Appendix 5.
Cost Estimation Borne by the Recipient Country

MINISTRY OF TRANSPORT
PROJECTS MANAGEMENT UNIT NO. 18
PROJECT IMPLEMENTATION DIVISION 2

1-19/8 Road, Mai Dich, Cau Giay, Hanoi, Vietnam
Tel: (84-4) 7680058 Fax: (84-4) 7680073

Hanoi, September 27, 2000

Mr. Hiroyuki Endo
Project Manager
Project for Construction of Small Bridges in Mekong Delta

Sub.: Project for Construction of Small Bridges in Mekong Delta

In response to the request by JICA Study Team to get information on counter budget for the said Project, PMU 18 would like to provide you with the followings:

I- 21-BRIDGES GROUP

1- The Government of Japan is going to provide Grant Aid for the whole construction work of 21 bridges, including bridges and approach roads.
2- Counter budget provided by the Government of Vietnam: Estimated cost is around 11 billion to 13 billion VND, including the following items:
   - Site preparation (please refer to the attachment for the information on volume and cost) including conpensation for residential land, agricultural land, other land; for housing, plants; for public facilities (power system, water system, communication system...); for demolition of the existing bridges, construction of temporary bridges...
   - Disposal of bombs left after the war
   - General management cost
   - Banking charge
   - Cost for tender document preparation and evaluation of contractors' proposals
   - Cost for survey and design work
   - Cost for evaluation of detailed design

II- 17-BRIDGES GROUP

1- The Government of Japan is going to provide Grant Aid for procurement of girders
2- Counter budget to be provided by the Government of Vietnam, including:

   a- Construction cost (construction of bridges and approach roads) is temporarily estimated a follows:

Bridge	Number	Length (m)	Cost (VND)
Xeo Dua	10	30.10	2,550,000,000
Saintard	11	92.20	6,915,000,000
Nga Tu	14	60.20	4,530,000,000
Soc Triet	19	84.20	6,315,000,000
Cai Nai	20	33.10	2,490,000,000
Kenh Tu	22	90.20	6,800,000,000
My Hoa	25	90.20	6,800,000,000
Suoi	28	72.20	5,415,000,000
Dai Su	29	50.20	3,840,000,000
Huong My	36	30.10	2,550,000,000
Tan Tru	37	63.20	4,740,000,000
Vinh Cong	39	30.10	2,550,000,000
Xe Be	43	30.10	2,250,000,000
Rach Ro	46	27.10	2,032,000,000
So 5	50	40.15	3,100,000,000
Bau Xeo	54	21.00	1,700,000,000
Song Thao	55	21.00	1,700,000,000
TOTAL			**66,277,000,000**

b- Counter budget for other costs is 26,490 million VND (estimated cost), including:
- Site preparation including conpensation for lands and properties in the project site area
- Disposal of bombs left after the war
- Supervision consultants
- Operation cost for PMU
- Cost for survey and preparation of F/S and detailed design
- Cost for evaluation of detailed design
- Cost for preparation of tender document for contractor selection
- Cost for project insurance
- Cost for evaluation of and approval on final payment
- Contingency
- Escalation

III- OTHERS

1- For the smooth evaluation of and approval on the Project F/S by MOT and the Government of Vietnam, PCI is kindly requested to provide the followings to PMU 18:
  - Construction cost of 21-bridges Group
  - Girder procurement cost of 17-bridges Group

2- Explanation based on the design standards:
  - 15 bridges were proposed to have their loading capacity H increased
  - Navigation clearance

We hope the above information will be valuable and useful to you.

Approved by Mr. Vu Ngoc Van, Director of PID 2

MINISTRY OF TRANSPORT
PROJECTS MANAGEMENT UNIT NO. 18
No.: /PID 2
V/v: Site preparation work volume

Hanoi, September 27, 2000

SITE PREPARATION WORK VOLUME OF PROJECT FOR CONSTRUCTION OF SMALL BRIDGES IN MEKONG DELTA

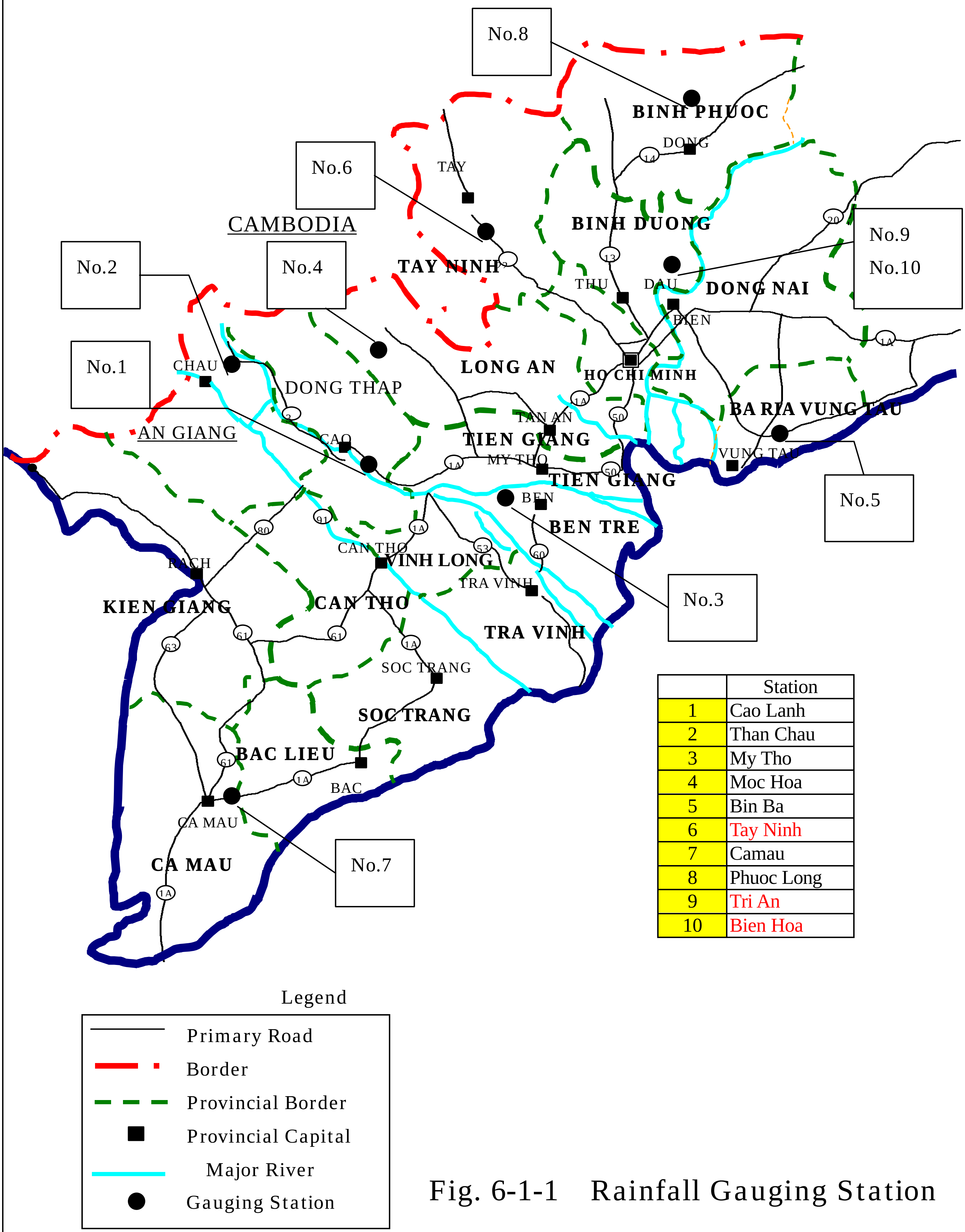
21-BRIDGE GROUP

Bridge	No.	Province	Housing			Residential land			Other land			Public facilities		Average land
			Area (m2)	Unit price (1,000VND/m2	Amount (million VND)	Area (m2)	Unit price (1,000VND/m2	Amount (million VND)	Area (m2)	Unit price (1,000VND/m2	Amount (million VND)	Type	Cost (million VND)	rental fee (1,000VND/m2/year)
Hoa Binh 2	3	Bac Lieu	1,000	250	250.00	1,000	200	200.00	3,128	20	62.50	E	100	200
Den	4		-	250	-	-	200	-	2,741	20	55.00			200
Vam Dinh	6	Ca Mau	540	260	140.50	540	260	140.50	4,000	26	104.00			260
Kinh Kiem Lam	7		-	260	-	-	260	-	3,630	26	94.50			260
Huynh H. Nghia	8	Soc Trang	1,000	280	280.00	1,000	310	310.00	1,073	30	32.00	E, W	150	310
Long My	12	Can Tho	-	380	-	-	400	-	7,300	40	292.00			400
Vam Sang T.D	15	Kien Giang	-	310	-	-	250	-	4,800	25	120.00			250
Ha Giang	16		800	310	248.00	800	250	200.00	5,430	25	135.00			250
Thoai Giang	18	An Giang	495	320	158.50	495	300	148.50	8,000	30	240.00	E	100	300
Tram Chim	21	Dong Thap	250	360	90.00	250	350	87.50	2,780	35	97.50			350
Hoa Tinh	23	Vinh Long	690	380	262.20	690	300	207.00	5,000	30	150.00	E, UC	170	300
Tan An	26	Tra Vinh	-	360	-	-	300	-	3,889	30	117.00	UC	50	300
Long Binh	30	Tien Giang	690	390	262.20	690	330	227.50	5,000	35	175.00	E	100	330
Tra Tan	32		400	390	156.00	400	330	120.00	4,609	35	162.00			330
Ranh Tong	35	Ben Tre	600	360	216.00	600	280	168.00	2,240	30	67.50			280
Ba Ly	38	Long An	150	360	54.00	150	350	150.00	3,994	40	159.00			350
Sai Gon	40	Tay Ninh	100	300	30.00	100	300	30.00	2,953	25	74.00			300
Chua	45	Binh Duong	-	300	-	-	280	-	910	20	18.00			280
Da Kia	48	Binh Phuoc	-	290	-	-	220	-	3,675	20	74.50			220
Chay	53	Dong Nai	100	400	40.00	100	400	40.00	2,347	40	94.00			400
Ap Tan Binh	58	Vung Tau	-	280	-	-	400	-	4,675	45	210.50			400
TOTAL					2,187.40			2,029.00			2,534.00		670	

Approved by Mr. Vu Ngoc Van, Director of PID 2

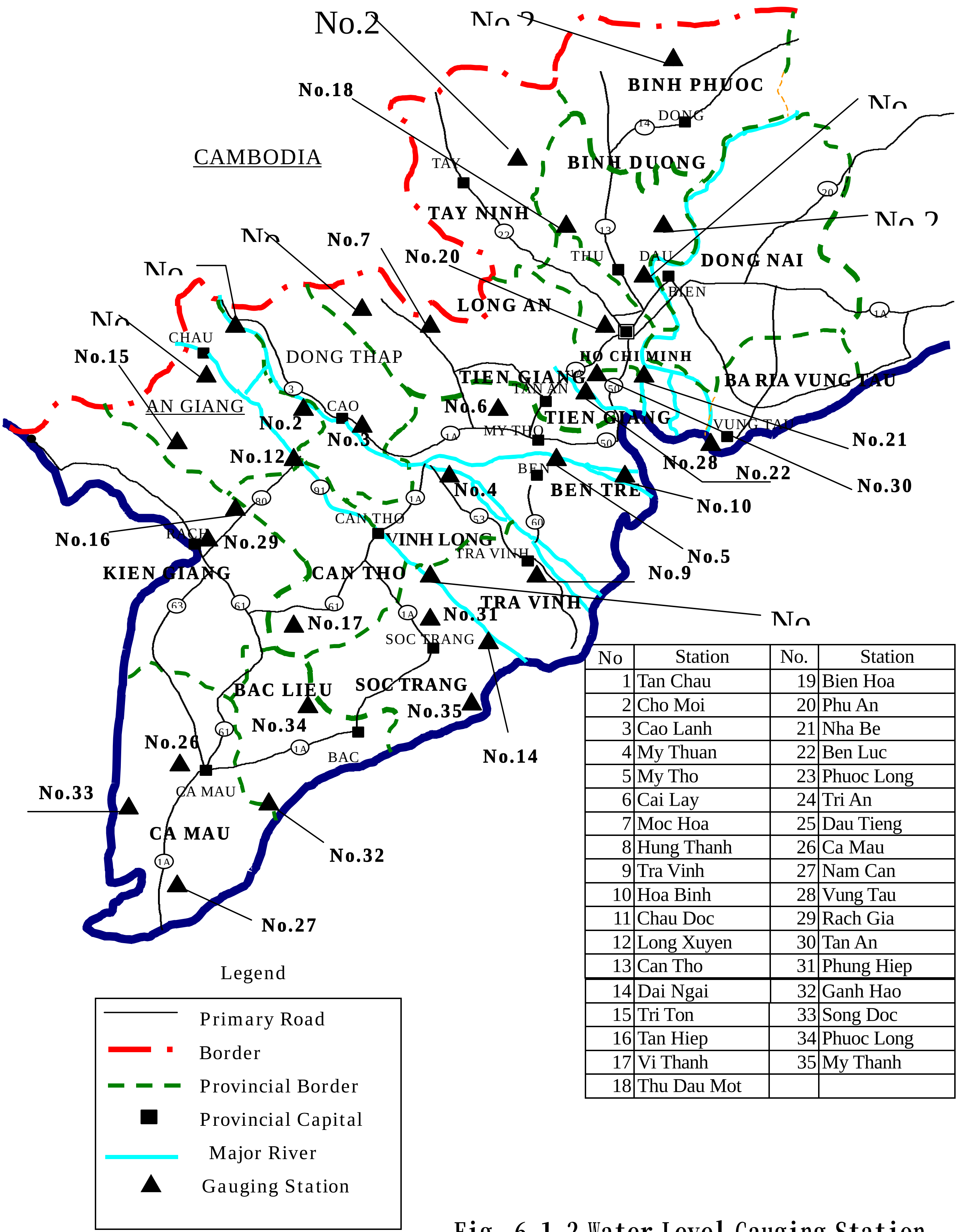
Appendix 6.
Survey Result of Hydrology

Appendix6-1 Data of Climate and Meteorology



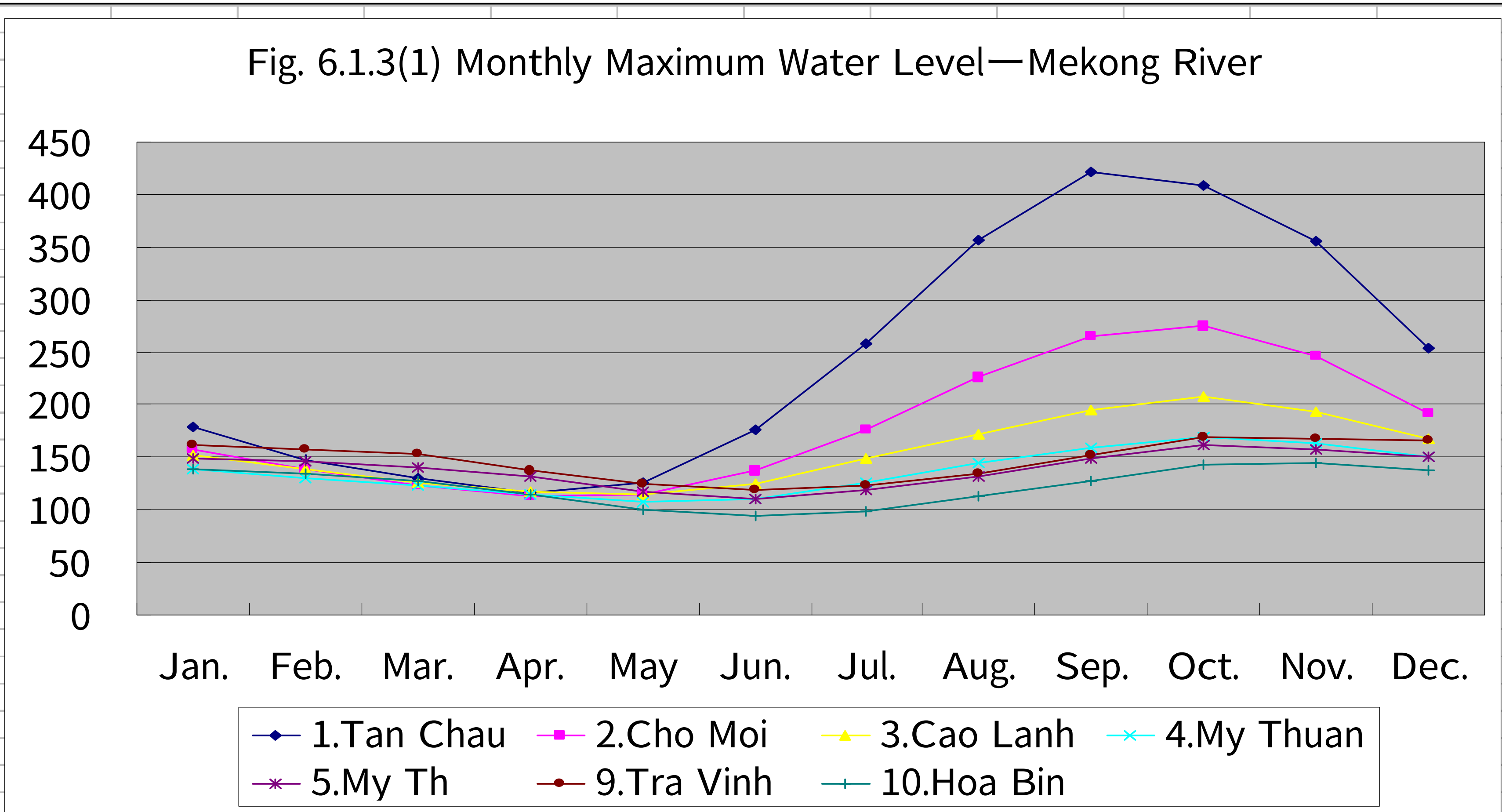
	Station
1	Cao Lanh
2	Than Chau
3	My Tho
4	Moc Hoa
5	Bin Ba
6	Tay Ninh
7	Camau
8	Phuoc Long
9	Tri An
10	Bien Hoa

Fig. 6-1-1 Rainfall Gauging Station



No	Station	No.	Station
1	Tan Chau	19	Bien Hoa
2	Cho Moi	20	Phu An
3	Cao Lanh	21	Nha Be
4	My Thuan	22	Ben Luc
5	My Tho	23	Phuoc Long
6	Cai Lay	24	Tri An
7	Moc Hoa	25	Dau Tieng
8	Hung Thanh	26	Ca Mau
9	Tra Vinh	27	Nam Can
10	Hoa Binh	28	Vung Tau
11	Chau Doc	29	Rach Gia
12	Long Xuyen	30	Tan An
13	Can Tho	31	Phung Hiep
14	Dai Ngai	32	Ganh Hao
15	Tri Ton	33	Song Doc
16	Tan Hiep	34	Phuoc Long
17	Vi Thanh	35	My Thanh
18	Thu Dau Mot		

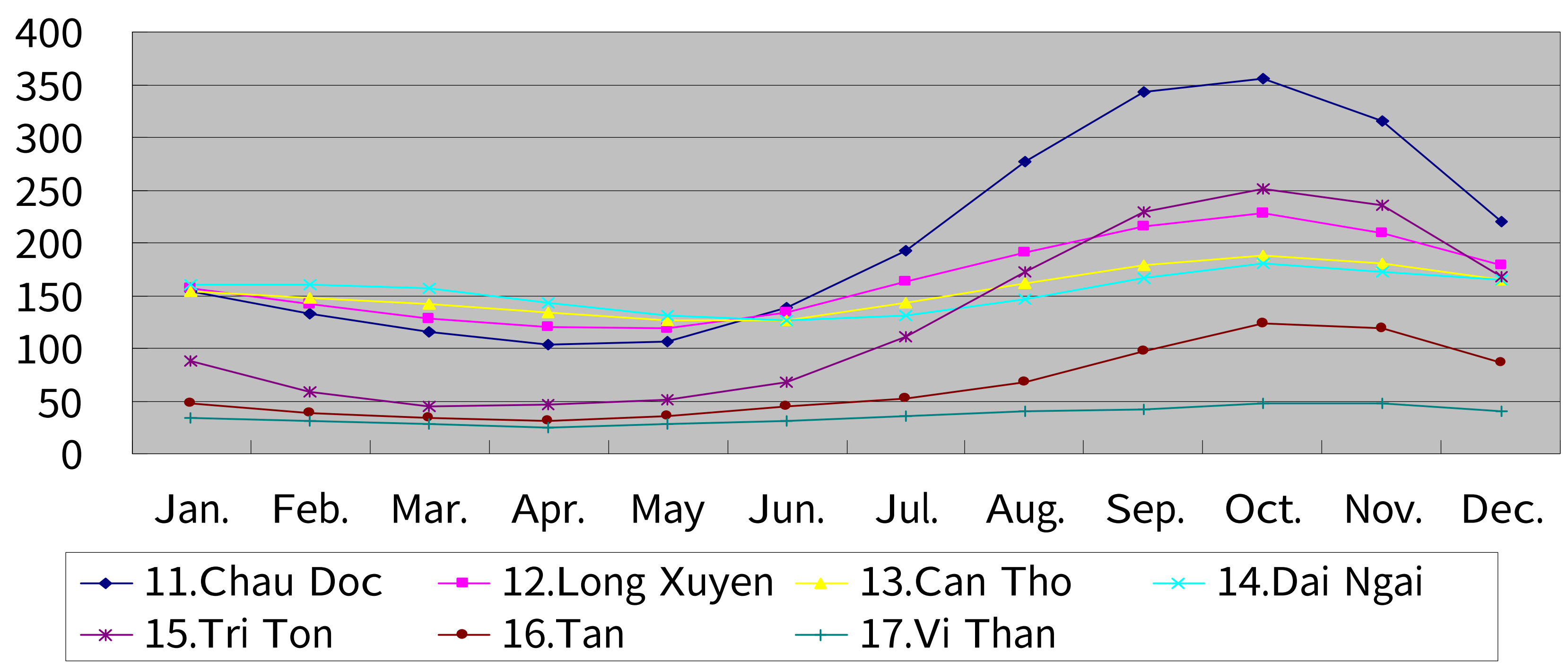
Fig. 6.1.2 Water Level Gauging Station



Datum:HN(m)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1.Tan Chau	179	147	130	117	125	176	258	356	421	408	355	254
2.Cho Moi	157	138	124	113	115	138	177	227	266	275	247	192
3.Cao Lanh	152	139	127	117	114	125	150	172	195	208	194	168
4.My Thuan	139	131	123	114	108	110	127	145	159	169	163	151
5.My Tho	149	146	140	131	118	110	119	131	149	162	158	151
9.Tra Vinh	163	158	153	138	125	119	123	135	152	169	167	167
10.Hoa Binh	140	134	128	115	100	95	98	114	128	143	144	138

