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バングラデシュ人民共和国

メグナ・メグナグムティ橋建設計画調査
報　告　書

（資　料　編）

昭和60年3月

国　際　協　力　事　業　団

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AP. TABLE 2-1 : MONTHLY NORMAL TEMPERATURE AT DHAKA AND COMILLA STATIONS

(Unit : Centigrade)

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Dhaka	Max.	25.5	28.1	32.5	35.1	36.2	31.8	30.7	31.0	31.2	30.9	28.7	26.3	30.5
	Min.	11.8	13.4	18.8	23.4	25.4	25.9	26.0	26.0	30.9	23.7	17.6	12.7	21.4
Comilla	Max.	26.4	28.3	32.5	33.6	32.9	31.3	30.9	31.0	31.6	31.2	29.2	26.9	30.5
	Min.	12.1	14.7	19.7	23.2	24.6	25.5	25.4	25.4	24.2	23.7	18.3	13.8	20.9

Note : Based on data for 1931 - 1960

Source : Bangladesh Bureau of Statistics

AP. TABLE 2-2 : RAINFALL AT DHAKA AND COMILLA CENTRES

(Unit : Millimetres)

Centre	1974	1975	1976	1977	1978	1979-80	1980-81	1981-82	1982-83	Average
Dhaka	2213	2044	2645	2112	1537	2458	2409	1034	1514	1996
Comilla	2118	2752	1885	2047	1878	2987	2663	1182	1610	2124

Note : From 1978 - 79 on wards data have been shown on July - June basis.

Source : Bangladesh Meteorological Department.

AP. TABLE 2-3 MONTHLY NORMAL RAINFALL AT DHAKA AND COMILLA STATIONS

(Unit : Millimetres)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Dhaka	18	31	58	103	194	322	437	304	236	169	25	23
Comilla	10	44	53	158	316	479	404	417	337	226	45	2.5

Note : Based on data for 1931 - 1960

Source : Bangladesh Meteorological Department.

AP. TABLE 2-4 MONTHLY MAXIMUM WIND SPEED (IN KNOTS) AT DHAKA

Mon / Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1953	9	14	24	53	60	35	11	19	25	15	13	9	23.9
54	9	13	20	18	60	16	17	14	15	24	5	7	18.1
55	10	12	78	71	60	15	16	13	40	16	10	7	29.0
56	12	9	60	52	25	26	35	16	22	12	9	9	23.9
57	27	14	14	35	43	30	16	14	12	14	7	9	19.6
58	10	40	16	30	71	35	18	20	18	12	7	9	24.4
59	9	16	35	22	87	18	22	15	12	19	7	9	22.6
60	10	16	26	60	40	18	25	18	16	28	9	7	22.8
61	7	13	39	52	60	35	18	16	16	14	10	10	24.1
62	14	17	48	52	43	19	19	14	35	9	10	13	24.4
63	12	17	25	45	40	36	21	20	22	-	-	-	-
64	9	45	50	43	65	70	19	19	25	25	13	9	32.7
65	9	9	39	31	79	25	19	19	13	9	40	13	25.4
66	9	9	14	28	30	30	13	10	10	30	5	5	16.0
67	9	9	35	15	50	36	13	13	13	9	9	5	18.0
68	9	9	52	52	65	30	35	13	13	13	5	5	27.6
69	17	9	30	17	9	13	9	13	17	13	5	5	13.1
70	15	28	60	65	40	20	28	18	24	90	40	10	36.5
71	14	13	-	-	50	25	25	20	13	20	20	-	-
72	12	22	35	60	45	29	42	26	20	18	15	10	27.8
73	9	60	20	60	40	13	10	9	9	9	13	25	21.4
74	6	5	35	55	31	9	10	14	19	5	5	5	16.6
75	14	27	25	50	44	35	9	9	5	5	-	-	-
76	17	5	35	48	17	42	13	19	19	15	5	5	20.3
77	20	30	35	50	52	37	13	20	13	5	5	9	24.1
78	9	43	40	55	45	10	12	13	19	13	9	9	23.1
79	5	9	25	65	40	25	19	25	9	13	13	5	21.1
80	5	45	52	74	95	38	38	15	9	15	5	5	33.0
81	15	13	19	19	19	20	13	13	13	9	9	44	17.2
82	10	9	13	19	19	13	18	19	9	9	5	9	12.7

Source : Bangladesh Meteorological Department

1 KNOT = 1.852 Km/Hr

100 KNOTS = 51.4 m/sec.

AP. TABLE 2-5 MONTHLY MAXIMUM WIND SPEED (IN KNOTS)

AT COMILLA

Year \ Mon	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1951	4	20	16	22	16	18	21	18	08	16	08	04	14.3
52	12	16	18	20	18	18	18	16	10	09	09	06	14.2
53	05	09	10	09	12	09	09	05	09	09	02	02	7.5
54	03	05	09	13	09	14	09	13	09	07	05	02	8.2
55	02	03	14	15	10	12	14	12	09	07	05	02	8.8
56	-	-	-	-	-	-	11	15	08	02	00	02	-
57	05	08	09	24	24	10	10	16	10	02	02	02	10.2
58	03	03	07	17	21	17	12	09	05	25	00	03	10.2
59	00	12	09	07	14	12	14	09	09	06	00	06	8.2
60	06	11	09	15	15	19	25	19	19	35	09	09	15.9
61	09	19	19	19	19	19	19	19	13	09	09	00	14.4
62	09	09	13	13	19	13	13	13	19	09	05	00	11.3
63	09	09	13	19	19	19	13	19	13	31	05	00	14.1
64	05	13	09	13	09	13	13	13	13	13	05	05	10.3
65	00	09	05	19	31	19	09	09	05	05	05	09	10.4
66	02	07	07	13	09	09	13	13	09	15	03	02	8.5
67	-	09	09	13	13	09	13	13	13	13	05	05	-
68	09	02	13	13	13	19	13	13	09	25	00	09	11.5
69	05	05	09	19	09	09	09	-	09	09	00	00	-
70	05	09	-	-	-	13	05	09	09	30	19	-	-
71	-	05	05	-	05	13	-	19	09	09	13	-	-
72	-	-	22	34	25	25	09	20	09	15	09	10	-
73	10	13	15	35	20	15	12	11	13	12	19	25	16.7
74	05	07	15	25	35	40	15	20	15	07	15	07	17.2
75	15	15	15	30	25	25	-	20	12	10	02	05	-
76	-	-	-	25	18	18	20	18	15	12	10	10	-
77	07	09	07	09	12	09	15	16	21	12	09	02	10.7
78	07	12	03	13	13	05	17	18	28	13	05	07	11.8
79	05	13	10	18	21	12	15	13	09	13	03	02	11.2
80	07	15	12	22	25	14	18	16	09	13	05	05	13.4
81	-	-	15	20	15	15	15	18	10	09	04	35	-
82	04	07	15	20	15	09	15	18	15	12	07	08	12.1

Source : Bangladesh Meteorological Department

1 KNOT = 1.852 km/Hr

100 KNOTS = 51.4 m/Sec

AP.TABLE 2-6 RECORD OF CYCLONIC STORMS WHICH AFFECTED VICINITY OF MEGHNA ESTURARY AND BRIDGE SITES

Date of Occurrance	Affected Area	Nature of the Phenomena	Approximate Loss/Damages
May 16-19, Oct. 21-24, both 1958	East Meghna esturary near 91 east of Barisal and Noakhali also West Meghna esturary	Cyclonic storm	Damage report not available
Oct. 9-10, 1960	Eastern Meghna estuary	Severe cyclonic storm 125 miles per hour, maximum storm wave 10 ft.	Caused considerable damage to Char Jabbar, Char Amina, Char Bhati, Ramgati, Hatya and Noakhali. 3,000 people reported killed.
May 9, 1961	West Meghna estuary, Comilla and Dhaka	Severe cyclonic storm speed 90-92 miles and wave 8-10 ft.	Rail track between Noakhali and Harinarayanpur damaged. Heavy loss of life in Char Allanda.
May 11-12, 1965	Barisal, Faridpur, Khulna, Jessore, Chittagong, Sylhet and Noakhali	Most severe cyclonic storm, maximum speed at Dhaka 100 miles per hour, with storm wave 12 ft.	Total loss of life 19,270. In Barisal 14,193 people were killed.
Nov. 12-13, 1970	Meghna estuary	Most severe cyclonic storm accompanied by moderate severe storm surge. Naval ship at Chittagong reported speed 138 miles per hour.	The entire belt from Khulna to Chittagong and offshore islands experienced hurricane winds for about 9 hours accompanied by storm surge of moderate to severe intensity which caused widespread damage to crop and properties. Innumerable human lives estimated to be about 200,000 were lost. A great number of animals were also killed.

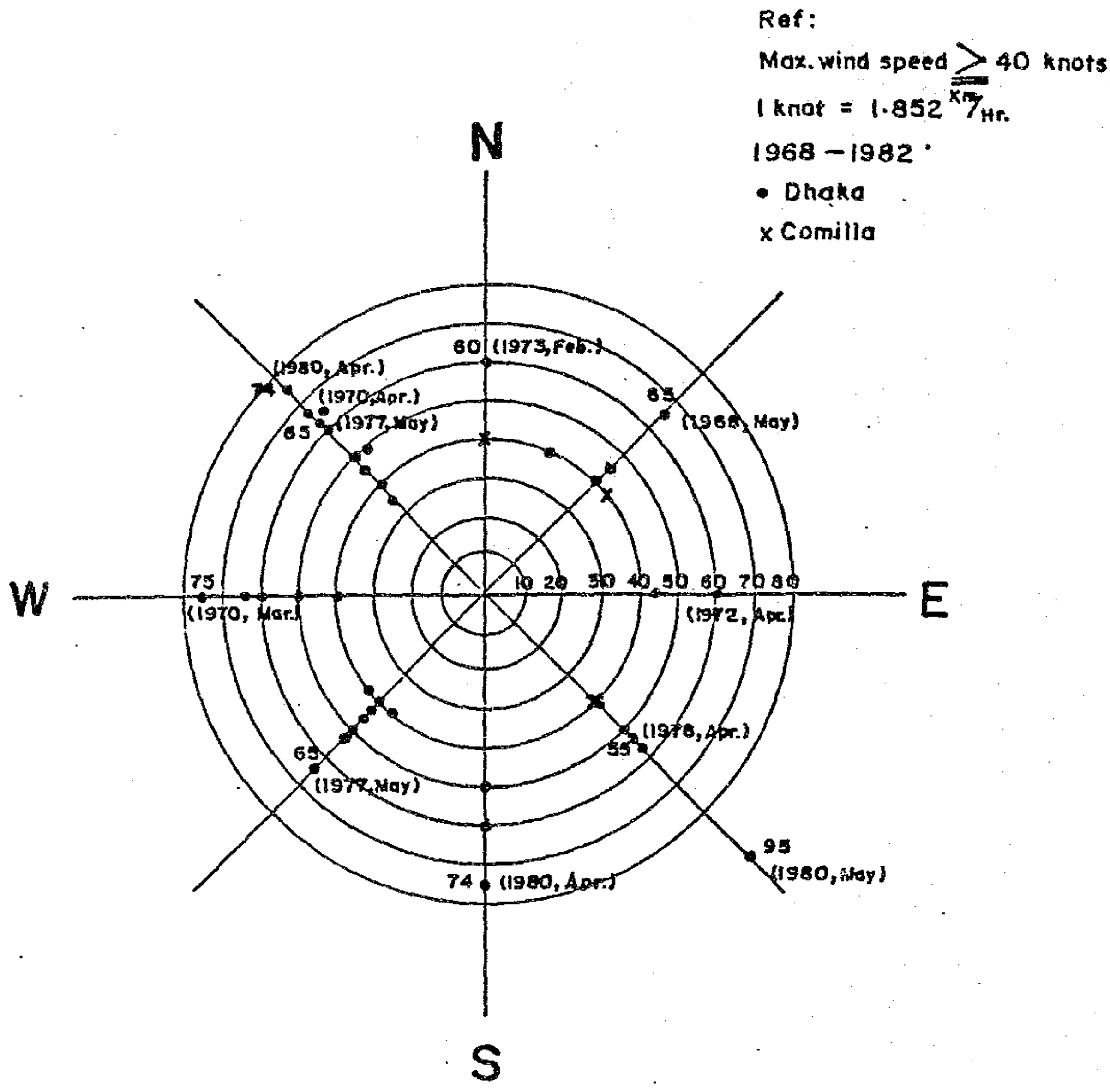
Source : The 1982 Statistical Yearbook of Bangladesh

AP. TABLE 2-7 MAXIMUM WIND SPEED IN KNOTS DIRECTION

Year Station / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1977												
Comilla	N/NW14	S15	S25	S35	S/SW25	SE25	S/SE19	S16	S17	NE10	N08	NW10
1978												
Comilla	SE07	N12	SE06	S09	SE19	S/SE5	S17	S18	S/SW12	SE13	S/SE5	N07
1979												
Comilla	NNW12	V13	S16	V13	S19	S18	S22	E20	S04	SE07	SE05	N03
Dhaka	V05	NW21	SW40	NW65	W50	E/SE25	SE/S19	SE25	SE/S09	SE/S13	N/NE13	NW05
1980												
Comilla	N08	NW15	NW12	S20	N25	SE14	SE18	SE16	E05	SE13	N05	NW05
Dhaka	NW05	NE/E45	SE/SW52	S/NW74	SE95	SE/S38	SE/S38	SE15	SE09	E15	N/NW05	NW05
1981												
Comilla	n.a.	n.a.	N15	S20	E15	SW15	S15	SE18	S10	S09	NE04	S35
Dhaka	N15	SW13	NW19	SE19	NW19	SE20	S13	SE13	SE13	N09	W09	SW44
1982												
Comilla	N04	N07	N15	S20	SE15	S09	S15	S18	SE15	W12	NW07	S08
Dhaka	NW10	W09	N13	W19	N19	SE13	S18	S19	S09	SW09	E05	W09

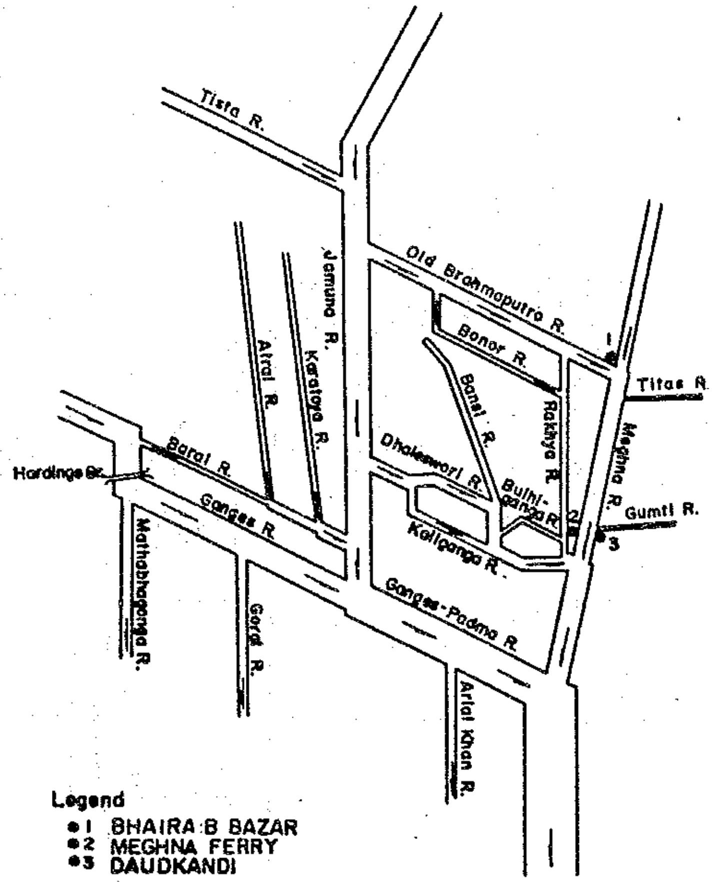
Note : V - Variable
n.a.-data not available

