONDITION	PROPOSED LOCATION OF NEW BRIDGE	DETOUR DURING CONSTRUCTION	DEMOLITION OF EXISTING BRIDGE	CONDITION OF ACCESS ROAD	REMARKS
1.	01.02	MAPHILINDO BRIDGE .Km.220+900 Biec-Lomboy Road Binmaley, Pangasinan, .Region, I	.Deteriorated trestle .Load limit 5 tons	.Upstream	.Existing bridge can be used	Not necessary.	.Good Condition .221 km from Manila	Relocation of Electric power line by Electric Company
2.	03.03	BACONG BRIDGE .Km.105+360 Lucan-Bacong Road, Bacong, Bataan .Region, III	.Deteriorated trestle .Load limit 2 tons	.Upstream because of Power line and water line	.Existing bridge can be used	Not necessary	.Good Condition .151 km from Manila	-
3.	03.07	SAN ROQUE BRIDGE .Km.57+284 San Roque Barangay Road, Hogonoy, Bulacan .Region, III	.Deteriorated trestle .Passable to tricyles only	.Same location of Existing Bridge because of road alignment	.Fordcrossing because of Stream but temporary bridge is required for erection	.Necessary before Construction of New Bridge	.Good Condition .58 km from Manila	-
4.	03.10	DOLORES BRIDGE .Km.76+870 Dolores-Del Rosario Road, Dolores, Bacolor, Pampanga .Region, III	.Deteriorated timber	.Same Location of Existing bridge because of road alignment	.Existing bridge can be used	.Not necessary	.Good Condition .77 from Manila	-
5.	03.13	MANGKUYOG BRIDGE .Km.169+000 Camachile-Bantug Road Nueva Ecija .Region, III	.No Existing Bridge	.Along-the existing road	.Fordcrossing for Detour	.Not necessary (No existing bridge)	.Good Condition .169 km from Manila	.Several Weak Bridges (Load limit 3-5 tons) are located leading to the bridge site. .Rainy season:

No.	BRIDGE No.	NAME & LOCATTION OF BRIDGE	PRESENT CONDITION	PROPOSED LOCATION OF NEW BRIDGE	DETOUR DURING CONSTRUCTION	DEMOLITION OF EXISTING BRIDGE	CONDITION OF ACCESS ROAD	REMARKS
6.	03.17	SULA BRIDGE .Km 150+000 Tarlac-Sula Road Sula, Tarlac Tarlac .Region, III	.No existing bridge	.Along the existing road	.Detour is required at downstream	.Not necessary (No existing bridge)	.Good condition .151 km from Manila	.Rainy season; May to November
7.	04.07a	CAMAGONG BRIDGE .Km 23+700 Quezon-Alabat Perez Road, Alabat, Quezon .Region, IV-A	.Deteriorated trestle .Load limit 5 tons	.Same location of Existing bridge because of road alignment	.Detour is required at down stream	.Necessary before Construction of New bridge	.Good Condition .19 km from Quezon	-
8.	04.20a	PARAGUSAN BRIDGE .km 91+84 San Pable-San Isidro Road, San Isidro, San Pablo City, Laguna .Region, IV-A	.Deteriorated trestle .Passable to light and medium vehicle	.Same locatión of Existing bridge because of road alignment	.Detour is required at downstream	.Necessary before Construction of New bridge	.Good Condition .94 km from Manila	.Removal of Several Coconut trees are required .Relocation of Electric power line by Electric Company
9.	04.07b	TAN-AGAN BRIDGE .km 11+100 Odiongan-San Andres Road, Tan-Agan, San Andres Romblon .Region, IV-b	.Detriorated timber .Load limit 3-5 tons	.Same location of Existing bridge because of road alignment	.Detour is required at downstream	.Necessary before Construction of New bridge	.Good Condition .13 km from Odiongan	-
10.	04.10b-2	IHATUB BRIDGE .km 116+832.85 Boac-Gasan Road Ihatub, Boac .Marinduque .Region, IV-B	.Spillway .Impassable during rany season because of overflow	.Downstream because of	.Existing Spillway can be used	.Not necessary	.Good Condition	.Relocation of Electric powerline by Electric Company

(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 5 and the detailed analysis is compiled in a 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 rainfall 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 and fall 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.

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:

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

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 basic 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 (m^3/sec)

Pi = ordinate of design storm at i^{th} time (mm/sec)

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

$$\left(\text{equals } \frac{\text{cross sectional area}}{\text{wetted perimeter}}\right)$$

S = hydrographic gradient

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

The Maximan Flood water Level were finally decided based not only on Manning Formula but also on other factors such as by interview, safety, construction conditions, topographical conditions, economical conditions geological conditions. etc.

For the hydrological analysis, M.F.L. of Maphilindo Bridge (Number of Bridge 01.02) and San Roque Bridge (Number of Bridge 03.07) are decided elevation by mean of "Gumbel Formula" in addition to the conventional method as the river located in an estuary and river branches off in the upperstream.

The hydrological condition of each bridge is given in Table 5.3-1.

TABLE 5.2-2 RAINFALL DATA OF THE BRIDGE SITES

Bridge No.	Bridge Name	Location (Province)	Type of Climate	Rainfall Intensity Data Reference	Source of Dimensionless U.H.	Peak Flow Frequency Reference
01.02	Maphilindo	Pangasinan	I	(Gumbel Extreme Value Analysis)		
03.03	Bacong	Bataan	I	Iba, Zambales	DUH for Central Luzon	Curve of Region III
03.07	San Roque	Bulacan	I	(Gumbel Extreme Value Analysis)		
03.10	Dolores	Pampanga	I	Sta. Cruz, Porac Pampanga	DUH for Central Luzon	Curve of Region III
03.13	Mangkuyog	Nueva Ecija	I	Gabaldon, Nueva Ecija	DUH for Central Luzon	Curve of Region III
03.17	Sula	Tarlac	I	HDA Luisita, Tarlac, Tarlac	DUH for Central Luzon	Curve of Region III
03.19	Laoag	Zambales	I	Iba, Zambales	DUH for Central Luzon	Curve of Region III
04.07a	Camagong	Quezon	II	Alabat, Quezon	DUH for Region IV	Curve of Region IV
04.20a	Paragusan	San Pablo City	IV	Baler, Quezon	DUH for Region IV	Curve of Region IV
04.07b	Tan-Agan	Romblon	III	Masbate, Masbate	DUH for Region IV	Curve of Region IV
04.10b -2	Ihatub	Marinduque	IV	Calapan, Oriental Mindoro	DUH for Region IV	Curve of Region IV

TABLE 5.2-3 THE RESULTS OF THE HYDROGRAPHIC ANALYSIS

BRIDGE NO.	NAME OF BRIDGE	DRAINAGE AREA (Km²)	DESIGN DISCHARGE (m³/S)	REQUIRED OPENING (m²)	BRIDGE LENGTH (m)	WATER DEPTH (m)	AVERAGE VELOCITY (m/S)	M.F.L (m)		
								COMPUTED (Elv.)	INTERVIEW (Elv.)	DESIGN (Elv.)
01.02	MAPHILINDO BRIDGE	Gumbel Extreme Valve Analysis			164	5.0	—	21.34	20.85	21.34
03.03	BACONGBRIDGE	119.6	2,247.47	258	53	5.0	8.38	51.72	50.95	50.95
03.07	SAN ROQUEBRIDGE	Gumbel Extreme Valve Analysis			56	5.5	—	21.26	20.79	20.79
03.10	DOLORES RIDGE	65.21	598.37	133	49	2.8	4.51	18.22	19.28	18.22
03.13	MANGKUYOG BRIDGE	8.32	101.254	25	98	2.8	6.82	99.51	99.60	99.60
03.17	SULA BRIDGE	51.79	534.59	169	62	3.6	3.79	22.17	21.31	21.31
04.07a	CAMAGONGBRIDGE	10.56	393.41	106	45	4.0	3.61	21.26	20.07	21.26
04.20a	PARAGUSAN BRIDGE	181.9	2,571.47	384	47	13.4	6.13	44.89	45.70	45.70
04.07b	TAN-AGANBRIDGE	16.22	422.66	55	37	2.3	6.05	10.18	10.53	10.53
04.10b-2	IHATUB BRIDGE	4.16	155.72	57	47	2.0	2.86	2.40	2.11	2.40

(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 6, 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 at every 20 meters and at changeable inclination points on the proposed centerline were surveyed.

3) Cross Section Survey
Along roads : 10 meter intervals, 50 meters in width
Along rivers: 20 meter intervals, 60 meters in width
Accuracy : Traversing 1/10,000
Leveling 5 cm + 3 cm 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

The topographical condition of each bridge site are given in Table 5.3-1.

(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 7, 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 San Roque Bridge, the following additional tests were conducted to analyze settlement and embankment failure because of the deep soft ground:

- PL (plastic limit test)
- CU (unconfined compression test)
- UW (unit weight)

For the Maphilindo Bridge, the unconfined compression test was conducted to analyze for piles for horizontal in sand because of the fine sand in the upper layer of the river bed.

The geological profile and geological condition are given in table 5.3-1.

5.3 Types of Bridges

5.3.1 Description on Bridge Site Condition

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

The determination of the bridges type and length, etc. for the Group 1 Bridges was based on the Basic Data of Bridges which was submitted by the DPWH.

For Group 2 Bridges, the hydrological and geological conditions of each bridge were discussed to determine the most appropriate type of bridge. Table 5.3-1 summarizes a brief description of those conditions.

(1) 01.02 Maphilindo Bridge

Hydorological Condition

The Basing River is a wide, low velocity and relatively shallow waterway. The existing structure crossing the river is a type of bailey with 129 meter in length. The river widens 147 meter width and the bank of bridge approach serves also as the embankment for fishing pond.

In the rainy season, the water offenly overflows the bank but does not damage the agricultural products in the area where is located in an estuary and with a plenty of fishing ponds.

For the hydrological analysis, M.F.L. is decided 21.34 meter in elevation by mean of "Gumbel" in addition to the conventional method as the river located in an estuary and the river branches of in the upperstream.

Topographical and Geological Condition

The proposed area is a low land near the sea, where the sediment of diluvial formation has been developped. The surface is covered with homogenous sand (N: 7-26, thickness: 17 meter), and lower part consists of Silt (N: 4-35, thickness: 35 meter)

The silt in lower part is expected for bearing stratum, and the pile foundation system is recommended for pier and abutment foundation.

Construction Condition

The lyang river, located in an estuary, 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.

(2) 03.03 Bacong Bridge

Hydrological Condition

The Bacong River has an intermediate width of about 46 m and a deep riverbed. The ordinary water level was changed from 46.4 m (when site investigation) to 49.3 m (present condition), because of new earth dam has been constructed for the purpose of water for irrigation, after site investigation by study team.

Topographical and Geological Condition

The proposed bridge is located in the flood plain composed on its bank of impaired terrace deposits previously associated with the old beds and layers of alluvial deposits on river bed consists of clayey sand to silty sand with depth, but was eroded and transported or filled into other areas.

Bed rock is sandstone, however pockets of clay and silt would still be encountered but will decrease with depth.

Pile foundation is recommended to penetrate into sand stone of the lower layer.

Construction Condition

The pile bent type was adopted for the substructure the river is deep water (more than 4 m) river. Construction of the abutments were adopted to steel sheet piles, and this steel sheet piles become permanent structure.

(3) 03.07 San-Roque Bridge

Hydrological Condition

The San-Roque River has an intermediate width of about 53 m and deep riverbed, the lyang river, located estuary and human havitation. This river is smooth and well defined channel causing uniform, steady flow.

For the hydrological analysis, M.F.L. is decided 21.26 m in elevation by mean of "Gumbel" in addition to the conventional method as the river located in an estuary and the river branches off in the upperstream. However M.F.L. (interview) of EL: 20.79 m, which is lower than that computed, was thus adopted for the final design, because the bridge is located at human havitation, given the magnitude of construction of the bridge approach and other conditions.

Topographical and Geological Condition

The proposed bridge site is situated along the San Roque Community by which the riverbed is layered by Sand to Clay. Clay becomes dominant with depth until it becomes compacted particularly at -23 elevations.

Shell fragments are evident predominantly on Clayey formation (except on compacted clay were SPT shows refusal) which shows that the area was previously affected by seawater or sometime had been a shoreline until alluvium had been deposited as alluvial fans.
Pile foundation is recommended, however the tip of the pile should be carried down to the dense layer.

Construction Condition

The pile bent type was adopted for the substructure because the river is deep water (more than 4 m) river. Construction of the abutment were adopted to steel sheet piles and this steel sheet piles become parmanent structure.

(4) 03.10 Dolores Bridge

Hydrological Condition

The Dolores River has an intermediate width, a shallow riverbed and winding The M.F.L. (interview) of EL: 19.28 m, which is higher than that computed, was thus adopted for the final design, because of given the magnitude of economical construction for the bridge approach and other conditions.

Flood plain ranges wide in almost all areas, however during low flood the main stream traverses on the previously discussed river bed.

Topographical and Geological Condition

The proposed bridge site is situated on a wide alluvial fan deposit of sandy silt with increasing clay content at depth and becoming very dense at depth.

However the present river bed is compose mainly of another series of deposited sand and gravel which is dense with the first alluvial bed.

Pile foundation is recommended to penetrate into diluvial deposit.

(5) 03.13 Mangkuyog Bridge

Hydorological Condition

The Mangkuyog River is a small waterway on the downslope of the Gavaldon Ridge towards Nueva Ecija. 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.

This river is only 15 m in width during dry season, but its waterway width during flood with debris is difficult to estimate because of a flood and debris area, therefore the approaches of bridge is expect to construction of the spillway taking into consideration safety and above conditions.

Topographical and geological Condition

The proposed bridge is situated on the alluvial deposit by debris flow of clay and silt which constitutes the present riverbed. The river banks are of paired terraces of sand and clay and shows that the river had been constructed thru the formation of channels by stream erosion. Stream bed erosion would still be active within the following years since the river gradient is about 20%.

Bed rock is at about Elevation 88 as evident from drilling and is presumably of conglomerate, overlain by sand/gravel formation as diluvial deposit.

(6) 03.17 Sula Bridge

Hydrological Condition

The Sula River is a shallow and well defined waterway with about 40 m in width, but floods are anticipated during the rainy season.

A proposal of 3-spans bridge with span length of 20 m was used in the hydraulic computation and the result shows M.F.L. of EL 22.17 m and V of 3.65 m/s. M.F.L. (interview) of EL 21.31 m, which is lower than that computed, was thus 21.31 adopted for the final design Because of given the magnitude of economical construction for the bridge approach and other conditions.

Topographical and Geological Condition

The proposed bridge site is on hard rock formation presumably overlain by sand and gravel peneplain with small sand bars and underlain by conglomerates as bed rock and is reachable at about 3 meters below present surface.

Pile foundation is recommended to penetrate into sand and gravel of the lower layer.

(7) 04.07a Camagong Bridge

Hydrological Condition

The Camagong River, located in a estuary, is bounded by concrete retaining walls on both riverbanks, and both side of river is coconut plantation.

During ordinary conditions, the water flows through a small and narrow channel. The river is a shallow and well defined waterway with about 15 m in width, but be affected by tide.