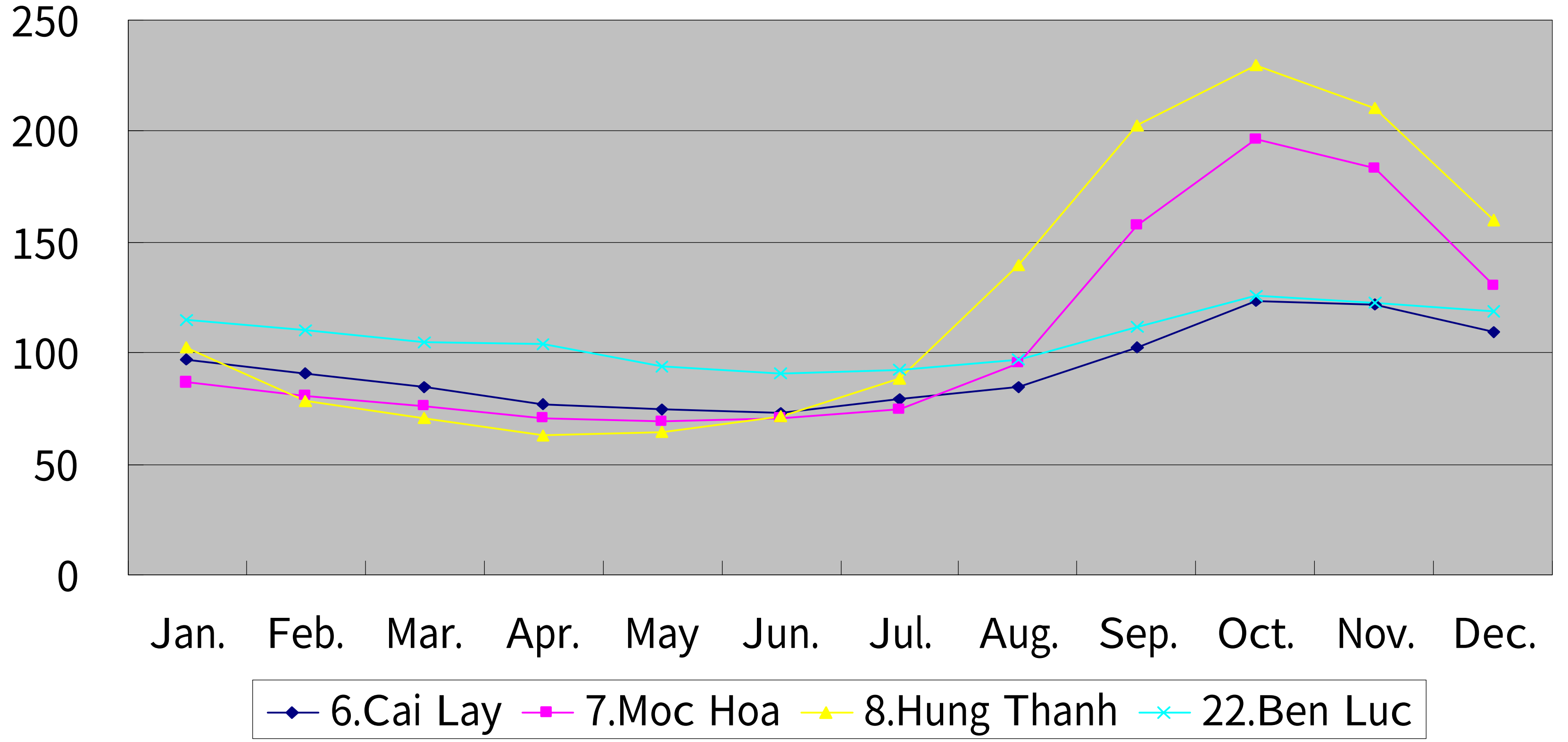
Fig 6-1-3(2) Monthly Maximum Water Level—Bassc River and Connesting Channels



Datum:HN(m)

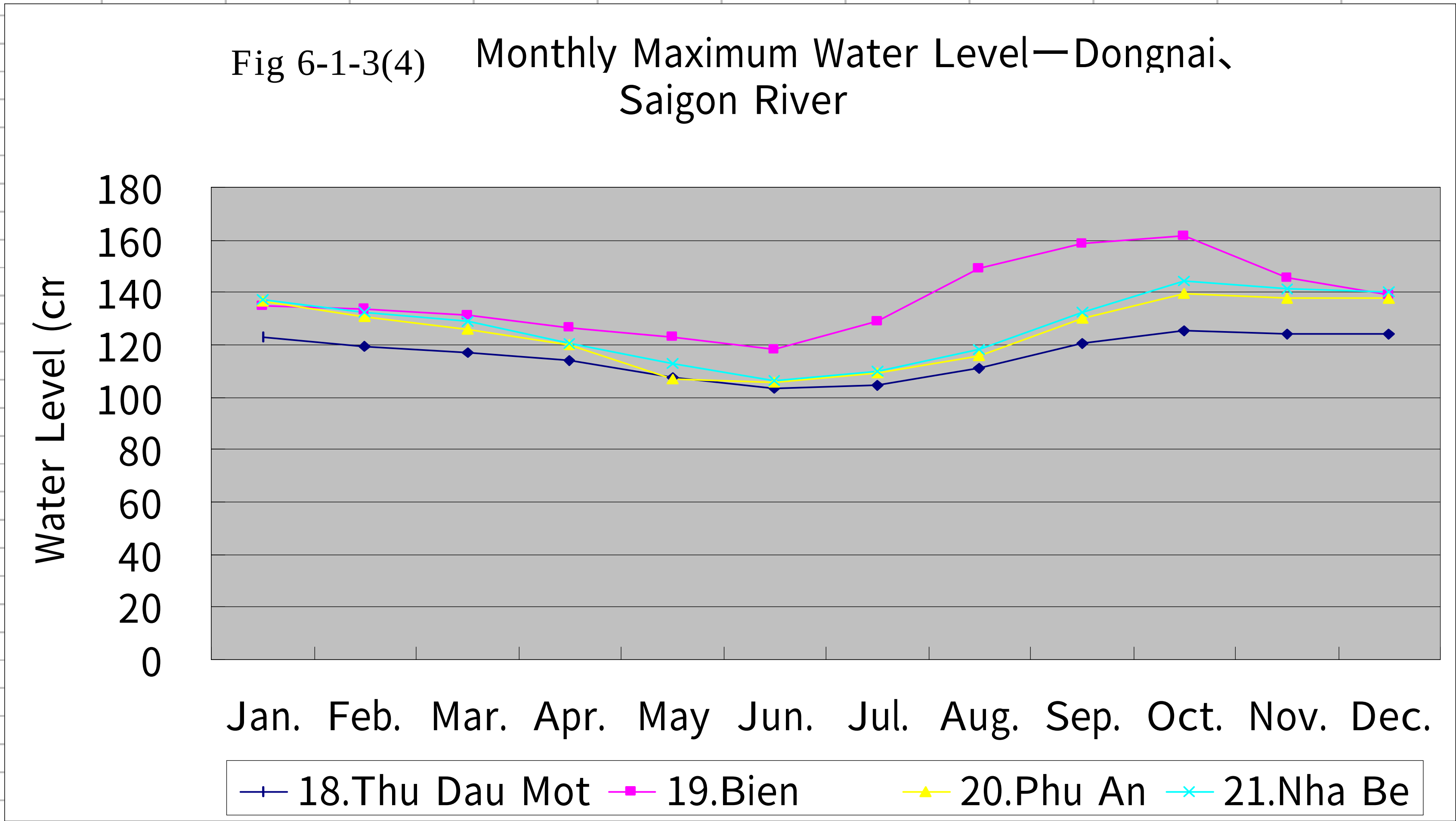
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
11.Chau Doc	154	132	116	104	107	138	193	277	344	356	315	220
12.Long Xuyen	156	141	128	120	119	133	163	190	216	228	210	179
13.Can Tho	154	147	142	135	127	127	144	162	178	188	180	165
14.Dai Ngai	161	160	156	143	131	125	131	146	166	180	172	164
15.Tri Ton	88	58	44	47	51	67	111	172	230	251	236	168
16.Tan Hiep	48	38	34	31	35	45	53	67	98	124	119	87
17.Vi Thanh	34	31	27	25	27	31	35	40	42	48	47	40

Fig 6-1-3(3) Monthly Maximum Water Level—Vam Co Tay、Vam Co Dong River



Datum:HN(m)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
6.Cai Lay	97	91	85	77	74	73	79	85	102	124	122	110
7.Moc Hoa	87	81	76	71	69	71	74	96	157	196	183	131
8.Hung Thanh	102	79	71	63	64	72	89	140	203	230	210	160
22.Ben Luc	115	110	105	104	94	91	92	97	112	126	123	119



Datum:HN(m)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
18.Thu Dau Mot	123	120	117	114	107	103	104	111	121	125	124	124
19.Bien Hoa	135	134	131	126	123	118	129	149	159	162	146	139
20.Phu An	136	131	126	120	107	106	109	116	130	140	138	138
21.Nha Be	137	132	129	121	113	106	110	118	133	144	141	140

Table 6-1-1 Meteoro-Hydrological Data

	Station	1	2	3	4	5	6	7	8	9	10	11	12	Total	Remarks(Data Source)
1	Chau Doc	2	1	27	78	196	123	124	152	152	307	201	54	1417	Prov
2	Moc Hoa	12	4	9	48	183	167	155	159	247	292	128	43	1447	Prov
3	HCM City	14	4	10	50	218	312	294	270	327	267	116	48	1930	Prov
4	Can Tho	12	2	10	50	177	206	227	218	273	277	155	41	1648	Prov
5	Ca Mau	16	8	34	100	276	322	323	349	348	326	182	82	2366	Prov

2Humidity (%) (Data Source:Local Givernment)

	Station	1	2	3	4	5	6	7	8	9	10	11	12	Average	Remarks(Data Source)
4	Can Tho	80	81	79	79	82	86	88	91	90	89	83	82	84	Prov

3。Wind Velocity (m/s) (Data Source:Local Givernment)

	Station	1	2	3	4	5	6	7	8	9	10	11	12	Average	Remarks(Data Source)
1	Phuoc Long	1.2	1.1	1.3	1.4	1.4	1.6	1.3	1.4	1.1	1.0	1.3	1.5	1.3	Prov
2	Chau Doc	1.0	1.1	1.2	1.4	1.3	1.8	1.6	2.0	1.4	1.4	1.9	1.8	1.5	Prov
3	Moc Hoa	1.6	2.1	2.2	1.8	1.8	2.4	2.0	2.5	2.2	2.0	2.0	1.6	2.0	Prov

4。Temparature (C) (Data Source:Local Givernment)

	Station	1	2	3	4	5	6	7	8	9	10	11	12	Average	Remarks(Data Source)
1	Phuoc Long	23.6	25.0	26.8	27.4	26.9	25.7	25.4	25.1	25.0	24.8	24.3	23.3	25.3	Prov
2	Chau Doc	25.6	26.0	27.6	28.5	28.3	27.6	27.6	27.5	27.8	27.8	27.3	25.8	27.3	Prov
3	Moc Hoa	25.8	27.0	27.7	28.7	28.5	27.7	27.4	27.4	27.7	27.7	27.2	26.0	27.4	Prov
4	HCM	26.5	27.3	28.3	29.3	28.9	28.5	27.8	27.9	27.6	27.3	26.9	26	27.7	Prov

Table 6-1-2 Daily Max and Monthly Rainfall

1. Cao Lanh

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	Daily Max	4.0	0.0	9.6	2.8	23.6	40.6	79.8	41.6	98.3	71.8	115.5	13.8	
	Monthly	4.0	0.0	12.6	4.7	61.6	164.5	232.9	239.7	362.5	337.2	229.2	28.1	1,677.0
1996	Daily Max	0.0	0.0	0.0	22.0	35.0	51.5	28.2	17.9	52.6	42.0	67.2	29.0	
	Monthly	0.0	0.0	0.0	53.6	116.2	214.5	225.5	79.1	229.5	317.1	423.0	68.4	1,726.9
1997	Daily Max	0.4	9.4	0.0	32.1	34.5	17.5	26.6	51.1	43.0	44.0	58.6	4.6	
	Monthly	0.4	17.7	0.0	66.4	165.6	45.7	161.1	184.9	179.3	252.9	157.5	6.7	1,238.2
1998	Daily Max	0.0	0.0	0.0	3.1	46.2	25.1	37.1	74.7	43.5	52.3	64.3	10.3	
	Monthly	0.0	0.0	0.0	3.1	102.8	189.7	223.1	222.8	182.9	271.0	287.6	46.8	1,529.8
1999	Daily Max	21.6	57.8	42.8	78.3	71.5	31.5	33.0	45.8	35.6	128.1	57.2	23.8	
	Monthly	48.3	72.8	49.0	248.6	209.9	135.1	246.4	131.2	85.4	528.0	216.5	49.7	2,020.9

2. Tan Chau

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	Daily Max	0.0	0.0	27.2	30.1	30.3	14.2	38.8	62.1	58.6	119.8	53.1	7.4	
	Monthly	0.0	0.0	30.8	62.2	66.9	81.0	153.8	275.3	269.4	304.3	147.1	44.8	1,435.6
1996	Daily Max	0.0	0.0	0.0	114.0	35.2	37.9	42.2	23.6	86.5	73.1	67.5	25.6	
	Monthly	0.0	0.0	0.0	168.4	135.2	121.6	217.7	79.5	243.1	283.5	385.2	72.0	1,706.2
1997	Daily Max	0.0	25.6	8.4	6.4	38.6	37.1	48.9	24.1	56.4	82.0	31.1	0.0	
	Monthly	0.0	25.6	8.4	12.2	130.6	79.6	149.9	94.9	212.3	428.7	72.2	0.0	1,214.4
1998	Daily Max	0.0	0.0	0.0	17.9	111.9	25.0	41.0	19.4	62.0	56.4	28.5	29.4	
	Monthly	0.0	0.0	0.0	19.8	153.3	151.8	133.8	132.1	254.4	279.5	182.1	85.3	1,392.1
1999	Daily Max	19.7	13.2	47.6	62.1	28.5	31.1	13.7	35.9	13.8	81.8	57.5	5.5	
	Monthly	24.0	13.2	76.4	228.6	113.6	107.8	94.4	146.7	62.1	301.1	189.4	18.1	1,375.4

3. My Tho

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	Daily Max	0.4	0.0	0.3	0.5	39.7	44.5	58.0	53.0	46.6	27.3	13.0	12.5	
	Monthly	0.4	0.0	0.3	0.7	129.8	209.0	259.7	223.2	275.4	199.6	28.0	29.4	1,355.5
1996	Daily Max	3.0	0.0	0.0	38.9	33.6	65.8	64.6	35.2	85.0	58.7	49.4	7.0	
	Monthly	9.5	0.0	0.0	79.0	175.1	245.6	205.3	124.9	317.0	303.1	249.8	34.4	1,743.7
1997	Daily Max	0.0	4.4	0.0	12.7	35.0	18.0	36.0	36.4	124.2	83.0	88.0	15.0	
	Monthly	0.0	10.2	0.0	23.6	129.6	62.7	239.4	200.1	288.1	427.7	171.4	16.9	1,569.7
1998	Daily Max	0.0	0.0	0.0	46.0	28.5	55.9	30.7	46.6	60.5	27.3	19.3	12.4	
	Monthly	0.0	0.0	0.0	47.2	86.5	202.5	98.7	201.2	265.2	151.0	90.3	68.8	1,211.4
1999	Daily Max	11.4	5.6	7.2	71.9	82.4	22.7	27.2	44.4	35.8	83.0	31.8	14.2	
	Monthly	18.1	6.8	10.2	361.6	344.1	92.9	183.3	157.6	106.2	322.2	232.6	48.6	1,884.2

4. Moc Hoa

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	Daily Max	0.5	0.0	5.4	22.1	59.1	36.9	49.6	50.3	93.4	240.4	31.0	13.6	
	Monthly	0.5	0.0	14.9	28.8	160.0	153.7	178.3	209.3	388.5	734.5	124.8	26.8	2,020.1
1996	Daily Max	4.6	0.0	0.0	54.5	26.4	46.6	76.2	25.4	151.1	88.8	63.7	53.2	
	Monthly	4.6	0.0	0.0	191.9	154.3	222.1	336.3	149.7	533.8	431.0	314.8	82.4	2,420.9
1997	Daily Max	0.2	47.4	0.0	86.4	45.1	19.2	34.1	31.7	90.2	107.0	57.9	7.2	
	Monthly	0.3	85.5	0.0	165.3	242.1	46.8	202.9	113.2	234.2	567.8	121.1	7.2	1,786.4
1998	Daily Max	0.0	0.0	0.0	20.3	27.8	31.2	27.2	59.8	37.0	71.3	54.8	46.4	
	Monthly	0.0	0.0	0.0	35.4	108.7	117.5	112.7	216.1	186.0	231.9	310.0	141.0	1,459.3
1999	Daily Max	20.8	6.2	15.9	34.6	29.9	60.2	26.5	55.8	25.4	60.9	150.9	10.0	
	Monthly	70.8	7.4	40.9	232.6	147.6	182.5	146.4	130.4	139.5	314.9	374.5	30.5	1,818.0

5. Tay Ninh

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	Daily Max	29.6	0.0	63.1	32.9	29.1	142.1	54.9	67.4	61.9	71.2	40.0	1.3	
	Monthly	29.8	0.0	90.1	35.7	128.3	418.4	262.6	257.2	312.3	349.1	108.6	3.4	1,995.5
1994	Daily Max	22.8	0.0	23.2	104.3	49.5	87.9	18.7	20.2	57.0	62.8	21.0	20.2	
	Monthly	23.1	0.0	34.0	122.6	208.5	314.4	112.5	89.1	371.4	212.6	33.3	20.6	1,542.1
1995	Daily Max	0.0	0.0	27.1	18.2	65.0	20.5	38.9	39.0	169.2	77.0	32.6	20.0	
	Monthly	0.0	0.0	36.7	25.5	350.5	142.8	230.1	202.1	672.4	312.9	68.1	42.7	2,083.8
1996	Daily Max	9.5	31.3	0.5	57.0	26.0	44.3	23.9	37.4	87.2	66.7	45.9	21.7	
	Monthly	13.2	31.5	0.5	90.9	176.9	257.6	139.6	199.4	469.9	441.9	275.1	25.5	2,122.0
1997	Daily Max	0.1	15.6	0.3	49.9	100.2	19.6	43.5	41.0	45.0	59.8	14.0	0.0	
	Monthly	0.1	35.6	0.3	144.9	312.7	112.3	227.3	200.0	171.6	432.9	61.5	0.0	1,699.2
1998	Daily Max	0.0	0.0	0.0	72.8	55.0	100.1	28.2	42.3	61.3	58.2	186.0	46.0	
	Monthly	0.0	0.0	0.0	122.5	78.0	308.7	134.5	216.7	443.3	194.9	430.5	119.6	2,048.7
1999	Daily Max	26.1	6.2	26.6	90.8	108.8	34.8	56.4	53.6	28.4	38.6	39.6	47.6	
	Monthly	63.7	9.8	27.3	374.0	246.6	118.7	232.7	196.0	240.2	169.6	119.7	79.9	1,878.2

6. Ca Mau

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	Daily Max	0.5	0.0	0.0	69.3	58.5	53.9	25.8	27.5	66.0	42.7	71.6	11.9	
	Monthly	0.5	0.0	0.0	214.0	183.9	340.1	203.8	245.4	292.0	297.3	188.1	43.8	2,008.9
1991	Daily Max	0.0	16.5	37.1	122.1	40.8	47.0	88.6	47.1	38.8	62.0	67.8	15.5	
	Monthly	0.0	16.5	49.4	172.4	162.7	202.9	548.0	383.7	232.2	300.7	156.4	23.3	2,248.2
1992	Daily Max	8.3	47.2	0.2	48.2	44.7	85.3	44.2	114.1	52.3	82.7	30.8	17.7	
	Monthly	14.1	80.7	0.2	96.2	206.1	432.9	311.8	589.4	204.2	460.6	86.4	37.0	2,519.6
1993	Daily Max	4.8	1.2	1.9	25.4	104.8	77.0	152.2	84.7	59.7	38.5	71.8	15.6	
	Monthly	4.8	1.2	3.5	29.8	284.3	593.6	470.5	315.9	314.8	329.1	245.7	47.7	2,640.9
1994	Daily Max	17.0	0.0	14.3	5.8	62.5	110.6	77.4	126.9	76.5	28.6	24.4	36.6	
	Monthly	22.9	0.0	37.9	12.9	448.3	419.0	398.4	456.4	447.4	104.2	65.4	76.9	2,489.7
1995	Daily Max	32.3	0.0	10.7	18.4	78.8	97.4	77.8	41.0	55.0	47.2	36.5	36.1	
	Monthly	35.0	0.0	17.8	27.9	204.7	463.0	266.7	197.2	493.2	378.4	108.0	107.5	2,299.4
1996	Daily Max	34.2	15.8	5.6	53.6	41.2	46.9	97.4	66.9	57.4	142.5	53.4	12.9	
	Monthly	62.5	15.8	5.6	238.2	190.8	257.2	473.4	253.4	276.5	690.0	265.4	42.7	2,771.5
1997	Daily Max	0.1	25.9	14.5	71.6	64.4	57.6	44.8	88.7	70.7	58.6	105.1	3.6	
	Monthly	0.1	56.8	28.1	144.7	262.0	337.4	441.2	401.9	321.5	323.0	231.6	7.9	2,556.2
1998	Daily Max	0.0	0.0	0.0	9.0	34.6	62.4	103.0	131.2	63.2	104.1	45.2	43.1	
	Monthly	0.0	0.0	0.0	9.0	82.6	285.4	271.0	354.8	420.4	748.7	286.5	137.3	2,595.7
1999	Daily Max	31.4	52.0	37.6	83.2	59.5	82.7	61.2	51.4	48.6	109.2	46.5	78.3	
	Monthly	115.7	61.7	77.5	446.5	262.2	496.2	406.6	321.1	286.2	475.4	371.5	228.8	3,549.4

7. Tra Vinh

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	Daily Max	0.0	0.0	0.0	39.0	20.6	40.0	25.0	46.7	30.2	56.8	40.0	3.2	
	Monthly	0.0	0.0	0.0	55.0	24.0	85.4	135.0	172.6	184.6	147.1	104.8	3.2	911.7
1991	Daily Max	0.0	0.0	9.7	15.3	57.0	51.0	70.1	76.0	45.5	27.5	51.5	0.0	
	Monthly	0.0	0.0	17.7	15.3	164.2	171.5	224.2	277.7	301.8	143.6	80.4	0.0	1,396.4
1992	Daily Max	0.0	0.0	0.0	27.5	19.2	29.2	45.5	44.4	36.5	84.5	12.5	0.3	
	Monthly	0.0	0.0	0.0	30.1	41.1	163.7	216.7	259.3	104.9	350.3	12.5	0.3	1,178.9
1993	Daily Max	0.0	3.5	0.0	0.0	36.6	85.8	47.2	34.4	65.2	105.0	33.1	14.2	
	Monthly	0.0	3.5	0.0	0.0	135.3	310.8	308.4	139.3	273.2	269.8	90.4	25.4	1,556.1
1994	Daily Max	6.9	0.0	0.0	6.5	51.5	57.5	46.5	49.2	66.0	78.0	0.0	48.8	
	Monthly	6.9	0.0	0.0	13.3	192.7	290.3	228.1	222.4	272.9	247.8	0.0	94.5	1,568.9
1995	Daily Max	0.4	0.0	0.0	1.4	44.0	46.0	49.4	61.7	55.8	39.2	14.5	6.2	
	Monthly	0.4	0.0	0.0	1.4	139.9	255.0	207.1	218.5	314.1	190.4	40.4	14.4	1,381.6
1996	Daily Max	8.5	0.0	0.0	13.3	33.4	75.5	30.5	27.8	50.2	80.8	37.6	41.2	
	Monthly	11.0	0.0	0.0	29.2	75.6	329.1	273.9	82.6	202.6	374.3	118.7	66.4	1,563.4
1997	Daily Max	0.0	7.1	0.0	31.9	68.0	33.6	43.5	94.1	29.2	30.6	113.3	0.0	
	Monthly	0.0	7.9	0.0	53.5	144.3	122.1	338.5	393.8	111.1	168.7	197.9	0.0	1,537.8
1998	Daily Max	0.0	0.0	0.0	21.2	9.5	107.6	32.2	46.9	34.5	94.6	43.4	71.0	
	Monthly	0.0	0.0	0.0	21.2	23.9	312.8	140.9	228.4	195.8	231.8	94.0	111.5	1,360.3
1999	Daily Max	0.5	2.5	3.1	47.4	109.0	24.2	34.5	46.7	30.3	69.7	55.5	15.3	
	Monthly	0.5	3.6	4.3	194.6	391.8	142.6	193.9	192.2	142.5	288.5	225.4	32.5	1,812.4