Source : Bangladesh Meterological Department



Source: Bangladesh Meteorological Department

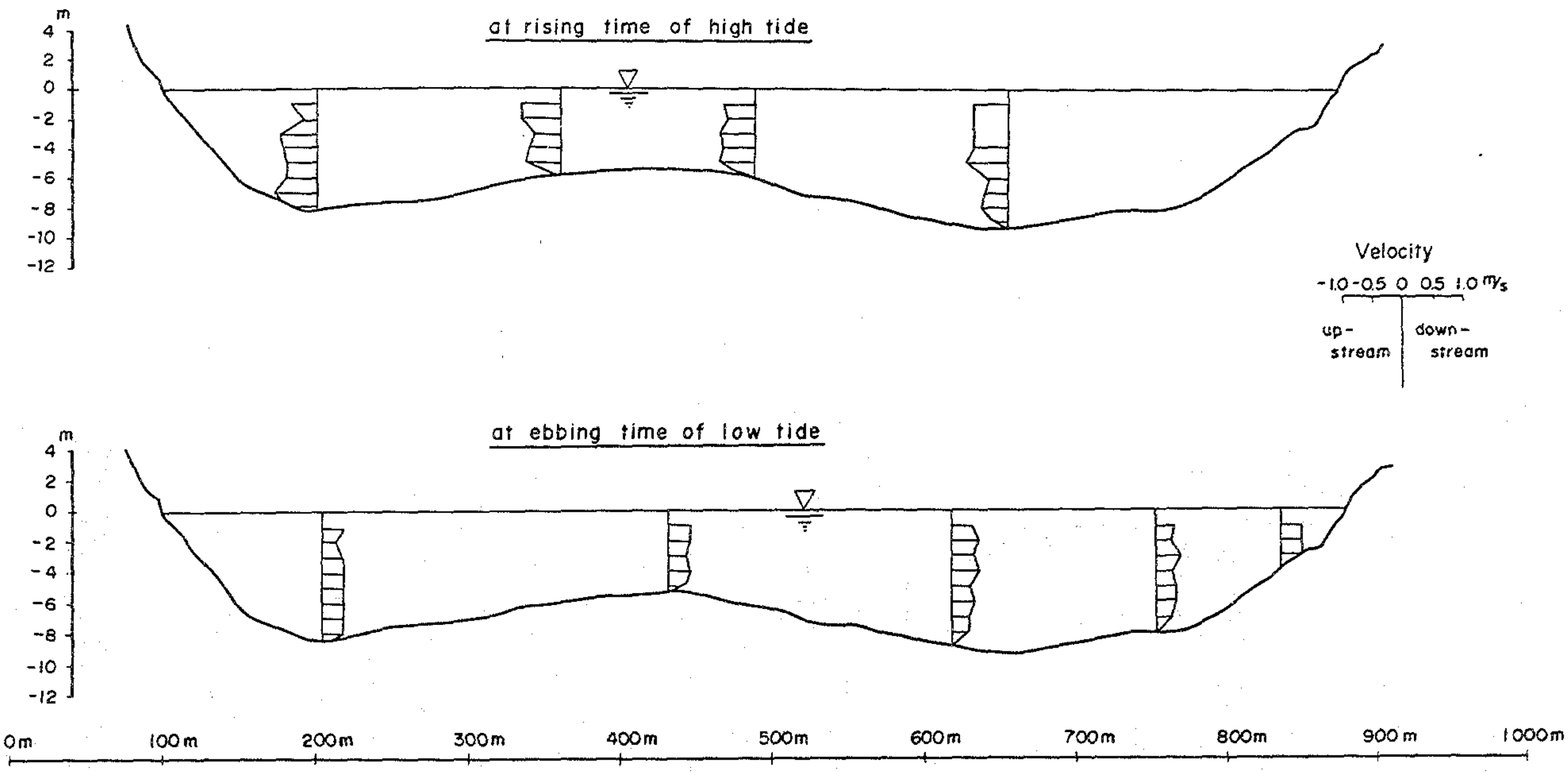
AP.FIG. 2-1 PAST MAXIMUM WIND SPEEDS AND DIRECTIONS



Item \ River	MEGHNA. R	BRAHMAPUTRA. R.	GANGES. R.
Total stream length (km)	880	2 800	2 560
Stream length in Bangladesh (km)	560	275	400
Catchment area (km^2)	77 000	580 000	900 000
Catchment area in Bangladesh (km^2)	46 500	31 000	39 000
Maximum experienced discharge (km^2)	19 500	70 000	85 000
Minimum experienced discharge (m^3/s)	370	3 300	1 200
Annual mean discharge (m^3/s)	3500	12 900	11 700
Water surface slope	1 : 8 800	1 : 16 000	1 : 20000

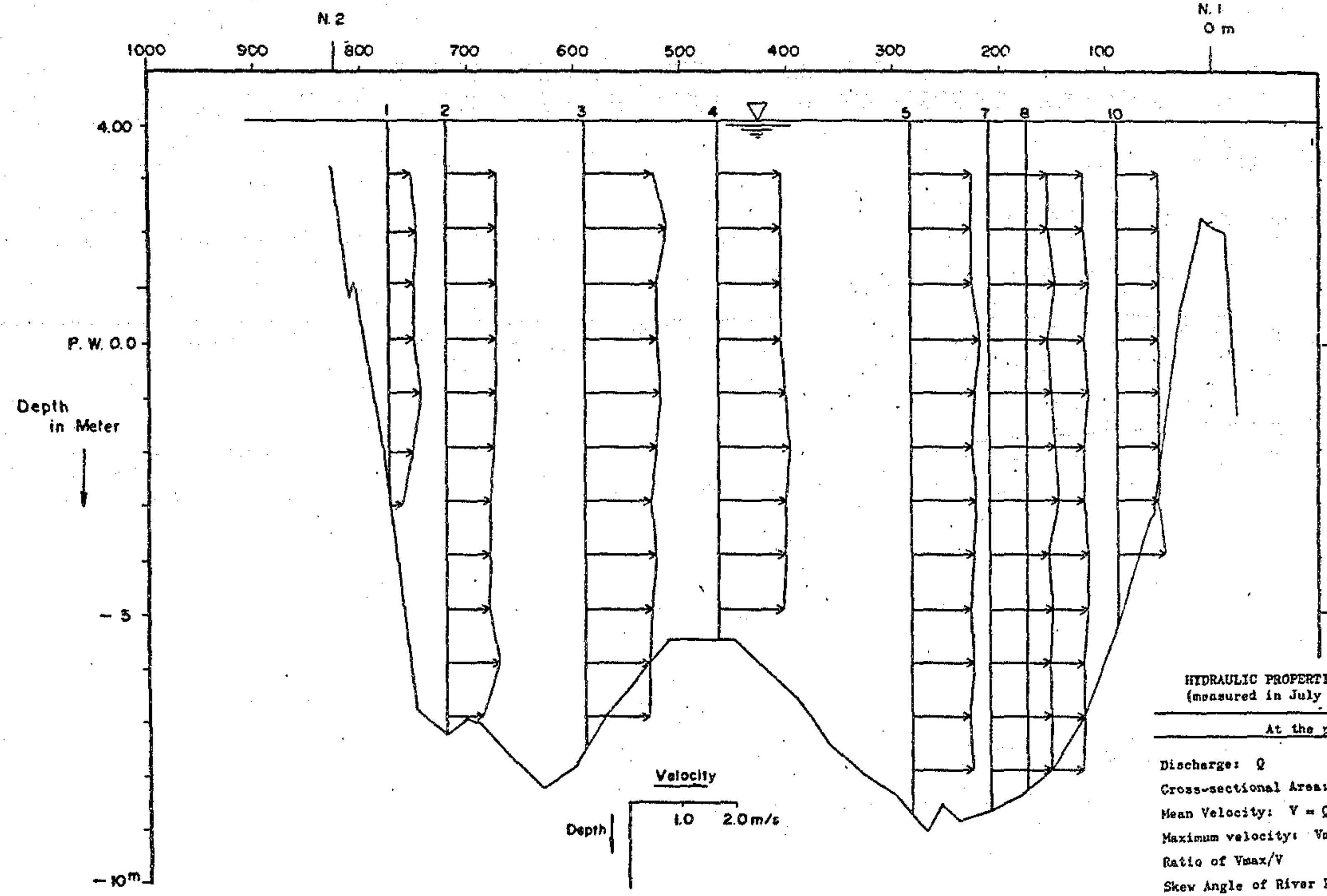
Source: Report "Flood Control in Bangladesh" by DR. MD SAYEEDUL ISLAM KHAN, 1977

AP. FIG. 2-2 RIVER SYSTEM AROUND THE MEGHNA RIVER AND GENERAL FEATURE OF THE MAIN RIVERS IN BANGLADESH



Source: The Study Team

AP. FIG. 2-3 VELOCITY OF RIVER FLOW AT THE PROPOSED MEGHNA BRIDGE SITE, MEASURED IN APRIL, 1984

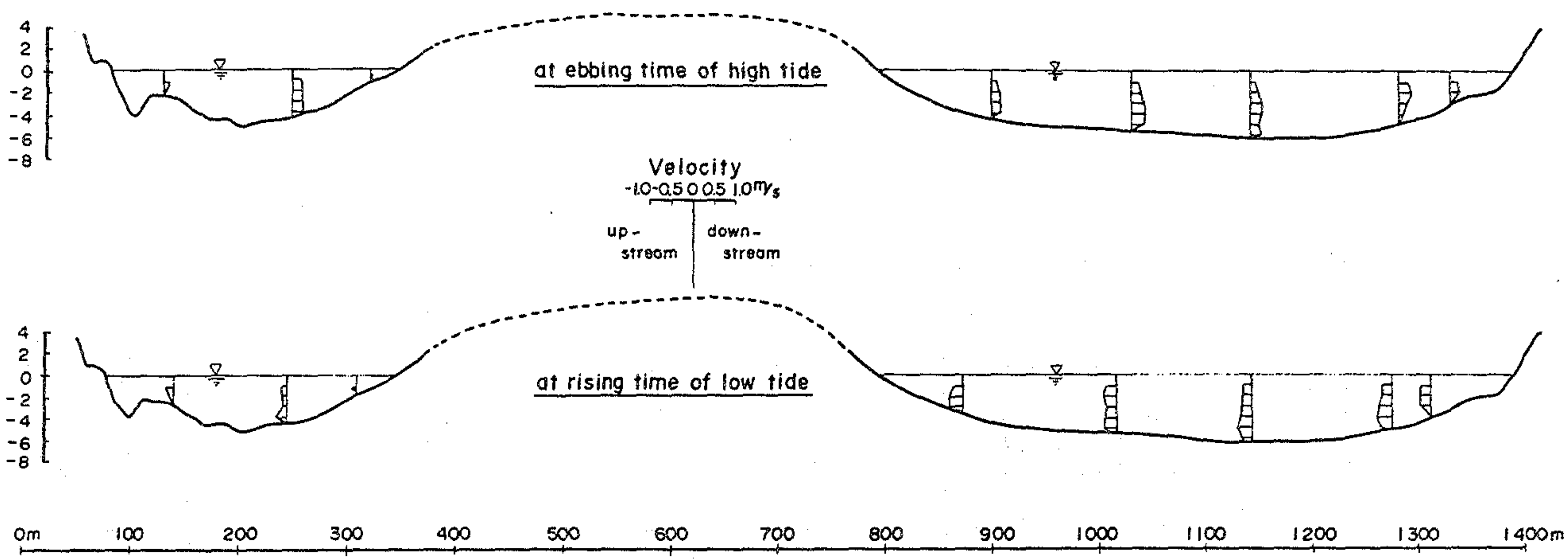


HYDRAULIC PROPERTIES OF MEGHNA RIVER
(measured in July 1984)

	At the proposed site of Meghna Br.
Discharge: Q	9,020 m^3/s
Cross-sectional Area: A	8,181 m^2
Mean Velocity: V = Q/A	1.10 m/s
Maximum velocity: Vmax	1.54 m/s
Ratio of Vmax/V	1.40
Skew Angle of River Flow	29 degrees

Source: The Study Team

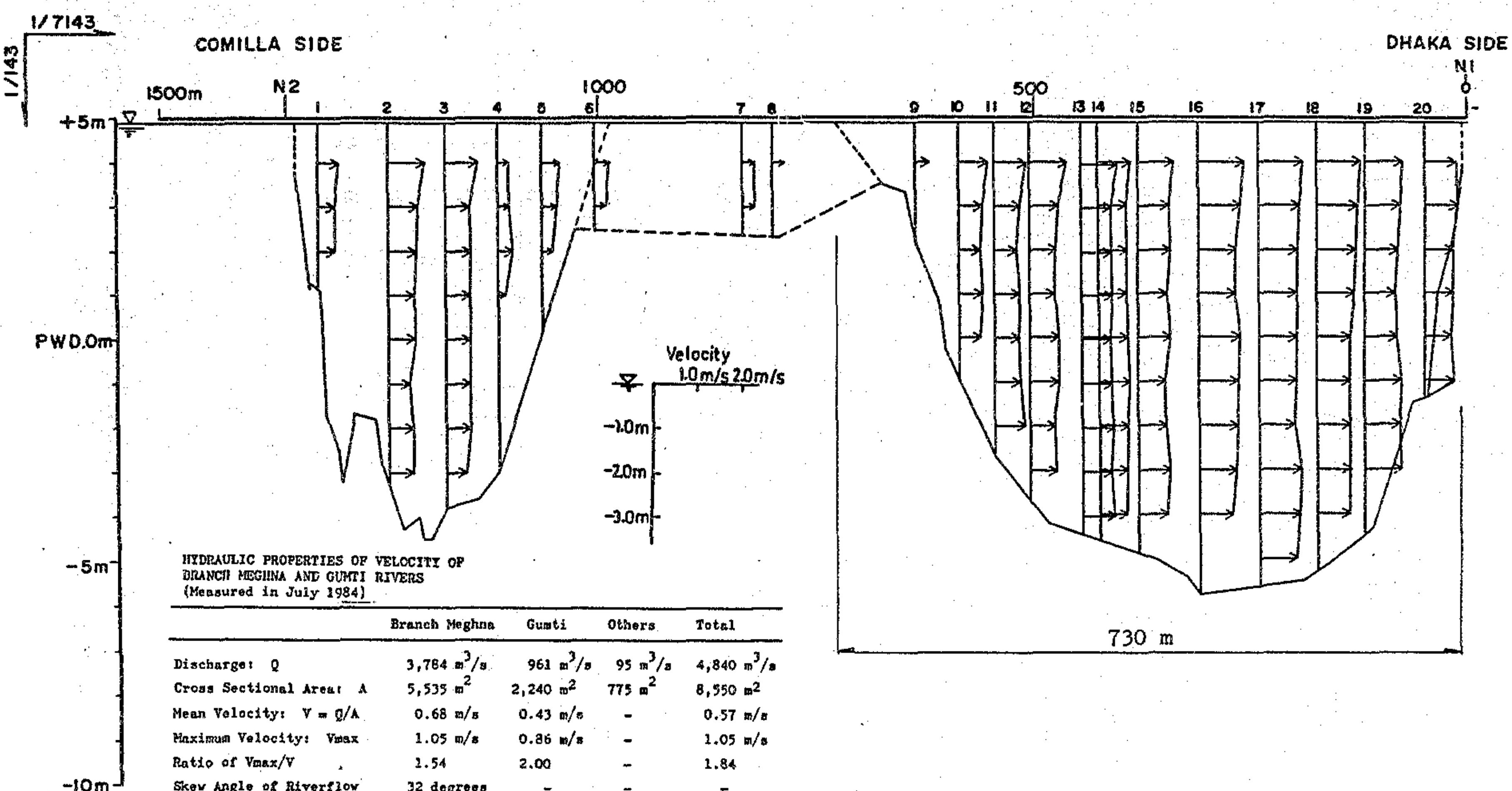
AP. FIG. 2-4 VELOCITY OF RIVER FLOW AT THE PROPOSED MEGHNA BRIDGE SITE, MEASURED IN JULY, 1984



Source: The Study Team

AP. FIG. 2-5 VELOCITY OF RIVER FLOW AT THE PROPOSED MEGHNA-GUMTI BRIDGE SITE, MEASURED IN APRIL, 1984

NO 3

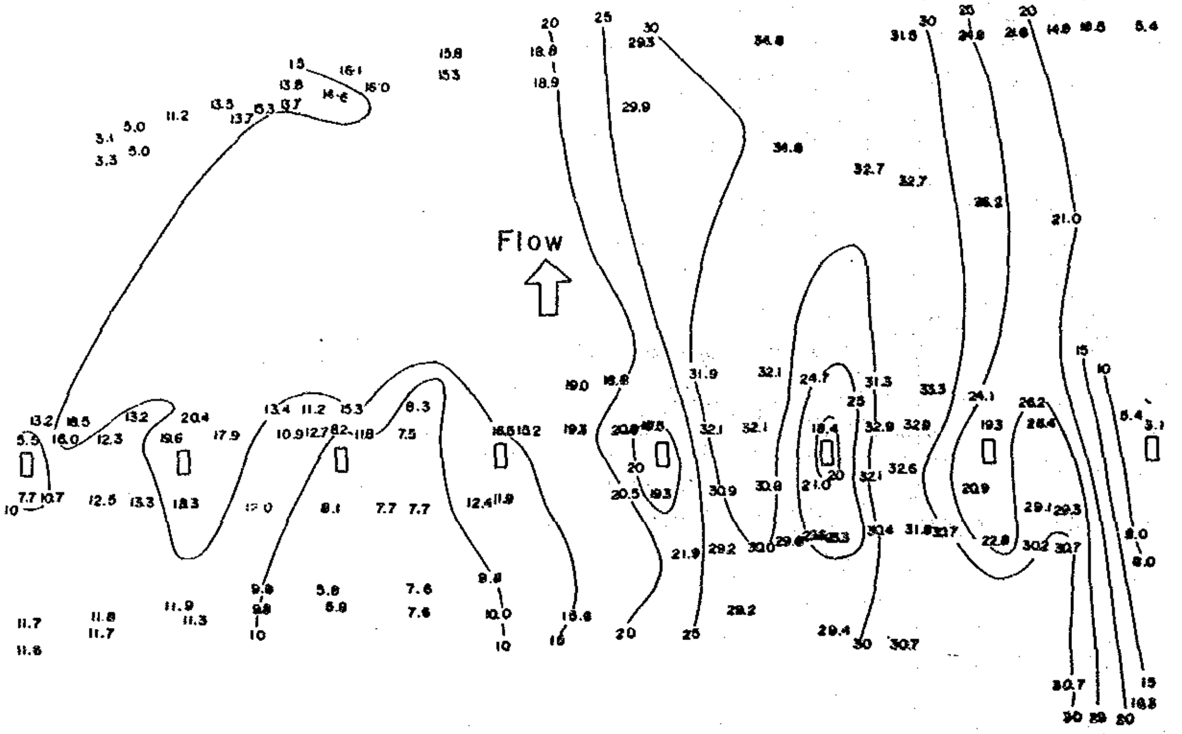


HYDRAULIC PROPERTIES OF VELOCITY OF BRANCH MEGHNA AND GUMTI RIVERS (Measured in July 1984)