Because of an angle of river flow direction, an skew bridge is recommended.

Topographical and Geological Condition

The bridge site is located on a wide flood plain extending thru the coconut trees (on level floors). The river bank is terraced pairly by sandy clay with coral fragments. This layer is presumably a flat lowland submerged on sea water and later emerge (on sea water decline) creating a channel within the riverbed exposing silty clay that extends flatly after bank and presumably thru out the level floors of the flood plain. The stream has been deposited with alluvial fan before the channel was constructed.

The first layers were soft, however it becomes hard with depth, thus pile foundation is recommended until the hard strata to be spread footed.

(8) 04.20a Paragusan Bridge

Hydrological Condition

The Paragusan Bridge, located in hilly country, is smooth and well defined channel causing uniform, steady flow, with about 40 m in width, but the rainfall catchment area of the river is so wide.

A proposal of 2-Spans bridge with a span length of 15 m + 30 m is used in the hydraulic computation and the result shows M.F.L. of EL 44.89 m and V of 6.13 m/s. M.F.L. (interview) of EL 45.70 m, which is greater than that computed, is thus adopted for the final design.

Topographical and Geological Condition

The proposed site for the bridge is located on a strata of alluvial plain of layered clay and sand (almost flat) which shows impaired stream terraces with abundance of tuffaceons materials. The strata becomes dense to very dense with depth as shown by the SPT values (N-30-Refusal).

Hard formation is already at about 3 meters at depth and bed rock is not so deep, bed rock is sandstone as evident even on the river base.

Spread footing foundation is recommended for the pier. However pile foundation is recommended to penetrate into soft lock for the abutments.

(9) 04.07b Tan-Agan Bridge

Hydorological Condition

Tan-Agan River is a shallow estuary and well defined waterway with 19 m in width, but be effected by tide.

As 2-span bridge with span length of 18 m is proposed after comparison of several schemes, which became the basis of the hydrological analysis. The result shows M.F.L. of EL 10.18 m and V of 6.05 m/sec. These results are both permissible, since M.F.L. (computed) is less than M.F.L. (interview) and the velocity is excessive. For design safety, however, the higher flood level 10.53 m (interview) was finally adopted.

Topographical and Geological Condition

The proposed bridge site is located on a wide flood plain of alluvial deposits consisting mainlu of sand which varies from silty clayey with depth and very dense with depth.

BH-3 shows predominantly the present (time river deposit while BH-1 and BH-2 formation shows previous riverbed Sandy Silt to silty sand where just deposited as alluvial fan on the area. On due process of stream erosion (maybe due to Hydraulic plocking or abrasion), a channel was constructed up to the hard strata, and further several strea, transport, a sandy silty clay is evident thru SPT values (channel fill is about N=11, while its bed is of refusal).

(10) 04.10b-2 Ihatub Bridge

Hydorological Condition

The Ihatub River is a narrow and relatively shallow waterway. An existing 2-600 mmϕ 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.

As 2 spans bridge with 23 m span length is proposed for the hydrological analysis. Analysis shows that, when there is complete replacement of the existing structure, the maximum flood level

(M.F.L.) equals EL 2.40 m with an average velocity (v) of 2.86 m/s.

Topographical and Geological Condition

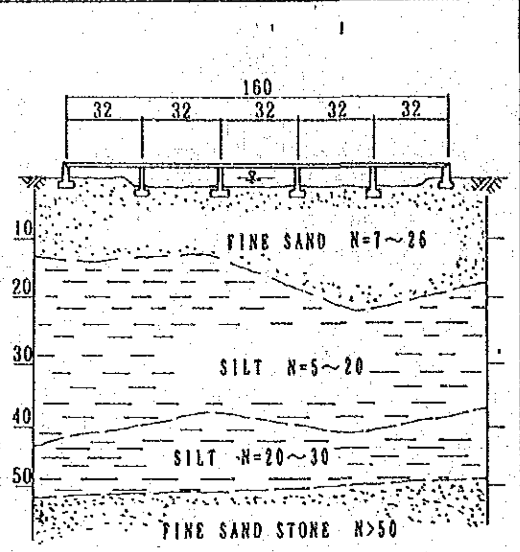
The proposed bridge site is located on a thick alluvial deposit of sand and sometimes associated with gravel and shell fragments becoming hard with depth (10 meters below, floor elevation) and overlying on bed rock of conglomerate.

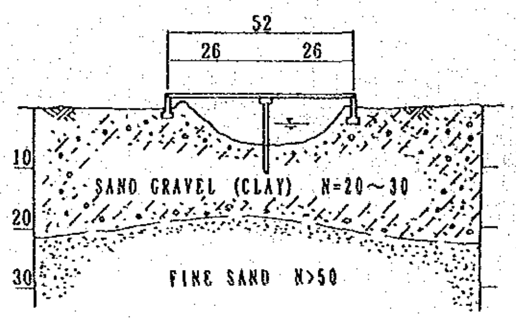
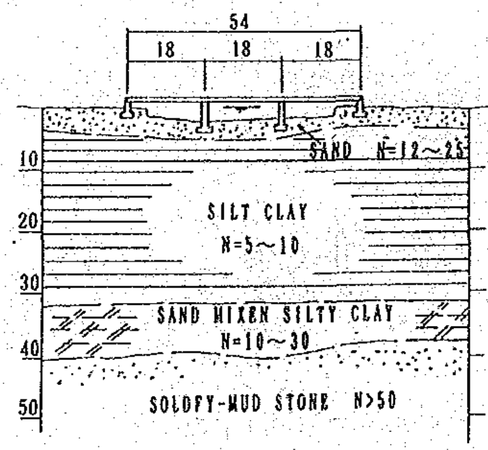
River gradient is inconsistent thru out the length. Road profile should be elevated that the present set up and be checked with flood level and to follow the bridge flow elevation.

Approaches should be protected as well as the road profile.

Pile foundation is recommended before reaching the hard strata, by where spread footing would be undertaken.

TABLE 5. 3-1 TOPOGRAPHIC & GEOLOGICAL CONDITIONS (1/3)

<table>
<tr><th>Bridge No.</th><th>Bridge Name</th><th>Location of Bridge Site</th><th>Geological Profile (Approximation)</th><th>Topographical Feature</th><th>Geological Feature</th><th>Recommendation for Bridge Design</th><th>Remarks</th></tr>
<tr><td>01. 02</td><td>MAPHILINDO
Bridge</td><td>km. 220+900
Biec-Lomboy Road,
Binmaley,
Pangasinan</td><td>
</td><td>o Bridge site is in the form of a delta (coastal lowland)
o River is a large scale meander
o There are many fish pond and swampy area in the bridge site
o Runing water over flows during the paste floods
o Bridge site is nearly the sea shore

Tidal river</td><td>o Thickness of alluvial delta deposite is 50m.
o Bearing bed of bridge foundation existance at the 40 ~50m.</td><td>o Protection of river side is necessary
o High tide-low tide= 100m</td><td></td></tr>
<tr><td>03. 03</td><td>BACONG
Bridge</td><td>km. 105+360
Luacan-Bacong Road,
Bacong,
Bataan</td><td>
</td><td>o Bridge site is in the form of a terrace
o River is a large scale meander
o There is levee at both sides of river
o Runing water over flows the levee during the past floods</td><td>o Geology of bridge site consist of gravel and sand</td><td>o Flood occurs two times during the past years</td><td></td></tr>
<tr><td>03. 07</td><td>SAN ROQUE
Bridge</td><td>km. 57+284
San Roque
Barangay Road,
Hagonoy,
Bulacan</td><td>
</td><td>o Bridge site is in the forms of a delta (coastal lowland)
o Situation of bridge is 500m from sea shore
o Left side of riber is 0.5m lower than right side
o Every year during the flood
o There are many water ways on channels at the nearly bridge side

Tidal reiver</td><td>o Geology of nearly bridge site consist of five grain soil
o Thickness of alluvial soft soil is 40m
o Depth of bearing bed (bridge foundation is 30 ~40m)</td><td>o High tide=1. 00-1. 50m</td><td></td></tr>
</table>

TABLE 5. 3-1 TOPOGRAPHIC & GEOLOGICAL CONDITIONS (2/3)

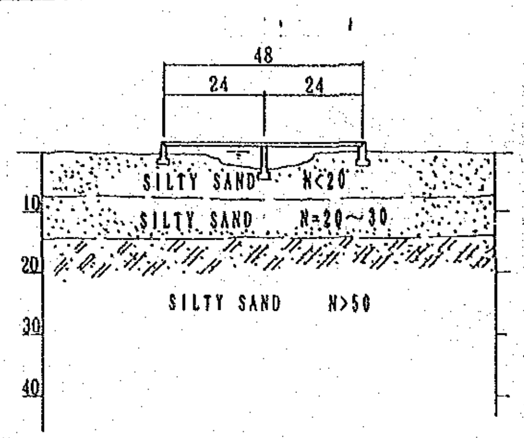
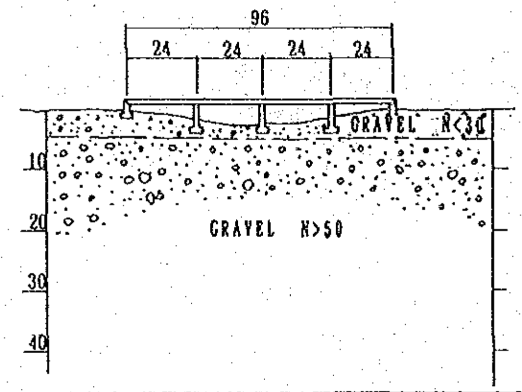
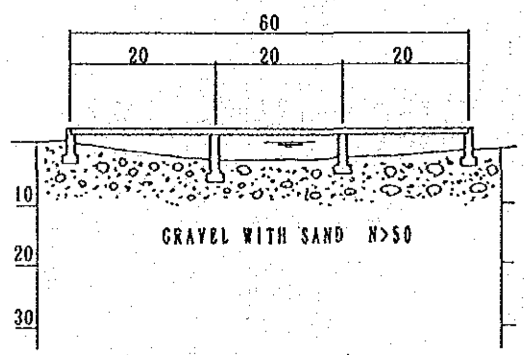
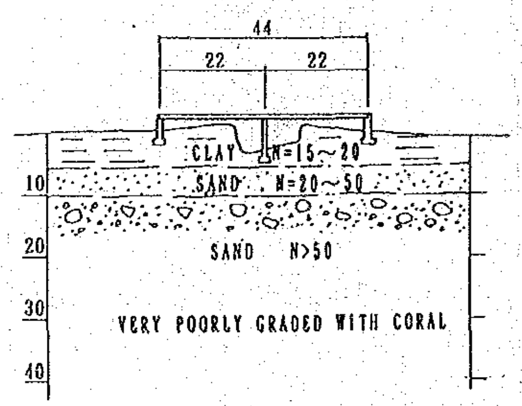
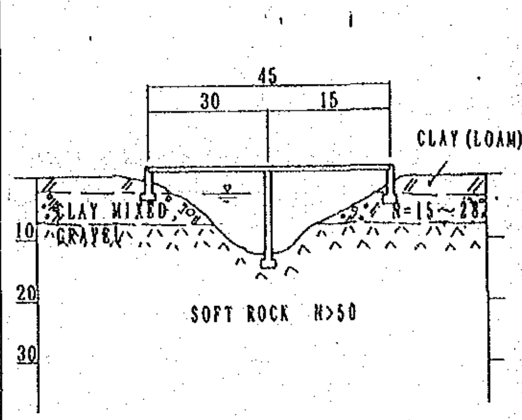
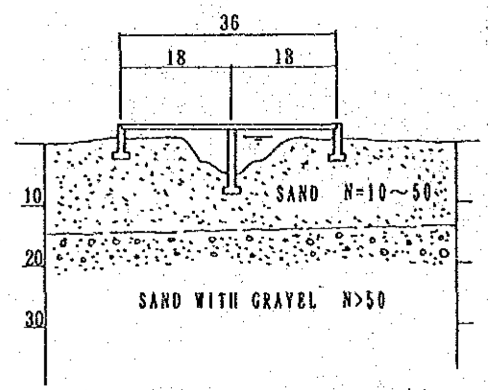
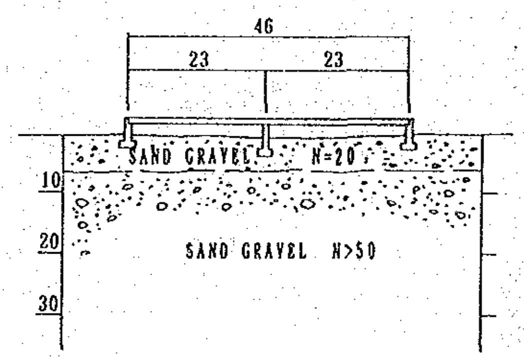
Bridge No.	Bridge Name	Location of Bridge Site	Geological Profile (Approximation)	Topographical Feature	Geological Feature	Recommendation for Bridge Design	Remarks
03. 10	DOLORES Bridge	km. 76+870 Dolores-Del Rosario Road, Dolores, Bacolor, Panpanga		o Bridge site is in the formed of terrace o River meandering is so large and narrowed at the bridge site o Running water is rapid at bit stream	o Geology of bridge site consist of sand	o No, flood but large catchment area	
03. 13	MANGKUYOG Bridge	km. 169+000 Camachile-Bantug Road, Nueva Ecija		o Bridge site is an alluvial flood plain o River bed is so wide and running water is ver fast o River stream usually change course o There is levee at the right side of river and debris flow trace uptream Ruin river	o Geology of bridge site is consist of gravel and sand including boulders (Flood Deposit) o Right side of river is lower terrace with grevel Flood deposit	o There are many traces of debris flowing from SIDOG to bridge site on the access road o River bed usually Changes during heavy rains o River have a large flood area o It is necessary to protect the levee	
03. 17	SULA Bridge	km. 150+000 Tarlac-Sula Road Sula, Tarlac, Tralac		o River is curved at the upstream 200m from bridge site o There is levee at both sides of river o Running water is very fast and large in volume Rapid river	o Geology of bridge site consist of terrace deposits which is gravel and sand (including brecia 30m) There are boulders and cobble gravel	o There are some narrow access roads leading to the bridge site o Excavation of bridge of foundaton is very difficult due to running water and gravel	
04. 07a	CAMAGONG Bridge	km. 23+700 Quezon-Alabat Perez Road, Alabat, Quezon		o Bridge site is in the form of a delta (coastal lowland) o Swampy area is at up stream of river and river meandering o Flood is often occurs and over flows the existing bridge	o Geology of bridge side consist of soft ground which is coastal lowland (soft ground m) o Thickness of soft ground is 17-20m There are bearing bed at 17-20m (depth) for bridge foundation	o High tide-low tide= 2.00m o It is necessary to protect the levee	

TABLE 5. 3-1 TOPOGRAPHIC & GEOLOGICAL CONDITIONS (3/3)

Bridge No.	Bridge Name	Location of Bridge Site	Geological Profile (Approximation)	Topographical Feature	Geological Feature	Recommendation for Bridge Design	Remarks
04. 20a	PARAGUSAN Bridge	km. 91+84 San Pablo-San Isidro, San Pablo City, Laguna		o Bridge site is in the form of a terrace (Terrace) o River is formed muldental valley and straight arrangement o Running water is very large volume at the heavy river Terrace form	o Geology of bridge site consist of terrace deposit o Geology of out of view 0-2m (loam) ash 2-4m graval mixed clay (terrace deposit) 4-7m tuff on tuff brecia	o It is necessary to consider the running water pressure in design of pier	
04. 07b	TAN-AGAN Bridge	km. 11+100 Odiongon-San Andres Road, Tan-Agan, San Andres, Romblon		o Bridge site is in the form of a coastal terrace o River water is very slow stream Tidal river	o Geology of bridge site consist of terrace deposits (sand and gravel)	o High tide-low tide= 1.00-1.50m o It is necessary to protect the levee	
04. 10b-2	IHATUB Bridge	km. 116+832.85 Boac-Gasan Road Ihatub, Boac, Marinduque		o Bridge site is in the form of a coastal terrace o River is large scale meander o Distance from coastal (sea shore) to bridge site is 100m	o Geology of bridge site consist of terrace deposits which is sand gravel	o Existing bridge is a spillway o High tide-low tide= 100m	

5.3.2 Bridge Length and Span Length

(1) Bridge length

1) Group 1 Bridges

The determination of bridges type and length, etc. for the Group 1 Bridges was based on the Basic Data of Bridge which were submitted by DPWH.