8. Phuoc Long

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	Daily Max	9.5	31.7	38.6	20.0	73.3	113.2	72.9	58.3	108.8	80.7	31.1	5.4	
	Monthly	9.5	31.7	65.5	32.0	242.1	299.6	342.7	395.8	447.6	385.5	43.5	12.7	2,308.2
1996	Daily Max	1.2	13.5	20.6	33.4	147.7	123.5	75.6	58.7	158.9	49.7	95.7	11.0	
	Monthly	2.0	15.0	56.2	160.7	548.2	527.7	390.7	283.4	673.6	290.3	244.8	13.8	3,206.4
1997	Daily Max	0.0	44.7	3.6	18.7	80.6	45.0	117.9	61.2	147.0	145.1	52.9	0.7	
	Monthly	0.0	64.3	7.1	97.3	393.0	259.9	771.1	442.8	331.4	415.0	144.1	0.7	2,926.7
1998	Daily Max	4.1	8.9	0.0	27.5	48.3	65.1	42.8	73.0	79.5	46.7	64.7	32.9	
	Monthly	4.1	10.0	0.0	42.7	165.6	249.1	281.3	318.7	624.4	235.3	257.9	116.2	2,305.3
1999	Daily Max	22.6	1.9	24.0	89.4	81.9	103.7	94.2	46.8	61.4	58.0	25.5	26.5	
	Monthly	79.0	2.5	71.0	330.6	537.4	573.7	601.8	281.1	453.4	351.2	102.4	45.4	3,429.5

9. Tri An

Year	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	Daily Max	20.2	35.3	4.0	32.8	118.9	80.3	116.0	73.5	87.2	48.6	31.7	6.7	
	Monthly	21.9	35.3	11.8	59.1	297.3	310.8	382.4	233.8	503.1	371.9	81.1	18.6	2,327.1
1996	Daily Max	10.0	0.1	0.5	28.1	32.6	20.6	68.6	51.6	47.9	74.6	49.6	24.6	
	Monthly	10.0	0.1	0.5	97.4	145.0	110.1	297.1	259.7	421.7	421.2	253.5	28.9	2,045.2
1997	Daily Max	0.2	35.3	0.0	79.3	51.6	40.1	45.2	41.6	41.3	29.3	36.7	1.0	
	Monthly	0.2	47.5	0.0	156.7	251.5	184.1	335.2	260.2	206.2	140.0	147.0	1.9	1,730.5
1998	Daily Max	0.0	6.2	0.0	51.8	93.0	20.9	63.3	80.0	116.4	57.6	85.8	28.6	
	Monthly	0.0	6.2	0.0	149.6	246.6	153.2	264.4	257.3	448.9	239.1	315.8	121.5	2,202.6
1999	Daily Max	2.8	0.9	22.4	62.1	95.7	115.0	111.7	90.7	75.5	54.9	83.0	4.0	
	Monthly	7.2	0.9	50.5	242.1	289.1	457.3	346.3	369.3	295.6	199.9	317.1	13.0	2,588.3

Table 6-1-3 Rainfall Days and Strength

1. Cao Lanh

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1995	216	32	62	43	12
1996	198	33	73	45	16
1997	239	33	51	30	12
1998	215	31	69	39	11
1999	195	37	74	38	21
Average	212.6	33.2	65.8	39	14.4

67.3%

2. Tan

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1995	268	2	49	32	14
1996	256	0	60	33	16
1997	277	5	45	25	13
1998	260	8	49	39	9
1999	241	14	68	32	10
Average	260.4	5.8	54.2	32.2	12.4

72.9%

3. My Tho

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1995	234	27	53	40	11
1996	206	28	77	37	17
1997	252	13	54	32	14
1998	234	36	57	28	10
1999	188	31	84	46	16
Average	222.8	27	65	36.6	13.6

68.4%

4. Moc Hoa

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1995	238	37	49	33	18
1996	194	41	61	44	25
1997	235	19	61	32	18
1998	220	37	61	34	13
1999	193	40	75	45	12
Average	216	34.8	61.4	37.6	17.2

5. Tay Ninh

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1993	207	46	58	33	21
1994	217	39	64	32	13
1995	217	36	57	32	23
1996	196	37	69	40	24
1997	219	38	55	35	18
1998	231	28	44	45	17
1999	172	60	79	40	14
Average	208.4	40.6	60.9	36.7	18.6

68.2%

6. Ca Mau

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1990	203	30	65	51	16
1991	206	26	59	56	18
1992	201	30	68	37	30
1993	204	32	59	39	31
1994	195	29	72	47	22
1995	205	34	56	43	27
1996	176	35	74	49	32
1997	207	27	61	41	29
1998	201	32	64	35	33
1999	152	26	82	60	45
Average	195.0	30.1	66.0	45.8	28.3

61.7%

7. Tra vin

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1990	286	9	39	24	7
1991	254	13	52	35	11
1992	283	6	39	28	10
1993	254	11	59	24	17
1994	266	5	52	25	18
1995	255	10	58	29	13
1996	254	8	52	37	15
1997	262	11	45	33	14
1998	260	15	49	28	13
1999	203	24	81	43	14
Average	257.7	11.2	52.6	30.6	13.2

8. Phuoc Long

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1995	200	33	72	35	25
1996	156	36	81	64	28
1997	194	24	75	41	31
1998	200	15	81	44	25
1999	156	30	85	55	39
Average	181.2	27.6	78.8	47.8	29.6

57.2%

9. Tri An

YEAR	Rainfall Strength(mm) and Days				
	0	0 ～ 1	1 ～ 10	10 ～ 30	30 ～
1995	222	30	57	29	27
1996	202	30	72	41	20
1997	214	23	67	47	14
1998	210	27	62	46	20
1999	191	34	73	38	29
Average	207.8	28.8	66.2	40.2	22.0

Appendix 6-2 : Hydrological Analysis and Design Water Level

Table 6-2-1: Water Level Gauging Stations and Water Level Data

EL..Dataum: State

Name of W.L Station	Provinces	River/Canal	Main River	No.of Data	Water Levels Max (cm)	Water Levels Min (cm)	Max-Min (cm)
1.Tan Chau	An Giang	Tien	Mekong River (upper)	41	512	281	231
2.Cho Moi	An Giang	Rach Ong Chuong	Mekong River	18	324	205	119
3.Cao Lanh	Dong Thap	Tien	Mekong River	18	230	177	53
4.My Thuan	Soc Trang	Tien	Mekong River	19	189	147	42
5.My Tho	Tien Giang	Tien	Mekong River (Down)	17	175	131	44
6.Cai Lay	Tien Giang	Rach Ba Rai	Rach Ba Rai	17	170	89	81
7.Moc Hoa	Long An	Vam Co Tay	Vam Co Tay River (upper)	18	279	106	173
8.Hung Thanh	Dong Thap	Phuoc Xuyen	Phuoc Xuyen Canal	12	314	147	167
9.Tra Vinh	Tra Vinh	Co Chien	Mekong River (Down)	18	182	154	28
10.Hoa Binh	Tien Giang	Tien	Mekong River (Down)	18	168	132	36
11.Chau Doc	An Giang	Hau	Bassac River (Upper)	41	490	254	236
12.Long Xuyen	An Giang	Hau	Bassac River (Upper)	18	266	185	81
13.Can Tho	Can Tho	Hau	Bassac River (Middle)	23	209	164	45
14.Dai Ngai	Soc Trang	Hau	Bassac River (Down)	23	203	162	41
15.Tri Ton	An Giang	Xang Tri Ton	Xang Tri Ton Canal	10	308	155	153
16.Tan Hiep	Kien Giang	Kenh Cai San	Kenh Cai San Canal	18	190	77	113
17.Vi Thanh	Can Tho	K enh Xa No	K enh Xa No Canal	18	78	41	37
18.Thu Dau Mot	Binh Duong	Sai Gon	Vam Co Dong River (Middle)	16	119	108	11
19.Bien Hoa	Dong Nai	Dong Nai	Dong Nai River (Middle)	16	202	129	73
20.Phu An	Ho Chi Minh	Sai Gon	Vam Co Dong River (Down)	17	144	122	22
21.Nha Be	Ho Chi Minh	Dong Nai	Vam Co Dong River (Down)	18	142	127	15
22.Ben Luc	Long An	Vam Co Dong	Vam Co Dong River (Down)	18	137	97	40
23.Phuoc Long	Binh Phuoc	Dong Nai	Dong Nai River (Upper)	14	1597	1306	291
24.Tri An	Dong Nai	Dong Nai	Dong Nai River (Middl3e)	10	6196	4079	2117
25.Dau Tieng	Tay Ninh	Sai Gon	Vam Co Dong River (Upper)	16	408	128	280
26.Ca Mau	Ca Mau	Ong Doc/Bay Hap	Ong Doc/Bay Hap	20	95	69	26
27.Nam Can	Ca Mau	Cua Lon	Cua Lon/East Sea/Thai Gulf	18	146	97	49
28.Vung Tau	Ba Ria Vung Tau	East sea	East Sea	25	149	115	34
29.Rach Gia	Kien Giang	Thailand Gulf	Thai Gulf	20	115	108	7
30.Tan an	Long An	Vam Co Tay	Vam Co Tay River (Middle)	20	175	73	102
31.Phung Hiep	Soc Trang	Quan La	Bassac River (Down)/Canal	16	147	122	25
32. Ganh Hao	Bac Lieu	East sea	East Sea	15	214	176	38
33.Song Doc	Ca Mau	Thailand Gulf	Thai Gulf	4	91	63	28
34.Phuoc Long	Bac Lieu	Phung Hiep	Phung Hiep Canal	15	60	38	22
35.My Than	Soc Trang	Thailand Gulf	East Sea	2	188	187	1

Table 6-2-2 (1) Maximum Water Level

Datum : State (cm)

River	Tien	Hau	Hau	East Sea
Year	1. Tan Chau	11.Chau Doc	14.Dai Ngai	28.Vung Tau
	Max.	Max.	Max.	Max.
1959	390	331		
1960	429	387		
1961	512	490		
1962	454	427		
1963	423	389		
1964	446	401		
1965	389	337		
1966	511	485		
1967	427	387		
1968	405	343		
1969	424	387		
1970	452	424		
1971	430	391		
1972	432	397		141
1973	417	379		127
1974	397	357		142
1975	427	380		149
1976	367	313		130
1977	352	283		128
1978	478	446		128
1979	394	341	184	132
1980	445	401	178	128
1981	452	377	180	129
1982	424	373	170	116
1983	402	349	179	121
1984	481	439	192	131
1985	416	383	173	114
1986	402	359	178	115
1987	355	311	181	115
1988	314	266	167	115
1989	348	307	186	125
1990	417	386	162	128
1991	464	427	177	128
1992	343	290	187	137
1993	344	314	183	131
1994	453	427	193	142
1995	431	392	185	146
1996	487	454	192	129
1997	418	379	203	
1998	281	254	189	
1999	418	384	190	

Table 6-2-2 (2) Maximum Water Level

River	Tien		Rach Ong Chuong		Tien		Tien		Tien		Rach Ba Rai		Vam Co Tay		Phuoc Xuyen	
Year	1. Tan Chau		2. Cho Moi		3. Cao Lanh		4. My Thuan		5. My Tho		6. Cai Lay		7. Moc Hoa		**8. Hung Thanh**	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1977							132									
1978							162									
1979							143									
1980							151									
1981							151									
1982			281	-78	200	-107	160	-141	145	-197			156	-91	207	-23
1983			262	-101	191	-127	153	-139	145	-204	99	-145	137	-120	183	-46
1984			313	-77	210	-104	156	-136	154	-194	131	-140	243	-113	252	-31
1985			273	-93	186	-112	153	-139	142	-198	96	-157	171	-103	184	-64
1986			255	-100	192	-128	156	-155	145	-190	107	-171	172	-127	N.A	N.A
1987			237	-84	174	-112	149	N.A	N.A	N.A	95	-151	144	-175	169	-53
1988	Ref. Table-(1)		213	-78	173	-96	140	-140	139	-211	100	-150	106	-114	N.A	N.A
1989			224	-76	193	-95	156	-126	150	-204	104	-133	145	-88	N.A	N.A
1990			268	-88	197	-96	149	-125	148	-189	99	-141	179	-88	N.A	N.A
1991			296	-82	209	-105	161	-128	153	-202	131	-132	246	-77	N.A	N.A
1992			224	-79	175	-99	156	-128	157	-199	93	-144	122	-98	N.A	N.A
1993			233	-77	178	-106	154	N.A	148	-191	89	-120	162	-74	164	-41
1994			309	-81	219	-110	177	-135	156	-189	137	-122	256	-84	253	-51
1995			265	-89	181	-120	N.A	-165	131	-214	105	-145	229	-90	246	-25
1996			324	-52	230	-82	165	-114	161	N.A	170	-97	279	-51	314	-1
1997			283	-57	210	-84	N.A	N.A	175	-121	138	-102	229	-63	256	-8
1998			205	-66	177	-88	N.A	N.A	156	-182	101	-96	132	-49	147	-11
1999			282	-68	205	-99	N.A	N.A	160	-190	125	-97	200	-46	235	-3

River	Co.Chien		Tien		Hau		Hau		Hau		Hau		Xang Tri Ton		Kenh Cai San		Kenh X
Year	9.Tra Vinh		10.Hoa Binh		11.Chau Doc		12.Long Xuyen		13.Can Tho		14.Dai Ngai		**15.Tri Ton**		16. Tan Hiep		17.Vi T
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1982	165	-224	132	-229			237	-75	160	-119			N.A	N.A	107	-58	44
1983	167	-166	152	-225			230	-84	163	-127			N.A	N.A	107	-52	52
1984	178	-157	151	-233			250	-63	169	-115			N.A	N.A	163	-42	44
1985	163	-161	141	-235			227	-72	154	-126			N.A	N.A	119	-43	47
1986	172	-215	147	-236			239	-82	159	-135			N.A	N.A	109	-42	48
1987	168	-210	144	-232			220	-72	157	-118			N.A	N.A	90	-52	44
1988	162	-212	145	-237			200	-67	150	-120			N.A	N.A	77	-44	49
1989	177	-205	147	-236			218	-70	169	-118			N.A	N.A	102	-40	47
1990	169	-212	148	-223	Ref. Table-(1)		234	-60	150	-107	Ref. Table-(1)		253	-21	126	-29	41
1991	174	-216	153	-225			257	-60	158	-106			276	-29	154	-38	54
1992	182	-197	156	-212			216	-59	166	-110			209	-27	104	-30	43
1993	154	-214	148	-222			220	-61	164	-146			218	-22	107	-37	41
1994	160	-211	143	-220			266	-72	176	-151			294	-24	171	-28	47
1995	163	-204	150	-202			226	-81	167	-142			276	-19	154	-20	59
1996	162	-201	168	-212			243	-70	173	-135			308	-6	190	-13	78
1997	180	-205	163	-205			230	-73	184	-135			275	-18	155	-30	60
1998	155	-205	160	-190			185	-76	167	-133			155	-24	83	-23	47
1999	170	-210	165	-211			222	-84	179	-136			250	-4	139	-6	59

River	Sai Gon		Dong Nai		Sai Gon		Dong Nai		Vam Co Dong				Dong Nai			
Year	18. Thu Dau Mot		19. Bien Hoa		20. Phu An		21. Nha Be		22. Ben Luc		23.Phuoc Long		24.Tri An		25.Dau Tieng	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1982			N.A		123	-239	128	-257	97	-183	N.A	N.A	N.A	N.A	N.A	N.A
1983			N.A		122	-238	127	N.A	102	-172	N.A	N.A	N.A	N.A	N.A	N.A
1984	114	-223	142	-196	128	-243	133	-257	106	-181	1398	902	4079	3562	408	-76
1985	108	-250	112	-186	123	-246	127	-274	105	-184	1375	899	4401	4032	185	-98
1986	115	-231	174	-196	N.A	N.A	132	-238	110	-171	1566	904	4540	4027	379	-103
1987	110	-239	132	-204	123	-243	131	-250	105	-168	1597	901	5088	4021	188	-95
1988	111	-248	113	-200	123	-246	127	-250	105	-168	1328	904	N.A	N.A	128	-90
1989	113	-249	151	-200	131	-247	140	-254	117	-184	1323	907	N.A	N.A	258	-92
1990	111	-234	185	-180	127	-236	129	-243	107	-187	1556	898	N.A	N.A	226	-90
1991	111	-236	150	-170	124	-231	131	-237	115	-178	1452	900	N.A	N.A	176	-88
1992	112	-216	156	-165	129	-221	140	-230	112	-179	1539	900	N.A	N.A	151	-92
1993	110	-223	144	-164	123	-228	129	-228	113	-178	1306	903	N.A	N.A	237	-90
1994	109	-217	179	-165	123	-227	129	-234	120	-177	1400	894	6182	4973	200	-75
1995	112	-213	164	-163	130	-216	134	-229	122	-174	1594	899	6162	4895	135	-74
1996	116	-206	179	-167	134	-211	140	-227	137	-174	1448	907	6184	5196	201	-72
1997	115	-214	160	-158	133	-214	137	-230	123	-176	1335	905	6177	4856	178	-79
1998	116	-210	159	-165	133	-215	136	-225	117	-156	N.A	N.A	6186	4960	351	-86
1999	119	-210	187	-148	144	-223	142	-249	120	-170	N.A	N.A	6196	5372	240	-95

Year	26. Ca Mau		27.Nam Can		28.Vung Tau		29.Rach Gia		30.Tan An		31.Phung Hiep		32.Ganh Hao		33.Song Doc	35.My Thanh	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.		34.Phuoc Long	
1977									122	N.A					Max.	Max.	Max.
1978	86						108	N.A	154	N.A							
1979	85						89	N.A	128	N.A							
1980	90						73	N.A	129	N.A							
1981	90						90	N.A	128	N.A							
1982	84	-72	105	N.A			76	N.A	134	N.A	126	N.A					
1983	88	-78	107	N.A			83	N.A	123	N.A	122	N.A					
1984	95	-65	106	N.A			115	N.A	133	N.A	130	N.A					
1985	88	-70	101	N.A			85	N.A	124	N.A	128	N.A	178			50	
1986	92	-74	103	N.A			82	N.A	129	N.A	142	N.A	177			47	
1987	89	-78	104	N.A			79	N.A	122	N.A	139	N.A	178			46	
1988	91	-71	97	N.A	Ref. Table-(1)		88	N.A	119	N.A	137	N.A	176			49	
1989	94	-68	100	N.A			97	N.A	130	N.A	147	N.A	188			48	
1990	94	-73	103	N.A			77	N.A	126	N.A	146	N.A	172			39	
1991	91	-70	107	N.A			100	N.A	143	N.A	129	N.A	180			45	
1992	88	-66	106	N.A			88	N.A	134	N.A	140	N.A	196			45	
1993	85	-67	106	N.A			70	N.A	159	N.A	135	N.A	178			38	
1994	74	-62	116	N.A			82	N.A	175	N.A	136	N.A	178			42	
1995	79	-48	120	N.A			88	N.A	108	N.A	128	N.A	177			53	
1996	75	-43	123	N.A			98	N.A	167	N.A	128	N.A	172		70	60	
1997	69	-48	146	N.A			93	N.A			129	N.A	214		63	57	
1998											N.A	N.A	183		72	48	189
1999											N.A	N.A	202		91	53	187

Note:

1).N.A : Not Available

Data 6-2-1 Design Water Level of 2 Bridges in Dong Tap Provinces

1.Water Levels in 1978 Floods

Unit: Nui Nai EL (m)

No.	Stations	Areas	1961	1966	1978	1984	1991	1994	1996	Max
1	Tan Chau	Mekong river	5.21	5.27	4.94	4.97	4.8	4.67	4.8	5.27
2	Hung Thanh	Plain of reeds			*2.45	2.45	2.54	2.94		2.94

Note

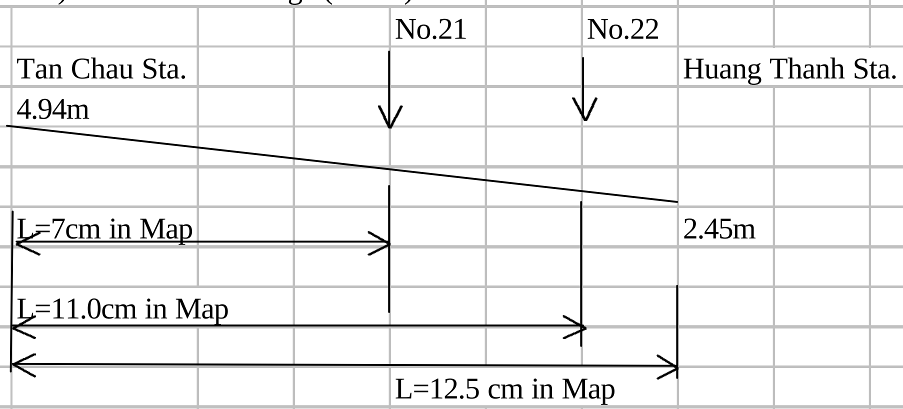
Datum : Mui Nai EL (=State EL+0.167m)

Datum : State=Mui Nai - 0.167m

*: Estimted Water Level referring to the water level relations of Tan Chau Station in 1978 and 1984

2.Estimate of Water Levels

Tram Chim Bridge (No.21) and Kenh Tu Bridge (No.22)



1).Tram Chim Bridge (No.21)	Mui Nai EL=3.5m	State EL=3.33m
2).Kenh Tu Bridge (No.22)	Mui Nai EL=2.7m	State EL=2.53m

Data 6-2-2 Design Water Level of 2 Bridges in Dong Tap Provinces

HYDROLOGICAL CACULATION FOR SAIGON BRIDGE

1). Calculation of Design discharge and water level

The SaiGon Bridge spans across the Saigon River at the upstream section belonging to Binh Phuoc Province. Due to the almost of river water flows in the main riverbed so causing a big velocity.

- The historical flood happened at the bridge site in 1990 with the maximum water level of 19.66m, which corresponding to the discharge of 766.20m^3/s and flow velocity of 2.126m/s.
- The second one happened in 1998 with the maximum water level of 18.84m and discharge of 660.24m3/s, and velocity of 2.084m/s
- The average annual maximum water level is corresponding to the maximum water level in 1990, which was 18.34m, and corresponding with discharge of 582.60 m3/s and flow velocity of 2.012m/s.
- Based on the rainfall records in Binh Phuoc and the discharge records at Thu Dau Mot, the coefficient of variation for river section was determined with result as below:

Cv = 1.52

Based on the coefficient of variation (Cv), it can determine the module coefficient K, which is the ratio between the maximum discharge of design frequency and the average maximum discharge, and based on the ready –calculated table No. 40 of the “ Bridge design” book compiled by BONDAKOB (Russian), with f = 1% k = 1.52

So design flood discharge with f = 1% is determined as follows:

Q 1% = k . Q 51% = 1.52 x 582.6m3/s

= 885.40m3/s

Based on the determined discharge and water level results, establishing the curve of discharges water level, and with Q1% = 885.40m3/s H1% = 20.095m and V1% = 2.20m/s.