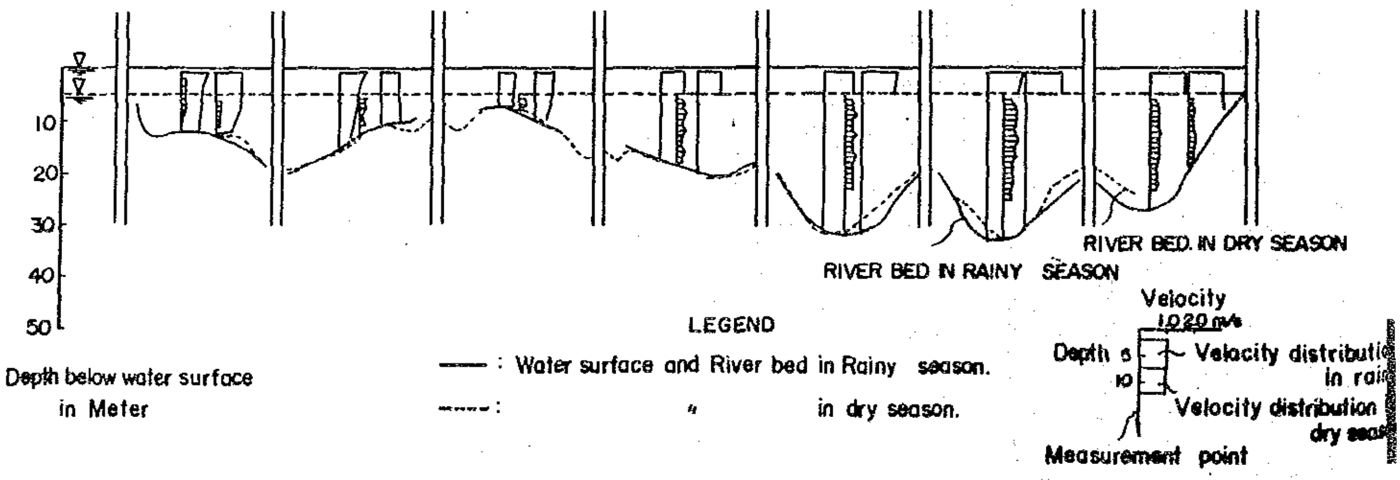
	Branch Meghna	Gumti	Others	Total
Discharge: Q	3,784 m^3/s	961 m^3/s	95 m^3/s	4,840 m^3/s
Cross Sectional Area: A	5,535 m^2	2,240 m^2	775 m^2	8,550 m^2
Mean Velocity: V = Q/A	0.68 m/s	0.43 m/s	-	0.57 m/s
Maximum Velocity: Vmax	1.05 m/s	0.86 m/s	-	1.05 m/s
Ratio of Vmax/V	1.54	2.00	-	1.84
Skew Angle of Riverflow	32 degrees	-	-	-

Source: The Study Team

AP. FIG. 2-6 VELOCITY OF RIVER FLOW AT THE PROPOSED MEGHNA-GUMTI BRIDGE SITE, MEASURED IN JULY, 1984

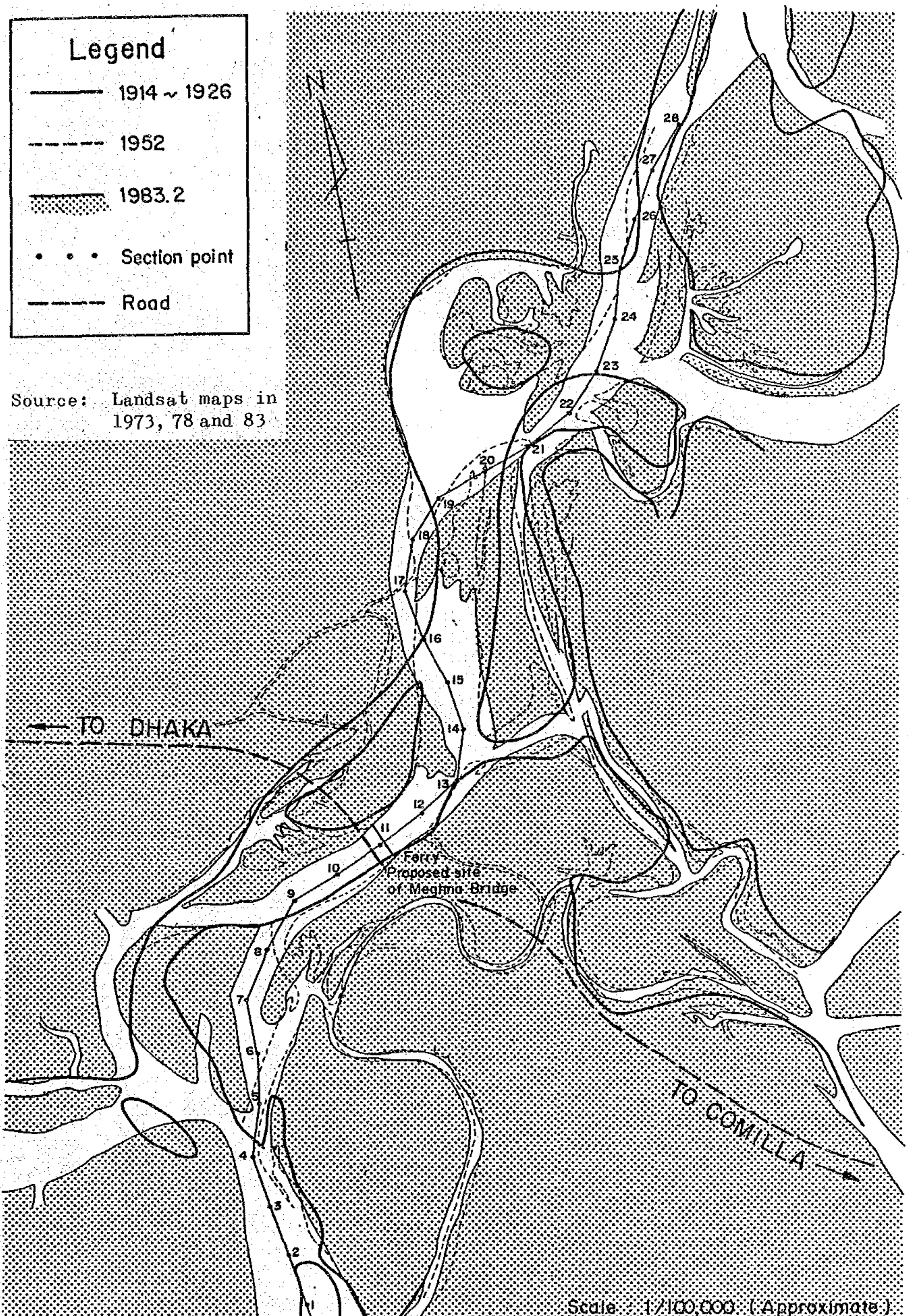


AP.FIG. 2-7 (a) RESULT OF SOUNDING INVESTIGATIONS DURING RAINY SEASON MEASURED AT BHAIRAB BAZAR BRIDGE IN 1984 JULY

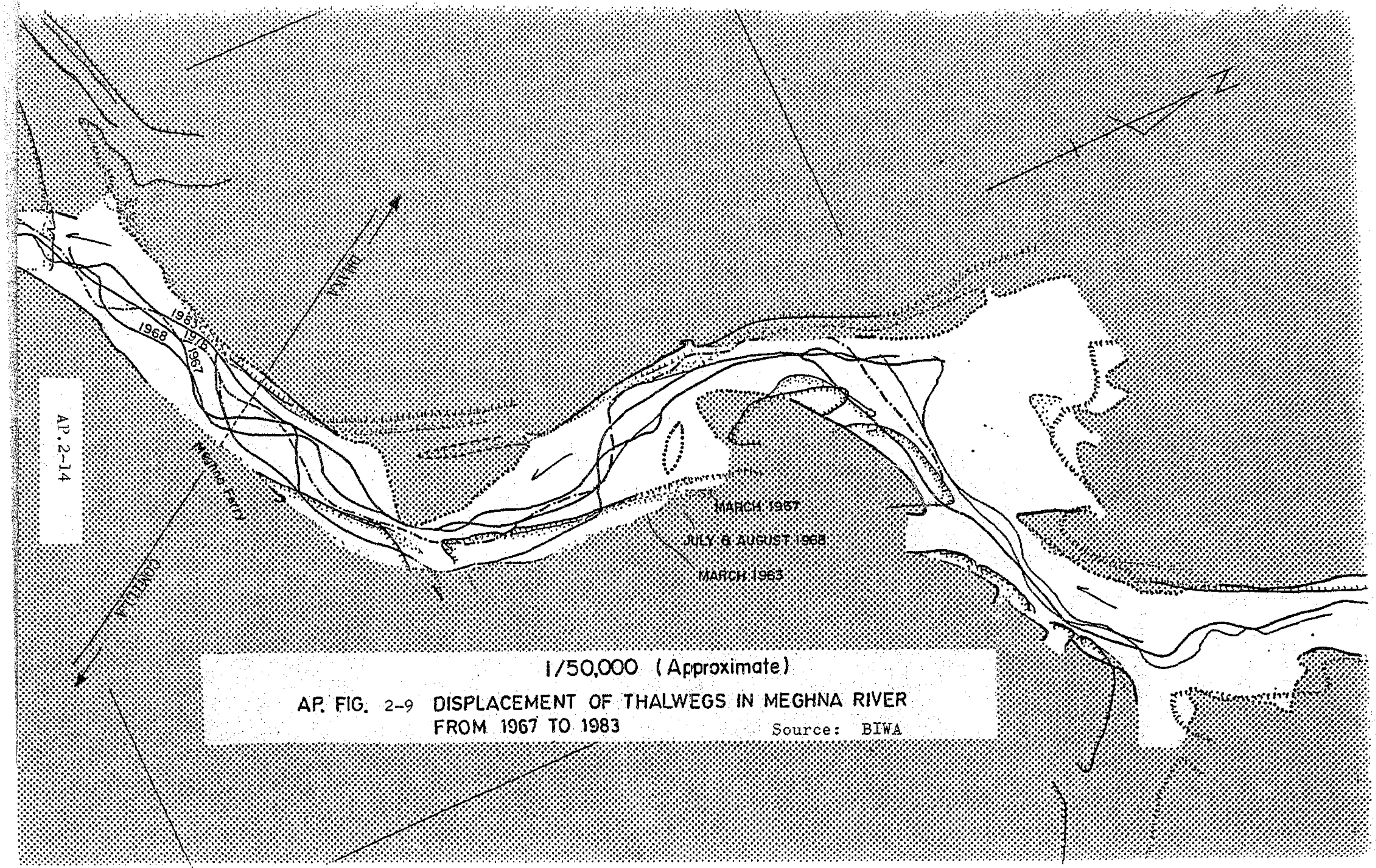


AP.FIG. 2-7 (b) PROFILE OF DRY SEASON IN 1984 APRIL AND RAINY SEASON IN 1984 JULY (At Bhairab Bazar)

Source: The Study Team



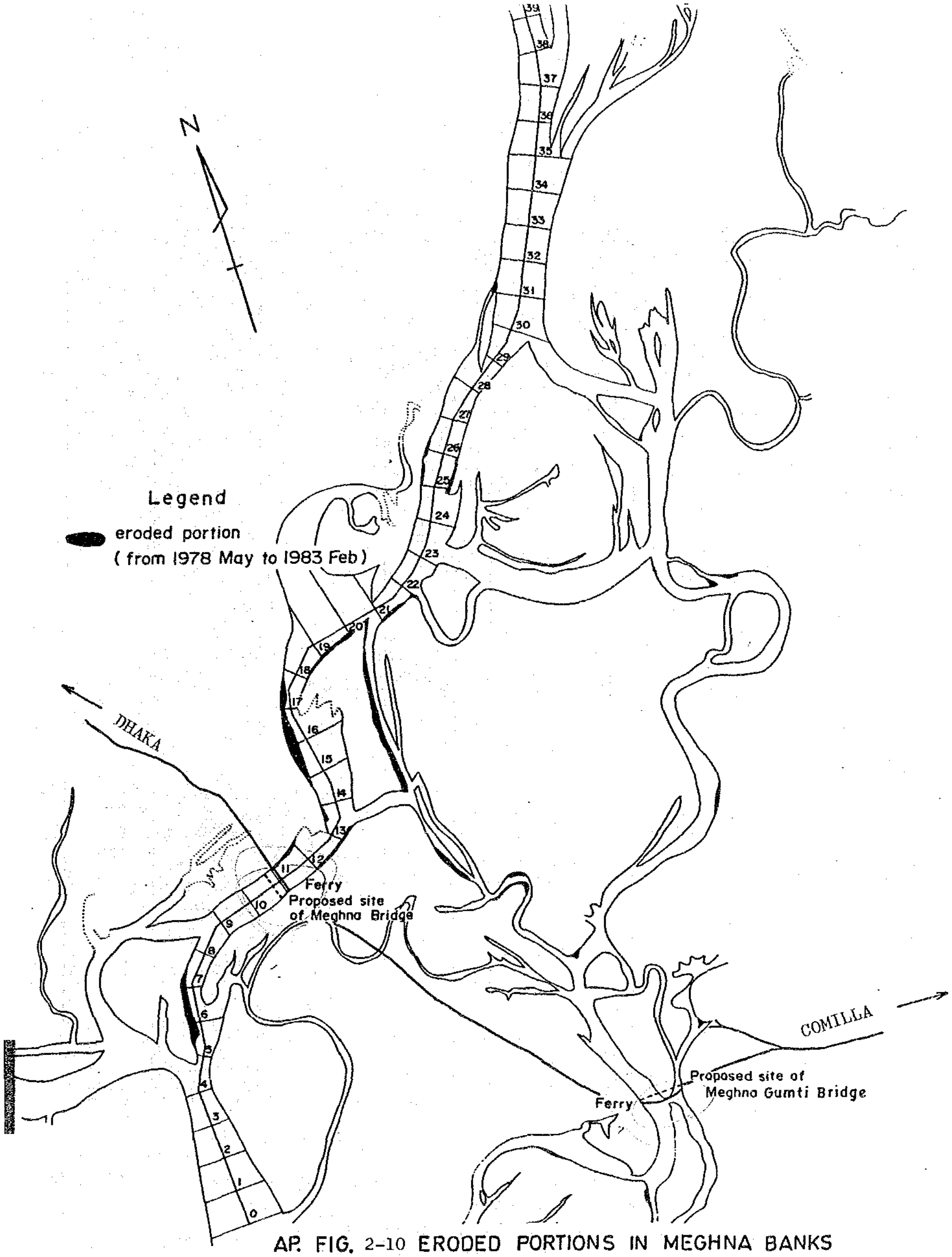
AP. FIG. 2-8 RIVER COURSE SHIFTING OF MEGHNA RIVER (FOR THE PAST 7 DECADES)



1/50,000 (Approximate)