Consequently, bridge lengths were decided based on M.F.L. (maximum floods level), topographic survey (topographic map, river cross section, road cross section) and photographs, etc., taking into consideration the physical conditions described above.

Taking into consideration the fabrication of steel girders in Japan and the construction method in the Philippines, the maximum Bridge Length and number of Spans was decided to be less than 50 m and two spans.

2) Group 2 Bridges

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 results of the hydrographic analysis are given in Table 5.2-3.) The outline of the hydrological analysis was described earlier in Section 5.2.2. The hydrological data for the analysis is shown in Appendix 5.

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

- 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.

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

- 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.

  - 01.02 Maphilindo Bridge
  - 03.07 San Roque Bridge
  - 03.10 Dolores Bridge
  - 03.17 Sula 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.

1) Group 1 Bridges

Taking into consideration the fabrication of steel girders in Japan and the construction method in the Philippine, the maximum span length of bridges was decided to be less than 25 m.

The determination of span length were based on the Basic Data of Bridges, similar to the determination method of bridge length.

2) Group 2 Bridges

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 DETERMINATION OF DESIGN SPAN LENGTH AND BRIDGE LENGTH

Bridge No.	Bridge Name	Span (m) (Computed)	Bridge Length by Hydrological Analysis (m)	Design span (m)
01.02	MAPHILINDO BRIDGE	-	164	32 x 5 span=160
03.03	BACONG BRIDGE	41	53	26 x 2 span= 52
03.07	SAN ROQUE BRIDGE	-	56	18 x 3 span= 54
03.10	DOLORES BRIDGE	23	49	24 x 2 span= 48
03.13	MANGKUYOG BRIDGE	20	98	24 x 4 span= 96
03.17	SULA BRIDGE	32	62	20 x 3 span= 60
04.07a	CAMAGONG BRIDGE	22	45	22 x 2 span= 44
04.20a	PARAGUSAN BRIDGE	43	47	15 +30 span= 45
04.07b	TAN-AGAN BRIDGE	22	37	18 x 2 span= 36
04.10b	IHATUB BRIDGE	21	47	23 x 2 span= 46

5.3.3 Types of Superstructures

(1) Types of Superstructures

The span lengths 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 is less than 25 m
Case 2 : Span length is more than 26 m

The number of spans by span length is summarized for each Group in Table 5.3-3.

TABLE 5.3-3 NUMBER OF SPANS

Group 1

Span Length	No. of Span
24.0	11
23.0	8
22.0	4
21.0	2
18.0	4
15.0	9
Total	38 spans
(Total length: 785 m)	

Group 2

Span Length	No. of Span
32.0	5
30.0	1
26.0	2
24.0	6
23.0	2
22.0	2
20.0	3
18.0	5
15.0	1
Total	27 spans
(Total length: 641 m)	

The type of superstructures was adopted as follows:

1) Span length less than 25 m H-beam girder
2) Span length more than 26 m Plate girder

The reasons for the selection of superstructure type can be explained as follows:

1) Case 1 : H-beam girder for less than 25 m

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

a) H-beam composite girder
b) Plate girder (non-composite build-up girder)
c) 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 5.3-4, the former was adopted.

TABLE 5.3-4 COMPARISON OF H-BEAM GIRDER AND PLATE GIRDER (for less than 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 difficulty	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 more than 26 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:

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

b) 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 5.3-5.

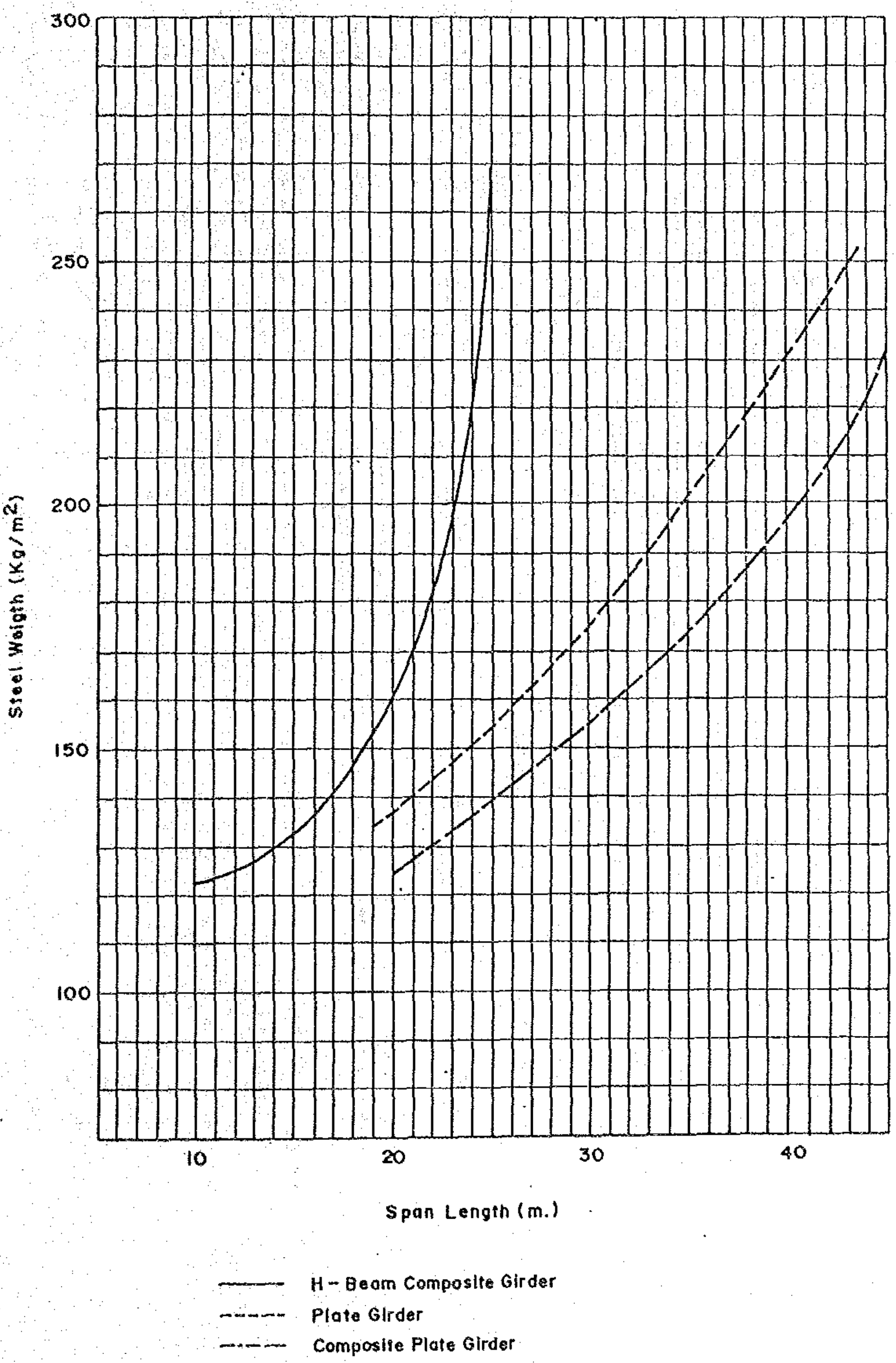


FIGURE 5.3-1 STEEL WEIGHT (EXCEPT INCIDENTAL FACILITIES)

TABLE 5.3-5 COMPARISON OF PLATE GIRDER AND COMPOSITE PLATE GIRDER

Evaluation Item	Plate Girder	Composite Plate Girder	Evaluation (advantage)
Slab Concrete	Required quality $k = 270\ kg/cm^2$	Required quality $k = 300\ kg/cm^2$	Plate girder $k = 270kg/cm^2$ 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.

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 5.3-2 (1/4, 2/4) shows a general view and typical section of H-beam composite girder, also Figure 5.3-2 (3/4, 4/4) shows a general view and typical section of Plate girder.

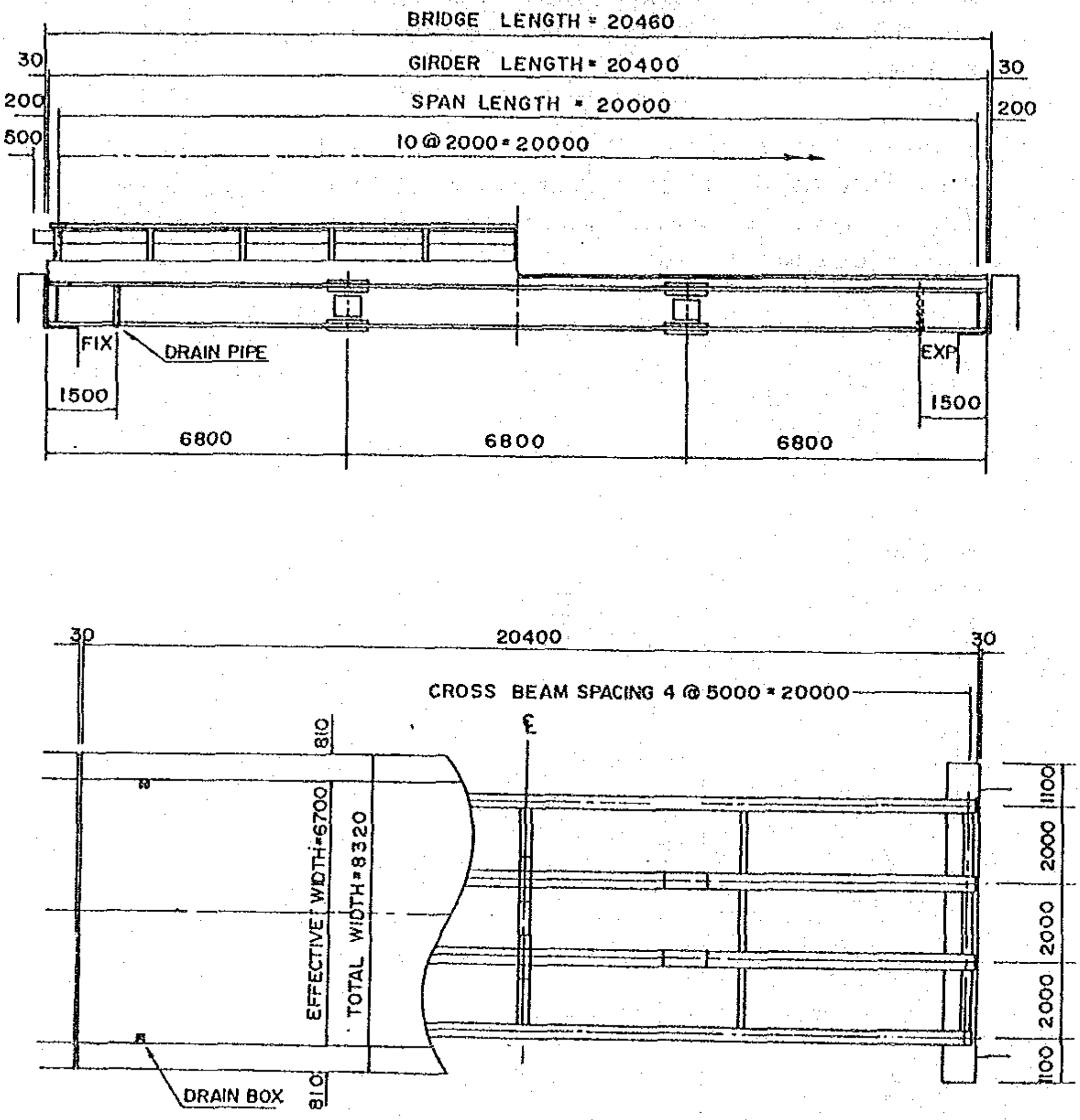
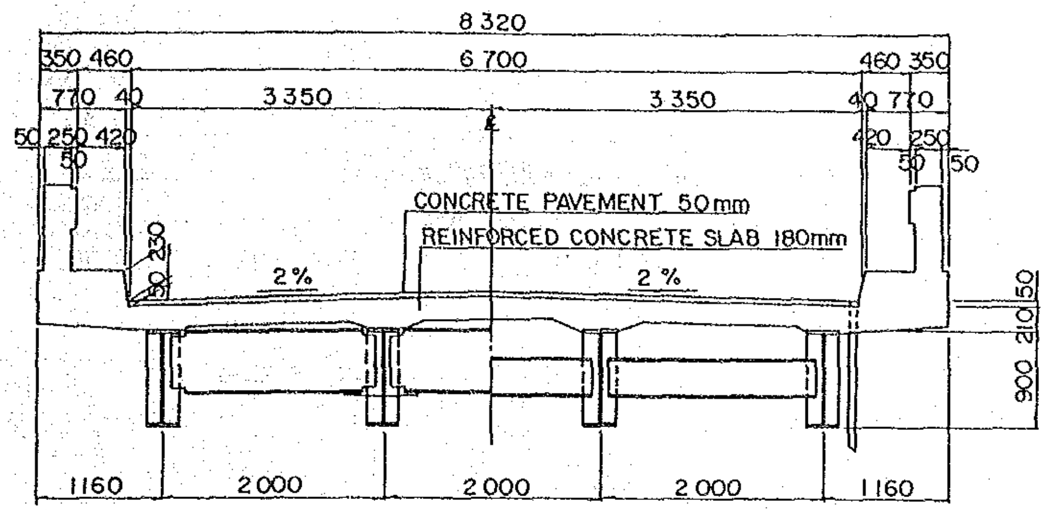