2) Calculation of Bridge Opening

The geological condition at Bridge site is bedrock through a long-term period, the weathered and weak upper layers have been eroded, and established a stable river bed.
With design 1% flood water level, H1% = 20.095m the river width is 62m and t he proposed bridge scheme of 3 spans in type of 24,54mreinforced concrete girders (3 x 24,54m) will be suitable.

3) Scour Calculation

- At the bridge site, the riverbed is rock so the scour calculation is not necessary.
- Maximum water level with p = 5%

H 5% = 18.84m

- The elevation of girder bottom will be : 18.84m + 3m = 21.84m

Appendix 7.
Survey Result of Geo-technical Investigation

APPENDIX-7 SURVEY RESULT OF GEOTECHNICAL INVESTIGATION

7.1 Topographic Survey

7.1.1 Regional Topography

The Mekong Delta is a very large delta of about fifty thousand square kilometers extending into the South China Sea. It is fed by the Mekong River, which flows for around four thousand kilometers from China through Myanmar, Thailand, Laos, Cambodia and Vietnam.

The capital of Cambodia, Phnom Penh, lies at the entrance to the delta. The delta then opens into roughly triangular region, the sides of the triangle being three hundred kilometers in length. At Phnom Penh the Mekong River divides into the main channel and the Bassac River. Both these rivers branch further into numerous channels before flowing into the South China Sea.

In Vietnam, the river is known as the Cuu Long River.

The Mekong Delta is located in the monsoon/savanna zone and rainfall is concentrated in the period May to December. In the dry season the region is arid and semi desert. The Mekong Delta can be divided into characteristic areas as follows:

(1) Developed Area of Mekong Delta

The upper reaches of the Mekong Delta lie in Cambodia and the lower reaches in Vietnam. Until the period of French rule, most of the Mekong Delta was marshland with the exception of riverside cities and towns and rice fields in the New Delta region. From the end of the nineteenth century, steady progress was made in the development of rice fields and by 1920, the Delta was a major world rice-producing region.

After the Second World War, rice output decreased sharply under a socialist agricultural administration and due to flooding of the area. From the 1980's after the socialist administration was discontinued, rice production recovered rapidly and by the 1990's the area was exporting 1.5 to 3.0 million tons annually.

(2) New Mekong Delta

The Mekong Delta is estimated to have been formed about 10,000 years ago in what is now Vietnam. The oldest delta deposits are in the region known as the New Delta and this zone of relatively higher land covers the central Mekong Delta, extending to the northeast and southwest roughly in the form of an arc. The three cities of My Tho, Vinh Long and Can Tho lie in this area. This area formerly suffered from a shortage of water, and in the wet season only single cropping of rice was possible. With the completion of a pumped irrigation network, paddies now work on a three-crop basis and fruit and vegetables are grown, and the area has become a centre of agricultural production.

(3) Marshland (including reed beds and salt marsh)

Marshland is extensively found to the north and south of the New Delta. The northern section is cut off from the sea by the higher land of the New Delta, and is called Dong Thap Muoi. The soil is strongly acidic and in the wet season is submerged under the rising waters of the Mekong River, consequently only float paddy cropping used to be possible. Since 1975 many canals have been constructed and double-cropping became possible, with the result that the area has become a centre of agricultural development.

The southern marshland is in low-lying land between the New Delta and the coastal sea dunes, and is extensive in the south and west of the Delta. In the early twentieth century, a drainage channel was cut through the dunes and development of the western area became possible. However, to the north of Rach Gia the presence of the eastern dunes prevents supply of water from the Mekong River and the area remains undeveloped.

(4) Dunes

Sand dunes are found in the southern part of the estuary, lying in an arc shaped area to the south and west of the marshland. The long-established ports of Tra Vinh, Soc Trang, Bac Lieu, Rach Gia are in this zone.

(5) Coastal Marshland

In the eastern part of the Delta, including the estuary of the Dong Nai River and the southernmost part of the Delta, the Ca Mau peninsula, the delta is still actively expanding. This region is vegetated with mangrove, nipa palm etc. At present, farming of shrimps, crab and other seafood for export is being developed in this area.

(6) Lower Terrace

The Lower Terrace lies between the central highland and the Mekong Delta. Ho Chi Minh City is located just to the northeast of the Mekong Delta, on the southern edge of the Low Terrace. The area has been developed for rubber plantations etc.

In this report, the results of a survey of the conditions at the site of 38 planned bridges are presented. The topographic survey included centreline, longitudinal section, cross-section, leveling and plain table surveys. Eight survey teams carried out the work in a one-month period. A summary of the survey work is given in the following table and those bridges are shown as location map.

7.1.2 Topographic Survey Summary

(1) Scope of Work

Number of bridges: 38 (construction 21, procurement 17)

Item	Survey Item	Bridge Type	Survey quantities
Plan extent of survey	Direction of road	Construction	50m + river width + 50m
		Procurement	150m + river width + 150m
	Direction of river	Construction	Upstream and downstream 25m from road centreline
		Procurement	Upstream and downstream 500m from road centreline
Survey item and method	Road centre line survey	Construction	Total length = 150m × 17 bridges = 2,550m
			{1 bridge = 50m + bridge length (50 m) + 50m = 150m}
		Procurement	Total length = 360m x 21 bridges = 7,560 m
			{1 bridge = 150 m + bridge length (60m) + 150m = 360m}
	Road cross section survey	Construction	Approach roads: each 20m pitch
			6 sections/site × width 50m (25m from road centreline)
			Total length = 6 × 50m × 17 sites = 5,100m
			Total 6 sections/site ×17 = 102 sections
		Procurement	Approach roads each 20m pitch
			14 sections/site × width 50m (25m from road centreline)
			Total length = 14 × 50m x 21 sites = 14,700m
			Total = 14 sections/site x 21 = 294 sections
	River longitudinal section	Construction	50m (upstream and downstream 25m) × 17 sites = 850m
		Procurement	1,000m (upstream and downstream) × 21 sites = 21,000m
	River cross-section survey	Construction	1 cross-section = 25m + 50m + 25m = 100m
			3 No. sections/site, total 3 × 17 = 51 sections
			Total length = 100m × 3 sections × 17 sites = 5,100m
		Procurement	1 cross-section = 25m + 60m + 25m = 110m
			5 No.sections/site, total = 5 × 21=105 sections
			Total length = 110m × 5 sections × 21 sites = 11,550m
	Plane table	Range	{(100x17)+(300x21)} × width 50m = 40.0ha
	Leveling	Installation of Temporary Bench Mark	
		Measurement by GPS for 38 Bridges	

(2) Survey Output

Bridge and Road	Plan Map	Scale	1/200
	Longitudinal Profile	Scale	V: 1/100 H: 1/200
	Cross Section	Scale	V. H: 1/100
River	Longitudinal Profile	Scale	V: 1/100 H: 1/500
	Cross section	Scale	V: 1/100 H: 1/200

7.2 Geotechnical Investigation

7.2.1 The Purpose and the Scope of the Investigation

Geotechnical investigation was carried out at a total of 26 bridge sites to obtain data for bridge foundation and soft ground treatment design. Of these, 21 bridges are to be constructed on site and 5 are to be prefabricated structures. In this report these are subsequently termed 'construction' and 'procurement' bridges respectively. Boreholes were carried out including standard penetration tests, undisturbed sampling, and laboratory soil testing (physical and mechanical properties).

A summary of the extent of the survey is shown in the tables below, table 7.2.2.and on the location map. Longitudinal soil profiles are shown in Appendix

(1) Boreholes

In order to determine the geological conditions at the 26 bridges, two boreholes were sunk at each site. The survey was carried out by eight drilling teams using XJ-100 type Chinese-made rigs over a one-month period. Details are shown in table 7.2.2 and in the table below.

Table 7.2.1 Quantities of ASTM Standards In-situ Tests and Laboratory Soil Tests

Item	ASTM standard	Bridge Foundation	Laboratory Soil Test	Total	Remarks
Standard Penetration Test	D-1586	1002	-	1002	
Undisturbed Sampling	D-1587	152	-	152	
Specific Gravity	D-854-58	-	136	136	
Natural Moisture Content	D-2216	-	136	136	
Grading	D-422	-	136	136	
Liquid Limit	D-423	-	136	136	
Plastic Limit	D-424	-	136	136	
Bulk Density	-	-	136	136	Caliper method
Unconfined Compression	D-2166	-	136	136	
Consolidation	D-2435	-	136	136	

Table 7.2.2 Quantities of Machine Boring Survey

Province / City	Bridge NO	Request				Machine Boring Survey and Test					
		Bridge Name	Length (m)	Width (m)	Const.: * Procu.:**	Boring NO.	Boring Depth (m)	Standard Penetration Test	Undisturbed Sampling	Laboratory Soil Test	Remark
BAC LIEU	(3)	HOA BINH-2	60	5.5	*	BH-1	26.0	16	3	3	
						BH-2	25.5	16	4	4	
	(4)	DEN	60	5.5	*	BH-1	28.5	18	3	3	
						BH-2	28.5	18	3	3	
CA MAU	(6)	VAM DINH	60	5.5	*	BH-1	50.0	33	4	3	
						BH-2	50.0	30	4	3	
	(7)	KINH KIEM LAM	80	5.5	*	BH-1	40.0	24	3	3	
		NO.1				BH-2	42.0	24	4	4	
SOC TRANG	(8)	HUYNH HUU NGHIA	45	5.5	*	BH-1	40.0	26	3	3	
						BH-2	35.0	23	3	3	
CAN THO	(12)	LONG MY	90	8.0	*	BH-1	30.0	19	5	3	
						BH-2	31.0	20	4	3	
KIEN GIANG	(15)	VAM SANG THI DOI	75	5.5	*	BH-1	29.5	19	3	3	
						BH-2	29.0	19	3	3	
	(16)	HA GIANG	70	5.5	*	BH-1	31.0	20	3	3	
						BH-2	32.0	21	3	3	
AN GIANG	(18)	THOAI GIANG	90	5.5	*	BH-1	20.3	13	6	3	
						BH-2	21.3	15	6	3	
DONG THAP	(21)	TRAM CHIM	80	6.5	*	BH-1	40.5	26	5	4	
						BH-2	41.0	26	4	3	
VINH LONG	(23)	HOA TINH	74	5.5	*	BH-1	62.0	40	5	5	
						BH-2	63.0	41	2	1	
TRA VINH	(26)	TAN AN	45	6.5	*	BH-1	45.0	30	4	3	
						BH-.2	46.0	30	4	3	
TIEN GIANG	(30)	LONG BINH	38	5.5	*	BH-1	54.5	30	3	3	
						BH-2	57.5	37	3	3	
	(32)	TRA TAN	75	5.5	*	BH-1	33.5	19	3	3	
						BH-2	33.5	21	3	3	
BEN TRE	(35)	RANH TONG	85	6.5	*	BH-1	50.0	29	3	3	
						BH-2	50.5	29	3	3	
LONG AN	(38)	BA LY	65	5.5	*	BH-1	34.0	22	3	3	
						BH-2	36.0	23	3	3	
	(39)	VINH CONG	40	6.5	**	BH-1	28.5	19	3	3	
						BH-2	28.0	26	3	3	
TAY NINH	(40)	SAIGON	80	6.5	*	BH-1	13.0	6	2	2	
						BH-2	14.2	6	3	3	
BINH DUONG	(45)	CHUA	30	5.5	*	BH-1	18.5	11	3	3	
	(46)	RACH RO	27	5.5	**	BH-1	23.0	15	3	3	
						BH-2	23.0	15	3	3	
BINH PHUOC	(48)	DAKIA	45	6.5	*	BH-1	10.0	-	-	-	Hard Rock
						BH-2	10.0	-	-	-	"
	(50)	NO.5	38	6.5	**	BH-1	14.0	6	2	2	
DONG NAI	(53)	CHAY	50	5.5	*	BH-1	53.0	29	3	3	
						BH-2	50.0	33	3	3	
	(54)	BAU XEO	30	5.5	**	BH-1	12.0	3	2	2	
	(55)	SONG THAO	20	5.5	**	BH-1	12.0	2	1	1	
BA RIA VUNG TAU	(58)	AP AN BINH	45	5.5	*	BH-1	50.0	28	3	3	
						BH-2	50.0	26	3	3	
TOTAL					(21+5)	(41+7)	48	46	46	46	
	26				26	48	1,645.8	1002	152	136	

(2) Seismicity

The Mekong Delta lies in the south part of the Indochinese Peninsular, to the southwest of the Pacific Rim seismic zone. This is a seismically inactive zone, since according to the International Seismic Centre of Tokyo University there are no records of earthquakes in Cambodia, South Vietnam, Southern Laos, Thailand and Malaysia.

Furthermore, according to the earthquake damage records (Mr. Utu Tokuji - 1990-) there are no recorded incidents of earthquake damage in the Mekong Delta. Locations of recorded earthquakes in the world are shown on Figures 7.2.1 to 7.2.3.

Figure 7.2.1 Earthquake distribution map of the world (M>4.0 Depth less than 100km 1975~1994)

Figure 7.2.2 Earthquake distribution map of the world (M>4.0 Depth over 100km1975~1994)

Figure 7.2.3 Distribution map of damage-causing earthquakes of the world (Damaging earthquakes and earthquakes of M >7.5)

Considering the above conditions, it can be judged that seismic risk for the project bridges is negligible. Therefore a design earthquake intensity of 0.05 is adopted, being the minimum value.

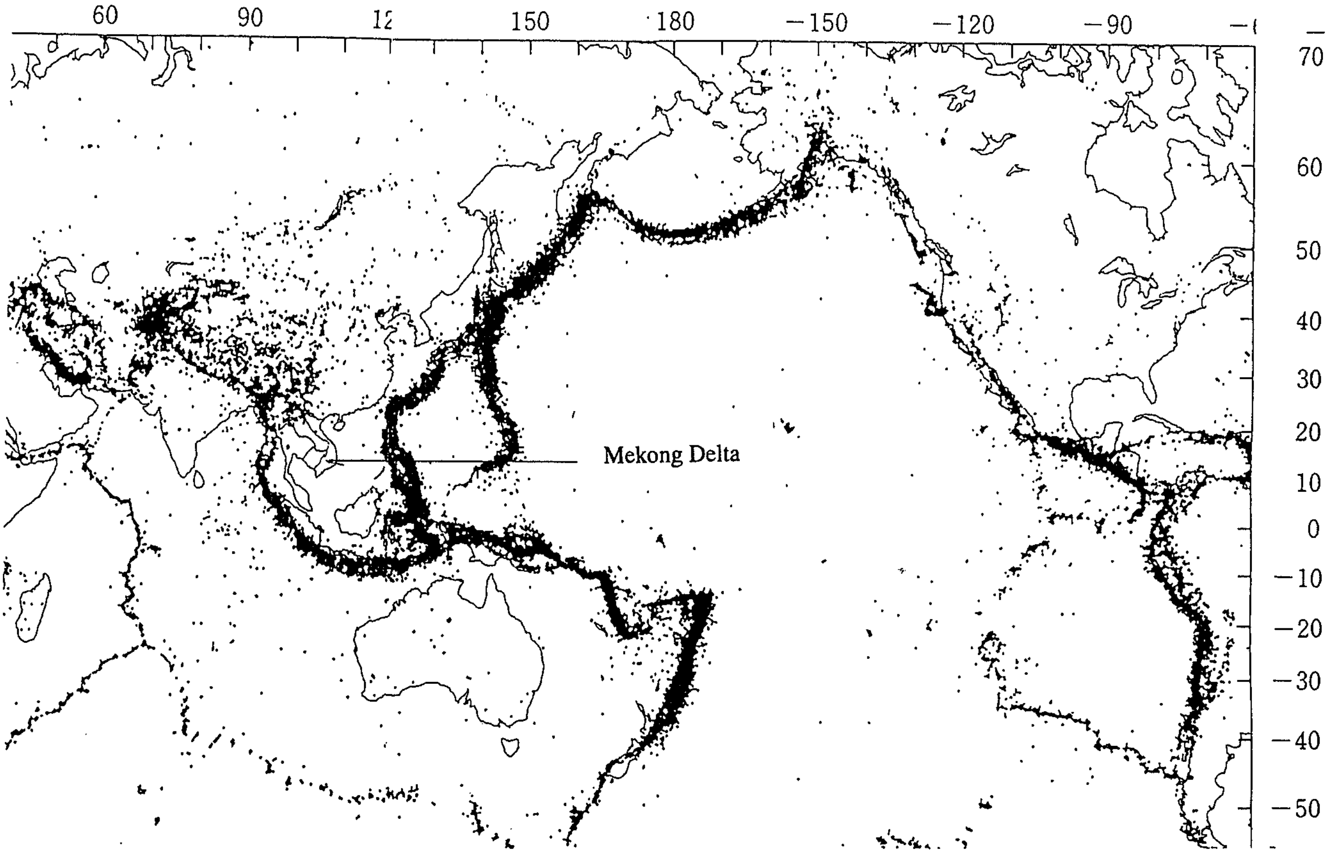


Figure 7.2.1 Earthquake distribution map in the world

(M≥4.0 depth: less than 100km 1975~1994)

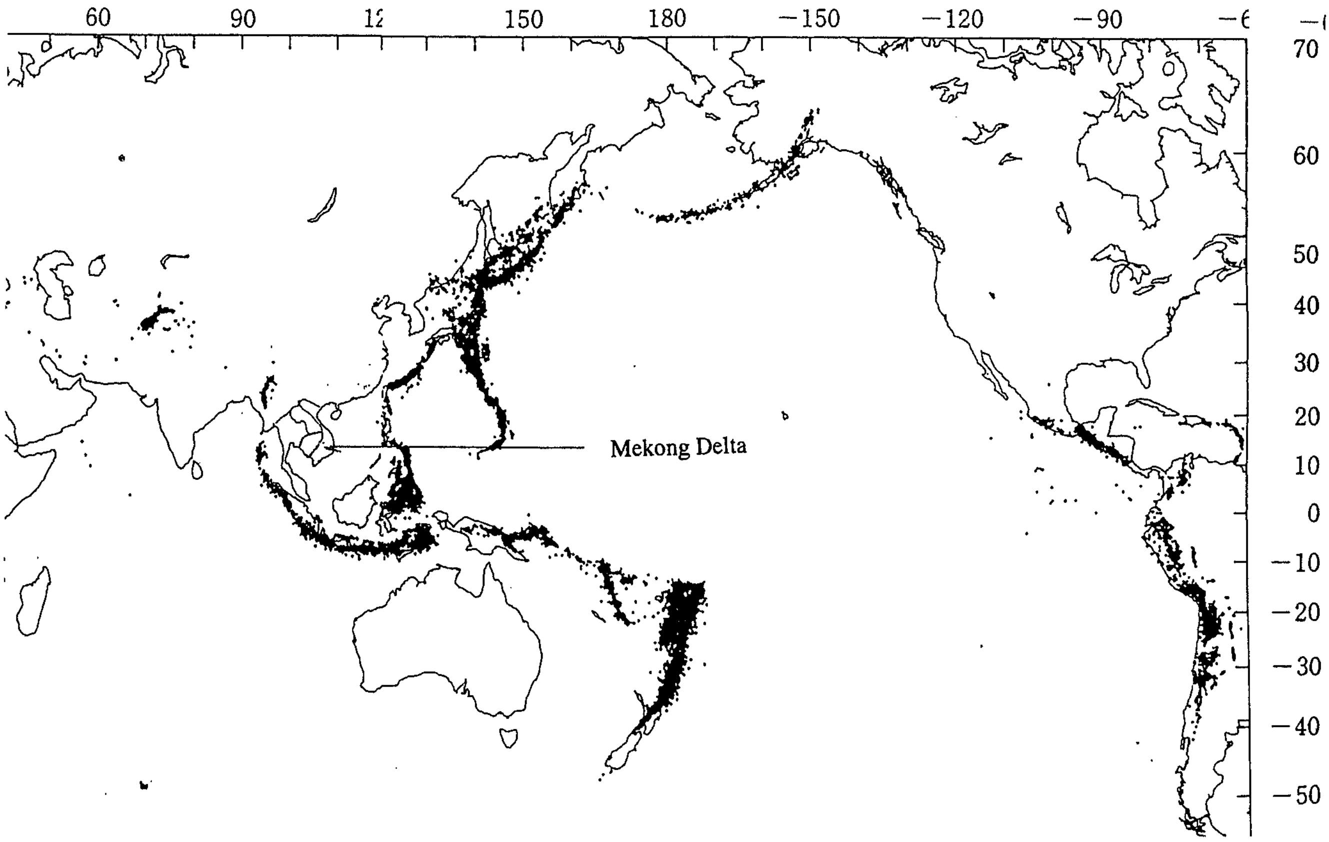


Figure 7.2.2 Earthquake distribution map in the world

(M≥4.0 depth: more than 100km1975~1994)

From Data of International Earthquake Center

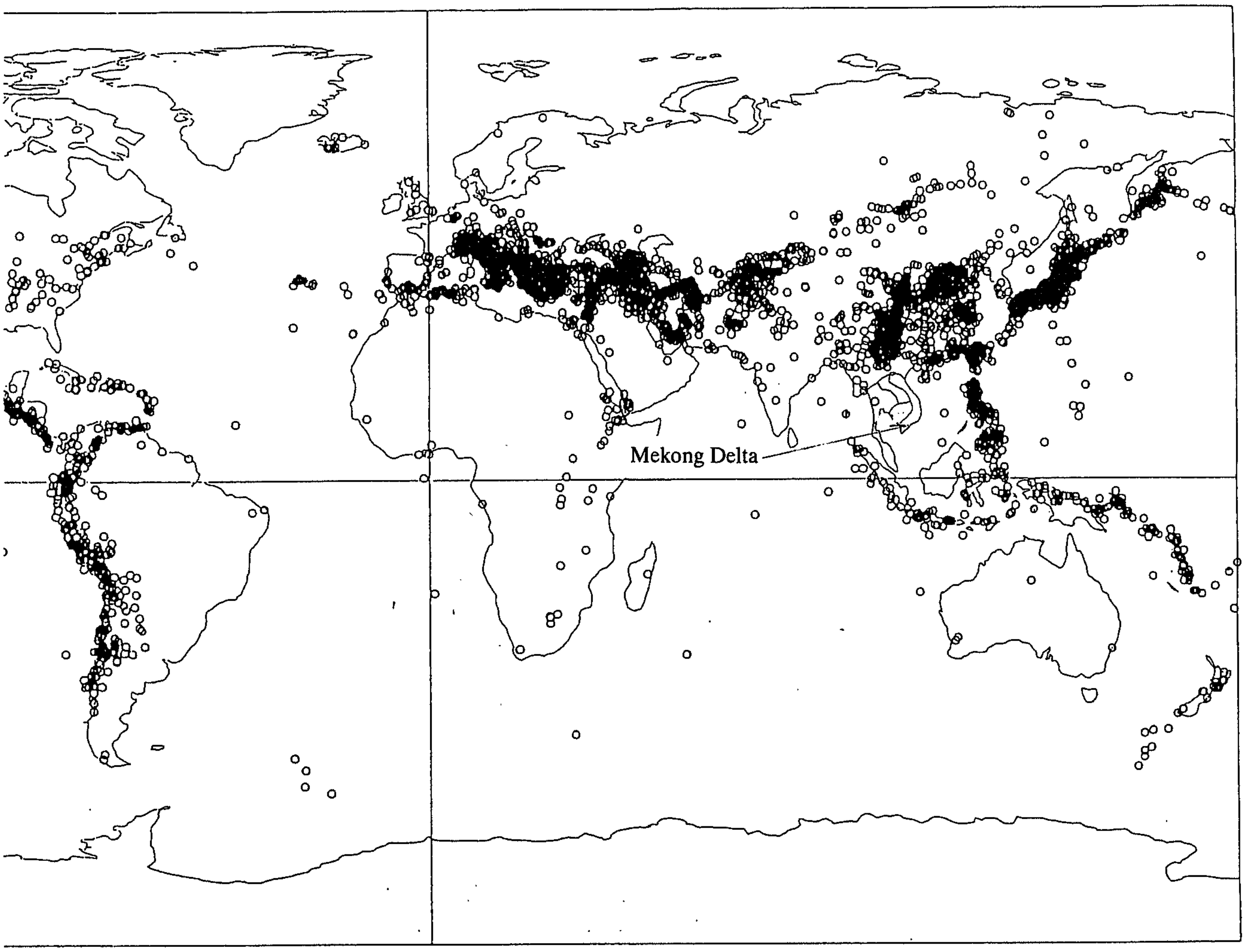


Figure 7.2.3 Distribution map of being damaged earthquake in the world

(Damaging earthquake and Earthquake of M >7.5)

From Report of Damaging Earthquake in the world (Tokuji Utu -1990-)

7.2.2 Survey Area Geology

(1) Outline of Survey Area Geology

The geological strata of the Mekong Delta Area are granite of all ages, basalt of the Pliocene Epoch, sedimentary rocks of the Mesozoic Era mainly consisting of shale and slate, all overlain by Quaternary formations, which consist of Alluvial and Diluvial formations.