AP. FIG. 2-9 DISPLACEMENT OF THALWEGS IN MEGHNA RIVER FROM 1967 TO 1983

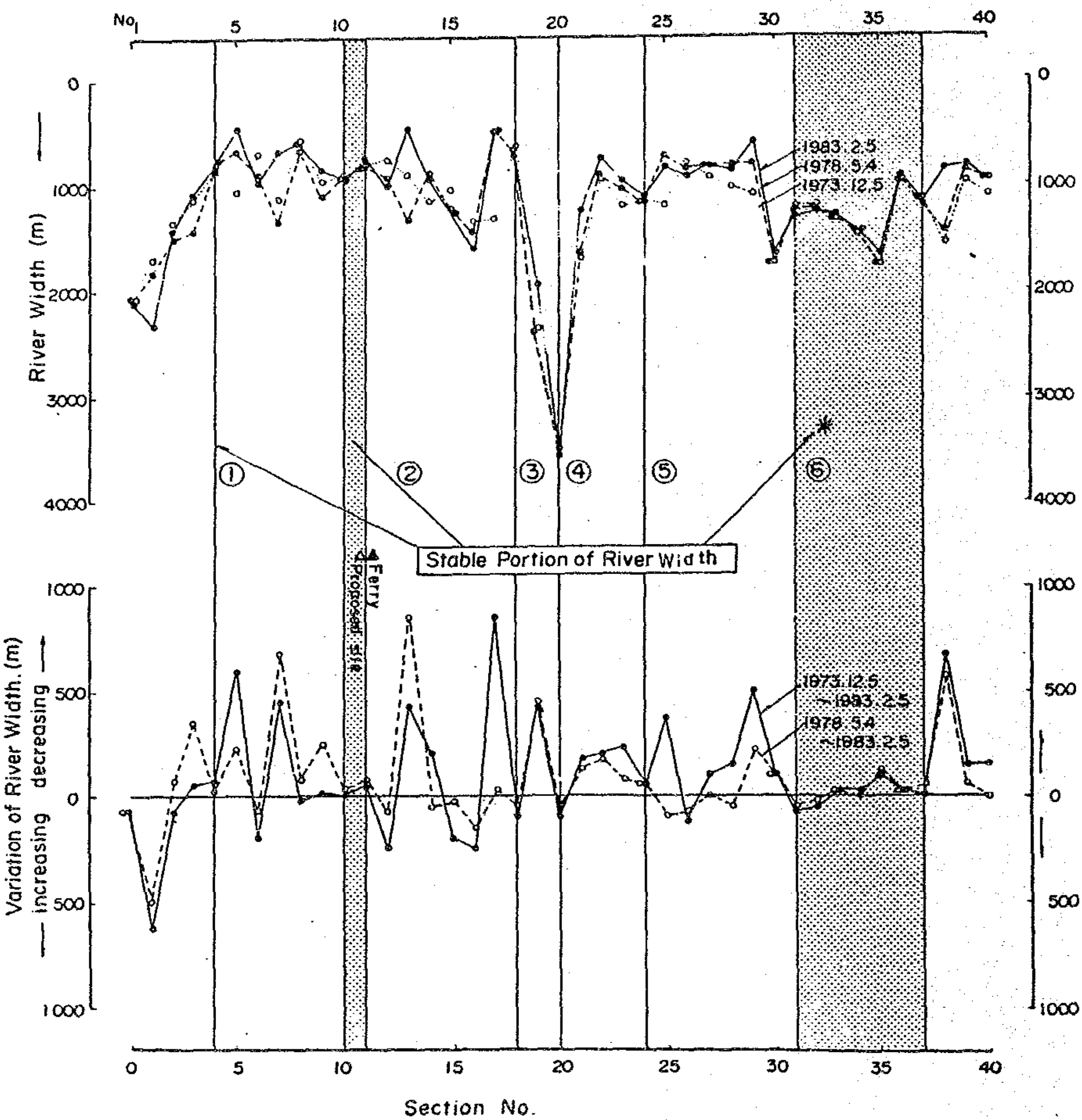
Source: BIWA



AP. FIG. 2-10 ERODED PORTIONS IN MEGHNA BANKS FROM 1978 TO 1983

Scale : 1 / 143,000 (Approximate)

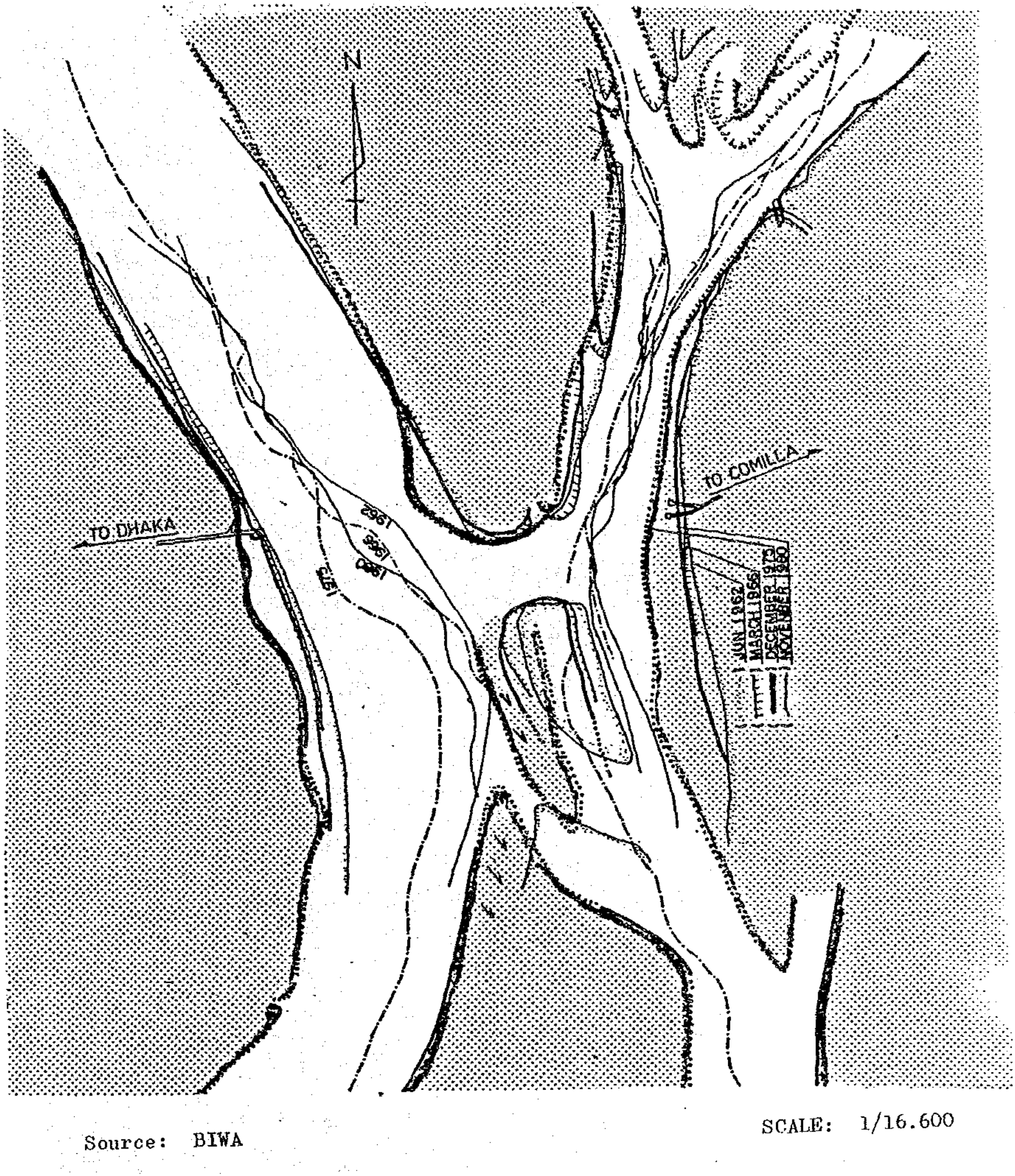
Source: Landsat mpas



Note: * The portion denoted by * is not preferable because it is far from the proposed bridge site.

Source: Landsat maps in 1973, 78 and 83.

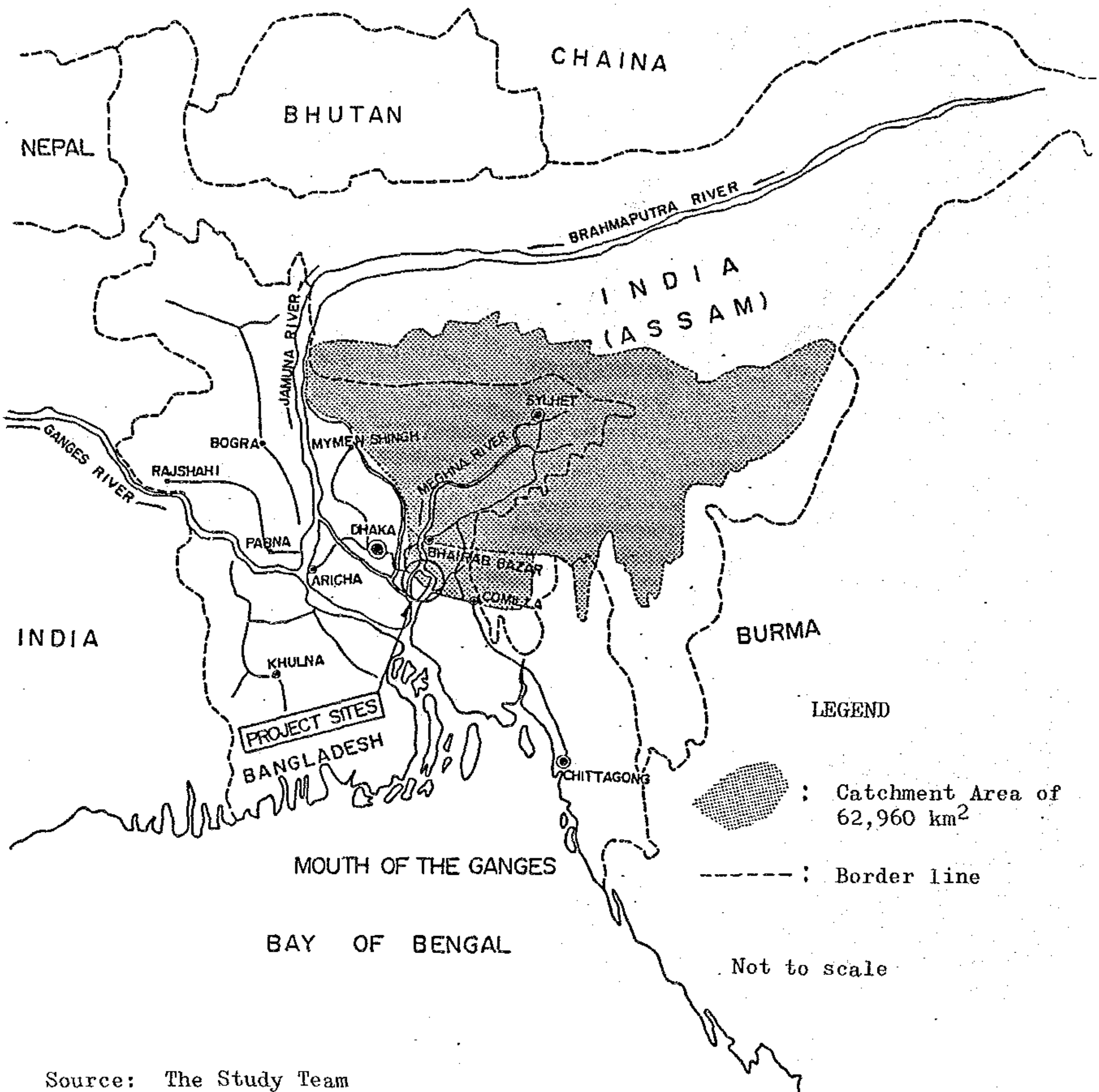
AP. FIG. 2-11 VARIATIONS OF MEGHNA RIVER WIDTH



Source: BIWA

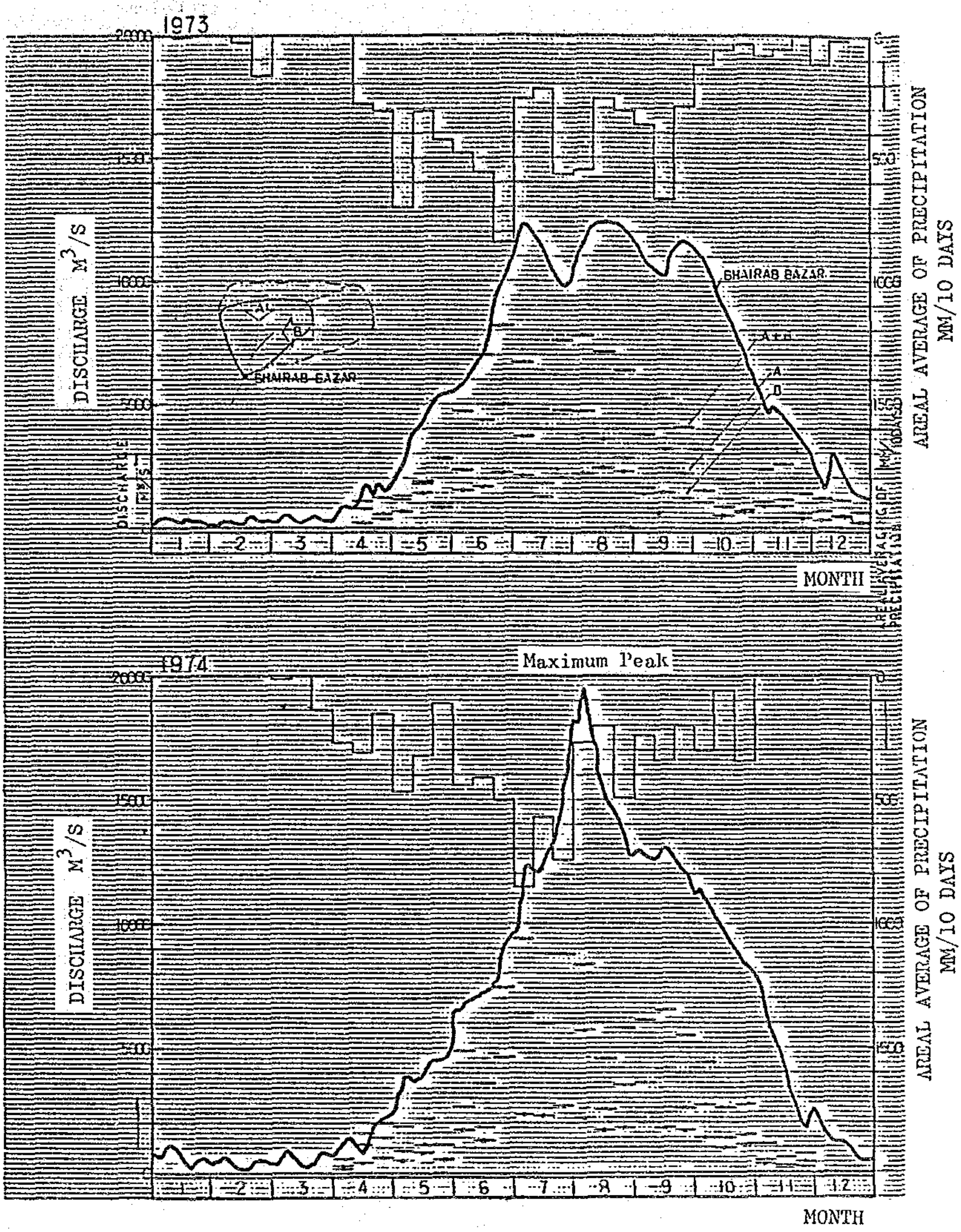
SCALE: 1/16.600

AP. FIG. 2-12 DISPLACEMENT OF THALWEGS AND BANKS OF MEGHNA-GUMTI RIVER



Source: The Study Team

AP. FIG. 2-13 CATCHMENT AREA OF THE MEGHNA RIVER



Source: The Study Team

AP. FIG. 2-14 TYPICAL TYPES OF RAINFALL AND RUNOFF

AP. TABLE 2-8 RAINFALL-RUNOFF RELATION (at Bhairab Bazar)

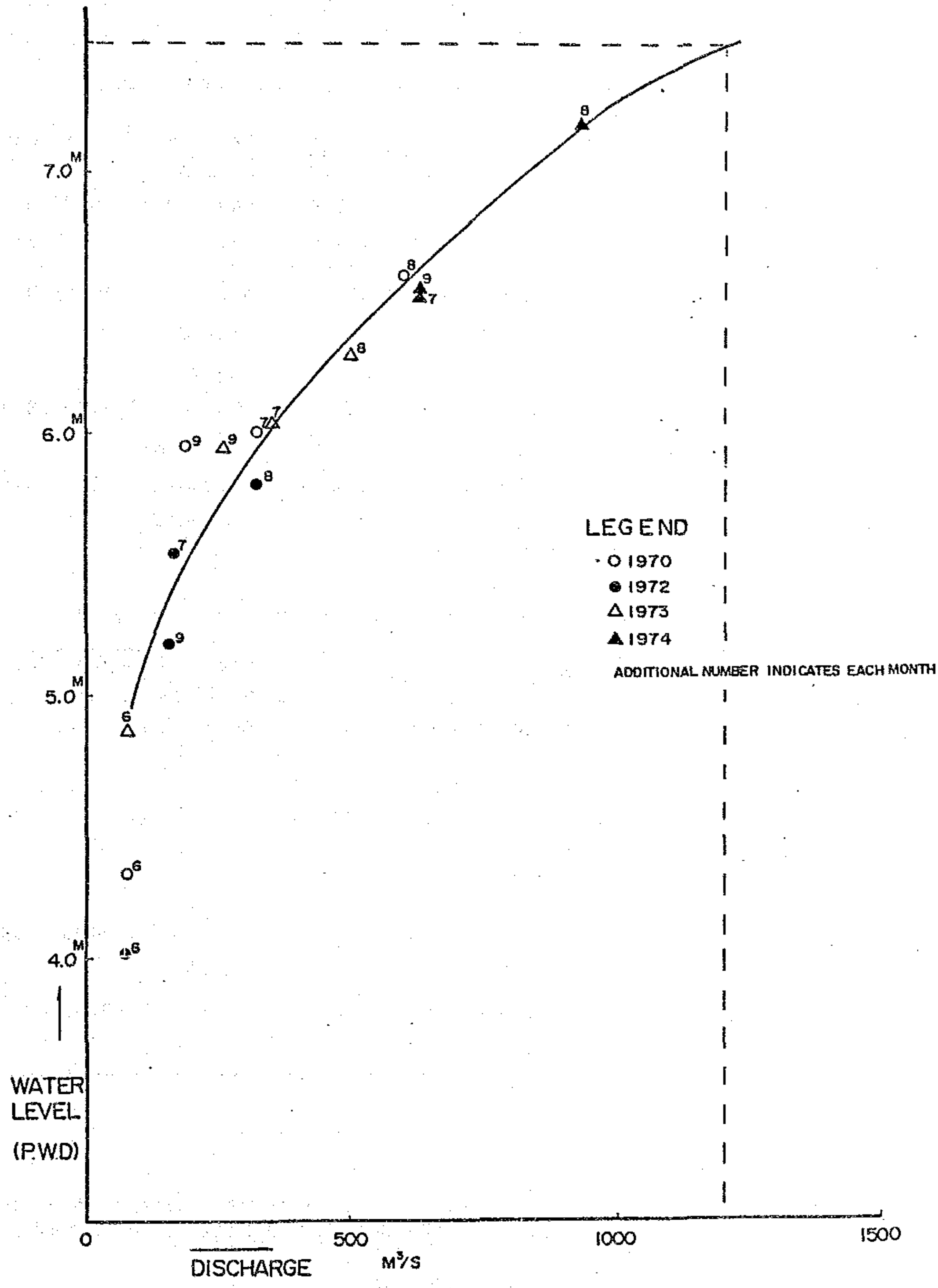
Unit		Rainfall Intensity for Return Period: 100 year mm/hr	Inflow from Out side of Bangla-desh m^3/s	Runoff Volume by Unit Hy-drograph m^3/s	Total Discharge m^3/s
1974, 4	(1)	0.697	336	182	518
	(2)	0.795	672	711	1,383
	(3)	0.403	1,637	1,588	3,225
5	(1)	1.206	2,031	2,755	4,786
	(2)	0.812	1,960	3,141	5,101
	(3)	0.278	2,225	3,118	5,343
6	(1)	1.115	1,167	3,262	4,429
	(2)	1.052	4,853	2,102	6,955
	(3)	1.286	3,582	2,588	6,170
7	(1)	2.153	7,458	4,433	11,891
	(2)	1.462	9,464	5,285	14,749
	(3)	1.873	8,769	7,962	16,731
8	(1)	0.703	11,951	9,189	21,140
	(2)	0.521	8,303	7,715	16,018
	(3)	1.253	4,616	7,031	11,645
9	(1)	0.612	5,810	4,979	10,789
	(2)	0.880	6,076	4,067	10,143
	(3)	0.496	6,503	5,104	11,607
10	(1)	0.700	4,538	5,400	9,938
	(2)	0.148	4,399	7,267	11,666
	(3)	0.885	2,567	6,383	8,950
11	(1)	0	2,703	6,719	9,422
	(2)	0	1,137	6,094	7,231
	(3)	0.097	644	4,150	4,794
12	(1)	0	-	2,763	
	(2)	0	-	667	
	(3)	0	-	798	