FIGURE 5.3-2 (1/4) TYPICAL GENERAL VIEW OF BRIDGE

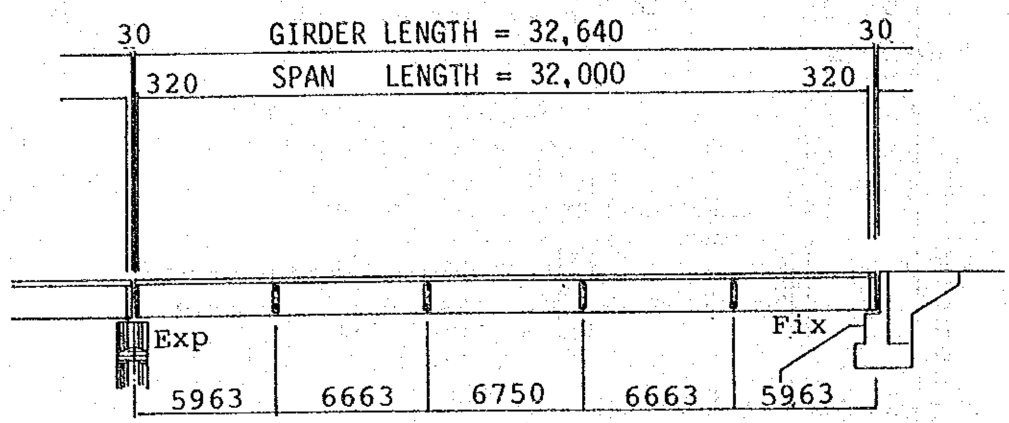


CROSS SECTION
(SPAN LENGTH : 24m)

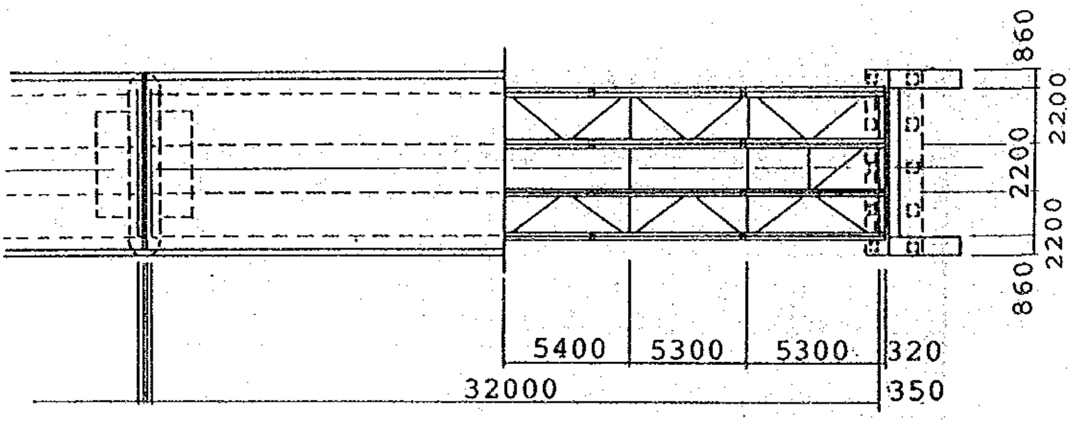
H-BEAM COMPOSITE GIRDER (SPAN : 15m、18m、20m、21m、22m、23m、24m)

SPAN LENGTH (m)	NO OF GIRDER	GIRDER HEIGHT (mm)	SECTION OF GIRDER (mm)	THICKNESS OF SLAB (mm)
15	4	700	700× 300×13×24	180
18	4	792	792× 300×14×22	180
20	4	890	890× 299×15×23	180
21	4	900	900× 300×16×18	180
22	4	900	900× 300×16×18	180
23	4	912	912× 302×18×24	180
24	5	900	900× 300×18×24	180

FIGURE 5.3-2 (2/4) TYPICAL CROSS SECTION OF SUPERSTRUCTURES



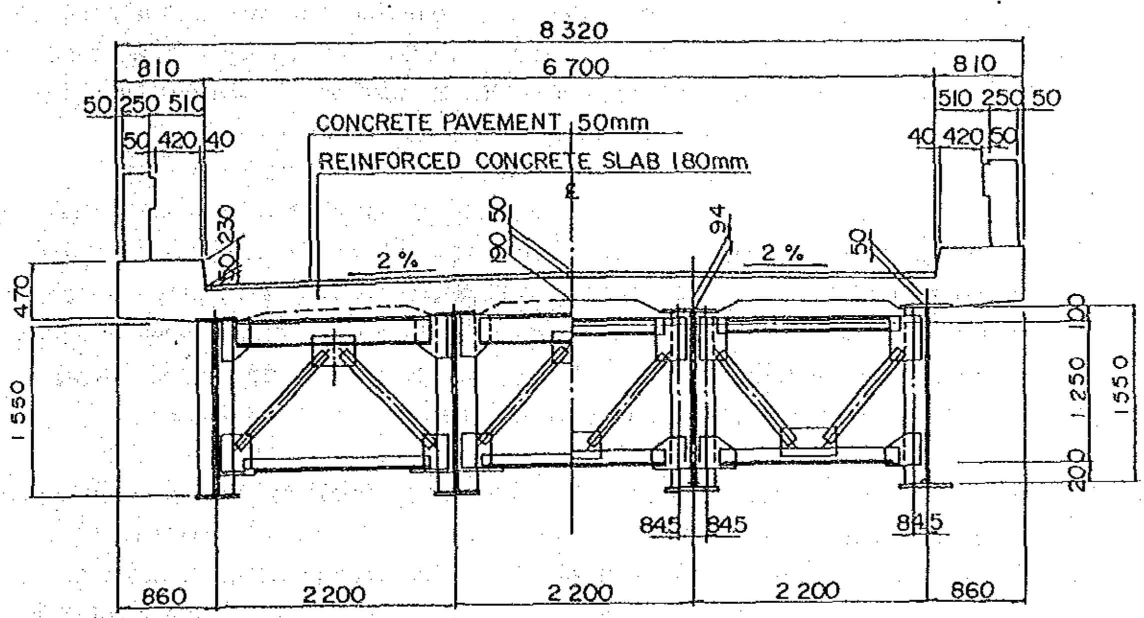
SIDE VIEW



PLAN

(SPAN LENGTH : 32 m)

FIGURE 5.3-2 (3/4) TYPICAL CROSS SECTION OF SUPERSTRUCTURES



CROOS SECTION
(SPAN LENGTH : 32 m)

BUILD-UP PLATE GIRDER (SPAN : 26m、30m、32m)

SPAN LENGTH (m)	NO OF GIRDER	GIRDER HEIGHT (mm)	SECTION OF GIRDER (mm)	THICKNESS OF SLAB (mm)
26	4	1400	1400×9	190
30	4	1400	1500×9	190
32	4	1400	1550×9	190

FIGURE 5.3-2 (4/4) TYPICAL CROSS SECTION OF SUPERSTRUCTURES (BUILD-UP PLATE GIRDER)

(2) Determination of Bridge Width

As adopted for Phase I and II bridges, the carriageway width of 8.32 m were proposed for Phase III bridges in compliance with the request of the Department of Public Works and Highways (DPWH). The Study Team finally adopted the proposed bridge with through the technical verification on its requirements based on the following reasons.

1) The highway specification of the DPWH calls for the minimum carriageway width of 6.1 m with shoulders of 0.3 m at both sides, the total width of 6.7 m. For the average type of roads in rural areas, the same width is usually applied. The clear zone of 0.46 m in width is provided inside hailrail section.

2) In line with the emphasis in the Medium-Term Philippine Development Plan that improvement of rural roads shall be given the precedence, the DPWH decided adoption of 2-lane roads for improvement and rehabilitation of rural roads. In accordance with this policy, 2-lane bridges is preferable for the project.

3) All bridges constructed under assistance of international lending institutions and with local resources such as reinforced concrete bridges, pre-stressed concrete bridges and steel bridges have 2-lane width or more.

   Refer to Figure 5.3-2 (4/4), Standard Cross-Section of Superstructu for details.

(3) Road Surface Height

Providing H.W.L + 1 m with allowance under bridge based on the DPWH standard, the road face height was determined by adding span height, slab thickness, pavement thickness, etc. to above size. Bridge top face is required to make level after construction.

. 03.07 San Roque Bridge

The proposed bridge site is located the San Roque community which is human havitation.

Providing H.W.L + less than one meter with allowance under bridge for side spans and also adopted viertical curve for the road alignment, because it given the magnitude of construction of the bridge approach and other conditions.

. 03.13 Mangkuyog Bridge

The proposed bridge is located on the alluvial deposit by debris flow of clay and silt.

Based on DPWH standard, above in case to be providing H.W.L + 1.5 m with allowance under bridge.

This bridge is adopted to H.W.L + 1.5 m for the allowance.

(4) Bridges for Weathering Steel

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 the sea.

TABLE 5.3-6 BRIDGES FOR WEATHERING STEEL

BRIDGE NUMBER	NAME OF BRIDGE	SPAN LENGTH (m)	GROUP
01.02	MAPHILINDO BRIDGE	5 X 32.0 = 160.0	2
03.01	PANGULISANIN BRIDGE	24.0	1
03.06	BALASING BRIDGE	15.0 + 23.0 = 38.0	1
03.11	PULO BRIDGE	23.0	1
03.18	SHINDOL BRIDGE	2 X 15.0 = 30.0	1
04.01a	SAN JUAN BRIDGE	23.0	1
04.02a	TABON-BATONG BRIDGE	22.0	1
04.04a	CAGLATE BRIDGE	23.0	1
04.06a	BUENAVISTA BRIDGE	24.0	1
04.07a	CAMAGONG BRIDGE	2 x 24.0 = 48.0	2
04.09a	ISABANG BRIDGE	2 x 24.0 = 48.0	1
04.10a	PANSIPIT BRIDGE	2 x 22.0 = 44.0	1
04.11a	SAN DIEGO BRIDGE	2 x 15.0 = 30.0	1
04.16a	PINGIT BRIDGE	2 x 21.0 = 42.0	1
04.17a	SALAY BRIDGE	2 x 15.0 = 30.0	1
04.18a	MIJARES BRIDGE	23.0	1
04.03b	MARUYUGON BRIDGE	24.0	1
04.04b	DAKOTON BRIDGE	2 x 18.0 = 36.0	1
04.06b	MADALAG BRIDGE	24.0	1
04.07b	TAN-AGAN BRIDGE	2 x 18.0 = 36.0	2
04.08b	PANIQUE BRIDGE	2 x 18.0 = 36.0	1
04.10b-1	DAYKITIN BRIDGE	24.0	1
04.10b-2	IHATUB BRIDGE	2 x 23.0 = 46.0	2

5.3.4 Types of Substructures

The types of substructures adopted for the Phase III Bridges are T-type abutments and column type piers.

The reason for selecting column type piers was since the rivers cross the bridges at oblique angles, column piers were adopted to avoid disturbing the stream lines. Refer to Table 5.3-7.

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 5.3-3 (1/5) - (4/5).

Rectangular R.C. piles of 400 x 400 were adopted for the pile foundations.

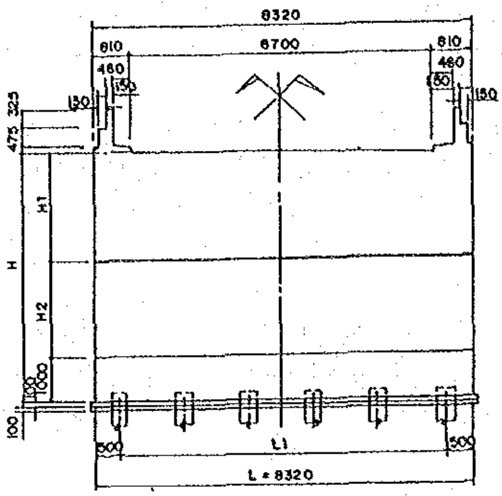
However, the pile bent type was adopted for the Bacong and San Roque Bridges, because both rivers are deep water (more than 4 m) rivers.

Pile bent type is shown in Figure 5.3-3 (5/5).

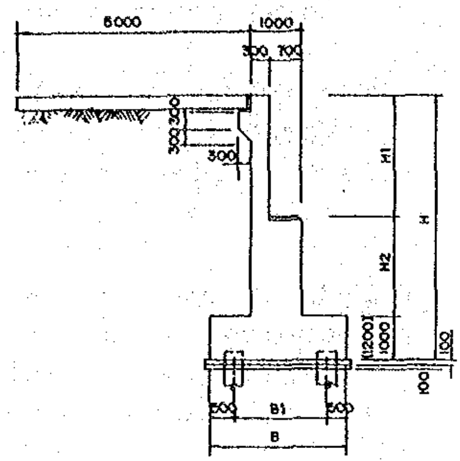
TABLE 5.3-7 STREAM ANGLE

BRIDGE NO.	NAME OF BRIDGE	STREAM ANGLE*	REMARKS
01.02	MAPHILINDO BRIDGE	90^{o}	5 x 32.0
03.03	BACONG BRIDGE	80^{o}	2 x 26.0
03.07	SAN ROQUE BRIDGE	90^{o}	3 x 18.0
03.10	DOLORES BRIDGE	90^{o}	2 x 24.0
03.13	MANGKUYOG BRIDGE	75^{o}	4 x 24.0
03.17	SULA BRIDGE	90^{o}	3 x 20.0
04.07a	CAMAGONG BRIDGE	60^{o}	2 x 22.0, 60^{o} Skew
04.20z	PARAGUSAN BRIDGE	90^{o}	15.0+30.0, Spread Foundation
04.07b	TAN-AGAN BRIDGE	75^{o}	2 x 18.0
04.10b-2	IHATUB BRIDGE	65^{o}	2 x 23.0