Geological Formations in the Mekong Delta Area

Geological Age		Formation	Description
Quaternary	Holocene	Alluvium	- Soft to firm cohesive soil - Lenses of sandy soil
	Pleistocene	Diluvium	- Stiff to hard cohesive soil - Medium dense to dense sand and gravel
Cretaceous Triassic		Igneous rock Sedimentary rock	- Granite, Basalt - Shale, Slate

1) Alluvial Deposits

Alluvium is extensively distributed in Mekong Delta Area and is mainly composed of dark gray to blackish gray very soft clay with lenses of loose fine sand.

The thickness of the deposit is about 10 to 40 m with SPT blowcounts of 0 to 1 recorded.

2) Diluvial Deposits

The Diluvium is composed of cohesive soil (Dc) and sandy soil (Ds). The top of stratum is located at a depth from 21 to 59.5 meters below ground level.

i) Cohesive Soil (Dc-stratum)

Cohesive soil (Dc) is distributed throughout the project area and is composed of brown to yellowish-brown clay to clayey silt. The Dc soil top of stratum is located 21 to 59.5 meters below ground level.

Confirmed thickness of the Dc-stratum is from 3 to 5 meters and is a very stiff to hard clay with sand lenses. SPT blowcount is 20 to 49.

ii) Sandy Soil (Ds-stratum)

The Sandy Soil is composed of yellow to dark gray silty fine sand with mica fragments.

Confirmed thickness of the Ds-stratum ranges from 3 to 5 meters with SPT blowcounts of 31 to 53. The Ds-soil top of stratum is 30 to 51m below ground level.

3) Base Rock

Base rock of this area is composed of granite of all ages, basalt of the Pliocene Epoch and sedimentary rock of the Mesozoic Era, which consists mainly of shale and slate.

(2) Geology of the Bridge Sites

1) Founding Strata for Bridge Design

The load bearing capacity of strata is assessed depending on the importance of the structure and the lateral loads imposed by the structure.

In general, the required bearing capacity for spread or piled foundations of bridge abutment and piers is defined by the following N-values:

Sandy and cohesive soil .... N > 50
Weathered rock...................................... N > 50

and for the case of small and lightly-loaded bridges

Sandy soil .... N > 30
Cohesive soil .... N > 20

2) Bearing Strata of Bridges

Boreholes were drilled at both abutments at all bridge sites except bridge Nos.45, 50, 54 and 55.

Soil suitable as a founding material for bridge abutment loads is found in the diluvial deposits. These are yellowish brown to dark gray cohesive soil and greenish gray fine sand.

The cohesive soil top of stratum is located at a depth from 21 to 59.5 meters below ground level, and has SPT blowcounts ranging from 20 to 49.

Sandy soil top of stratum is located 30 to 51 meters below ground level and has SPT blowcounts of 31 to 53.

It is noted that in the northern part of Ho Chi Minh City, Binh Phuoc and Binh Duong Province these bearing strata are located at a depth of 7 to 18 meters below ground level.

The results of the borehole investigation are shown as table 7.2.4, and based on the findings, recommended design soil parameters for use in the Mekong Delta Area are shown as table 7.2.3.

Table 7.2.3 Design Soil Parameters

Stratum	Average SPT Blowcount	Wet Density γt (t/m^3)	Cohesion of Initial Condition C (t/m^2)	Internal Angle of Friction Φ (degree)	Unconfined Test, Modulus of Deformation E50 (Kg/cm^2)
	0	1.58	0.75	-	3.44 (Note 1)
	21	1.80	7.0	-	51.3 (Note 2)
Ds	34	1.90	-	Fig. 7.2.11a	28N

Note 1: Eo= E50 = 13.147qu + 1.465 for Ac soil
2: Eo=E50 = 42.742qu - 12.795 for Dc soil

Table 7.2.4 Results of Machine Boring Survey in Mekong Delta Area

Province / City	Bridge NO.	Request: Bridge Name	Request: Length (m)	Request: Width (m)	Request: Const.: * Procu.:**	Result: Embankment Height(HE) (m)	Machine Boring Survey and Test: Boring NO.	Ground Elevation (m)	Boring Depth (m)	Thickness of Soft Ground (m)	Depth from G.Surface to Bearing Strata (m)	Bearing Strata	N-Value of Bearing strata	Ground Water Level GL−(m)
BAC LIEU	(3)	HOA BINH-2	60	5.5	*	6.0	BH-1	1.75	26.0	19.2	21.0	Silty Clay with sand & shell fragme	25~26	-1.20
							BH-2	2.22	25.5	19.8	21.6	"	22~31	-1.50
	(4)	DEN	60	5.5	*	3.0	BH-1	1.31	28.5	19.1	25.0	Silty Clay with some gravel	22~26	-1.50
							BH-2	1.39	28.5	19.2	24.5	Silty Clay with some gravel	21~24	-1.80
CA MAU	(6)	VAM DINH	60	5.5	*	5.5	BH-1	0.63	50.0	20.2	45.6	Silty Clay	21~28	-1.00
							BH-2	0.98	50.0	20.8	46.0	Silty Clay	21~34	-1.40
	(7)	KINH KIEM LAM	80	5.5	*	5.5	BH-1	0.87	40.0	20.7	32.5	Silty Clay --Sand	20~23	-1.80
							BH-2	0.33	42.0	20.5	34.9	"	27~30	-1.50
SOC TRANG	(8)	HUYNH HUU NGHIA	45	5.5	*	3.0	BH-1	0.82	40.0	25.4	32.0	Silty Fine Sand	30~47	-1.15
							BH-2	0.68	35.0	25.4	31.5	Sity Fine Sand	30~63	-1.35
CAN THO	(12)	LONG MY	90	8.0	*	5.5	BH-1	0.86	30.0	11.4	24.0	Clay	20~28	-0.60
							BH-2	0.98	31.0	11.0	26.0	Clay	22~27	-1.00
KIEN GIANG	(15)	VAM SANG THI DOI	75	5.5	*	5.0	BH-1	1.57	29.5	16.6	25.5	Silty Fine Sand	36~56	-1.20
							BH-2	1.58	29.0	16.1	25.5	Silty Fine Sand	46~58	-1.15
	(16)	HA GIANG	70	5.5	*	6.5	BH-1	1.25	31.0	2.9	27.0	Silty Clay	30~66	-1.60
							BH-2	0.90	32.0	4.2	25.5	Silty Sand ---Silty Clay	30~46	-1.50
AN GIANG	(18)	THOAI GIANG	90	5.5	*	5.0	BH-1	1.57	20.3	9.0	14.6	Clayey Medium to Fine Sand	33~75	-0.60
							BH-2	1.50	21.3	9.2	14.5	Clayey Medium to Fine Sand	33~75	-1.05
DONG THAP	(21)	TRAM CHIM	80	6.5	*	4.5	BH-1	3.91	40.5	3.7	16.5	Silty Clay	28~49	-2.36
							BH-2	3.49	41.0	3.9	14.5	Silty Clay	22~38	-3.25
VINH LONG	(23)	HOA TINH	74	5.5	*	3.5	BH-1	1.46	62.0	22.8	59.0	Clay	22~29	-0.95
							BH-2	1.16	63.0	19.8	59.5	Clay	30~37	-1.05
TRA VINH	(26)	TAN AN	45	6.5	*	4.5	BH-1	2.01	45.0	23.2	37.5	Clay--Sand	28~30	-1.13
							BH-2	1.92	46.0	22.5	38.0	Clay	20~50	-1.10
TIEN GIANG	(30)	LONG BINH	38	5.5	*	4.0	BH-1	2.45	54.5	44.0	51.0	Silty Fine Sand	41~44	-0.80
							BH-2	2.40	57.5	46.0	54.0	Silty Fine Sand	38~40	-1.00
	(32)	TRA TAN	75	5.5	*	5.5	BH-1	2.66	33.5	12.0	27.0	Silty Fine Sand	30~34	-1.60
							BH-2	3.34	33.5	11.5	30.0	Silty Fine Sand	36~53	-1.60
BEN TRE	(35)	RANH TONG	85	6.5	*	5.0	BH-1	1.35	50.0	23.0	46.5	Silty Fine Sand	30~36	-0.40
							BH-2	1.12	50.5	22.5	45.5	Silty Fine Sand	30~48	-0.50
LONG AN	(38)	BA LY	65	5.5	*	3.0	BH-1	1.47	34.0	17.4	30.0	Sand	31~38	-0.50
							BH-2	3.05	36.0	21.9	33.0	Sand	32~45	-0.80
	(39)	VINH CONG	40	6.5	**	3.5	BH-1	1.48	28.5	14.5	21.0	Clay	26~46	-0.80
							BH-2	1.10	40.0	14.2	21.0	Clay	22~34	-0.70
TAY NINH	(40)	SAIGON	80	6.5	*	2.0	BH-1	26.14	13.0	6.5	7.5	Hard Rock (Basalt)	>50	-1.70
							BH-2	26.01	14.2	2.0	7.5	"	>50	-1.65
BINH DUONG	(45)	CHUA	30	5.5	*	1.0	BH-1	7.99	18.5	-	3.0	Gravelly Clayey Sand	41~61	-7.00
	(46)	RACH RO	27	5.5	**		BH-1	5.45	23.0	-	18.0	Clay	23~32	-5.50
							BH-2	4.90	23.0	-	18.0	Clay	22~33	-4.80
BINH PHUOC	(48)	DAKIA	45	6.5	*	2.0	BH-1	92.30	10.0	-	3.0	Hard Rock (Shale)	>50	-
							BH-2	91.65	10.0	-	3.5	"	>50	-
	(50)	NO.5	38	6.5	**		BH-1	255.46	14.0	-	12.0	Hard Rock	>50	-7.50
DONG NAI	(53)	CHAY	50	5.5	*	3.0	BH-1	1.75	53.0	20.0	23.5	Clay	21~26	-1.50
							BH-2	1.50	50.0	29.2	33.0	Gravelly Clayey Sand to Clayey San	30~45	-1.40
	(54)	BAU XEO	30	5.5	**	3.0	BH-1	47.78	12.0	-	6.0	Gravel---Hard Rock	>50	-2.70
	(55)	SONG THAO	20	5.5	**	2.5	BH-1	70.75	12.0	-	8.0	Hard Rock (3.5~8.0m Gravel)	>50	-2.00
BA RIA VUNG TAU	(58)	AP AN BINH	45	5.5	*	4.0	BH-1	1.71	50.0	7.0	45.0	Clayey Sand	44~53	-1.00
							BH-2	1.20	50.0	7.5	41.0	Clayey Sand	30~44	-0.80
TOTAL					(21+5)		(41+7)							
	26				26		48		1,657.8		1,310.2			

(3) Soil Test Results

1) General

The soils analyzed for embankment and foundation design are Alluvial and Diluvial deposits of which a total of 136 samples were taken by undisturbed sampling. The following samples were analyzed:

Alluvium	(Ac):	35 Samples
Diluvium	(Dc):	67 Samples
Diluvium	(Ds):	34 Samples
Total		136 Samples

The type and quantity of tests and applicable standards are shown in Table 7.2.1. Based on the results of these soil tests, physical and mechanical properties of the Ac, Dc and Ds soils were determined and suitable bearing strata for bridge foundations decided.

2) Laboratory Soil Test Results

(a) Physical Properties

a) Particle Size Grading

The gradings of three soil categories are shown in the following table 3.3.4

Cohesive deposits (Ac and Dc) contain fines fraction, silt (44.2～48.2%) and clay (43.0～45.4%) total 88.1～93.6% by weight.

The Ds soil contains coarse sand and gravel over 73.5 % by weight.

Table 7.2.5 Soil Grading Results

Soil Fraction / Stratum	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	No.10 (2.00) (%)	No.40 (0.425) (%)	No.200 (0.075) (%)
	Average	Average	Average	Average	Average	Average	Average
	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values
Ac-cohesive Soil	0.0	6.7	48.2	45.4	100.0	99.6	93.6
	-	1.0 ~12.4	37.2~59.1	33.3~57.6	-	98.3~100.0	87.6~99.1
Dc-cohesive Soil	0	12.7	44.2	43.0	100.0	99.1	88.1
	-	0.6~24.8	33.8~54.5	30.7~55.2	-	97.1~100	76.5~99.7
Sandy Soil	7.4	66.1	17.3	9.3	87.4	70.3	26.6
	0~22.1	43.7~88.5	4.0~30.6	1.7~16.8	64.0~100	45.1~95.5	7.0~46.2

b) Consistency Test Results

The moisture content and index test results are summarized in table 7.2.6 and graphs in Figure 7.2.4.

Ac Soil

- Ac soil: No variation in strength, moisture content or plasticity with depth was observed.

- According to the classification chart, Ac-soil is classified as CH: 51.5% MH-OH: 37.1% CL-ML: 11.4%

- Colloidal activity
  Ac-soil is classified as follows:
  - Non-active clay (mainly Kaolinite) A< 0.75 .... 25.7%
  - Ordinary clay (mainly Illite) A=0.75~1.25.............................. 48.6%
  - Active-clay (including organic colloid) A= 1.25~ 2.00........... 25.7%

Ac soil is classified as being in an unstable condition since Wn=Wl, Ic= -0.8~0.5 and average Ic= -0.1

Dc Soil

Dc soil: No variation in strength, moisture content or plasticity with depth was observed.

- According to the classification chart, Dc soil is classified as CH: 40.3% CL: 40.3% ML-OL: 11.9% MH-OH: 7.5%

- Colloidal activity
  Dc soil is classified as follows:
  - Non active clay (mainly Kaolinite) A<0.75 .... 55.2%
  - Ordinary clay (mainly Illite) A=0.75~1.25.............................. 37.3%
  - Active clay (including organic colloid) A=1.25~2.00................ 7.5%

- Dc soil is classified as being in a stable condition with Wn< Wl, Ic=0.31~1.20 and average Ic=0.75

Table 7.2.6 Moisture Content and Plasticity Test Results

Stratum \ Test/Index		Wn (%)	Wl (%)	Ip	If	It	Ic	Activity Ratio
		Average	Average	Average	Average	Average	Average	Average
		Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values
Ac-Cohesive Soil	Average	65.9	66.5	33.4	10.7	3.4	- 0.1	1.0
	Range	47.0~84.8	50.7~82.3	22.0~44.7	6.6~14.8	1.7~5.1	- 0.8~0.5	0.6~1.3
Dc-Cohesive Soil	Average	30.9	50.3	23.5	10.9	2.3	0.75	0.7
	Range	18.8~43.0	34.7~65.9	13.1~33.8	6.9~14.9	1.2~3.4	0.31~1.2	0.4~1.1

Note

ML: Inorganic silt, very fine sand, rock flour, silty or clayey fine sand

CL: Inorganic clay of low to medium plasticity, gravely clay, sandy clay, silty clay, low cohesive clay

OL: Organic silt and organic silty-clay of low plasticity

MH: Inorganic silt, micaceous or diatomaceous fine sand or silt and plastic silt

CH: Inorganic clay of high plasticity, high cohesive clay

OH: Organic clay of medium to high plasticity

Wn: Natural water content

Wl: Liquid limit

Ip: Plasticity index

If: Flow index

If: Toughness index (It = Ip/If)
Degree of shear strength at plastic limit

Ic: Consistency index (toughness and stability of cohesive soil)

$$Ic = (Wl-Wn)/Ip$$

$Ic \geq 1$ Stable condition

$Ic = 0$ Unstable condition (liquefies when disturbed)

Colloidal activity: Colloidal activity has deep ties with clay mineral and geological condition of sediment, and is defined by Skempton.

Clay is classified into four groups from non-active clay to high-activity clay (activity >2). It is shown as the following formula.

$$\text{Colloidal activity} = \frac{\text{Plasticity index Ip}}{\text{Soil particle (\%) of less than 2 } \mu\text{m}}$$

Table 7.2.7 Classification by Colloidal Activity

Activity Ratio	Description	Main Clay Mineral	Deposition Conditions
A < 0.75	Non-active clay	Kaolinite	•Fresh water sediments •Marine deposits which have been leached
A=0.75 - 1.25	Ordinary clay	Illite	Marine and estuarine deposits
A > 1.25	Active clay	•Including organic colloid •A ≥ 2 includes Montmorillonite	

c) Specific Gravity, Bulk Density and Voids Ratio

Measured values of specific gravity, bulk density and voids ratio are summarized in table 7.2.8 and shown on graphs in Figure 7.2.5 and Figure 7.2.6.

- Specific Gravity (Gs)

  The test results yield consistent values with a standard deviation of 0.030~0.051

- Wet Density (γt)

  The tests show consistent values. The relationship between γt and other parameters is shown by the following formula:

$$\gamma t = \frac{1 + \frac{Wn}{100}}{\frac{1}{Gs} + \frac{\frac{Wn}{100}}{\frac{Sr}{100}}} * \gamma w$$

Where:

γt: Bulk density of soil (t/m^3)
Wn: Natural moisture content (%)
Sr: Degree of saturation (%)
Gs: Specific gravity

If the soil samples are fully saturated by high ground water at the project site, Sr=100% is applied to the above formula. The formula becomes the function of natural moisture content (Gs= constant).

$$\gamma t = \frac{1 + \frac{Wn}{100}}{\frac{1}{Gs} + \frac{Wn}{100}}$$

Table 7.2.8 Results of Gs, γt and e

Stratum \ Soil Properties	Specific Gravity Gs	Wet Density γt	Voids Ratio e
	Average	Average	Average
	Range of recorded values	Range of recorded values	Range of recorded values
Ac- Cohesive Soil	2.673	1.577	1.848
	2.622~ 2.724	1.489~1.665	1.400~2.296
Dc-Cohesive Soil	2.708	1.922	0.870
	2.678~ 2.738	1.775~2.069	0.520~1.220
Sandy Soil	2.672	1.991	0.639
	2.673~ 2.708	1.894~2.089	0.446~0.828

The values of Gs and Wn are plotted in Appendix- .The values of wet density adopted for design are as follows:

Ac $\gamma t = 1.580\ t/m^3$

Dc $\gamma t = 1.800\ t/m^3$

Ds $\gamma t = 1.900\ t/m^3$

- Voids Ratio (e)

The voids ratio of the Ac and Dc soils has a strong correlation with natural moisture content with follows:

Ac soil

$e = 0.022Wn + 0.369$

Variance = 8.814

Correlation coefficient = 0.953

Dc soil

$e = 0.027Wn + 0.027$

Variance = 3.977

Correlation coefficient = 0.942

(b) Mechanical Properties

Mechanical tests (Unconfined triaxial compression and consolidation tests) were carried out on undisturbed samples of Ac and Dc soils from each bridge site.

a) Unconfined Compression Test

Unconfined compressive test results are shown in table 7.2.9 and Figure 7.2.7 and Figure 7.2.8. The relationships between qu (kg/cm^2) and E_{50} (kg/cm^2) for the Ac and Dc soils are shown by the following:

Ac soil

$E_{50} = 14.38qu + 2.595$

Variance = 0.091

Correlation coefficient = 0.357

Dc soil

$E_{50} = 42.742qu - 12.795$

Variance = 39.48

Correlation coefficient = 0.810

Again, the relationships between qu (kg/cm^2) and the natural moisture content (Wn) for the Ac and Dc soils are shown by the following:

Ac soil

$qu = -0.002Wn + 0.306$

Variance = -0.791

Correlation coefficient = -0.487

Dc soil

$qu = -0.035Wn + 2.481$

Variance = -5.053

Correlation coefficient = -0.444

b) Consolidation Test

Consolidation test results are shown in table 7.2.9 and in the following figures.

Figure 3.3.4 e-logP Design Curve (Ac and Dc soils)

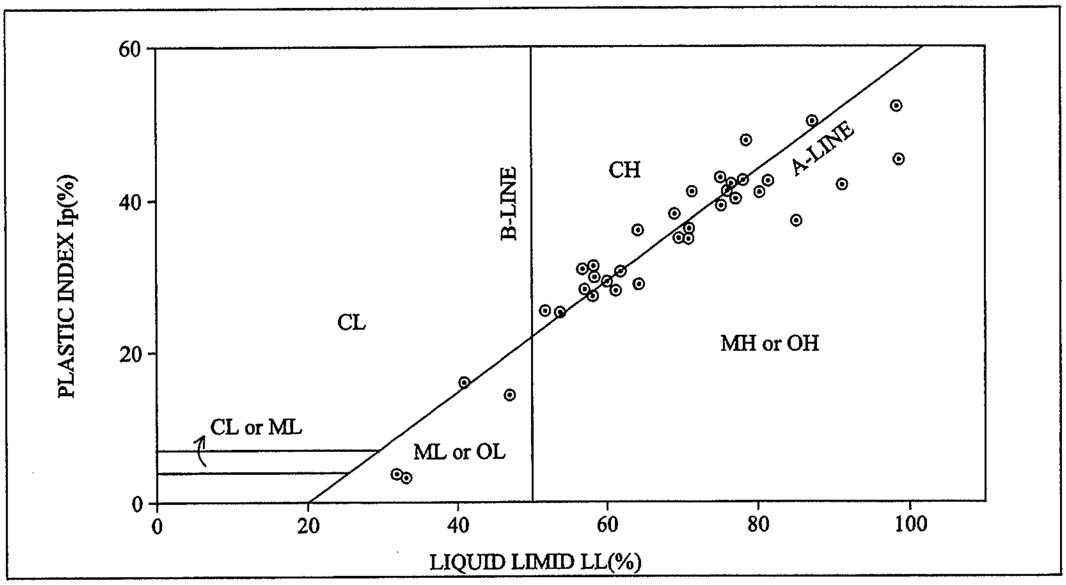
Figure 3.3.5 log Cv - logP Design Curve (Ac and Dc soils)

According to the test results, the Ac soil is in a state of incomplete consolidation.