Source: The Study Team

AP. TABLE 2-9 MAXIMUM DAILY DISCHARGE (at Bhairab Bazar)

Year	Discharge
1964	12,300 m^3/s
65	12,080
66	14,400
67	12,700
68	13,300
69	11,500
70	16,400
71	-
72	11,500
73	12,400
74	19,500
75	12,700
76	16,700

Source: The Study Team



AP. FIG. 2-15 WATERLEVEL-DISCHARGE DIAGRAM AT BHAIRAB BAZAR RAILWAY BRIDGE

Source: The Study Team & Hydrological Year Book of Bangladesh

AP. TABLE 2-10 (a) DISCHARGE DISTRIBUTION IN CASE OF PWD = 6.99 m

		Proposed Meghna Bridge	Proposed Meghna-Gumti Bridge
Water Level (PWD)	at P_{t-1}	Meghna Ferry: 6.99 m	Daudkandi: 6.99 m
	at P_{t-2}	Saitnal : 6.41 m	Saitnal : 6.41 m
Distance between P_{t-1} & P_{t-2}		Approximately 15,000 m	Approximately 13,000 m
Hydraulic Gradient: I		1/25,424	1/22,034
Hydraulic Roughness: n*		0.02	0.02
Hydraulic Mean Depth: R=A/W		$10,656m^2/825m$ = 12.92m	$11,230m^2/1,340m$ = 8.38m
Velocity: $V = 1/n \times R^{2/3} \times I^{\frac{1}{2}}$		1.73 m/s	1.39 m/s
Discharge: Q = A x V		$10,656 \times 1.73 = 18,435m^3/s$	$11,230 \times 1.39 = 15,610m^2/s$
Discharge Distribution (%)		54.1 %	45.9 %

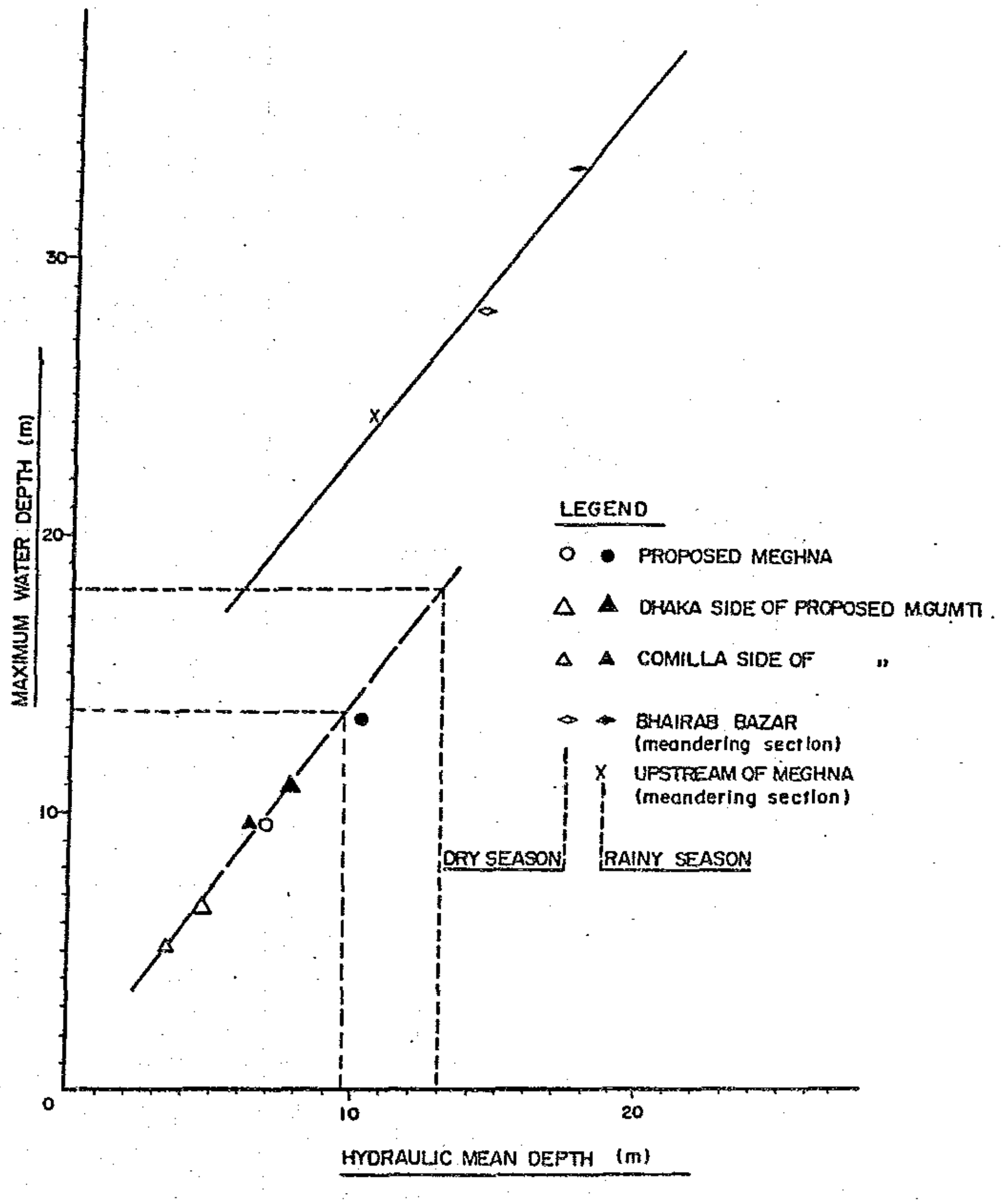
TABLE 2-10 (b) DISCHARGE DISTRIBUTION IN CASE OF PWD = 6.60 m**

		Proposed Meghna Bridge	Proposed Meghna-Gumti Bridge
Water Level (PWD)	at P_{t-1}	Meghna Ferry: 6.60 m	Daudkandi: 6.60 m
	at P_{t-2}	Saitnal : 6.41 m	Saitnal : 6.41 m
Distance between P_{t-1} & P_{t-2}		Approximately 15,000 m	Approximately 13,000 m
Hydraulic Gradient: I		1/78,947	1/68,421
Hydraulic Roughness: n		0.02	0.02
Hydraulic Mean Depth: R=A/W		$10,326m^2/825m$ = 12.52m	$10,694m^2/1,340m$ = 7.98m
Velocity: $V = 1/n \times R^{2/3} \times I^{\frac{1}{2}}$		0.959 m/s	0.763 m/s
Discharge: Q = A x V		$10,326 \times 0.959 = 9,903m^3/s$	$10,694 \times 0.763 = 8,160m^3/s$
Discharge Distribution (%)		54.8 %	45.2 %

Source: The Study Team

Note: * Coefficient of roughness 0.02 was same, as a result, with that of the JAMUNA RIVER BRIDGE CONSTRUCTION PROJECT FEASIBILITY STUDY REPORT LCT II. RIVER CONTROL. AUGUST 1976 (JICA)

** The value of 6.60 m is the water level at Meghna-Gumti River, with the return period of 100 years, which is analyzed based on the existing water level records at Daudkandi.



AP. FIG. 2-16 RELATION BETWEEN HYDRAULIC MEAN DEPTH & MAXIMUM WATER DEPTH

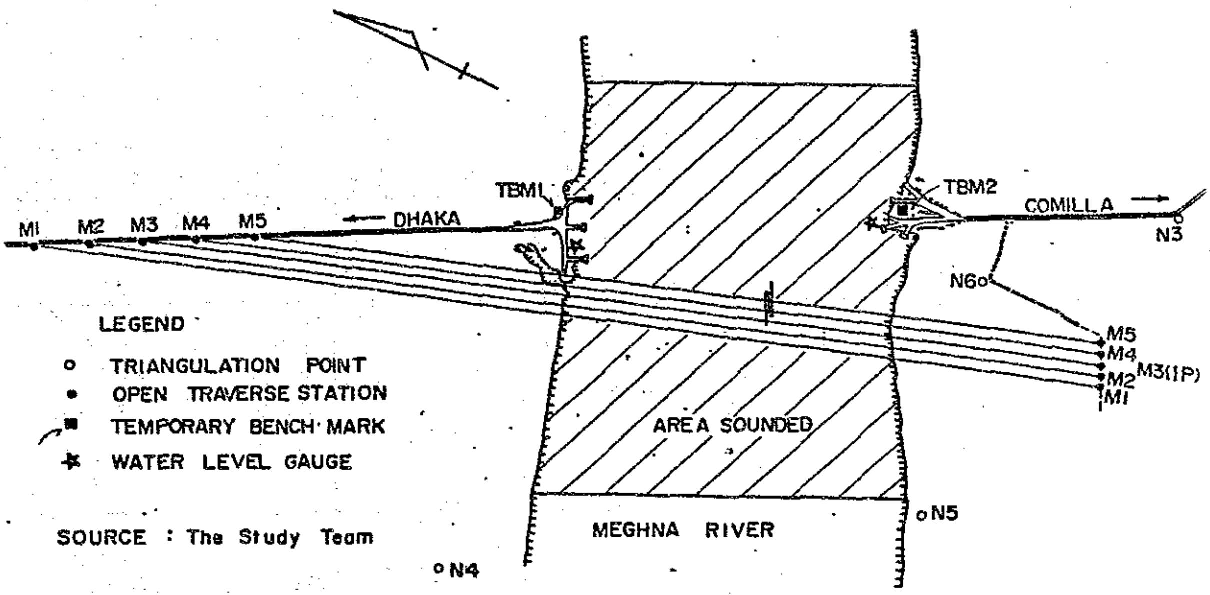
Source: The Study Team

AP. TABLE 2-11 COMPARISON OF THE SCOURING LEVELS CALCULATED BY DIFFERENT FORMULAS

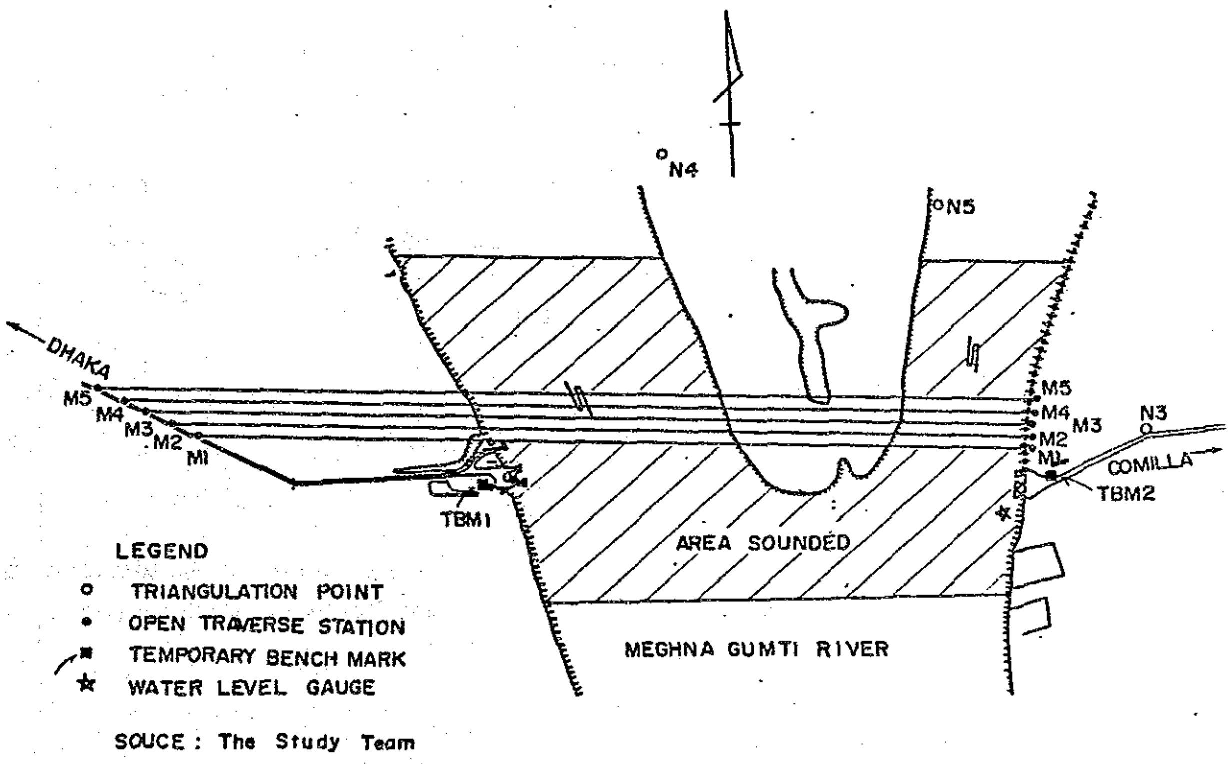
Proposers	Type of Equation	Calculated Values Meghna Bridge	Calculated Values Meghan-Gumti Bridge	Notes
Andru	Z/D=0.8 x ho/D ho:Water Depth D :Width of Piers	—	—	ho:18m $0<ho/D<1.5$ *
Tarapore	Z/D = 1.35	3.4	3.4	(ho/D)>1.15
Larras	$Z=1.42\ K\cdot D^{0.75}$	4.0	4.0	
Breusers	Z=1.4D	3.5	3.5	
Moza and Sanchex	$Z/D = ho/D(K_1 \cdot K_2 \cdot U_0{}^2 - {}^{3100cm}/D)$	2.7	1.9	
Neil	$Z/D = K\cdot(ho/D)^{0.3}$	10.9	10.2	
Qureshi	$Z/D = 1.8(ho/D)^{0.75} - ho/D$	2.9	4.0	
Carstens	$Z/D = 0.546\left(\frac{N_s{}^2-N_{s1}{}^2}{N_s{}^2-N_{s2}{}^2}\right)^{3/4}$ $N_s = \frac{U_o}{\sqrt{(\sigma/\rho-1)g\ d_m}}$ $N_{s2} = 2.24$ $N_{s1} = \frac{1}{2} N_{s2}$	2.1	2.2	U_o=1.73m/s
Shen	$Z = 0.0222R_p^{0.619}$ (cm) $R_p = \frac{D\cdot U_o}{\nu}$	-	-	U_o=1.73cm/S * ν =0.01cm²/s
Japan National Railways	Z/D = 1.6	4.0	4.0	
Public Works Research Institute, Ministry of Construction	Z/D - ho/D: Design Curve	9.2	8.6	$ho/D \leqq 3.50$
Laursen	Z/D - ho/D: Design Curve	11.0	10.2	
Poona	$D_s=1.70\ D\cdot(q^{2/3}/D)^{0.78}$ D_s:the depth of Scour below water level q :unit discharge per foot	4.5	4.1	
Lacy	$D'=0.473(Q/f)^{1/3}$ $D = 2 \times \delta'$ Q :maximum discharge in cusec f :silt factor $1.76\sqrt{m}$ m: :mean diameter of sand in mm D :maximum scouring depth below HFL	9.7	12.3	

Note: * Equations are not applicable to the proposed bridges and rivers.