Note: * Oblique angle between stream line and bridge



FRONT VIEW

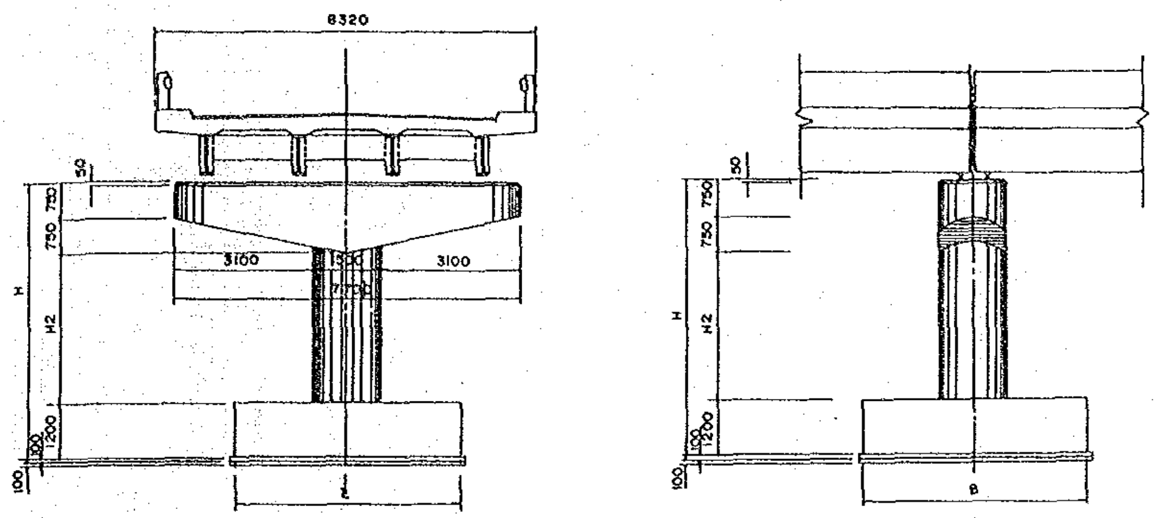


SIDE VIEW

ABUTMENT ON PILE FOUNDATION

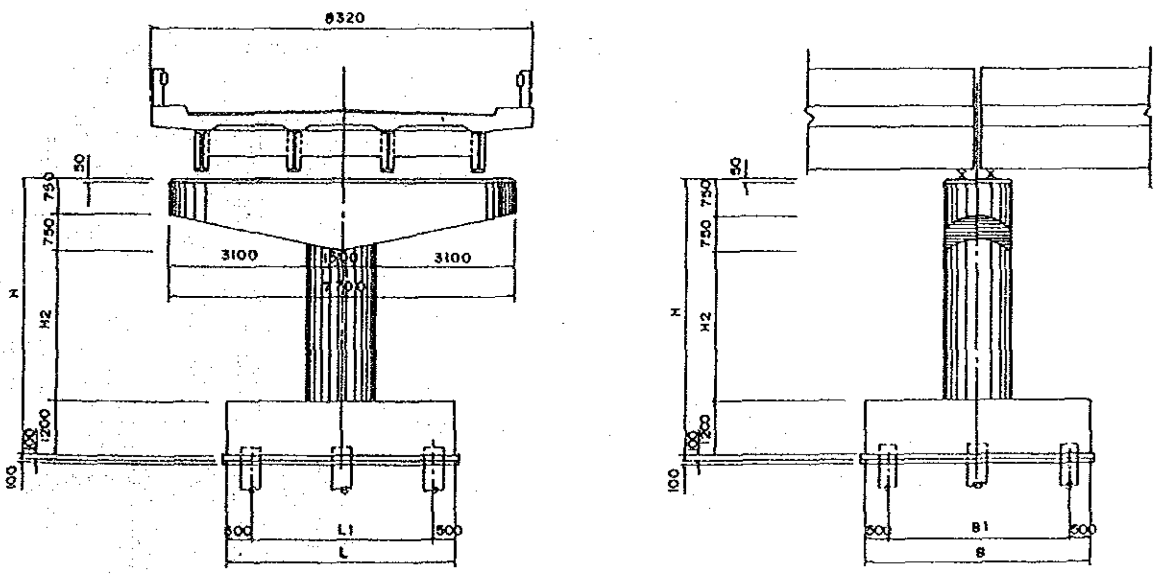
BRIDGE NO.	NAME OF BRIDGE		HEIGHT (m)				WIDTH (m)			PILE
			H	H_1	H_2	H_3	B	B_1	B_2	LENGTH (m) x No.
01. 02	MAPHILINDO BRIDGE	A1	5. 00	2. 05	1. 75	1. 20	3. 00	1. 20	0. 40	24. 0×12
		A2	4. 50	2. 05	1. 25	1. 20	3. 00	1. 20	0. 40	21. 0×12
03. 03	BACONG BRIDGE	A1	4. 50	1. 90	1. 60	1. 00	3. 00	1. 20	0. 40	24. 0×12
		A2	4. 50	1. 90	1. 60	1. 00	3. 00	1. 20	0. 40	24. 0×12
03. 07	SAN ROQUE BRIDGE	A1	3. 50	1. 24	1. 25	1. 00	2. 50	1. 00	0. 30	24. 0× 8
		A2	3. 50	1. 24	1. 25	1. 00	2. 50	1. 00	0. 30	24. 0× 8
03. 10	DOLORES BRIDGE	A1	5. 00	1. 37	2. 65	1. 00	3. 00	1. 00	0. 30	12. 0×12
		A2	5. 00	1. 37	2. 65	1. 00	3. 00	1. 00	0. 30	16. 0×12
03. 13	MANGKUYOG BRIDGE	A1	5. 00	1. 37	2. 65	1. 00	3. 00	1. 00	0. 3	8. 0×10
		A2	5. 00	1. 37	2. 65	1. 00	3. 00	1. 00	0. 3	8. 0×10
03. 17	SULA BRIDGE	A1	5. 50	1. 35	2. 65	1. 00	3. 00	1. 00	0. 30	6. 0×10
		A2	5. 50	1. 35	2. 65	1. 00	3. 00	1. 00	0. 30	6. 0×10
04. 07a	SUBRIDGE BRIDGE	A1	3. 50	1. 35	1. 14	1. 00	2. 50	1. 00	0. 3	7. 0×10
		A2	3. 50	1. 35	1. 04	1. 00	2. 50	1. 00	0. 3	7. 0×10
04. 20a	CAMAGONG BRIDGE	A1	3. 50	1. 16	1. 34	1. 00	2. 50	1. 00	0. 30	5. 0× 8
		A2	4. 00	2. 00	1. 00	1. 00	2. 50	1. 20	0. 40	5. 0×10
04. 07b	PARAGUSAN BRIDGE	A1	3. 50	1. 25	1. 25	1. 00	2. 50	1. 00	0. 30	8. 0× 8
		A2	3. 50	1. 25	1. 25	1. 00	2. 50	1. 00	0. 30	11. 0× 8
04. 10b-2	TAN-AGAN BRIDGE	A1	3. 50	1. 37	1. 13	1. 00	2. 50	1. 00	0. 3	7. 0×10
		A2	3. 50	1. 36	1. 13	1. 00	2. 50	1. 00	0. 3	5. 0×10

FIGURE 5. 3-3 (1/5) TYPICAL ABUTMENT



FRONT VIEW SIDE VIEW

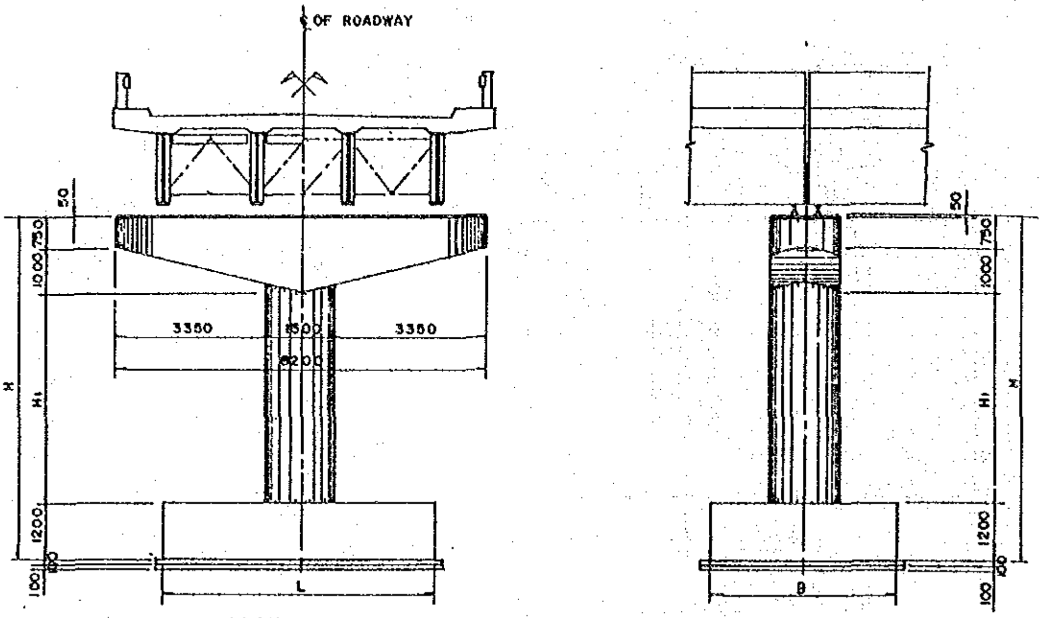
PIER ON SPREAD FOUNDATION



FRONT VIEW SIDE VIEW

PIER ON PILE FOUNDATION

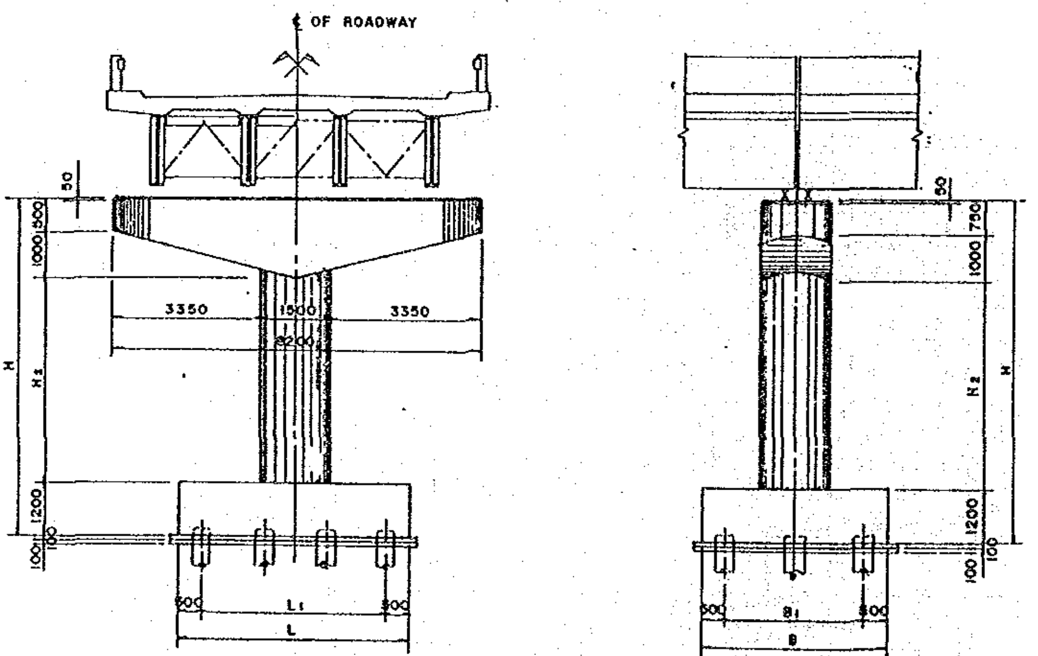
FIGURE 5. 3-3 (2/5) TYPICAL PIER (SPAN LENGTH; 15m ~25m)



FRONT VIEW

SIDE VIEW

PIER ON SPREAD FOUNDATION

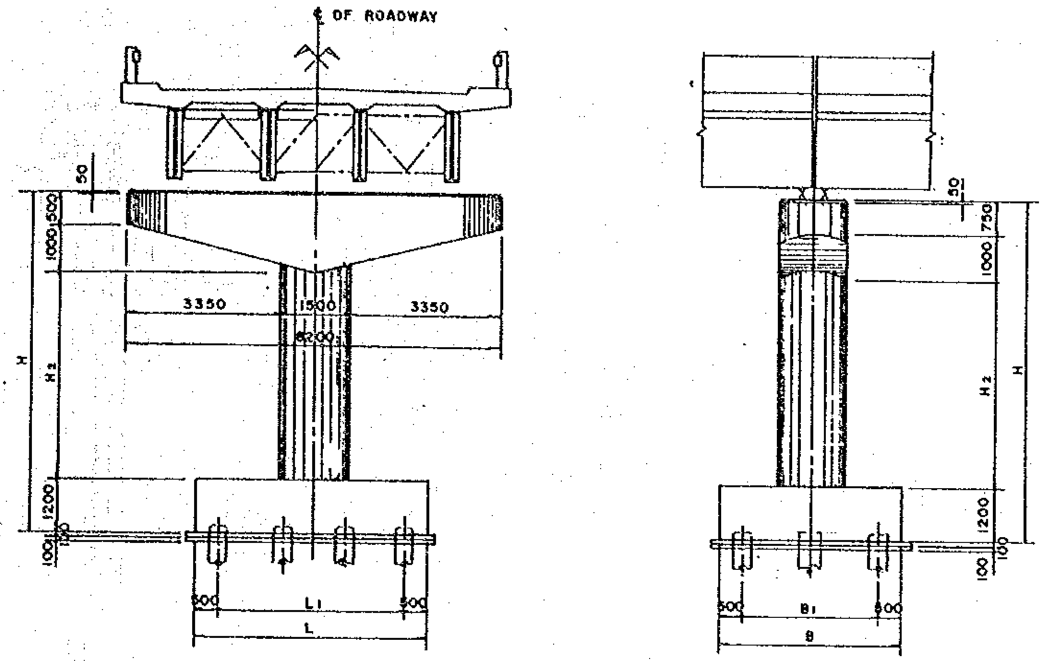


FRONT VIEW

SIDE VIEW

PIER ON PILE FOUNDATION

FIGURE 5.3-3 (3/5) TYPICAL PIER (SPAN LENGTH; 26m～32m)

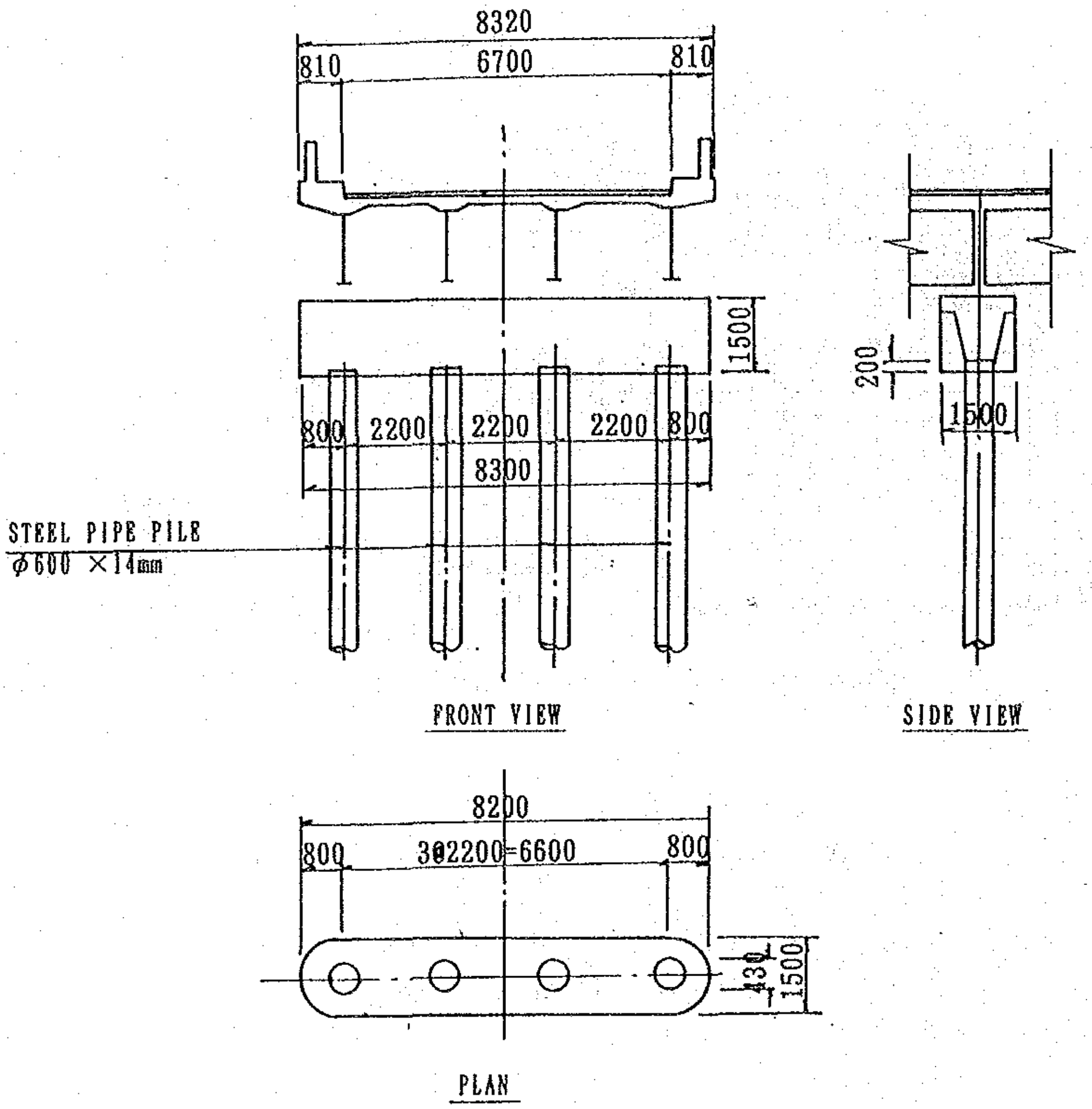


FRONT VIEW

SIDE VIEW

.PIER ON PILE FOUNDATION

FIGURE 5. 3-3 (4/5) PIER OF SKEW (SPAN LENGTH : 26m)