Table 7.2.9 Mechanical Test Results

Test / Stratum	Unconfined Triaxial Compression qu , E50 and			Consolidation Pc Cc	
	Qu (kg/cm^2)	E50 (kg/cm^2)	ε (%)	Pc (kg/cm^2)	*Cc*
	Average	Average	Average	Average	Average
	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values	Range of recorded values
Ac-Soft Cohesive Soil	0.180	5.30	7.80	0.52	0.75
	0.100 ~0.260	2.10 ~8.50	4.70 ~10.80	0.38 ~0.67	0.63 ~0.80
Dc-Stiff Cohesive Soil	1.404	47.50	7.80	1.86	0.226
	0.454 ~2.354	3.40 ~97.90	4.0 ~11.6	1.09 ~2.63	0.102 ~0.351

PLASTICITY CHART



COLLOIDIAL ACTIVITY

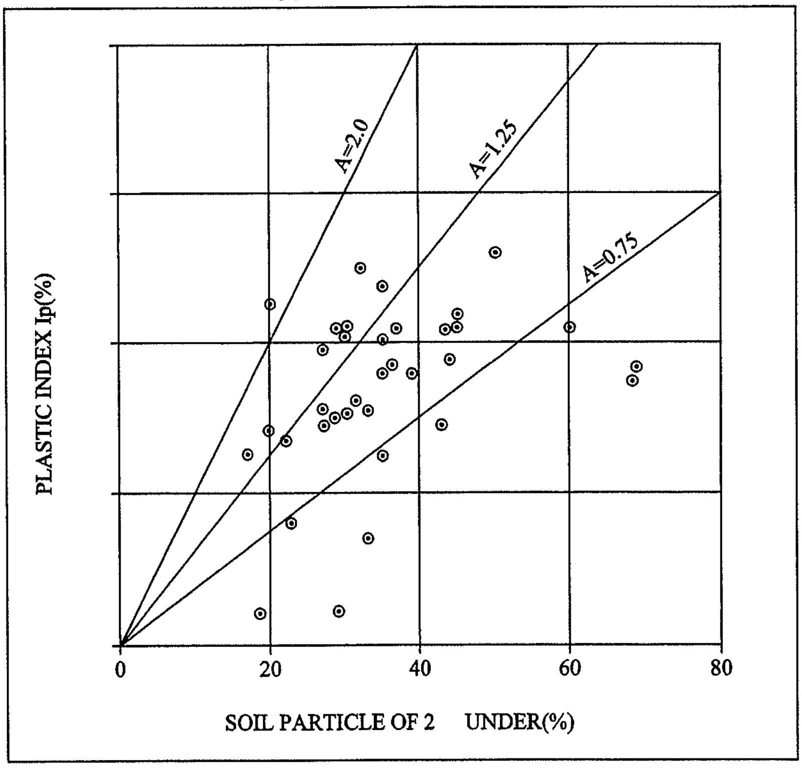


Figure 7.2.4	
BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA	CONSISTENCY CHART (soft soil)

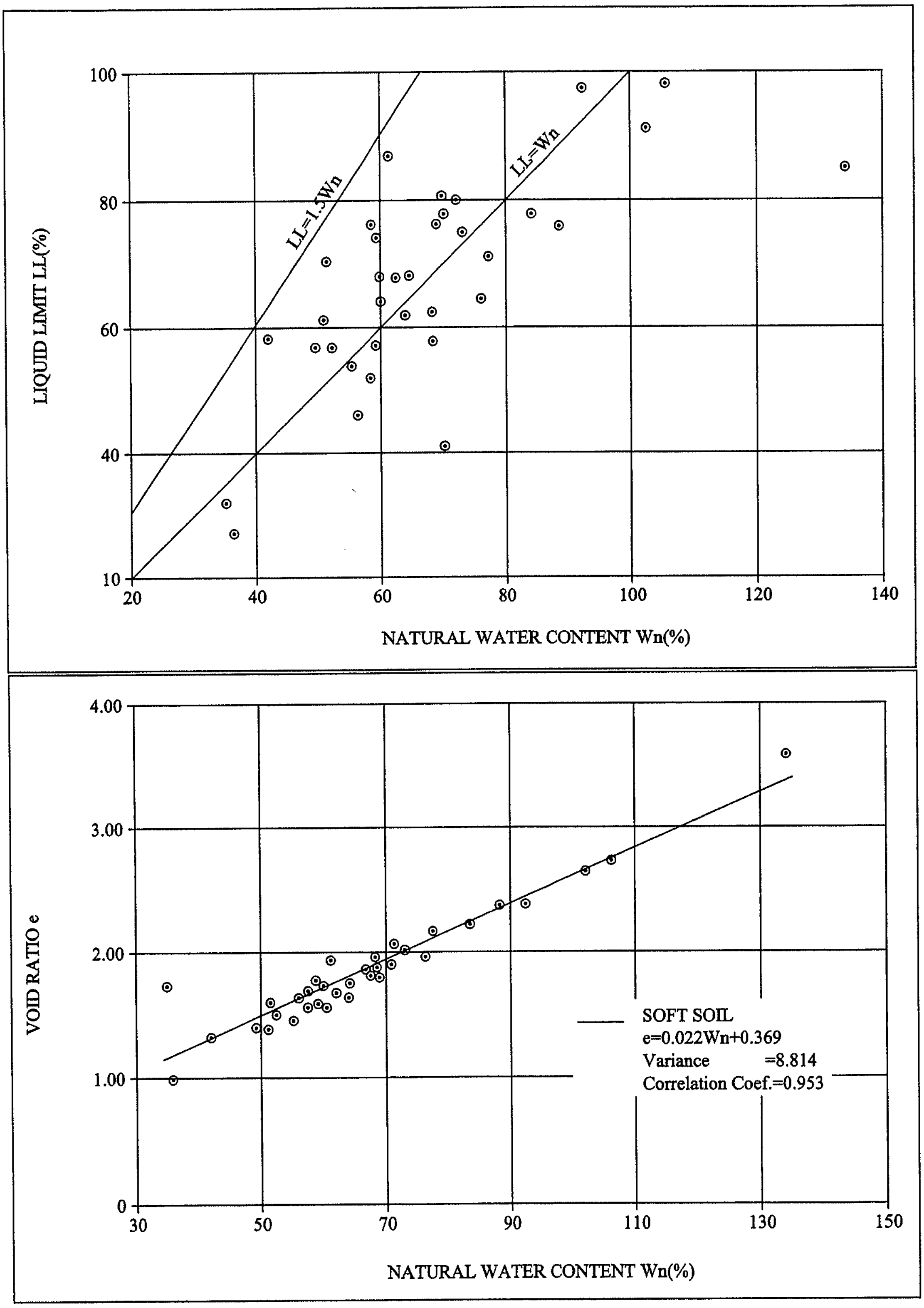


Figure 7.2.5	RELATIVE CHART OF NATURAL WATER CONTENT (Wn)AND LIQUID LIMIT LL,VOID RATIO(e) (soft soil)
BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA	

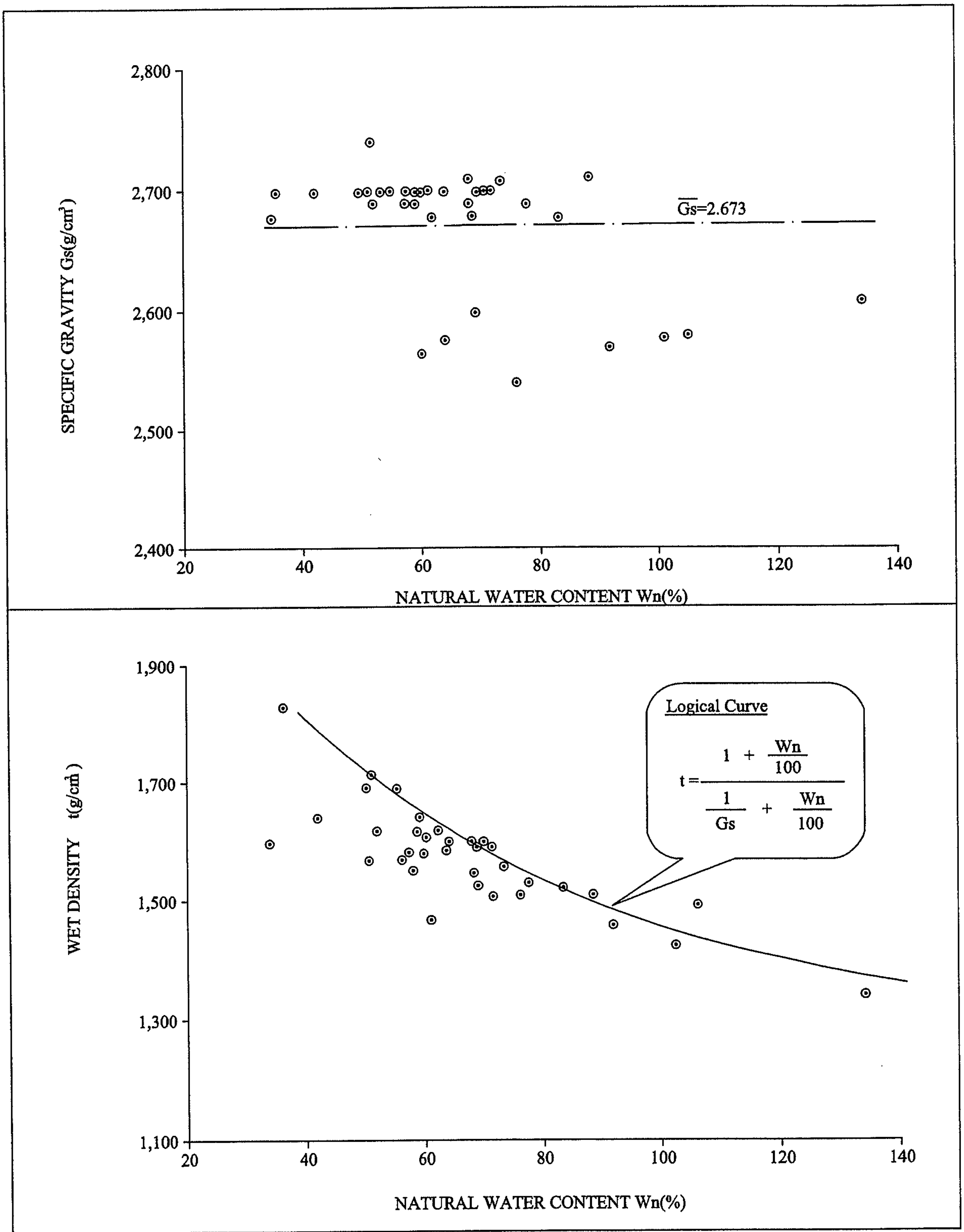
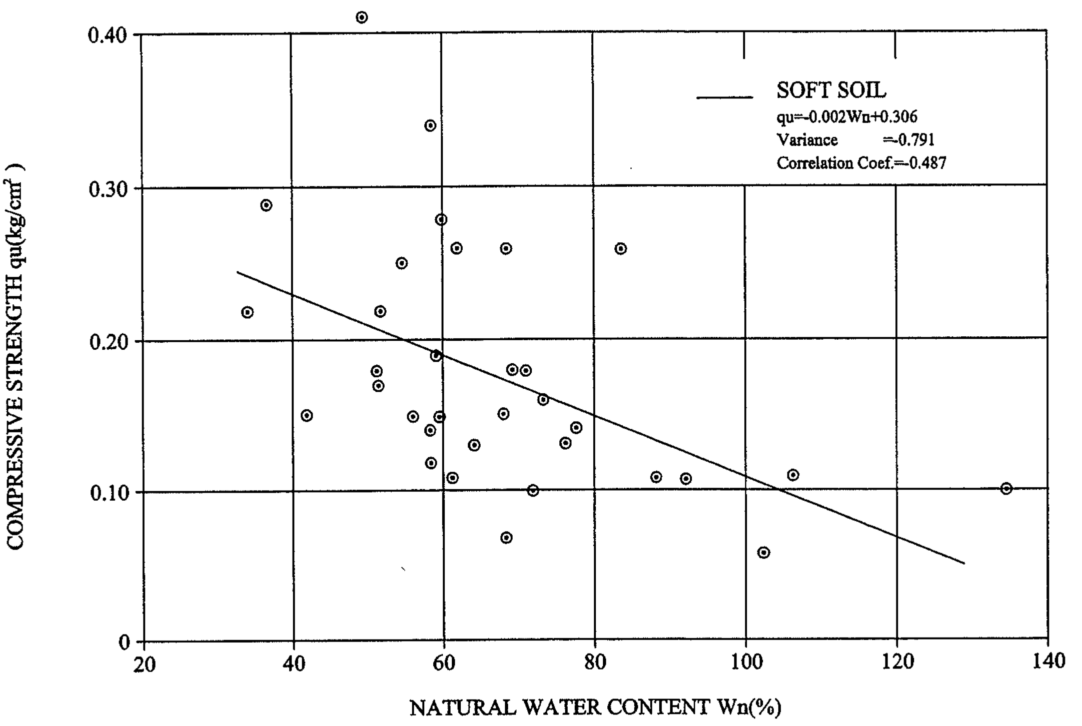


Figure 7.2.6	RELATIVE CHART OF NATURAL WATER CONTENT (Wn)AND SPECIFIC GRAVITY(Gs),WET DENSITY(t) (soft soil)
BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA	



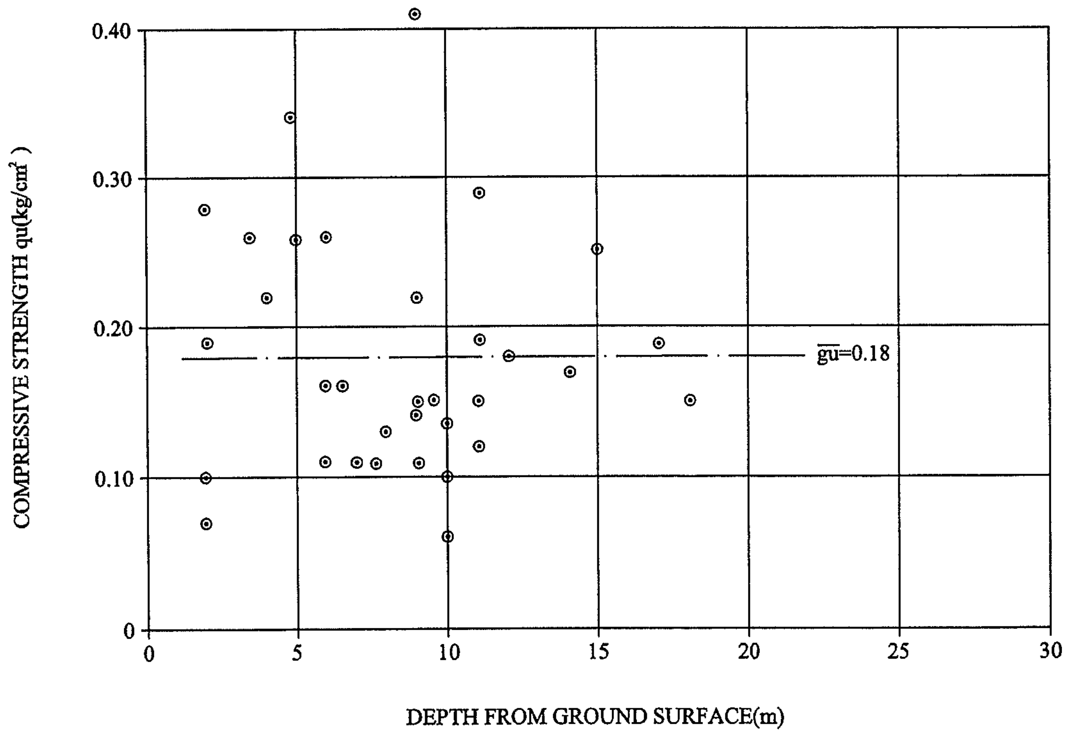


Figure 7.2.7	RELATIVE CHART OF NATURAL WATER CONTENT (Wn)AND (gu),Depth and (gu) (soft soil)
BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA	

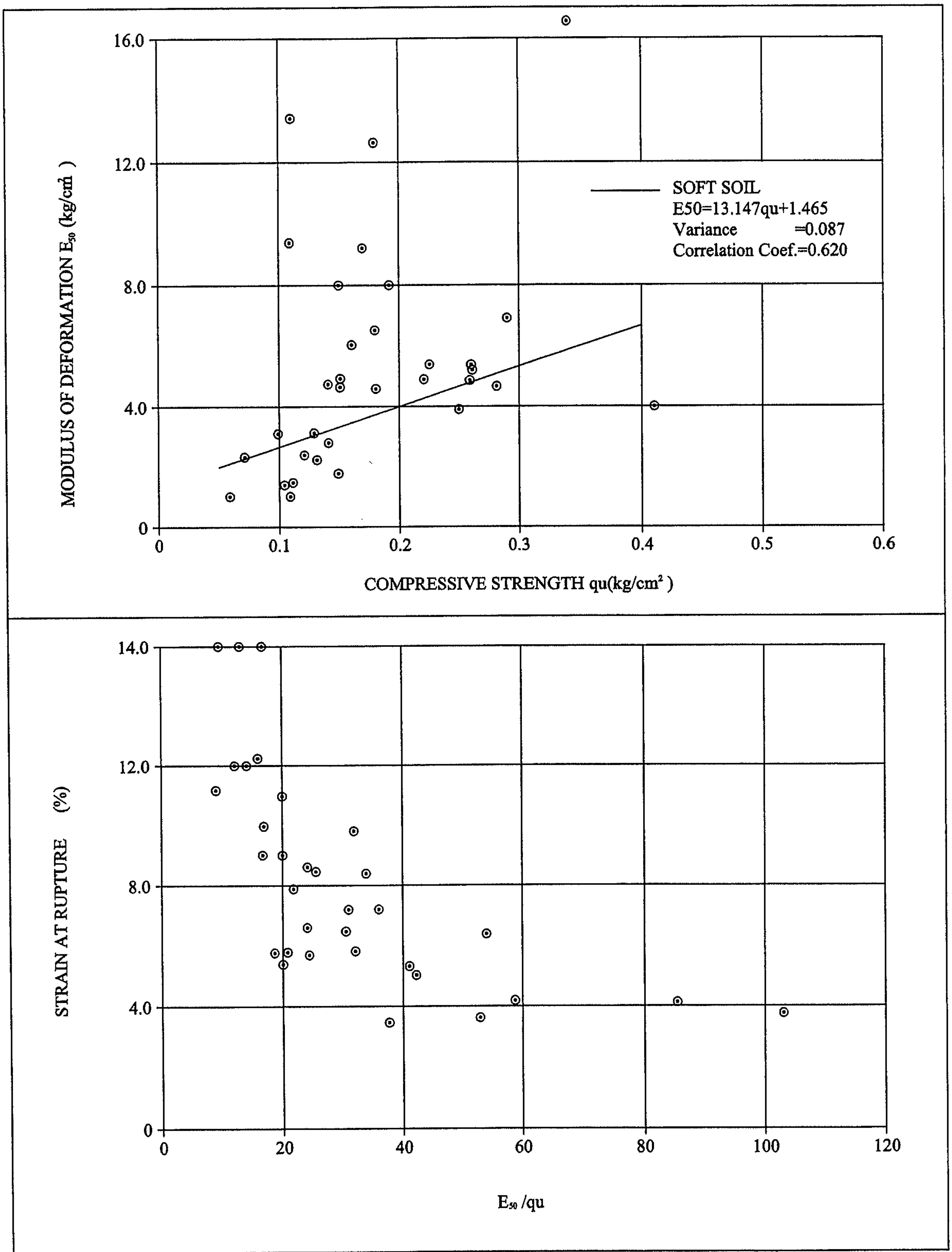


Figure 7.2.8	RELATIVE CHART OF qu AND E50, E50/qu AND (soft soil)
BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA	

(4) Design Soil Parameters

For design purposes, the behavior of the very soft alluvial (N=0) clay when acting as a foundation for high approach embankments must be considered. The stiff clay (ave. N=21) and sandy soil (ave. N=34) of the Diluvial deposits must be considered as a bearing stratum for bridge foundations.

Since the soils have formed in a sedimentary environment, the disposition of soil and its character at each bridge must be examined according to the following procedure, and design soil parameters selected.

- Determine soil profile
- Consider soil test results and select representative values
- Select design soil parameters and cross section

1) Classification of Soil Strata

Geological longitudinal profiles were produced based on the borehole logs and laboratory soil test results. In the Ac stratum, the possible presence of intermediate and lower sand strata is significant for its effect on rate of consolidation of the clay. Based on the findings of the borehole logs an appropriate drainage condition, either one or two-directional, may be chosen for design. The ground water level was taken from the geological longitudinal profile.

The soil classification considered for the design is as follow:

Alluvial soil (very soft clay) ....Ac
Diluvial soil (stiff to very stiff clay) ....Dc
" (medium dense to dense sand) ....Ds

2) Soil parameters for Ac soil

(a) Wet Density

The average values adopted for design are

Soil	Wet Density γt (t/m^3)	Number of Tests
Ac	1.580	35

(b) Cohesion of initial condition: Co (t/m^2)

Angle of internal friction (ϕuu) and shear strength (Cuu) under undrained unconsolidated conditions are as follows:

$$\text{Sin}\,\phi\,uu = \frac{\frac{\sigma 1}{2}}{\frac{\sigma 1}{2} + Cuu \times \cot\phi uu}$$

$$\therefore Cuu = \frac{\sigma 1}{2 \times \tan(45° + \frac{\phi uu}{2})}$$

Generally $\phi\,uu = 0^\circ$ for soft clay thus Cuu becomes:

$$Cuu = \frac{\sigma 1}{2} = \frac{qu}{2}$$

The unconfined compressive strength of the Ac soil is adopted as in sub-section (3)-2) (a)-c)

Soil	Undrained Shear Strength Co (tf/m^2)	No. of Tests
Ac	0.75	33

(c) The Rate of Increase in Strength by consolidation pressure

There are three methods to determine the strength / consolidation pressure relationship:

- By the variation with depth of the undrained shear strength
- Based on the plasticity index
- By triaxial compressive strength testing under undrained unconsolidated conditions or by simple shear box testing.

In this case, the plasticity index method is used, since it is recognized that the strength of the soft soil does not increase with depth.

The strength / consolidation pressure relationship can be calculated according to the A. W. Skempton formula:

m = Co/Po = 0.11 + 0.0037 * Ip

Where

m: The ratio of shear strength to consolidation pressure

Ip: Plasticity index

Co: Triaxial compressive strength obtained under undrained unconsolidated (UU) conditions.

Po: Vertical Effective Stress

The strength / consolidation pressure relationship calculated using this formula is shown in table 7.2.10

Table 7.2.10 The Rate of Increase in Strength by the Plasticity Index

Soil	Plastic Index Ip	The Ratio of Increase in Strength by Consolidation Pressure (m)	No. of Sample N	Calculation Method of Ip
Ac	33.4	0.234	35	Average of accumulated values

Available data on the ratio of Increase in strength by consolidation pressure is shown in tables 7.2.11and 7.2.12.