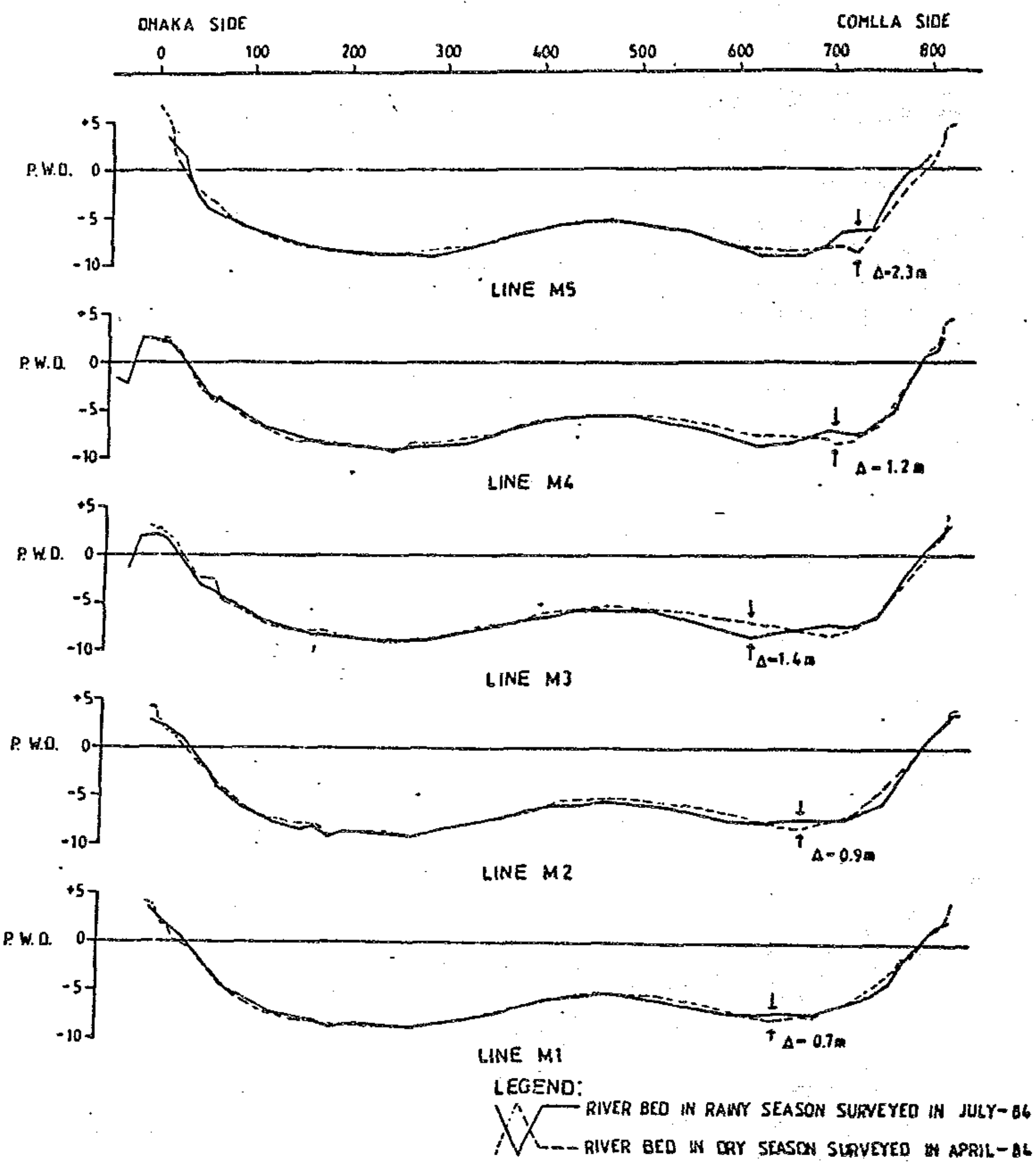
Source: The Study Team



AP. FIG. 3-1 LOCATION OF SURVEY POINTS AND AREA SOUNDED FOR MEGHNA BRIDGE SITE

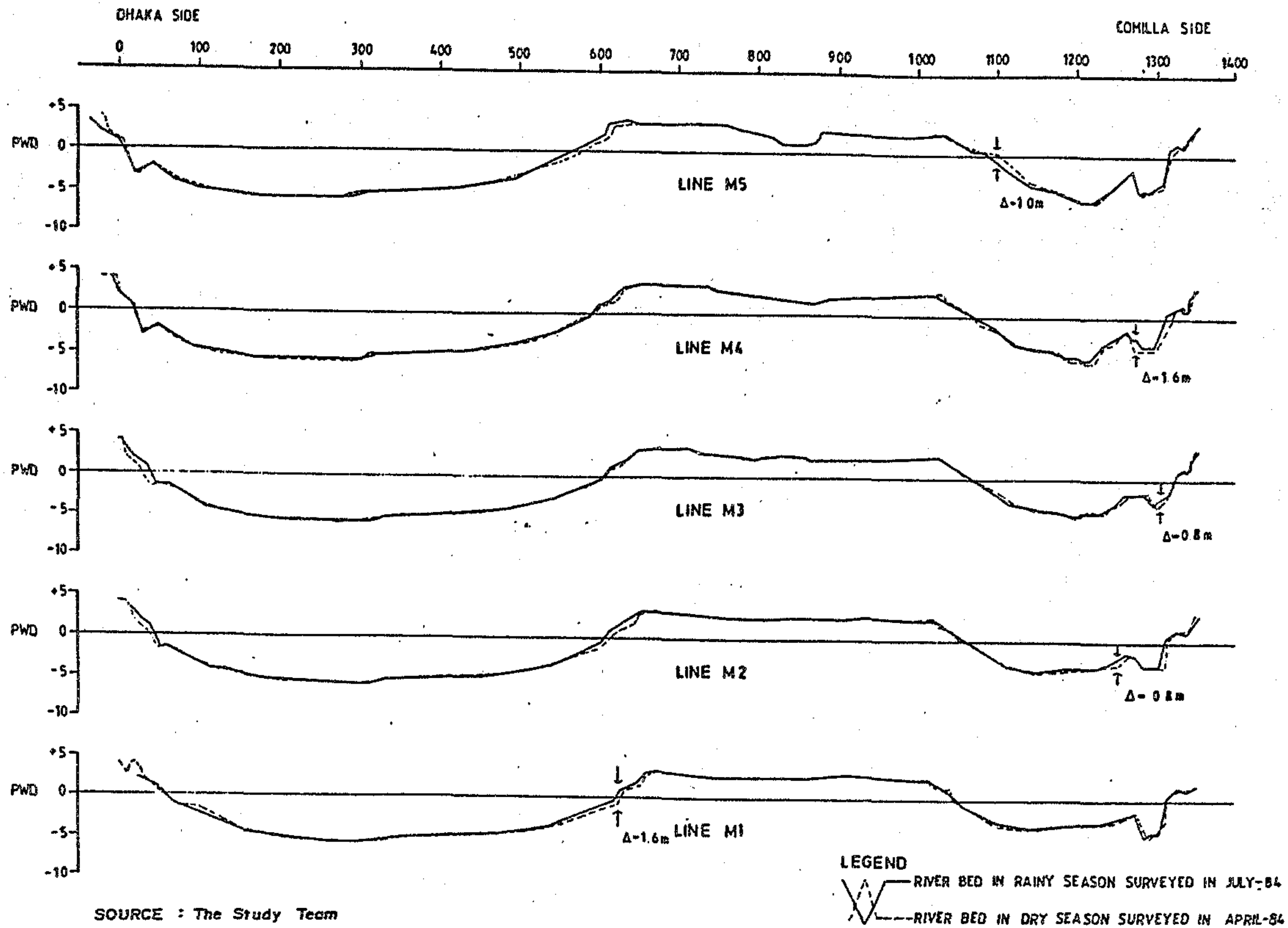


AP. FIG. 3-2 LOCATION OF SURVEY POINTS AND AREA SOUNDED FOR MEGHNA-GUMTI BRIDGE SITE



SOUCE : The Study Team

AP.FIG. 3-3 CROSS SECTIONS OF MEGHNA RIVER IN RAINY AND DRY SEASONS



SOURCE : *The Study Team*

AP.FIG. 3-4 CROSS SECTIONS OF MEGHNA-GUMTI RIVER IN RAINY AND DRY SEASONS

AP. NOTE 4–1 GEOLOGY AND SOILS OF BANGLADESH

地質：

バングラデシュの国土の大半は7.5ｍ以下の標高であり、三角洲あるいは平坦な沖積平地である。地質学的には3つの地形別の地域に分割される。それらは第三期台地、更新生高地、現世平地と呼ばれる。現世平地はさらに細かく山脈間の平地、洪水平地、三角洲平地、海岸平地に分類される。

第三期台地は南東部のチタゴンヒルトラクト地域にみられ、バングラデシュでは唯一のヒマラヤ山脈の造山活動と同時代に隆起したものである。この台地は砂岩と頁岩からなり、その平均的高度は約３００ｍで、ビルマとの国境にあるマウデゥクムアル山（1,００３ｍ）が最も高い頂上である。

更新生高地はダッカの北部にあるマデゥフプール地域とバングラデシュの北西部にかけてのバリンド地域を含む。マデゥフプール地域は標高が９ｍないし１８ｍあり、3,８００K㎡にもわたる広大な一つの台地となっている。したがってこの地域は洪水平地の中の唯一の島ともなっており、おそらく局部的に隆起したものとおもわれる。バリンド地域は分断された高地ではあるが、より広大な台地となっており、場所によっては４０ｍの標高の箇所もある。コミラ地区の近くにあるラルマイ台地は更新生高地の一つの飛び地と判断される。

上述以外の地域は平坦な土地である。北西部の地域にある山脈間の平地は急峻な平均勾配（５6.6cm／Km）により北より南へ向けて下っている。洪水平地は大陸から運ばれた堆積物により形成され、三角洲平地は海洋と大陸からの両方の堆積物によって形成されている。海岸平地は標高３ｍ以下にあり、主として海洋からの堆積物によって形成されている。これらの平地は国土全体の９０％におよぶ。チタゴン地区の海岸にみられる細い帯が海岸平地の代表的なものとみなされる。

バングラデシュにはおびただしい沼地が各地にある。その所在は南西部、北東部、北西部の３つの主な地域にわたるといえる。

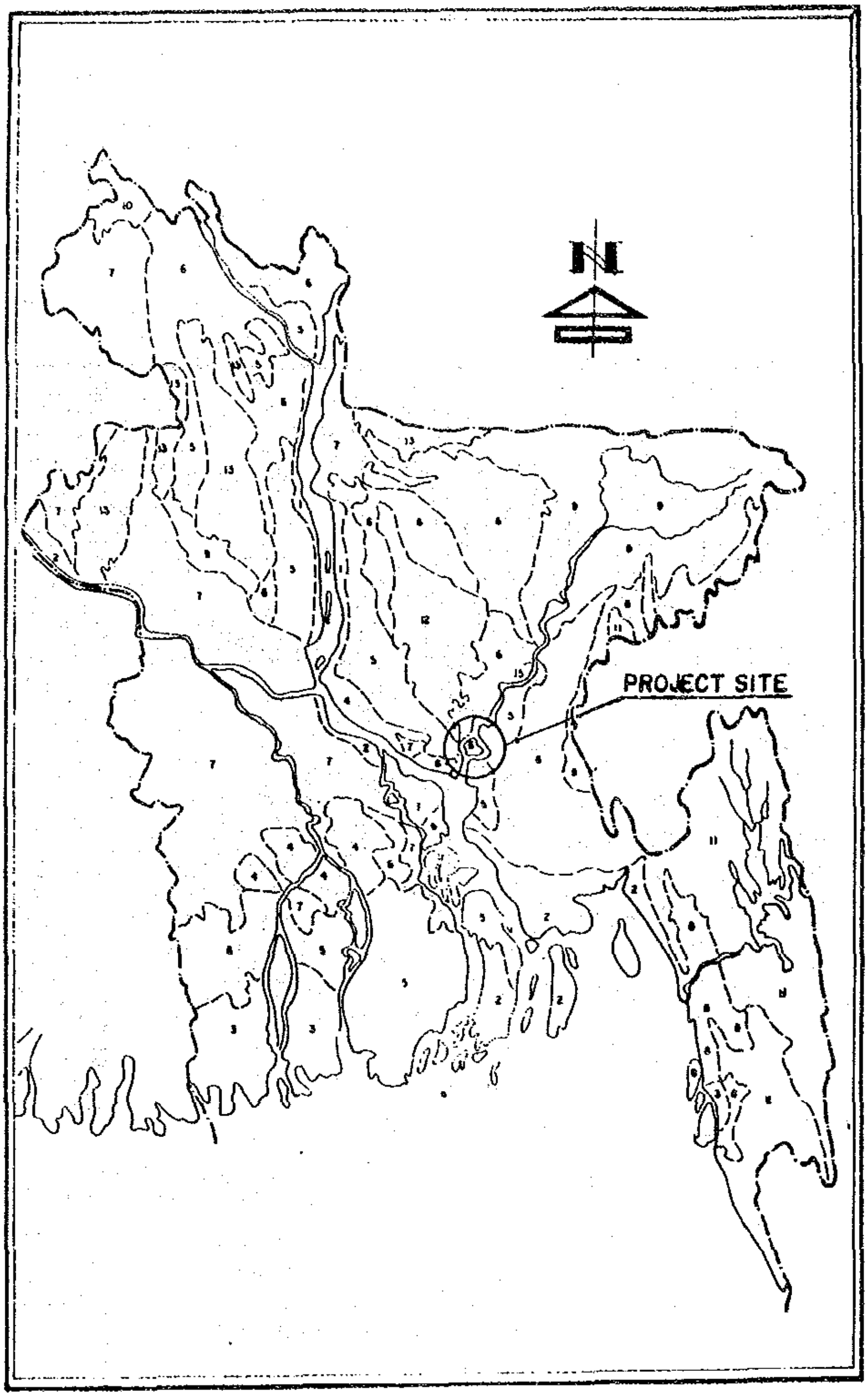
土質：

バングラデシュの土質は三大河川であるガンジス河、ブラマプトラ河（ジャムナ河）、メグナ河とその支流、分流の影響を受け、その種類を異にするが、大部分は何んの特質もみられない帯状の堆積土といえる。その堆積の過程により洪水平地、山地間平地、山角洲を形成し、

ほとんどがロームとみなされ、構成要素により砂、砂質ローム、粘土、粘性ローム、シルトローム等に分類される。しかし、このことは海岸の塩分を含む土とか更新生高地の区分の明確な地域の土質に言えることである。

バングラデシュの土質は一般にその地形、標高、そしてそこを流れる河川によって変化する。微少な地域による変化は構成要素による分類と同様に堤防、洪水平地、傾斜地、沼地といった場所がそこの農作物の種別にも影響している。

Ap.Fig.4－1はバングラデシュにおける土質の種別を示し、Ap.Fig.4－2はJ.P. Morgan とW.G.McIntive(1959)によるベンガル盤層の地質分布の概要を示す。



AP. FIG. 4-1 SOIL TYPES

SOURCE: BANGLADESH IN MAPS

A. FLOODPLAIN AND PIEDMONT SOIL:

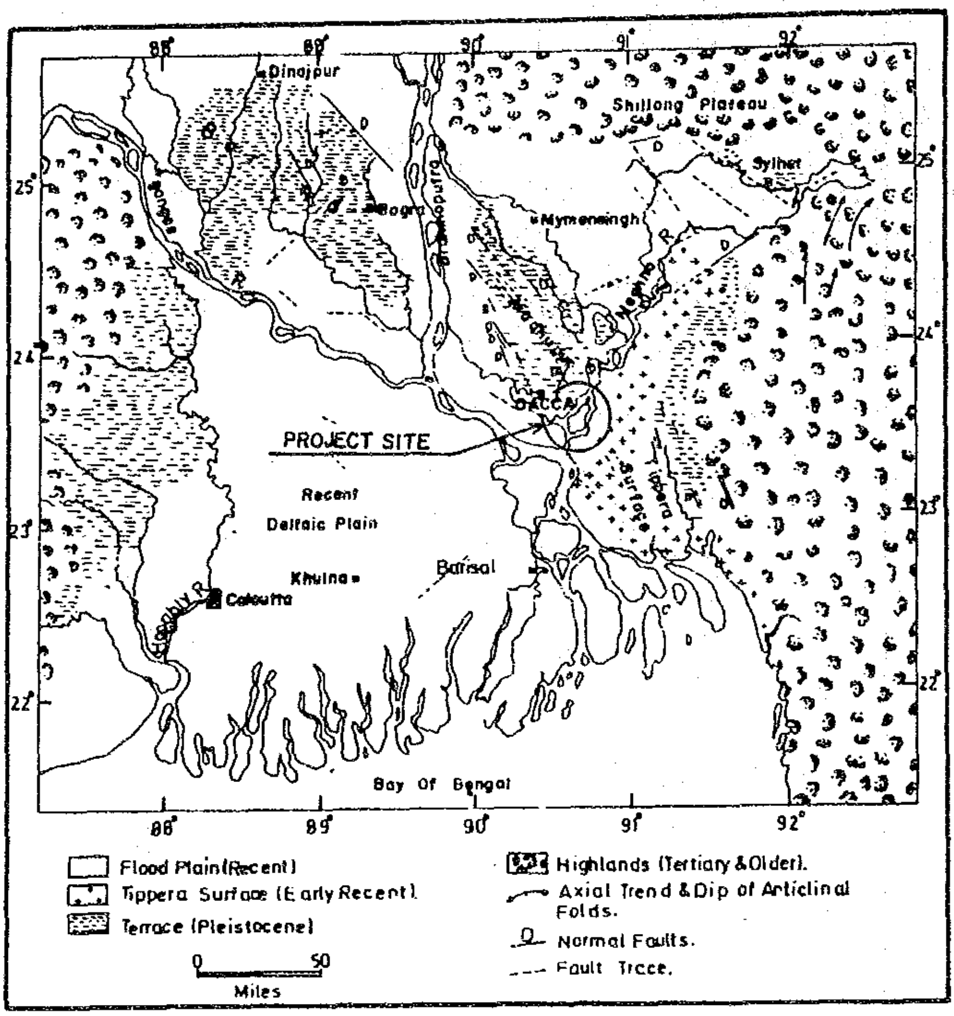
1. NON-CALCAREOUS ALLUVIUM.
2. CALCAREOUS ALLUVIUM.
3. ACID SULPHATE SOILS.
4. PEAT.
5. GREY FLOOD PLAIN SOIL.
6. NON-CALCAREOUS DARK GREY AND BROWN FLOOD PLAIN SOILS.
7. CALCAREOUS DARK GREY AND BROWN FLOOD PLAIN SOIL.
8. GREY PIEDMONT SOIL.
9. GREY FLOOD PLAIN SOIL AND ACID BASIN CLAYS.
10. BLACTERAI SOIL.