BRIDGE NO.	NAME OF BRIDGE	PIER	NO. OF PILE	PILE LENGTH (m)
03. 03	BACONG	P_1	4	16. 0
03. 07	SAN ROGUE	P_1, P_2	4	30. 0

FIGURE 5. 3-3 (5/5) PILE OF PILE BENT

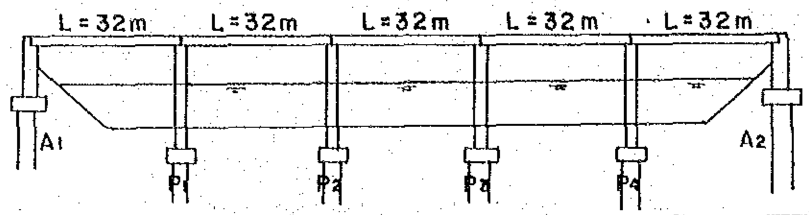
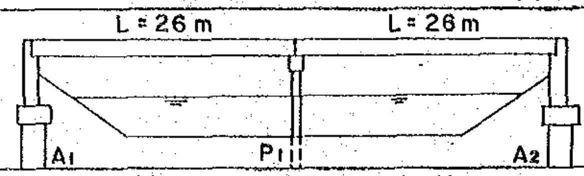
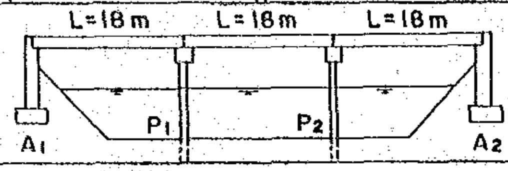
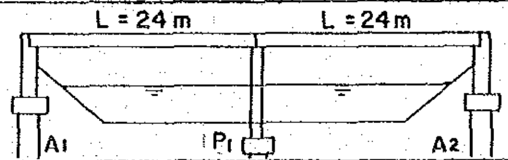
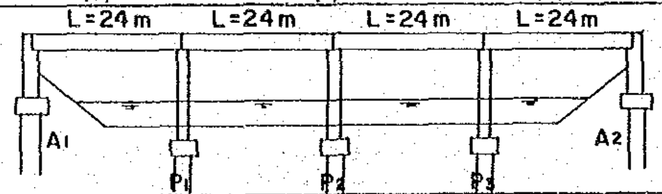
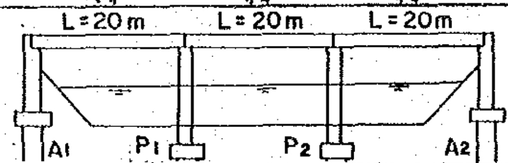
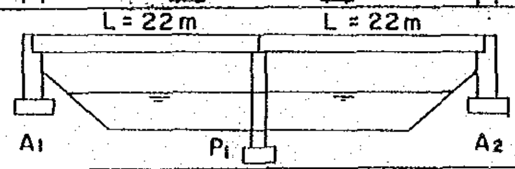
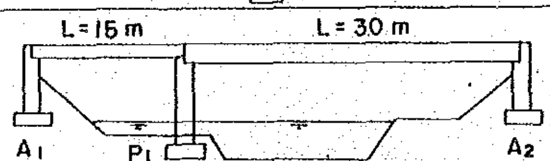
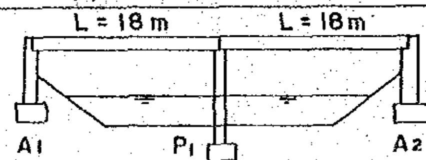
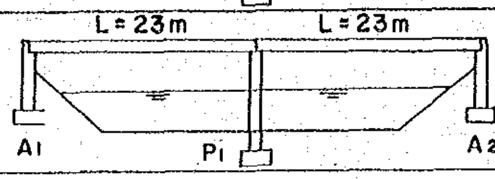
5.3.5 Proposed Bridge Types

The most appropriate type of bridge for each proposed site was finally selected as shown in Table 5.3-8 for Group 1 Bridges and 5.3-9 for Group 2 Bridges.

TABLE 5.3-8 SUMMARY OF GROUP 1 BRIDGES

No.	BRIDGE No.	NAME OF BRIDGE	TYPE OF BRIDGE	No.	BRIDGE No.	NAME OF BRIDGE	TYPE OF BRIDGE
1.	03.01	PANGULISANIN BRIDGE	F △ L=24m △ E	15.	04.16a	PINGIT BRIDGE	F △ L=21m E △ F L=21m △ E
2.	03.04	TIGBE BRIDGE	F △ L=22m △ E	16.	04.17a	SALAY BRIDGE	F △ L=15m E △ E L=15m △ F
3.	03.06	BALASING BRIDGE	F △ L=15m E △ E L=23m △ F	17.	04.18a	MIJARES BRIDGE	F △ L=23m △ E
4.	03.08	PIAS BRIDGE	F △ L=23m E △ F L=23m △ E	18.	04.19a	PALAYAN BRIDGE	F △ L=24m △ E SKEW ϕ-60°
5.	03.11	PULO BRIDGE	F △ L=23m △ E	19.	04.21a	TARAK BRIDGE	F △ L=24m △ E
6.	03.18	SINDOL BRIDGE	F △ L=15m E △ E L=15m △ F	20.	04.22a	STO. NINO BRIDGE	F △ L=23m △ E
7.	04.01a	SAN JUAN BRIDGE	F △ L=23m △ E	21.	04.23a	DEL PILAR BRIDGE	F △ L=24m △ E
8.	04.02a	TABON BATONG BRIDGE	F △ L=22m △ E	22.	04.03b	MARUYUGON BRIDGE	F △ L=24m △ E
9.	04.04a	CAGLATE BRIDGE	F △ L=23m △ E	23.	04.04b	DAKOTON BRIDGE	F △ L=18m E △ E L=18m △ F
10.	04.06a	BUENAVISTA BRIDGE	F △ L=24m △ E	24.	04.06b	MADALAG BRIDGE	F △ L=24m △ E
11.	04.09a	ISABANG BRIDGE	F △ L=24m E △ F L=24m △ E	25.	04.08b	PANIQUE BRIDGE	F △ L=18m E △ E L=18m △ F
12.	04.10a	PANSIPIT BRIDGE	F △ L=22m E △ F L=22m △ E	26.	04.09b	MARANLIG BRIDGE	F △ L=15m E △ E L=15m △ F
13.	04.11a	SAN DIEGO BRIDGE	F △ L=15m E △ E L=15m △ F	27.	04.10b-1	DAYKITIN BRIDGE	F △ L=24m △ E
14.	04.13a	BAGONG POOK BRIDGE	[illegible]				

TABLE 5. 3-9 SUMMARY OF GROUP 2 BRIDGES

BRIDGE NO.	NAME OF BRIDGE	TYPE OF BRIDGE	SUPERSTRUCTURE	SUBSTRUCTURE	REMARKS
01. 02	MAPHILINDO BRIDGE		BUILD-UP BEAM L ; 32+32+32+32+32=160m	A_1 Abut−RC Pile (400mm× 400mm×24. 0m×12Piles) p_1 Pier−RC Pile (400mm× 400mm×22. 0m×10Piles) p_2 Pier−RC Pile (400mm× 400mm×22. 0m×10Piles) p_3 Pier−RC Pile (400mm× 400mm×21. 0m×10Piles) p_4 Pier−RC Pile (400mm× 400mm×21. 0m×10Piles) A_2 Abut−RC Pile (400mm× 400mm×24. 0m×12Piles)	WEATHERING STEEL BRIDGE
03. 03	BACONG BRIDGE		BUILD-UP BEAM L ; 26+26=52m	A_1 Abut−RC Pile (400mm× 400mm×24. 0m×12Piles) p_1 Pier−Pile Bent (φ600, t=14mm, 16. 0m× 4Piles) A_2 Abut−RC Pile (400mm× 400mm×24. 0m×12Piles)	−
03. 07	SAN ROQUE BRIDGE		H−BEAM L ; 18+18+18=54m	A_1 Abut−RC Pile (400mm× 400mm×24. 0m× 8Piles) p_1 Pier−Pile Bent (φ600, t=14mm, 30. 0m× 4Piles) p_2 Pier−Pile Bent (φ600, t=14mm, 30. 0m× 4Piles) A_2 Abut−RC Pile (400mm× 400mm×24. 0m× 8Piles)	−
03. 10	DOLORES BRIDGE		H−BEAM L ; 24+24=48m	A_1 Abut−RC Pile (400mm× 400mm×12. 0m×12Piles) p_1 Pier−RC Pile (400mm× 400mm×16. 0m× 8Piles) A_2 Abut−RC Pile (400mm× 400mm×16. 0m×12Piles)	−
03. 13	MANGKUYOG BRIDGE		H−BEAM L ; 24+24+24+24=96m	A_1 Abut−RC Pile (400mm× 400mm× 8. 0m×10Piles) p_1 Pier−RC Pile (400mm× 400mm× 8. 0m× 8Piles) p_2 Pier−RC Pile (400mm× 400mm× 8. 0m× 8Piles) p_3 Pier−RC Pile (400mm× 400mm× 8. 0m× 8Piles) A_2 Abut−RC-Pile (400mm× 400mm× 8. 0m×10Piles)	−
03. 17	SULA BRIDGE		H−BEAM L ; 20+20+20=60m	A_1 Abut−RC Pile (400mm× 400mm× 6. 0m×10Piles) p_1 Pier−RC Pile (400mm× 400mm× 6. 0m× 8Piles) p_2 Pier−RC Pile (400mm× 400mm× 6. 0m× 8Piles) A_2 Abut−RC-Pile (400mm× 400mm× 6. 0m×10Piles)	−
04. 07a	CAMAGONG BRIDGE		H−BEAM L ; 22+22=44m	A_1 Abut−RC Pile (400mm× 400mm× 7. 0m×10Piles) p_1 Pier−RC Pile (400mm× 400mm× 6. 0m× 8Piles) A_2 Abut−RC Pile (400mm× 400mm× 7. 0m×10Piles)	WEATHERING STEEL BRIDGE SKEW φ 60°
04. 20a	PARAGUSAN BRIDGE		H-BEAM+BUILD-UP BEAM L ; 15+30=45m	A_1 Abut−RC Pile (400mm× 400mm× 5. 0m× 8Piles) p_1 Pier−Spread foundation A_2 Abut−RC Pile (400mm× 400mm× 7. 0m×10Piles)	−
04. 07b	TAN−AGAN BRIDGE		H−BEAM L ; 18+18=36m	A_1 Abut−RC Pile (400mm× 400mm× 8. 0m× 8Piles) p_1 Pier−RC Pile (400mm× 400mm×12. 0m× 8Piles) A_2 Abut−RC Pile (400mm× 400mm×11. 0m× 8Piles)	WEATHERING STEEL BRIDGE
04. 10b -2	IHATUB BRIDGE		H−BEAM L ; 23+23=46m	A_1 Abut−RC Pile (400mm× 400mm× 7. 0m×10Piles) p_1 Pier−RC Pile (400mm× 400mm× 5. 0m× 8Piles) A_2 Abut−RC Pile (400mm× 400mm× 5. 0m×10Piles)	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 (13rd Edition, 1983)
	: Specification for Highway Bridges, Japan Road Association, 1980
. Live Load	: AASHTO HS-20-44 (MS18) for Roadways
	: 2.873 KN/M2 for Sidewalks
. Temperature Change	: rise + 10°, fall - 10°
. Concrete Slab	: (3L + 11) x 1.05, L = span Length
. Max. Length of Member	: 8.5 m
. Concrete Strength	: Slab fc = 300 kg/cm^2 Railing fc = 130 kg/cm^2
. Reinforcing	: fy = 2,400 kg/cm^2

5.4.2 Design of Superstructures

The result of the analysis are given in the following tables:

(1) Size and Stress Intensity of Girders for Group 1 Bridges Table 5.4-1

(2) Size and Stress Intensity of Girders for Group 2 Bridges Table 5.4-2

(3) Size of Slabs, Girders and Shoes for Groups 1 and Group 2 Bridges Table 5.4-3