Table 7.2.11 The Rate of Increase in Strength (1)

(Standard of Japan Highway Corporation)

Soil	Soil Class	Ratio of Strength to Consolidation Pressure m
Clay	CH, CL, VH	0.30 ~ 0.44
Silt	MH, ML	0.25 ~ 0.40
Humid Soil or Black mud	OH, OL, OV, MH	0.20 ~ 0.35
Peat	Pt	0.35 ~ 0.50

Table 7.2.12 The Rate of Increase in Strength (2)

(Standard of Japan Highway Corporation)

Natural Water Content (Wn %)	The Rate of Increase in Strength by Consolidation Pressure (m)	
	Soil Depth < 10 m	Soil Depth > 10 m
> 200	0.25 ~ 0.40	
< 200	0.45 ~ 50	0.25 ~ 0.30

The ratio of strength to consolidation pressure of the alluvial deposit Ac is estimated (following table 3.9) as m= 0.25 ~ 0.40 based on the following available test results.

Ac Soil

Soil classification CH, MH-OH
Natural water content, Wn (%) 47.0~134.1%
Stratum thickness (m) 19.0 ~ 25.0 (from ground Level)
The Rate of Increase in Strength by Consolidation Pressure 0.20 ~ 0.40

Table 7.2.13 Comparison of the Rate of Increase in Strength by Consolidation Pressure Obtained by Various Methods

Method	Soil	Ratio of Strength to Consolidation Pressure, m	
		Range	Representative Value
Plastic Index	Ac	0.191 ~ 0.303	0.25
Based on Table 3.10		0.250 ~ 0.400	

As result the following value is proposed:

Ac soil, m = 0.25

(d) Design e-logP and log Cv-logP Curves

The design curves for the above were obtained after omitting unrepresentative values from the respective tests, and are shown in the following figures:

Figure 3.3.4 e-logP Design Curve (Ac)
Figure 3.3.5 logCv-logP Design Curve (Ac)

(e) Consolidation Yield Stress Pc (kg/cm2)

The consolidation yield stress of cohesive soil is theoretically the maximum consolidation stress borne in the past and can be estimated by the following three methods: based on consolidation test results, using Pc = 4.Co and using Pc = Po = Co/m.

- Using consolidation test results:

  This method estimates the Pc / depth relationship using the least squares method, but is not suitable this case, since an increase in strength with depth was not observed.

- Using Pc = 4.Co:

  This formula is empirical based on extensive data obtained for soft ground from which a good correlation between Pc and Co is obtained.

  (Source: Standard of Japan Highway Corporation)

  $qu = 1.5\ t/m^2$ -----> $Co = 0.75\ tf/m^2$ ($\varphi=0$)
  $Pc = 2qu = 4.Co = 3.0\ tf/m^2$

- Using Pc = Po = Co/m

  This formula is applicable when the yield stress is equal to the highest consolidation pressure experienced under historic periods of higher ground levels. In this case it is not applicable.

3) Summary of Design Soil Parameters

The soil parameters for the soft ground Ac soil selected for design are summarized in Table 7.2.13 and the respective design curves are shown in Figures 7.2.9 to 7.2.10

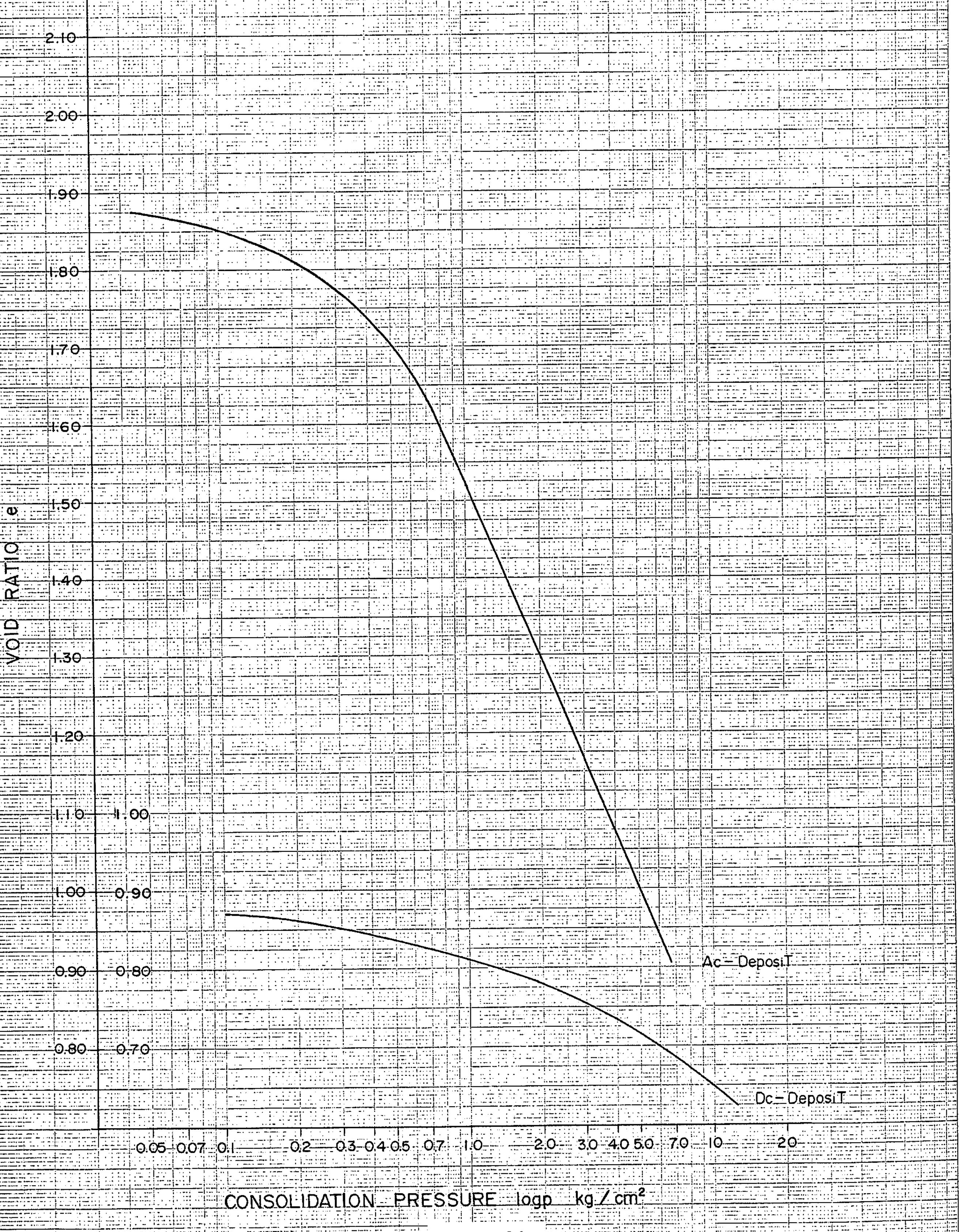
The soil strata boundaries, ground water level and presence or otherwise of sand strata that can assist with drainage are obtained from the geological longitudinal profile.

Table 7.2.14 Design Soil Parameters

Soil	Wet Density γt (t/m^3)	Cohesion of Initial Condition Co (tf/m^2)	Angle of Internal Friction Ø (Degrees)	e-log p Curve	log -Cv log p Curve	The Rate of Increase in Strength by Consolidation Pressure m	Consolidation Yield Stress Pc (tf/m^2)
Ac	1.580	0.75	-	Fig 7.2.9	Fig 7.2.10	0.25	3.00

Figure 7.2.9 e – logP DESIGN CURVE

Ac and Dc Cohesive Soil



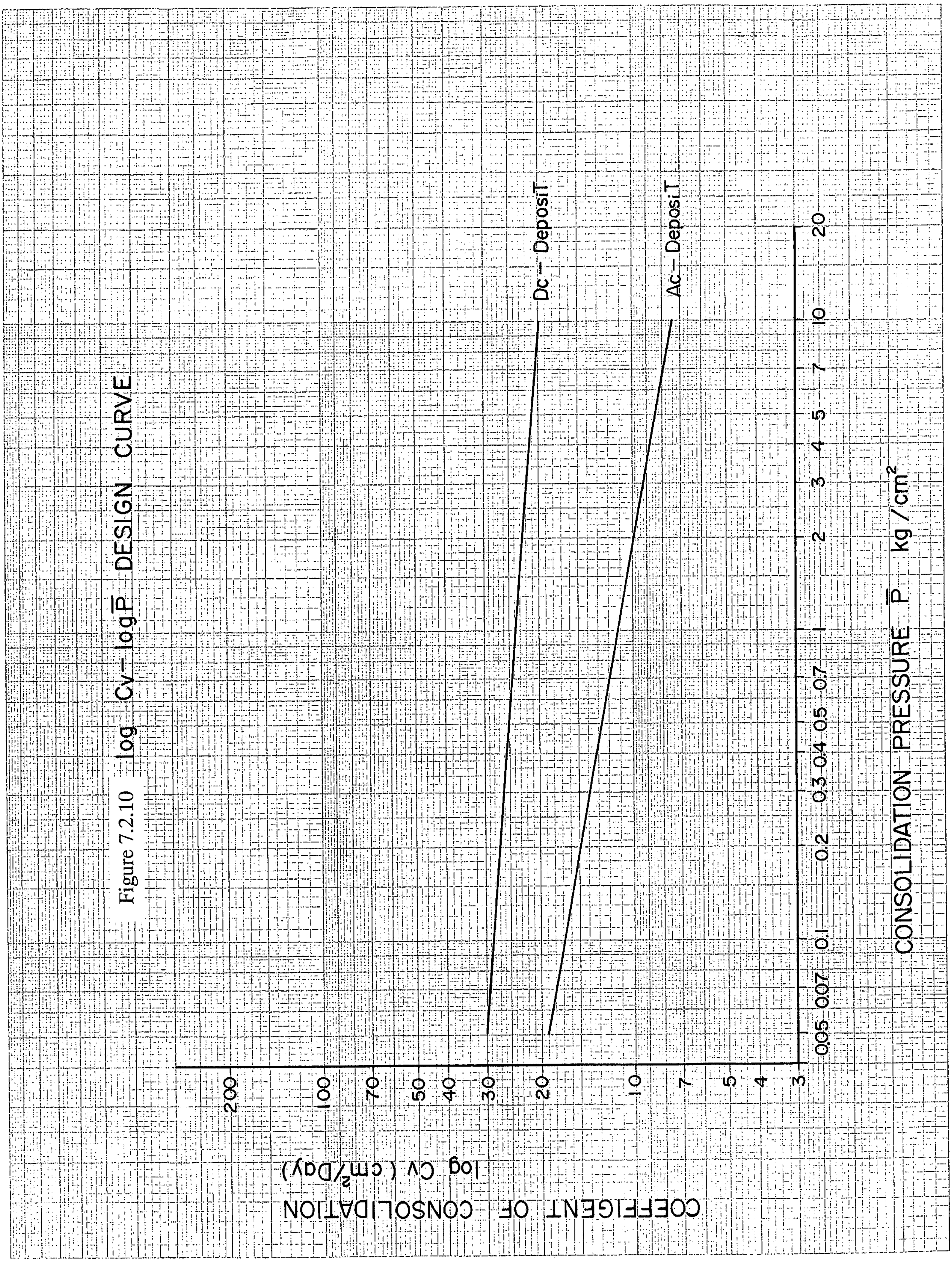


Figure 7.2.10 log Cv – log P̄ DESIGN CURVE
Dc – DeposiT
Ac – DeposiT
COEFFICENT OF CONSOLIDATION
log Cv (cm²/Day)
200
100
70
50
40
30
20
10
7
5
4
3
005
007
0.1
0.2
0.3
0.4
0.5
0.7
1
2
3
4
5
7
10
20
CONSOLIDATION PRESSURE P̄ kg / cm²

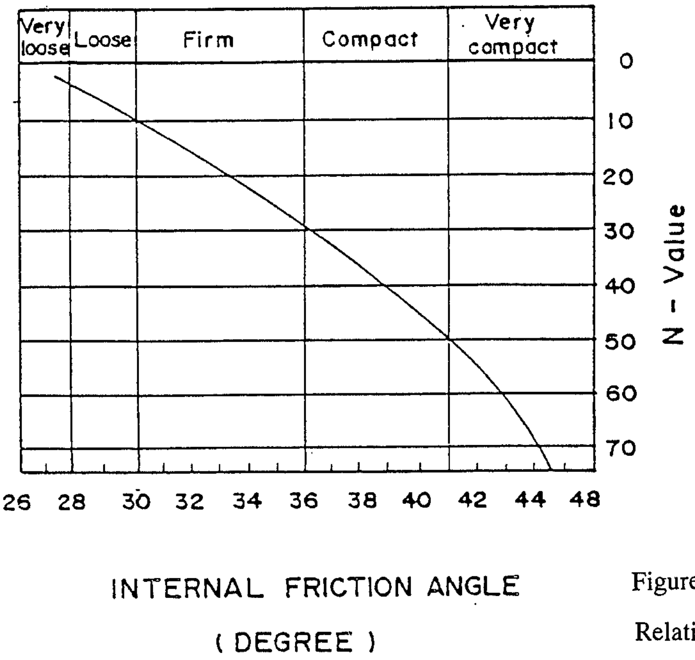


Figure 7.2.11a

Relative Chart for N-Value and Internal Friction Angle

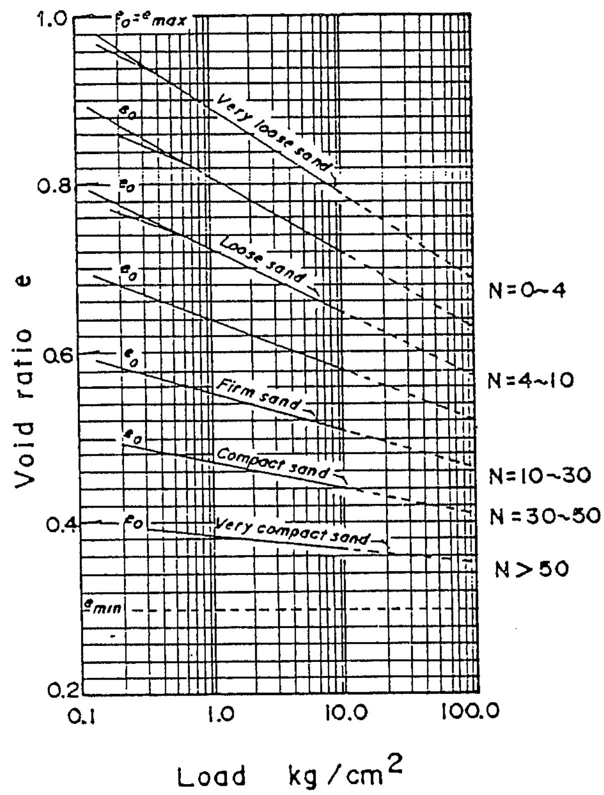


Figure 7.2.11b

Relative Chart for Load and Void Ratio of Sandy Soil

a/z

Figure 7.2.11	RELATIVE CHART FOR N-VALUE AND INTERNAL FRICTION ANGLE (Φ), AND VOID RATIO (e)
BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA	

7.3 Foundation Design

In this section treatment of soft ground and examination of strata as formations for carrying bridge foundation loads are investigated based on the analysis of borehole logs, geological longitudinal profiles and laboratory soil tests.

7.3.1 Soft Ground Treatment

(1) General

Areas of soft ground (Ac-deposit) are extensively distributed in the Mekong Delta Area extending up to 19~25 meters below ground level. In order to construct high embankments for approach roads to bridges, improvement of the soft ground is required.

Analysis for improvement of soft ground is carried out as follows:

- Select design soil parameters and stratigraphy.
- Determine design embankment profile and material.
- Select representative analysis section.
- Decide soft ground design method.
- Decide analysis method.
- Carry out analysis.

(2) Design soil parameters and stratigraphy

These are discussed in section 2 of this report and the parameters and stratigraphy used for analysis of the soft ground.

1) Embankment Profile and Material

Embankment profile and fill parameters are as follows:

- Embankment profile: width of road: 8.50 m
  slope gradient: embankment height less than 6 m 1: 1.5
  embankment height over 6 m 1: 1.75

- Embankment height: see Table 7.2.4 Borehole Results

- Design soil parameters for embankment fill
  - Wet Density $\gamma t = 1.80$ t / m^3
  - Cohesion $C = 2.20$ tf / m^2

- Angle of Internal Friction $\phi = 10$ (degree)
- Rate of Filling 3 cm / day

2) Representative Sections for Analysis

Sections for analysis will be made for each bridge at detailed design stage. In this report analysis is based on typical sections from Ca Mau, Bac Lieu and Soc Trang Province. The soft ground at these locations extends to about 20 meters below ground level.

(3) Soft Ground Design Method

1) Design Method

Soft ground design methods for high approach road embankments to bridges can be summarized as follows:

① EPS method: Reduction of embankment weight
② Soft ground treatment method: Increase strength of soft ground
③ Piled slab method: Embankment is supported by RC piles

Methods ① and ③ are very expensive, therefore method ② is adopted. There are many possible options included in method ②

The method adopted depends upon various factors such as the nature of the soil (bearing capacity and depth of individual strata), availability of soils, embankment height, and the construction period and cost.

These methods can be classified according to their main purpose, which may be either to prevent embankment slope failure, to accelerate settlement, or both.

Eight methods are summarized in table 7.3.1 and 7.3.2.

Table 7.3.1 Soft Ground Treatment Method

	Method	Description
1.	Ground surface treatment	- Use of sand, sheet, mat, etc. - Functions as upper discharge layer for consolidation - Prevents upward flowing ground water entering the embankment - Ensures access for construction plant - Cakar Ayam System - EPS method
2.	Replacement of soft ground	- Protects against slope failure and reduces settlement - Replacement depth is limited
3.	Berm (additional embankment)	- Increases resistance to slip circle failure - May be used for environmental reasons.
4.	Slow speed embankment construction	- To increase shear forces over a long period
5.	Surcharge	- To accelerate settlement prior to completion of the embankment and structure.
6.	Vertical drain	- To accelerate consolidation and strength increase - Sand drain, PVD drain (Card board drain) etc
7.	Compaction pile	- To increase strength and stability - Use of compacted sand and crushed stone
8.	Chemical soil stabilization	- To increase bearing strength and stability - Use of lime pile and cement grout, mortar injection

Table 7.3.2 Countermeasure for Soft Ground Treatment

ITEM	METHOD			
	SAND DRAIN	PVD	SAND COMPACTION	PRE-CAST RC PILE
Diameter (mm)	400	65	700	400 × 400
Increase in Strength Sub Soil (kg/cm^2)	C=0.3⇒1.0	C=0.3⇒0.5	C=0.3⇒3.0	-
Characteristic	This method is most popular	Construction Speed is Fast	Range of application is widely	No Settlement
Depth for practical application	30 m	10 m	35 m	30 m
Minimum Spacing	1.2 m	0.9 m	1.2 m	1.0 m
Construction Capacity	300 m/day	2,500 m/day	150 m/day	120 m/day
Ratio of Cost	1.0	0.2	2.4	11.0
Other	Many Satisfactory Result	Low depth for practical application		

2) Institution of Soil Criteria

General characteristics of the Soft Ground are as in the followings:

(a) Definitions of Soft Ground

General criteria of soft ground are as in following table.

Table 3.3.15 General Characteristics of Soft Ground

Soils	Peat or Clayey Soil		Sandy Soil
Stratum Thickness	Less than 10 m	More than 10 m	-----
SPT Blowcount	Less than 4	Less than 6	Less than 10
Unconfined Compressive Strength: qu (kgf/cm^2)	Less than 0.6	Less than 1	-----
Cone Resistance Dutch Cone Test: qc (kgf/cm^2)	Less than 8	Less than 12	Less than 40

(b) Classification by thickness of soft ground

The soft ground in the Mekong Delta can be classified in terms of its thickness as follows:

- Very Shallow : soft ground depth : $D < 2.5$ m
- Shallow : soft ground depth : 2.5 m $< D <$ 5.0 m
- Deep : soft ground depth : $D > 5.0$ m

(c) Selection of treatment method

For the selection of treatment methods the following criteria are applied:
- Stable and permanent foundations are required.
- Priority is given to a slow construction rate due to the substantial available time period, and due to the high cost of remedial works in the event of embankment failure.
- Sufficient program time to be allocated for settlement to occur.

- Replacement of soft ground to be limited to 2.5 m for economic reasons but to 5.0m for technical reasons
- Special attention to be paid to prevent heave of the surrounding ground

A number of alternatives have been considered, including vertical sand drains and drainage blanket as set out below.

(4) Method of Analysis

The embankment is analyzed for stability and for settlement. Improvement is calculated by reference to the case of no treatment. Formulae for analysis are as follows:

1) Ultimate settlement

$$Sc = \frac{eo - e1}{1 + eo} H$$

Where

Sc: Ultimate settlement (cm)

eo: Initial voids ratio

e1: Voids ratio after consolidation

H: Thickness of soil layer to be consolidated (cm)

2) Consolidation Time

- No Treatment Case

$$t = \frac{d^2 \times T}{Cv}$$

Where

t: Consolidation time (days)

D: Drainage path length (cm)

Cv: Consolidation coefficient (cm^2/day)

T: Time factor

- Sand Drain Case

$$t = \frac{De^2 \times T}{Cv}$$

Where

De: Effective drain radius (m) in square arrangement of sand pile, =1.13Dc

Dc: Centre to centre spacing of sand pile (m)

T: Time factor (obtained by n= De/Dw)

Dw: Diameter of sand pile (m)

3) Stability

$$Fs = \frac{\Sigma\{Cl + \tan\phi(W\cos\theta - ul - KW\sin\theta\ )\}}{\Sigma(W\sin\theta - KW\cos\theta\ )}$$

Where

C: Cohesion

ϕ: Angle of internal friction

l: Length of base of slice (embankment and existing ground layers)

W: Weight of soil slice

θ: Angle of base of slice to horizontal

u: Pore water pressure

k: Seismic coefficient

(5) Analysis Condition

- The stress distribution in the soil beneath the embankment is obtained from Figure 4.2 and 4.3. The intensity of the distributed embankment load is calculated at points in Figure 4.2

- The sand pile grid size determined was that where 30 days after completion of the embankment the degree of settlement remaining will be less than 10 cm

- Condition for sand pile.

Diameter of pile: Dw = 40 cm

Centre to centre spacing of piles: 1.2 < Dc < 3.0 meters

- Sliding check of existing ground treated by sand pile is carried out for two cases, immediately upon completion of the embankment and at a time thirty days after completion.

(6) Target for Settlement and Stability

- 30 days after completion of the embankment remaining settlement is not to exceed 10cm.