B. HILL SOIL:

11. BROWN HILL SOIL.

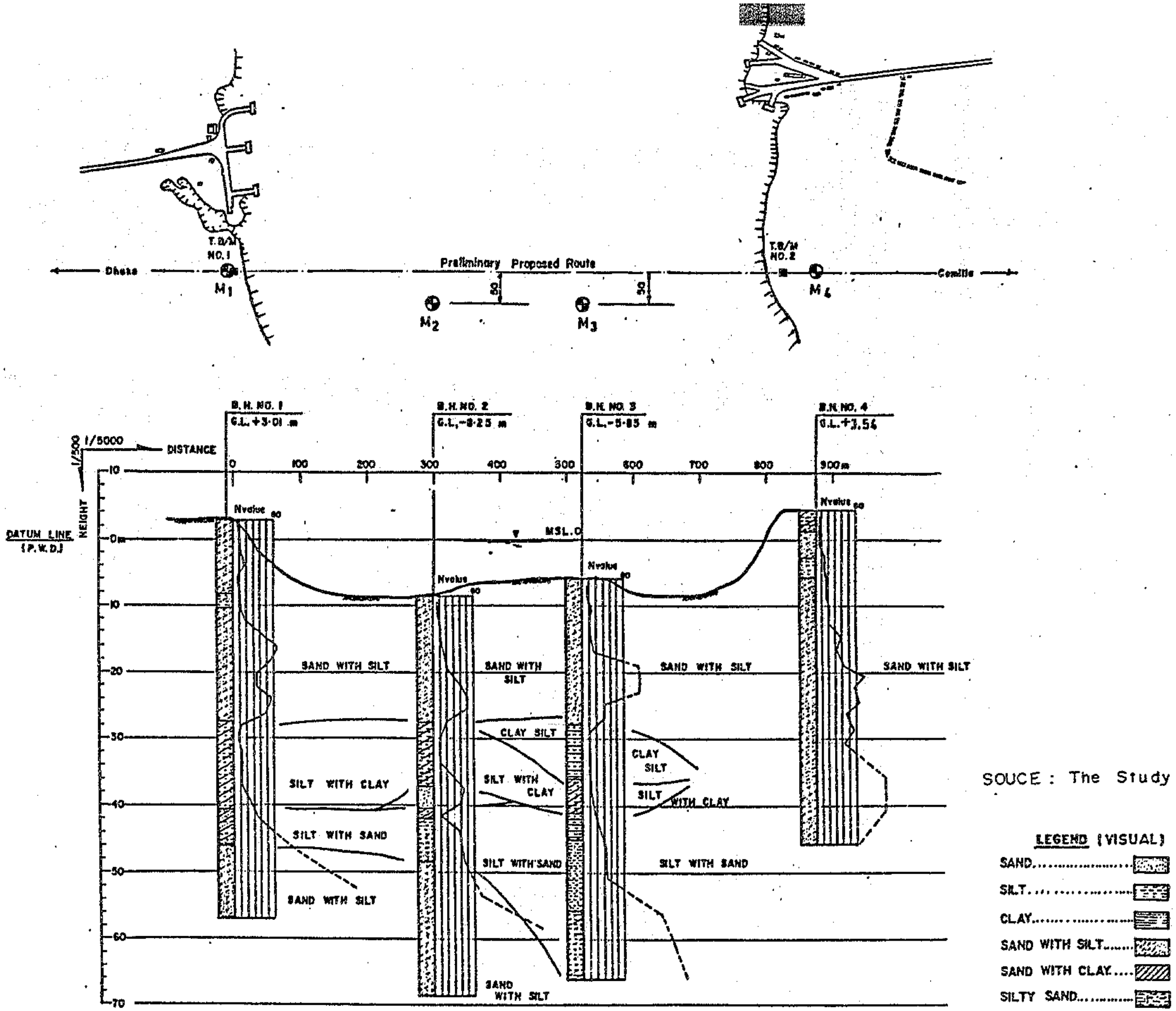
C. TERRACE AND OLD PIEDMONT SOIL:

12. RED BROWN TERRACE SOILS.
13. GREY TERRACE SOILS.



SOURCE: AFTER MOGAN AN Mc INTIVE 1959

AP. FIG. 4-2
THE OUTLINE OF THE QUARTERNARY GEOLOGY OF THE BENGAL BASIN



SOUCE : The Study Team

AP. FIG. 4-3 BORING LOGS (M1, M2, M3 & M4) FOR MEGHNA RIVER

AP. TABLE 4-1 CORRECTED SPT VALUES BY RIVER SITE

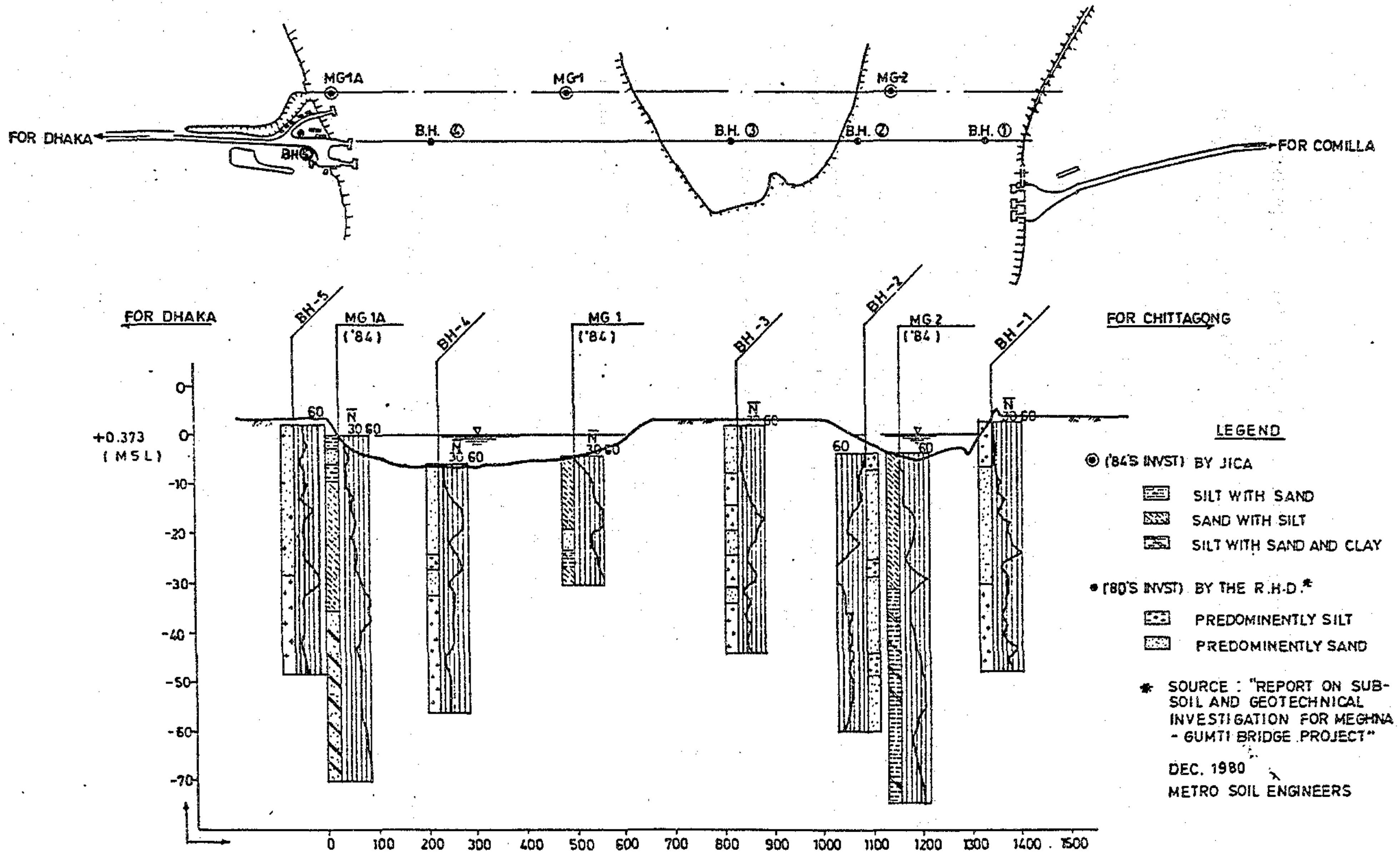
MEGHNA RIVER

Depth in metres below G.L.	Value of Corrected SPT at Different Bore Holes			
	M 1	M 2	M 3	M 4
0.85	7	5	5	5
2.85	10	6	7	5
4.85	11	10	12	4
6.85	15	10	10	12
8.85	6	14	11	13
10.85	10	17	15	15
12.85	10	26	48	15
14.85	16	34	50	18
16.85	26	33	49	17
18.85	41	16	22	26
20.85	35	10	23	23
22.85	25	8	9	27
24.85	24	9	10	42
26.85	36	20	8	35
28.85	32	30	7	39
30.85	12	27	11	29
32.85	8	8	12	35
34.85	12	25	15	28
39.85	12	29	23	58
44.85	25	44	23	82
49.85	54	88	66	39
54.85	72	100	75	-
59.85	68	120	78	-

MEGHNA-GUMTI RIVER

Depth in metres below in G.L.	Value of Corrected SPT at Different Bore Holes		
	M -G1/A	M - G 1	M - G 2
0.85	3	3	2
2.85	8	17	3
4.85	14	22	13
6.85	3	24	8
8.85	9	26	7
10.85	8	35	9
12.85	19	38	22
14.85	15	21	24
16.85	20	22	22
18.85	19	25	18
20.85	17	27	11
22.85	23	33	20
24.85	23	36	46
26.85	20	-	19
28.85	26	-	18
30.85	30	-	17
32.85	39	-	19
34.85	34	-	20
36.85	38	-	24
38.85	27	-	26
40.85	27	-	29
42.85	22	-	30
44.85	26	-	33
46.85	27	-	33
48.85	25	-	32
50.85	26	-	34
52.85	26	-	27
54.85	28	-	25
56.85	28	-	21
58.85	33	-	19
60.85	40	-	23
62.85	35	-	27
64.85	41	-	29
66.85	42	-	30
69.85	45	-	33

Source: Soil Investigation Report on Meghna, Meghna-Gumti Bridges Construction Project, 1984 by the Study Team



AP. FIG. 4-4 BORING LOGS (MG1 MG1A AND MG2) FOR MEGHNA-GUMTI BRIDGE PROJECT.

AP. NOTE 4–2 CALCULATION OF PILE BEARING CAPACITIES

選ばれた橋梁の基礎杭の支持力は日本道路協会発行の「道路橋示方書、Ⅳ下部構造編」にもとづいて、以下のように計算された。

1. 適用式

次の公式が適用された。

$$Ra = \frac{1}{n} Ru = \frac{1}{n} (qd \cdot A + U \Sigma \ell i \cdot fi)$$

where Ra = allowable bearing capacity of a pile (tons)

Ru = total ultimate bearing capacity (tons)

qd = ultimate bearing strength (tons/m²), generally 300 tons/m² in case of a cast-in-situ pile in sandy soils which have SPT values of more than 30.

A = considering a 1.5 m diametre pile, an area of pile cross section (1.767 m²)

U = perimetre of a pile (4.712 m)

ℓi = layer depth around pile (m)

fi = maximum skin friction around a pile in sandy soil: 0.5 × N tons/m², but not exceeding 20 tons/m² for a cast-in-situ pile

N = corrected SPT value of the stratum

n = safety factor: 3 for normal condition and 2 for seismic condition

支持力の概略試算に際しては、コンクリート杭自体の重量の影響は比較的小さいので、これを無視した。

2. メグナ橋の基礎杭支持力

次の条件が計算に際して考えられた。

a) ボーリングM－2、M－3からの土質柱状図（Ap. Fig. 4－3）

b) 杭の諸元

杭　径：1.5 *m*

杭　長：43.5 *m*

杭の深さ：－５５.０ *m*（PWD標高）

c) 洗掘深さ：－２２.０ *m*（PWD標高）

(1) ボーリング柱状図Ｍ－２の場合

PWD (m)	Boring Depth	ℓi (m)	Soil Condition	N_{max}-N_{min}	$\bar{N}$	f_i (tons/m^2)	$U\cdot\ell i\cdot f_i$ (tons)
-22	14						
-27	19	5	Sand	50 - 36	43	20	471
-36	28	9	Clayey silt	25 - 9	17	15	636
-40	32	4	Sand	45 - 40	42	20	377
-48	40	8	Sand	39 - 9	24	12	452
-50	42	2	Sand	42 -	42	20	188
-55	47	5	Sand	60 -	60	20	471

$U\Sigma\ell_i\cdot f_i$ = 2,595 tons

Ru = qd·A + UΣℓi·fi = 530 + 2,595 = 3,125 tons

Ra of (1)
- Normal: $\frac{1}{3}$Ru = 1,040 tons
- Seismic: $\frac{1}{2}$Ru = 1,562 tons

(2) ボーリング柱状図M－3の場合

PWD (m)	Boring Depth	ℓi (m)	Soil Condition	N_{max}-N_{min}	$\bar{N}$	f_i (tons/m²)	U·ℓi·f_i (tons)
-22	16						
-29	23	7	Sand	31 - 22	26	13	428
-37	31	8	Clayey silt	11 - 7	7	9	339
-50	44	13	Silt	27 - 11	19	9	551
-51	45	1	Silt	30 -	30	15	70
-55	49	4	Sand	60 -	60	20	377

$U\Sigma \ell_i \cdot f_i$ = 1,765 tons

Ru = qd·A + UΣℓi·fi = 530 + 1,765 = 2,295 tons

Ra of (2)
- Normal: $\frac{1}{3}$Ru = 765 tons
- Seismic: $\frac{1}{2}$Ru = 1,147 tons

(1)、(2)の計算結果より安全側の計算値をメグナ橋を代表する値とした。

3. メグナ・グムティ橋の基礎杭支持力

次の条件が計算に際して考えられた。

a) ボーリングMG－1／A、MG－2からの土質柱状図（Ap. Fig. 4－4）

b) 杭の諸元

杭　　径：1.5 m

杭　　長：51ないし67 m

杭の深さ：－70 m（PWD標高）

c) 洗掘深さ：－19.0 m（PWD標高）

(1) ボーリング柱状図MG－1／Aの場合

PWD (m)	Boring Depth	ℓi (m)	Soil Condition	N_{max}-N_{min}	$\bar{N}$	f_i (tons/m²)	U·ℓi·f_i (tons)
-19	19.3						
-32.7	33	13.7	Sand	38 - 16	27	13	839
-60.0	60.3	27.3	Silty sand	30 - 21	25	12	1,543

$U\Sigma \ell_i \cdot f_i$ = 2,382 tons

$$Ru = qd \cdot A + U\Sigma \ell i \cdot fi = 530 + 2{,}382 = 2{,}912 \text{ tons}$$

$$\text{Ra of (1)} \quad \begin{cases} \text{Normal: } \frac{1}{3} Ru = 970 \text{ tons} \\ \text{Seismic: } \frac{1}{2} Ru = 1{,}456 \text{ tons} \end{cases}$$

(2) ボーリング柱状図ＭＧ－２の場合

PWD (m)	Boring Depth	ℓi (m)	Soil Condition	$N_{max}-N_{min}$	$\bar{N}$	f_i (tons/m^2)	$U \cdot \ell i \cdot f_i$ (tons)
-19	22						
-23	26	4	Sand	42 - 17	30	15	283
-48	51	25	Silty	31 - 17	24	12	1,413
-70	63	12	Silt	31 - 17	24	12	678