(4) Reaction for Abutments and Pier Beams Table 5.4-4

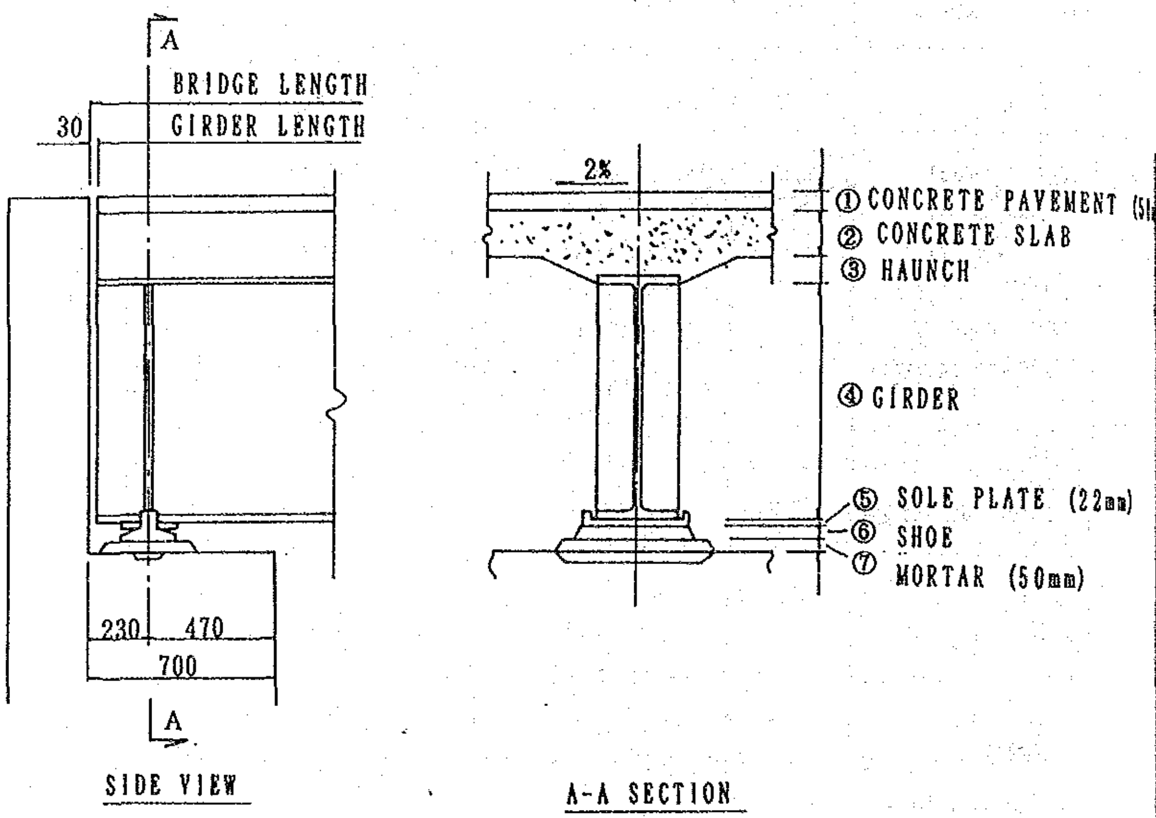
TABLE 5.4-1 SIZE AND STRESS INTENSITY OF THE GIRDER FOR GROUP1 BRIDGES

SPAN LENGTH (m)		15	18	20	21	22	23	24
CARRIAGEWAY (m)		6. 7	6. 7	6. 7	6. 7	6. 7	6. 7	6
TYPE		H-beam	H-beam	H-beam	H-beam	H-beam	H-beam	H-bea
GIRER HEIGHT (mm)		H700x300	H792x300	H890x299	H900x300	H900x300	H912x302	H912x
TYPE OF STEEL MATERIALS		SMA50	SMA50	SMA50	SMA50	SMA50	SMA50	SMA5
SECTION	PRINCIPAL MOMENT OF INTERTIA (cm^4)	201. 000	254. 000	345. 000	411. 000	411. 000	498. 000	498.
	SECTION AREA (cm^2)	235. 5	243. 4	270. 9	309. 8	309. 8	364. 0	364.
	SECTION MODULUS (cm^3)	4. 980	6. 410	7. 760	9. 140	9. 140	10. 900	10.
BENDING MOMENT	LOADING (t・m)	111. 2	153. 2	183. 8	199. 7	216. 6	233. 8	24
BENDING STLESS	STRESS (kg/cm^2)	1. 610	1. 991	1. 999	1. 874	2. 030	1. 858	2.
	ALLOWABLE STLESS (kg/cm^2)	2. 100	2. 100	2. 100	2. 100	2. 100	2. 100	2.
SHEARING	LOADING (t)	31. 7	35. 6	38. 3	39. 5	40. 7	42. 0	42
SHEARING STRESS	STLESS (kg/cm^2)	374	340	201	293	301	276	[illegible]
	ALLOWABLE STLESS (kg/cm^2)	1. 200	1. 200	1. 200	1. 200	1. 200	1. 200	1.
DEFLECTION	DEFLECTION	1/1, 563	1/1, 208	1/1, 220	1/1, 228	1/1, 100	1/1, 139	1/1, 05
	ALLOWABLE DEFLECTION	1/1, 333	1/1, 111	1/1, 000	1/952	1/909	1/870	1/83

TABLE 5.4-2 SIZE AND STRESS INTENSITY OF THE GIRDER FOR GROUP2 BRIDGES

SPAN LENGTH (m)		18	20	22	23	24	26	30	32
CARRIAGEWAY (m)		6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
TYPE		H-beam	H-beam	H-beam	H-beam	H-beam	PI-Girder	PI-Girder	PI- Girde
GIRER HEIGHT (mm)		H700x300	H792x300	H890x299	H900x300	H900x300	1,400	1,500	1,550
TYPE OF STEEL MATERIALS		SMA50	SMA50Y	SMA50Y	SMA50	SMA50	SMA50Y	SMA50Y	SMA50
SECTION	PRINCIPAL MOMENT OF INTERTIA (cm^4)	254,000	345,000	411,000	498,000	498,000	1184,000	1619,000	1883,000
	SECTION AREA (cm^2)	243.4	270.9	309.8	364.0	364.0	319.6	370.0	397.1
	SECTION MODULUS (cm^3)	6,410	7,760	9,140	10,900	10,900	16,400	20,900	23,400
BENDING MOMENT	LOADING (t・m)	153.2	183.8	216.6	233.8	247.3	328.9	423.5	474.1
BENDING STRESS	STRESS (kg/cm^2)	1,991	1,999	2,030	1,854	2,029	2,035	2,047	2,048
	ALLOWBABLE STLESS (kg/cm^2)	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
SHEARING	LOADING (t)	35.6	38.3	40.7	42.0	42.6	52.4	58.0	60.7
SHEARING STRESS	STLESS (kg/cm^2)	340	201	301	276	280	416	430	435
	ALLOWABLE STLESS (kg/cm^2)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
DEFLECTION	DEFLECTION	1/1,208	1/1,220	1/1,100	1/1,139	1/1,053	1/783	1/675	1/630
	ALLOWABLE DEFLECTION	1/1,111	1/1,000	1/909	1/870	1/833	1/769	1/667	1/625

TABLE 5.4-3 SIZE OF SLABS, GIRDERS AND SHOES FOR GROUP 1 AND GROUP 2 BRIDGES



SPAN LENGTH (m)	①	②	③	④	⑤	⑥	⑦	SHOE	TOTAL (mm)
15	50	180	70+(20)	700	22	63	50	45	1,155
18	50	180	70+(20)	792	22	63	50	45	1,247
20	50	180	70+(20)	890	22	63	50	45	1,345
21	50	180	70+(20)	900	22	63	50	45	1,355
22	50	180	70+(20)	900	22	63	50	45	1,355
23	50	180	70+(20)	912	22	63	50	45	1,367
24	50	—	—	912	22	63	50	45	1,352
26	50	190	116	1400	25	75	44	75	1,900
30	50	190	116	1500	25	75	44	75	2,000
32	50	190	116	1550	25	75	44	75	2,050

NOTE : TOTAL HIGHT (MM) SHOWS HIGHTS OF BRIDGE CENTER

TABLE 5.4-4 REACTION AND DESIGN REACTION OF ABUTMENTS FOR GROUP 1 & 2 BRIDGES

(Unit ; Ton)

SPAN (m)	NORMAL CONDITION			SEISMIC CONDITION			
	VERTICAL REACTION			LONGITUDINAL		LATERAL	
	Dead L.	Live L.	Total	Vertical	Horizontal	Vertical	Horizontal
15	56.4	55.0	111.4	56.4	13.5	56.4	6.8
18	67.6	57.4	125.0	67.6	16.2	67.6	8.1
20	75.0	59.0	134.0	75.0	18.0	75.0	9.0
22	82.4	60.0	142.4	82.4	19.8	82.4	9.9
23	86.4	60.4	146.8	86.4	20.7	86.4	10.4
24	82.7	63.0	145.7	82.7	19.8	82.7	9.9
26	104.8	68.3	173.1	104.8	25.2	104.8	12.6
30	120.9	77.0	197.9	120.9	29.0	120.9	14.5
32	129.0	81.3	210.3	129.0	31.0	129.0	15.5

SPAN (m)	LIVE LOAD (t)	RATIO OF INTER GIRDER/OUT GIRDER	IMPACT	G 1 (t)	G 2 (t)
15	55.0	1.197	0.288	16.1	19.3
18	57.4	1.190	0.272	16.7	19.8
20	59.0	1.187	0.263	17.1	20.2
22	60.0	1.184	0.254	17.2	20.4
23	60.4	1.182	0.250	17.3	20.5
24	63.0	1.182	0.246	17.9	21.3
26	68.3	1.325	0.238	18.2	24.1
30	77.0	1.320	0.224	20.3	26.8
32	81.3	1.318	0.218	21.3	28.3

Note ; Reaction of G1 & G2 includes Impact

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 (13rd Edition, 1983)

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

- Concrete Strength at 28 days: fc = 210 kg/cm^2

- Reinforcing Steel : fy = 2,100 kg/cm^2

- Steel Pile : fy = 2,400 kg/cm^2

5.5.2 Design of Substructures

For the convenience of structural design, 20 abutments and 17 piers were grouped into nine (9) cases for Group 2 Bridges, as shown in Table 5.5-1 (1/4 - 4/4), also typical section of abutment and pier as shown in Table 5.3-3 (1/5 - 5/5).

The dimensions of abutments and piers of Group 2 Bridges were applied Group 2 Bridges.

The reaction of the piles for the abutments and piers are shown in Table 5.5-1 (1/4 - 4/4).

TABLE 5.5-1 SUBSTRUCTURE TYPES AND REACTION OF PILE (ABUTMENT) ([illegible])

TYPE	BRIDGE No.	ABUTMENT	BRIDGE LENGTH	BEARING	ABURMENT (HEIGHT)	ABUTMENT (WIDTH)	No. OF PILE	REACTION OF PILE NORMAL CONDITION (t/Pile) max	min	H	SEISMIC CONDITION (t/Pile) max	min	H	ALLOWABLE HORIZONTAL FORCE (t) N-VALUE	TYPE OF PILE	NORMAL CONDITION Ha	SEISMIC CONDITION Ha
1	01.02	A_1	32.0	FIX	5.0	3.0	12	41.2	33.9	5.0	41.5	10.0	10.1	10	A	7.8	10.4
2	01.02	A_2	32.0	EXP	4.5	3.0	12	38.6	32.4	4.1	33.7	14.1	7.4	1/3x9 3	A	5.8	7.7
3	03.03	A_1	26.0	FIX	4.5	3.0	12	37.9	26.8	4.1	32.9	10.7	8.3	7	A	7.1	9.5
		A_2	26.0											7	A	7.1	9.5
4	03.07	A_1	18.0	FIX	3.5	2.5	8	47.6	23.6	4.0	29.8	13.4	7.9	6	A	6.8	9.1
	03.07	A_2	18.0	EXP										4	A	5.8	7.9
	04.07b	A_1	18.0	FIX										12	A	8.1	10.9
	04.07b	A_2	18.0	EXP										7	A	7.1	9.5
	04.20a	A_1	15.0	FIX										13	A	8.1	10.9
5	03.10	A_1	24.0	FIX	5.0	3.0	12	37.4	37.7	5.0	36.9	7.6	9.4	8	A	7.4	9.9
	03.10	A_2	24.0	EXP										7	A	7.1	9.5
	03.13	A_1	24.0	FIX			10	44.9	33.2	6.0	44.3	9.1	11.3	20	A	9.2	12.3
	03.13	A_2	24.0	EXP										20	A	9.2	12.3
6	03.17	A_1	20.0	FIX	5.5	3.0	10	43.9	35.4	7.1	47.8	7.0	12.5	30	A	10.2	13.6
	03.17	A_2	20.0	EXP													

NOTE ; TYPE OF PILE A ; ϕ30-8 STEEL BARS B ; ϕ25-8 STEEL BARS

TABLE 5.5-1 SUBSTRUCTURE TYPES AND REACTION OF PILE (ABUTMENT) (2/4)

TYPE	BRIDGE No.	ABUTMENT	BRIDGE LENGTH	BEARING	ABURMENT (HEIGHT)	ABUTMENT (WIDTH)	No. OF PILE	REACTION OF PILE NORMAL CONDITION (t/Pile)			SEISMIC CONDITION (t/Pile)			ALLOWABLE HORIZONTAL FORCE (t)			
								max	min	H	max	min	H	N-VALUE	TYPE OF PILE	NORMAL CONDITION Ha	SEISMIC CONDITION Ha
7	04.07a	A_1	22.0	FIX	4.5	2.5	10	46.9	26.6	5.7	39.5	8.4	10.4	13	A	8.1	10.9
	04.07a	A_2	22.0	FIX													
8	04.20a	A_2	30.0	FIX	4.0	3.0	10	44.2	34.2	4.0	37.8	13.9	9.1	13	A	8.1	10.9
9	04.10b-2	A_1, A_2	23.0	FIX	3.5	2.5	10	40.0	20.9	3.2	26.6	11.3	6.8	20	A	9.2	12.3

NOTE ; TYPE OF PILE A ; ϕ30-8 STEEL BARS B ; ϕ25-8 STEEL BARS

TABLE 5.5-1 SUBSTRUCTURE TYPES AND REACTION OF PILE (PIER) (3/4)

TYPE	BRIDGE No.	PIER	BRIDGE LENGTH	BEARING	PIER (HEIGHT)	PIER (WIDTH)	No. OF PILE	REACTION OF PILE: NORMAL CONDITION (t/Pile) max	min	H	SEISMIC CONDITION (t/Pile) max	min	H	ALLOWABLE HORIZONTAL FORCE (t): N-VALUE	TYPE OF PILE	NORMAL CONDITION Ha	SEISMIC CONDITION Ha
1	01.02	P_1	32.0	E-F	5.5	4.0	10	44.5	41.6	-	56.4	13.3	4.5	15	B	7.6	10.3
		P_2	32.0	E-F	5.5	4.0	10										
2	01.02	P_3	32.0	E-F	6.5	4.0	10	45.0	41.8	-	59.8	10.6	4.6	Liquefaction 1/3N =1/3x10	B	5.1	6.9
		P_4	32.0	E-F	6.5	4.0	10										
3	03.10	P_1	24.0	E-F	5.0	3.0	8	41.0	27.9	-	50.9	12.4	4.1	10	B	6.9	9.4
	03.13	P_1 P_2 P_3	24.0	E-F	5.0	3.0	8							20	B	8.2	11.0
	04.10b-2	P_1	23.0	E-E	5.0	3.0	8							6	B	6.0	8.2
4	03.17	P_1	20.0	F-E	5.5	3.0	8	36.8	33.9	-	45.9	10.0	3.7	30	B	9.1	12.2
		P_2															
5	04.07a	P_1	22.0	E-E	6.5	3.0	8	40.1	37.1	-	57.2	8.1	4.1	13	B	7.2	9.8
6	04.20a	P_1	15.0+ 30.0	E-E	11.0	5.0	speed fundation	fmax=18.5t/m²<30			fmax=35.1t/m²<40 Emax=1.286mm<8/3=1.67			-	B	-	-
7	04.07b	P_1	18.0	E-E	5.0	3.0	8	34.5	31.8	-	41.2	10.9	3.4	6	B	6.2	8.2

E ; Exp F ; Fix

NOTE ; TYPE OF PILE A ; φ30-8 STEEL BARS B ; φ25-8 STEEL BARS

TABLE 5.5-1 SUBSTRUCTURE TYPES AND REACTION OF PILE (PIER) (4/4)