- Factor of safety against slip circle failure

  a) Upon completion of the embankment: $Fs > 1.10$

  b) 30 days after completion of the embankment: $Fs > 1.20$

  c) when traffic open: $Fs > 1.25$

(7) Degree of Consolidation

Graphs of degree of consolidation and time factors are shown in Figure 7.3.3

(Source: Standard of Japan Highway Corporation)

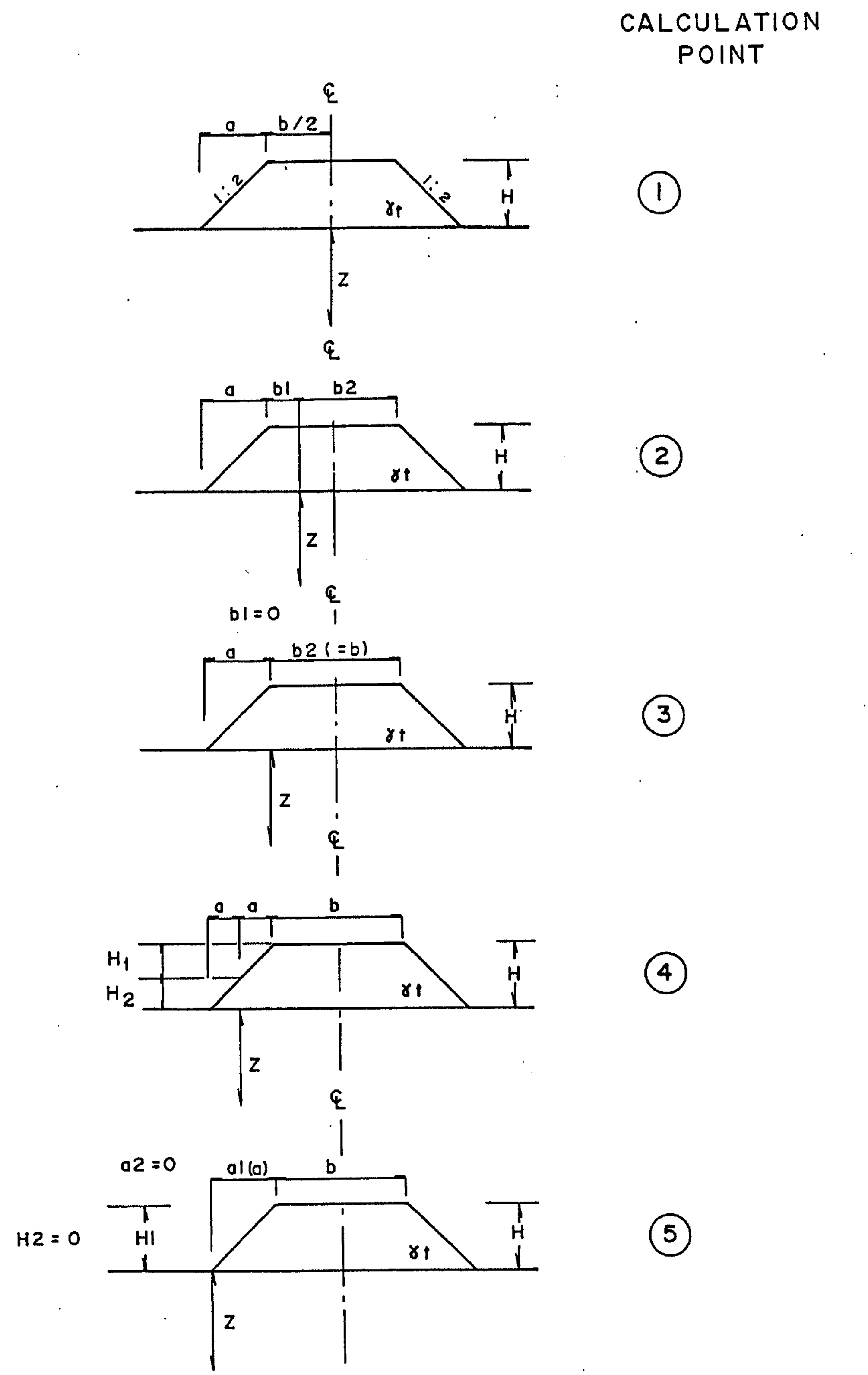


図 8.3.1

BASIC DESIGN STUDY ON THE PROJECT FOR
CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA

EMBANKMENT LOAD
AND
CALCULATION POINTS

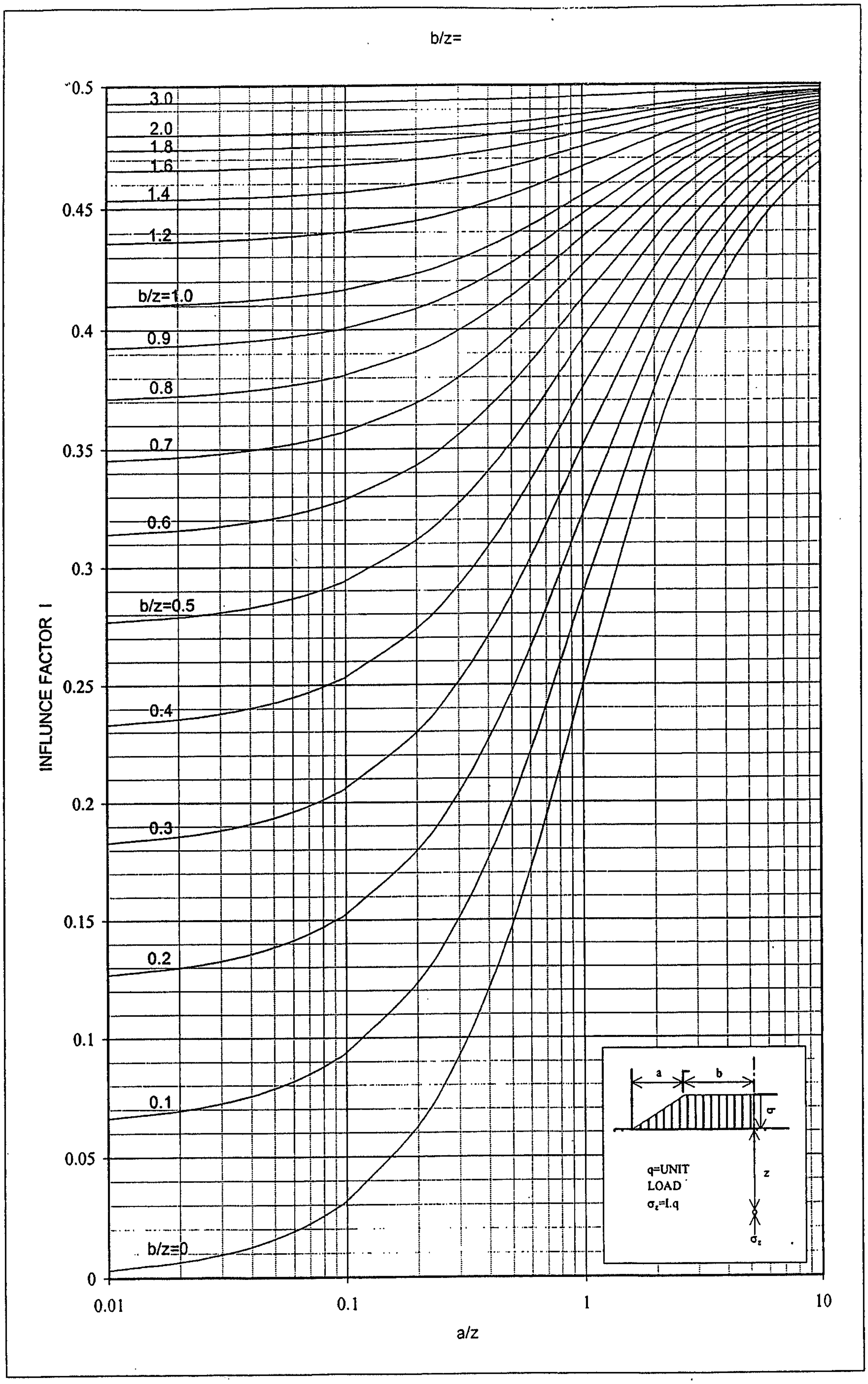
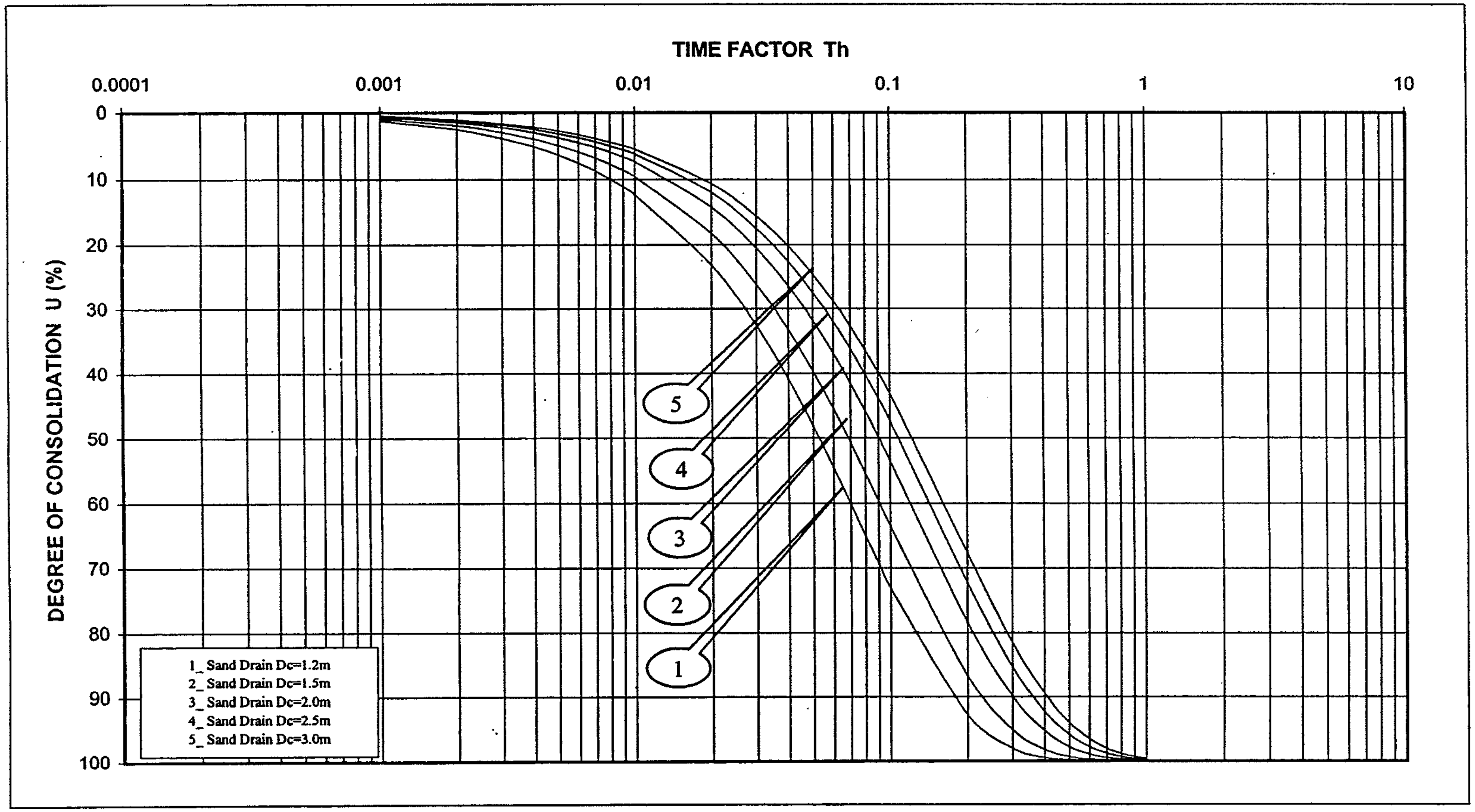


図 8.3.2

BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA

GRAPH OF INFLUNCE LINE (BY OSTERBERG)



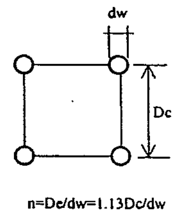


図 8.3.3

BASIC DESIGN STUDY ON THE PROJECT FOR
CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA

RELATIVE CHART OF
DEGREE OF CONSOLIDATION U(%) AND TIME FACTOR Th
FOR VERTICAL DRAIN METHOD

7.3.2 Result of Soft Ground Analysis

For a representative case of soft ground in the Mekong Delta Area, analysis of soft ground by the sand drain method is given below.

(1) Condition of Soft Ground

1) Extent of soft ground, and ground water level: refer to table 7.2.4
2) Design parameters of soft ground

γ t = 1.580 tf/m^3
qu = 1.50 tf/m^2
Co = 0.75 tf/m^2
Py = 3.00 tf/m^2
Ratio of strength to consolidation pressure m = 0.25
Figure 3.3.4 e-logP Design Curve
Figure 3.3.5 log Cv-logP Design Curve

3) Embankment Details

Embankment profile and fill parameters are summarized as follows:

- Embankment profile Width of road: 8.50m

Slope gradient:	embankment height less than 6m	1: 1.5
	embankment height over 6m	1: 1.75

- Embankment height: refer to Table 7.2.4 Borehole Results
- Fill parameters

  - Wet Density .... γt = 1.80 t / m^3
  - Undrained Shear Strength................ C = 2.20 tf / m^2
  - Angle of Internal Friction .... ϕ = 10 (degree)
  - Rate of Filling.................................. 3 cm / day

(2) Results of Analysis

Maximum permitted embankment height based on representative soft ground conditions

- Embankment on untreated soft ground

When Fs = 1.20 H_E = 2.20 m
When Fs = 1.10 HE = 2.50m

- After soft ground treatment by sand drain method

  When safety factor Fs = 1.20, maximum embankment height H_E = 5.60m
  Sand drain details

  - Square arrangement of sand piles
  - Spacing of piles: 1.20m
  - Diameter of piles: 0.40m
  - Length of piles: 20m

- Settlement HE = 7.70m→5.60m ∴Sc = 2.10m (at centre of embankment)

- Remaining settlement (180days to be left after embankment completion)

  Rsv = 11.9cm

- Embankment heights for approach roads to bridges are less than HE=5.6m

(2) Notes for Construction

Soft ground (very soft clay), which is extensively distributed in the Mekong Delta Area, is characterized by the following features.

① Natural water content Wn about equal to the liquid limit W_L
② Coefficient of consolidation value Cv (cm^2/day) is very low

Feature ① indicates the possibility of liquefaction when disturbed, resulting in loss of soil strength, therefore after construction of sand piles a recovery period of 60~90 days is required prior to embankment construction.

Feature ② indicates long consolidation periods are required. In order for residual settlement to not exceed 12cm, a consolidation period of 180 days is required after completion of an embankment (H_E = 4~5m).

(2) Extent of Sand Drains

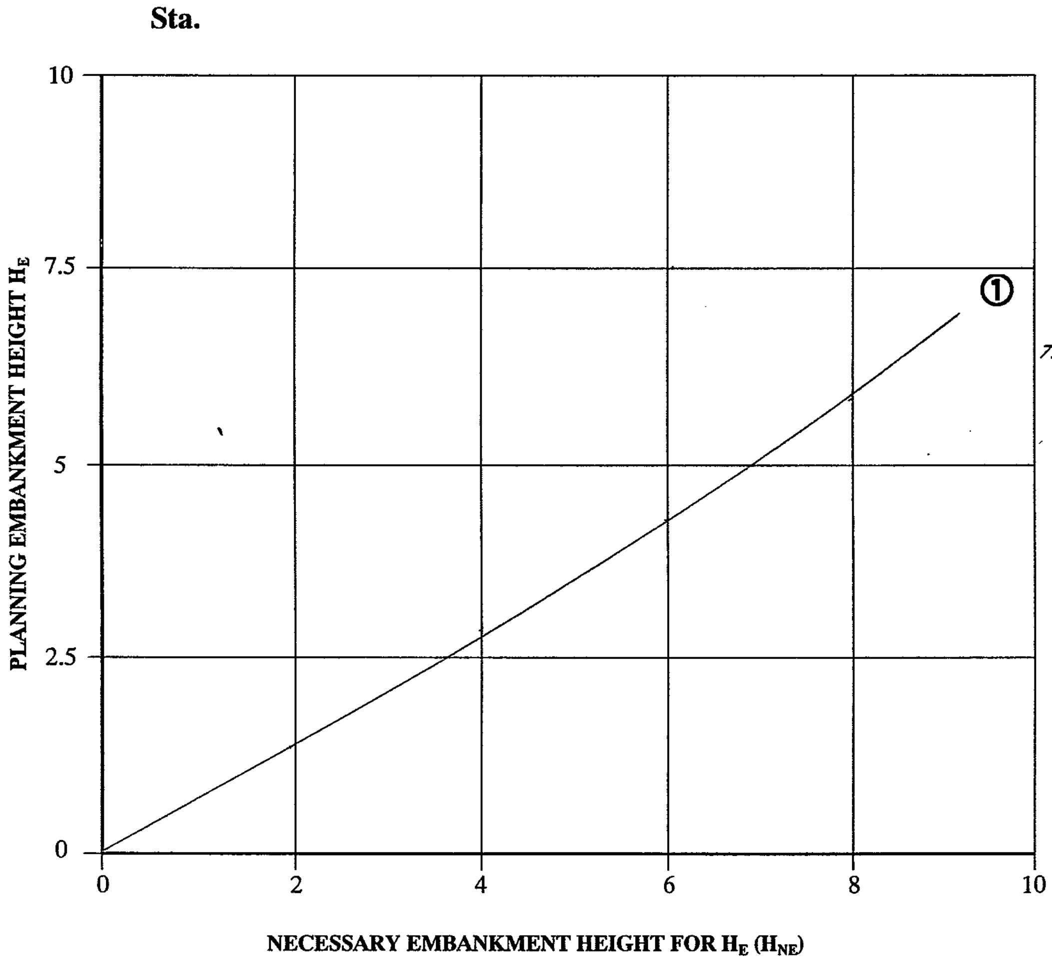
The required extent of treatment by sand drains is: in the direction of the centerline from the abutment to the point where the embankment height H_E=1.75m(in case of safety factor Fs=1.2), and in cross section from toe of left shoulder to toe of right shoulder.

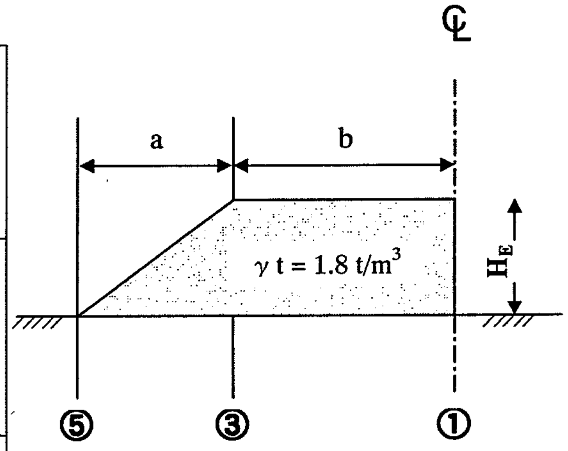
Table 7.3.4 **SOIL SECTION AND INVARIABLE SOIL VALUE FOR DESIGN**

EXAMINED LOCATION:

STA. Representative Bridge in Melcong Delta Area

Depth	Division of soil	Thickness of soil	Depth of central stratum	N Value	Wet unit weight	Cohesion of initial condition	Modulus of deformation	The rate of increase in strength	Yield stress	Remark
(m)		H (m)	(m)		γ (t/m^3)	Co (t/m^2)	E_{50}(t/m^2)		Py (t/m^2)	
2.20	Ac.1	2.20	1.10	0	1,580	0.750	-	0.25	3.00	2.20 ▽
20.00	Ac.2	17.80	11.10	0	0.580	0.750	-	0.25	3.00	
25.50	Dc.1	5.50	22.75	23	0.800	7.000	-	-	-	





H_E (m)	S_E (m)	H_{NE} (m)
2,126	0.874	3.00
3,541	1.459	5.00
5,056	1,944	7.00

図 8.3.4

BASIC DESIGN STUDY ON THE PROJECT FOR
CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA

RELATIVE CHART OF
PLANNING EMBANKMENT HEIGHT (H_E)
AND NECESSARY EMBANKMENT HEIGHT (H_{NE})

LIMITED EMBANKMENT HEIGHT

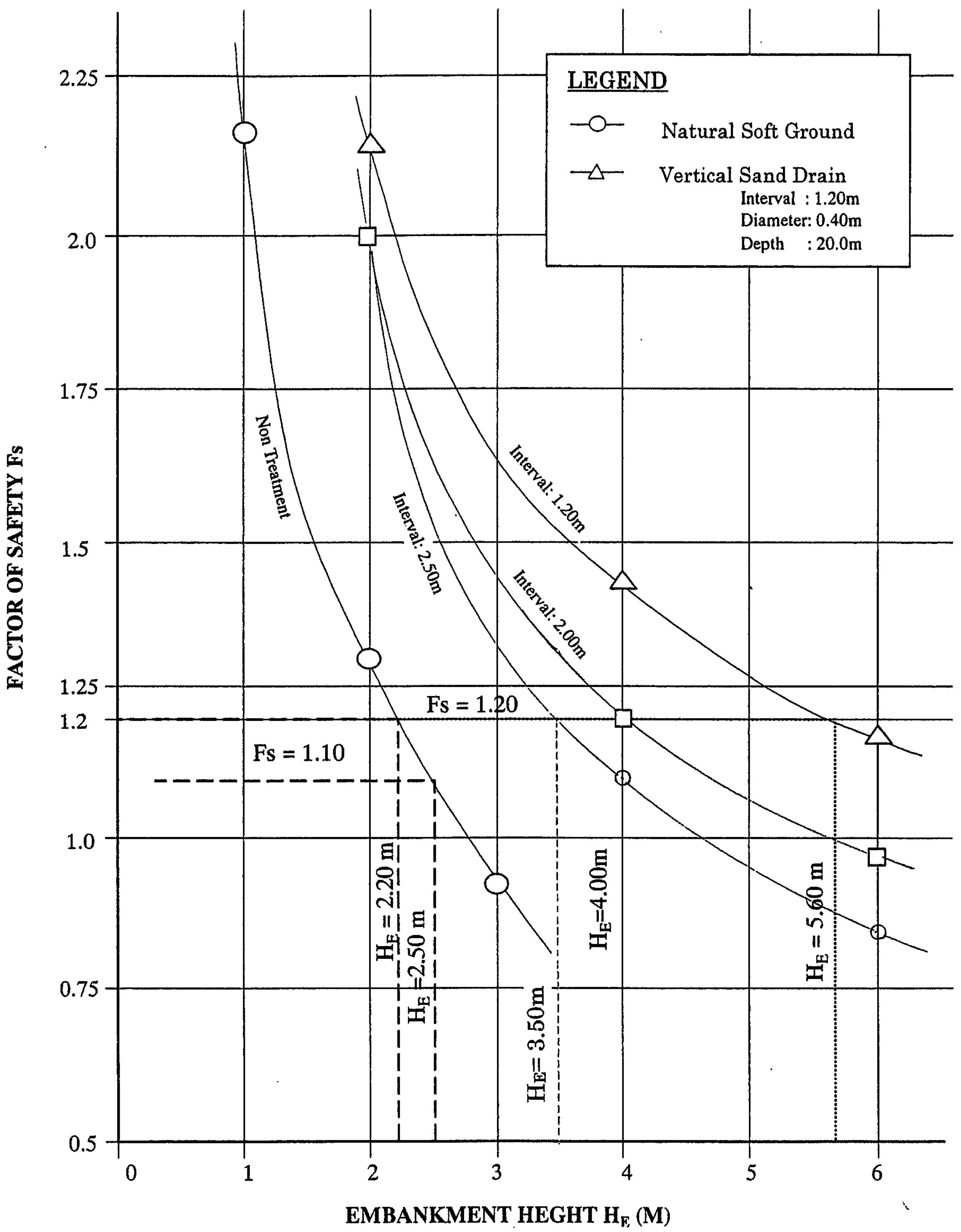


図 8.3.5	RELATIVE CHART OF EMBANKMENT HEIGHT (H_E) AND FACTOR OF SAFETY (Fs)
BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF BRIDGES IN MEKONG DELTA AREA	