TYPE	BRIDGE No.	PIER	BRIDGE LENGTH	BEARING	PIER (HEIGHT)	PIER (WIDTH)	No. OF PILE	REACTION OF PILE NORMAL CONDITION (t/Pile) max	min	H	SEISMIC CONDITION (t/Pile) max	min	H	ALLOWABLE HORIZONTAL FORCE (t) N-VALUE	TYPE OF PILE	NORMAL CONDITION Ha	SEISMIC CONDITION Ha
	Pile Bent PIER φ 600mm、t=14mm																
8	03.03	P_1	26.0	E-E	7.0		4	81.0	-	-	99.5	28.3	6.63	15	ℓ =16.0m SP.P	δs 1.773	δsa 1.862
9	03.07	P_1 / P_2	18.0	F-E	8.0		4	57.1	-	-	70.0	15.3	5.13	5	ℓ =30.0m SP.P	1.603	1.862

E ; Exp F ; Fix

NOTE ; TYPE OF PILE A ; φ30-8 STEEL BARS B ; φ25-8 STEEL BARS

5.6 Design of Approach Roads

5.6.1 Design Criteria

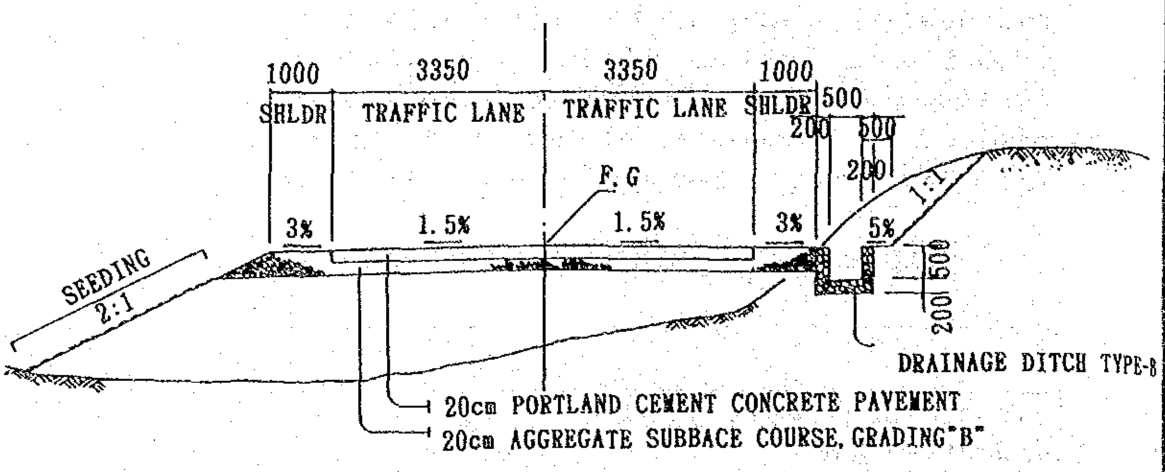
The design standard for secondary class national roads specified in the Highway Design Guideline of the Philippines was adopted for the design of the approach roads. Its geometric standard is shown in Table 5.6-1 and was also adopted for the Phase I Bridges.

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

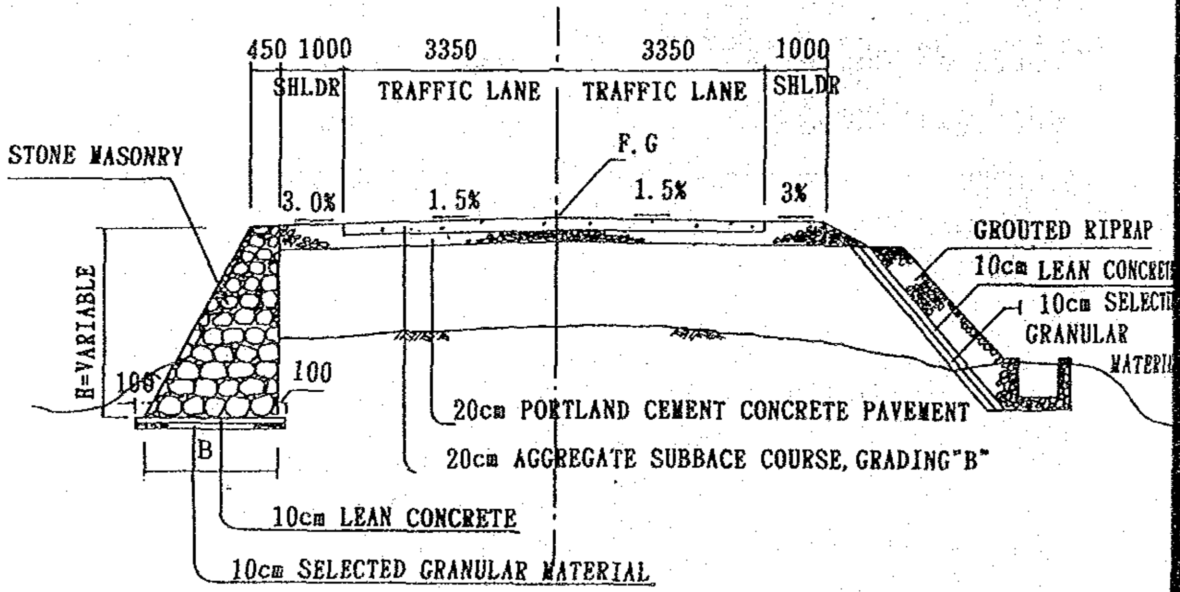
5.6.2 Typical Roadway Sections

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



SECTION IN FILL

SECTION ON CUT



SECTION WITH STONE MASONRY WALL

SECTION WITH GROUTED RIPRAP

FIGURE 5.6-1 TYPICAL ROADWAY SECTION

5.6.3 Analysis of Soft Ground

As a result of the geotechnical survey, it was ascertained that the subsoil of the San Roque Bridge site in Bulacan is soft ground.

The problems of 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, steel piles (ϕ600 m, l=30 m) for piers and 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 in which the embankment must be implemented.

(1) Soil Property Constants and Embankment Section Model

Laboratory tests were conducted to determine such soil property constants as unit weight, moisture content, liquid limit, plastic limit and uncon-fined 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 the figure mean the following:

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

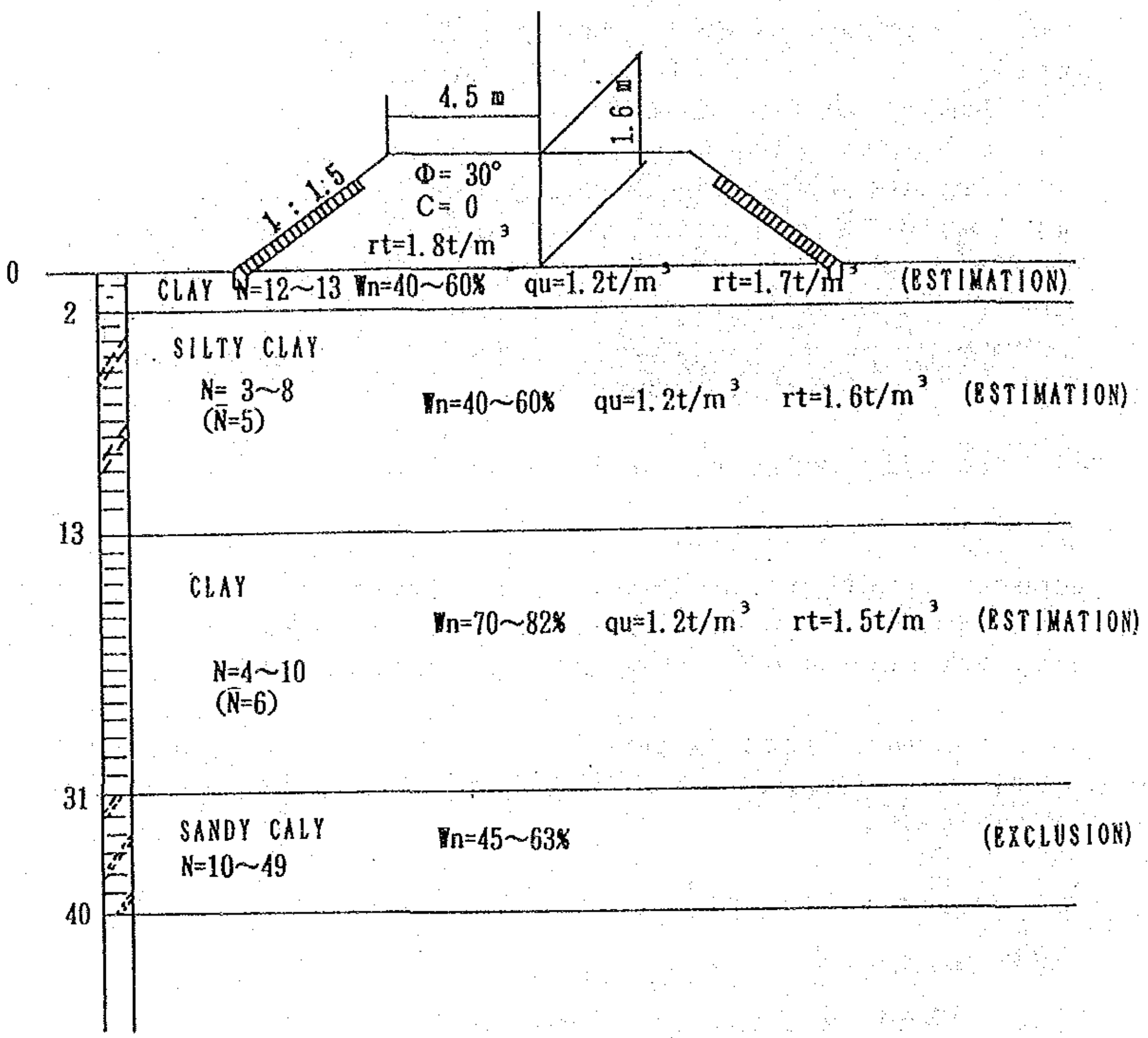


FIGURE 5.6-2 EMBANKMENT SECTION MODEL

(2) Consolidation Settlement Analysis

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

$$S_c = \Sigma \frac{E_0 - E_1}{E_0 + 1} \times H$$

where: Sce = consolidation settlement (cm)
E0 = initial void ratio
E1 = consolidated void ratio
H = depth of each soft layer (cm)

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

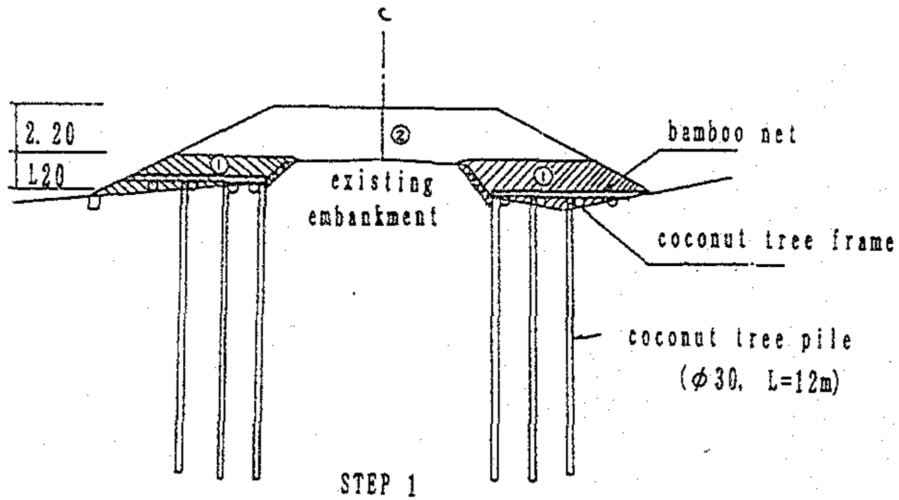
where: t = settlement time
T = coefficient of time
d = drain distance
Cv = coefficient of consolidation

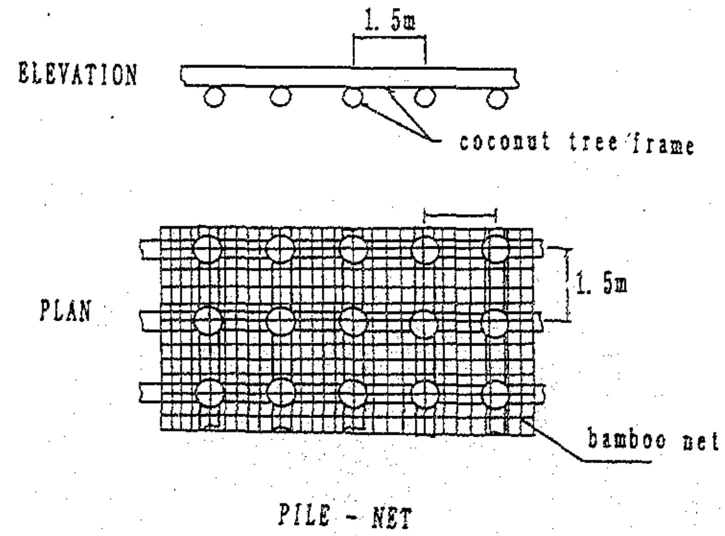
The consolidation settlement analysis is presented in Appendix 7. The analysis resulted in a complete settlement of 28.1 cm at road center. Assuming a thickness of 5 cm of embankment is executed daily, 80% of complete settlement will be completed in 2 years.

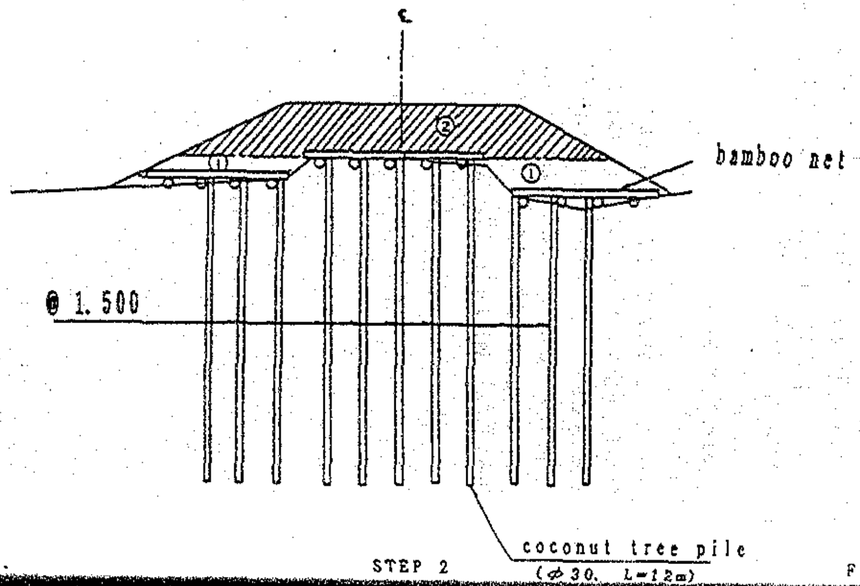
Based on the results of the analysis, a countermeasure may be provided against settlement, although this is not severely critical.

(3) Countermeasure

As a countermeasure, the preloading, 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 tp existing embankment. (Riprap shpould 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 porposed grade.

FIGURE 5. 6-3 COUNTERMEASURE ON SOFT CROUDN (PILE-NET METHOD)