$U\Sigma \ell_i \cdot f_i = 2{,}374$ tons

$$Ru = qd \cdot A + U\Sigma \ell i \cdot fi = 530 + 2{,}374 = 2{,}904 \text{ tons}$$

$$\text{Ra of (2)} \quad \begin{cases} \text{Normal: } \frac{1}{3} Ru = 968 \text{ tons} \\ \text{Seismic: } \frac{1}{2} Ru = 1{,}452 \text{ tons} \end{cases}$$

以上の計算結果より、許容支持力は以下のとおりである。

	メグナ橋	メグナ・グムティ橋
通常の場合	７００ｔ	９００ｔ
地　震　時	1,１００ｔ	1,４００ｔ

4. 必要な杭の本数

上部工および橋脚によって基礎工へ伝えられる荷重総トン数は、メグナ橋の場合次のとおりである。

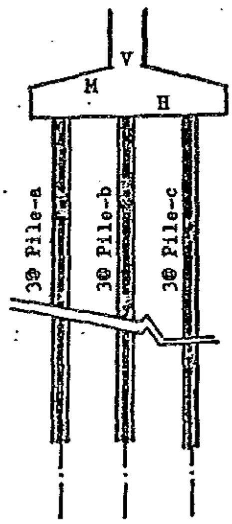
フーチング底部中央における荷重

		Normal Conditions: Vertical Forces (t)	Earthquake Loadings		
			Vertical (t)	Horizontal (t)	Moment (t-m)
Live Load		240	-	-	-
Dead Load of Superst.		2,165	2,165	108	3,995
Dead Load of Pier		1,740	1,740	87	945
Buoyancy		-415	-415	-	-
Total	Max.	4,145	3,905	195	4,940
	Min.	3,730	3,490	195	4,940

次の２つの検討により、フーチング一基当り９本の基礎杭が必要であると計算される。

a) フーチング下部における作用力合計と杭１本当り反力

Pile Reaction



External Forces

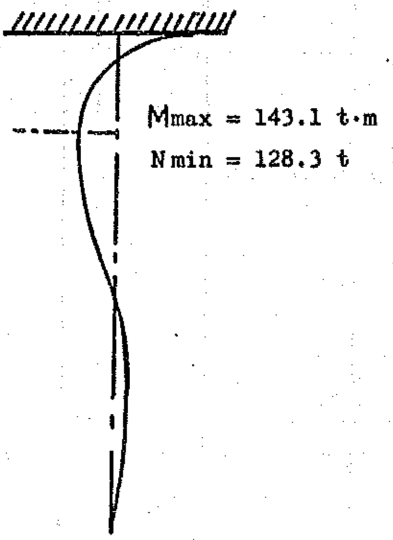
V = 3,490 t
H = 195 t
M = 4,941 t.m

	Reaction		
	Vertical (t)	Horizontal (t)	Moment (t.m)
Pile-a	647.3	21.7	143.1
Pile-b	387.8	21.7	143.1
Pile-c		21.7	143.1

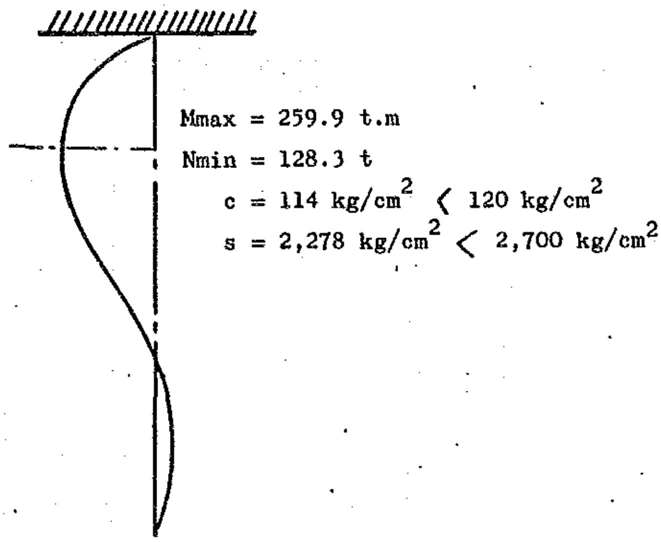
６４７.３ t ＜ 許容応力（Ｒａ）＝７００ t

b) 荷重によってもたらされる杭の1本当り内部応力

杭内部への作用力と内部応力



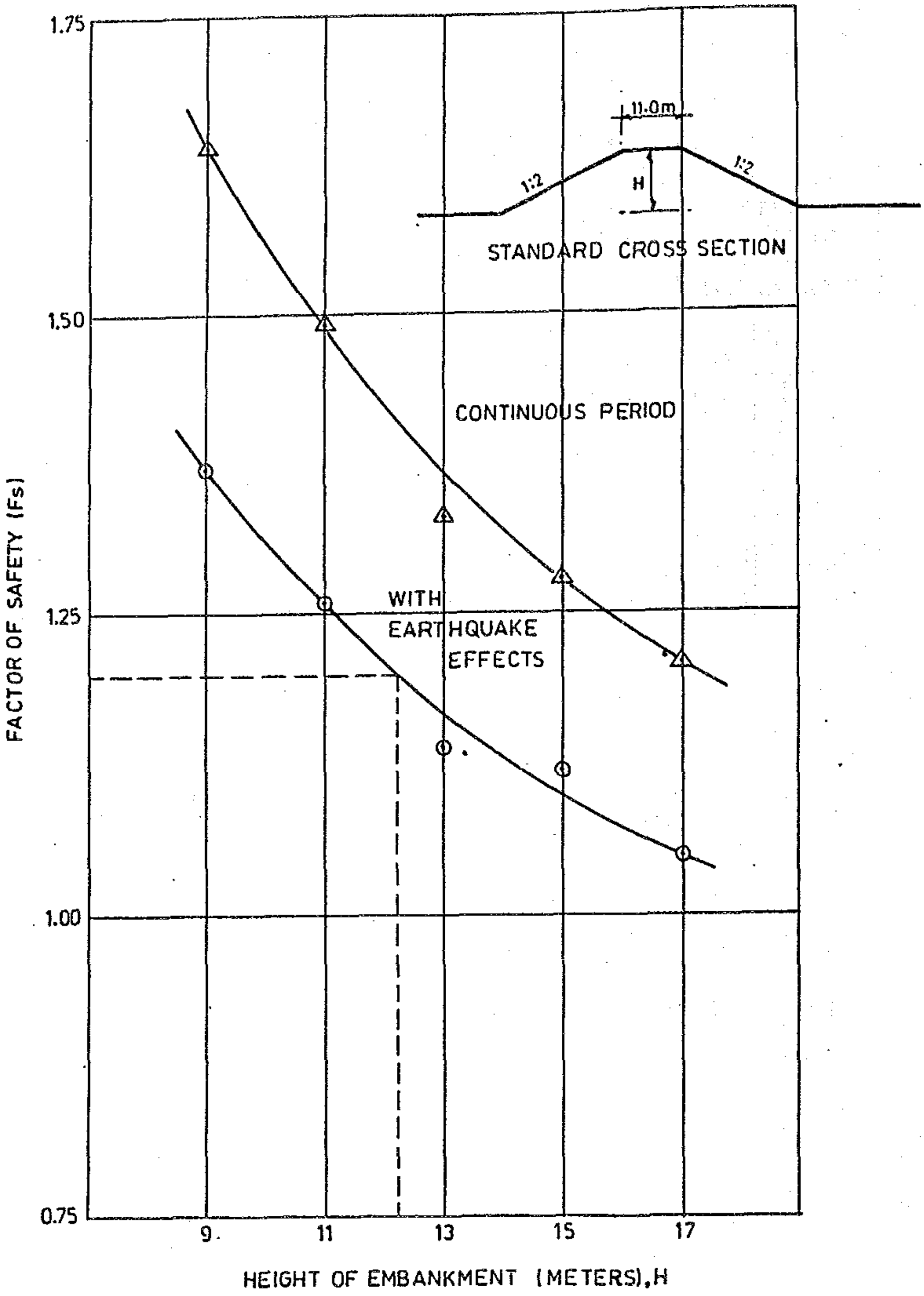
(1) 剛結された場合の
杭の曲げモーメント図



(2) ヒンヂ結合の場合の
杭の曲げモーメント図

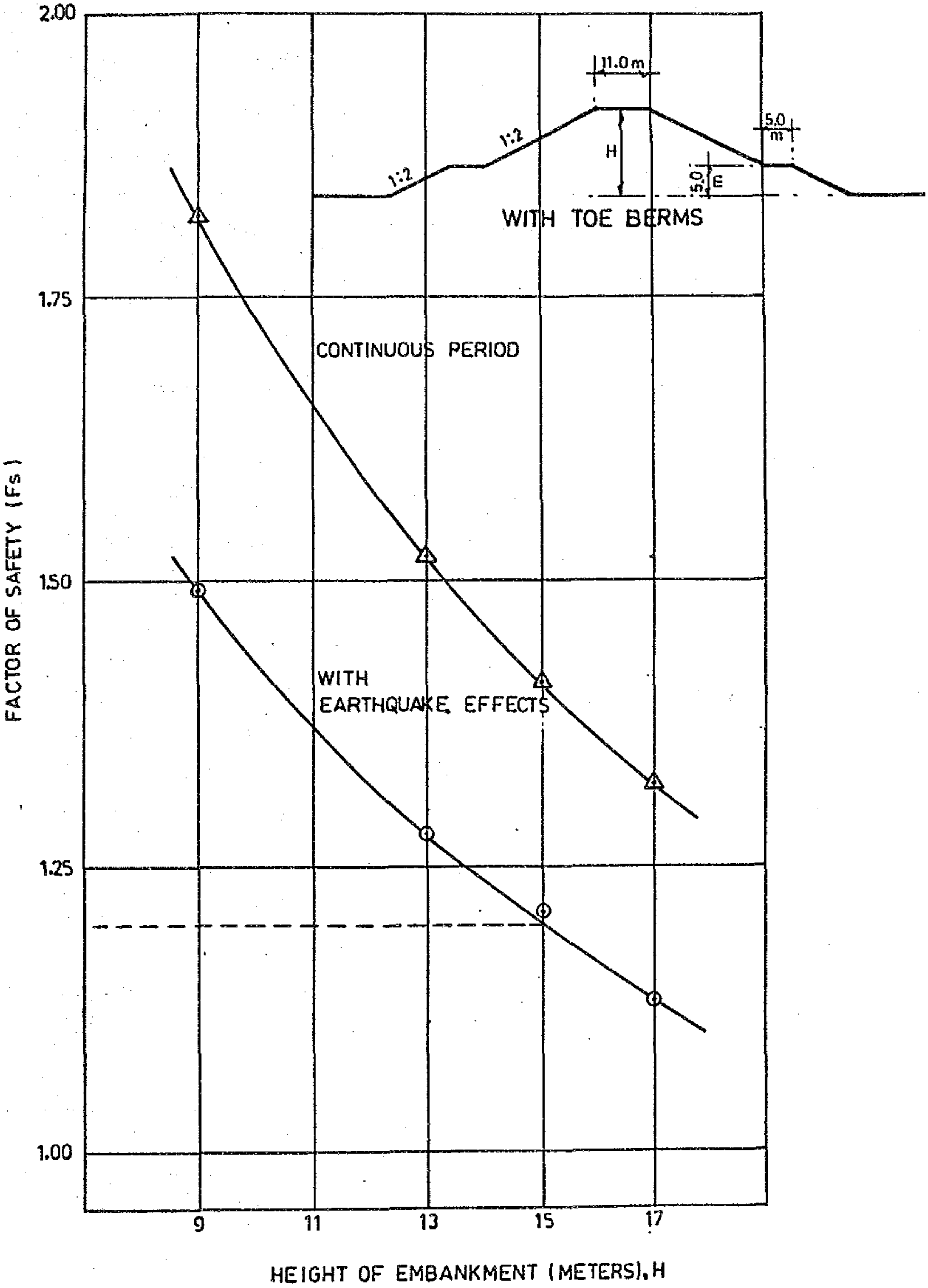
(2)のヒンヂ結合の場合における杭内部への作用力に対して、コンクリートの応力(c)と鉄筋の応力(s)を検討したところ、いずれも許容応力度以下であることが確認出来た。

上記の a)、b) の作用力は弾性基礎における梁と柱の部材としての構造理論にもとづいて計算された。



Source: The Study Team

AP.FIG. 4-5 EMBANKMENT HEIGHT AND FACTOR OF SAFETY
(STANDARD CROSS SECTION)



Source: The Study Team

AP. FIG. 4-6 EMBANKMENT HEIGHT AND FACTOR OF SAFETY (WITH TOE BERMS)

AP. TABLE 5-1 CONSTRUCTION MATERIALS OF MEGHNA BRIDGE (1)

Item No.	Work Item	Volume	Materials required	Quantities required	Remarks
402	Site Reclamation	110,000 m^3	(L/C=1.35)	457,920m^3	
101	Road Filling	229,200 m^3	Sandy Soil		
102	Sub-base Course	4,100 m^3	Sand	2,870m^3	
			Pea gravel	2,870m^3	
103	Base Course	2,300 m^3	Pea gravel	920m^3	
			Shingle	1,610m^3	
			Pit sand	690m^3	
	Asphalt Concrete	(4,520 ton)	Pea gravel	1,260m^3	
104	Asphalt Surface	2,560 ton	Sand	1,240m^3	
105	Bridge Surface	810 ton	Pit sand	560m^3	
600	Traffic Maintenance	1,150 ton	Cement	140 ton	
			Asphalt	340 ton	
	Concrete Class A	(9,650 m^3)			
108	Box Culvert	707 m^3	Cement	3,250 ton	
110	Slope Protection	385 m^3	Sand	2,230 m^3	
111	Back Abutment Slab	52 m^3	Pit sand	2,230 m^3	
112	Drainage, etc.	200 m^3	Shingle	3,790 m^3	
204 & 302	Footing Concrete	3,010 m^3	Crushed stone	3,790 m^3	
205 &303	Pier Concrete	4,500 m^3			
212	Footpath and Kerb	233 m^3	Plasticiser	9.7 ton	
301	Precast Concrete Pile	522 m^3			
504	Pier Protection	40 m^3			
	Concrete, Class X	(3,390 m^3)	Cement	1,320 ton	
201	Reverse Circulation Pile	2,040 m^3	Sand	800 m^3	
203	Seal Concrete	1,350 m^3	Pit sand	800 m^3	
			Shingle	1,190 m^3	
			Crushed stone	1,190 m^3	
			Plasticiser	3.4 ton	
	Concrete Class P	(7,290 m^3)	Cement	2,990 ton	
207	PC Box Concrete	7,070 m^3	Sand	1,530 m^3	
304	PC Girder Concrete	220 m^3	Pit sand	1,530 m^3	
			Shingle	2,770 m^3	
			Crushed stone	2,770 m^3	
			Plasticiser	7.3 ton	
	Remarks : Total of cement & aggregate for Approach Road and Bridge		Cement	7,700 ton	
			Sand	8,670 m^3	
			Pea gravel	5,050 m^3	
			Shingle	9,360 m^3	
			Pit sand	5,810 m^3	
			Crushed stone	7,750 m^3	

AP. TABLE 5-1 CONSTRUCTION MATERIALS OF MEGHNA BRIDGE (2)

Item No.	Work Item	Volumes	Materials required	Quantities required	Remarks
	TORSTEEL	(2040 ton)			
108	Box Culvert	78 ton			
111	Back Abutment Slab	6 ton			
201	Reverse Circulation Pile	1100 ton	TORSTEEL Bar	2,040 ton	
206	TORSTEEL Bar	692 ton			
210	Railing	65 ton			
212	Footpath & Kerb	12 ton			
301	Precast Concrete Pile	83 ton			
	Deformed Bar	(840 ton)			
208	Deformed Bar of PC Box	810 ton	* Deformed Bar	840 ton	
305	Deformed Bar of PC Beam	27 ton			
	High Tensile Bar				
209	PC Cable Stressing	420 ton	* High Tensile Bar	420 ton	
	High Tensile Wire		* High Tensile Wire		
306	PC Cable Stressing	9 ton		9 ton	
	Fabricated Steel Goods	(106 ton)			
211	Expansion Joint	36 ton	* Fabricated Steel or Cast Iron	106 ton	
213	Centre Hinge	20 ton			
214	Bearing Shoe	2 ton			
307	Bearing Shoe	6 ton			
109	Guard Rail	42 ton			
	Shape Steels	(6,910ton)			
201	Reverse Circulation Pile	914 ton			
202	Excavation in River	2,130 ton			
401	Temporary Staging	2,230 ton	* Shaped Steels	6,910 ton	
403	Temporary Quay	920 ton			
502	Sheet Piling	490 ton			
504	Pier Protection	35 ton			
600	Traffic Maintenance	191 ton			

* Note : Imported Material

Source: The Study Team

AP. TABLE 5-2 CONSTRUCTION MATERIALS OF MEGHNA-GUMTI BRIDGE (1)

Item No.	Work Item	Volume	Materials required	Quantities required	Remarks
402 (G)	Site Reclamation	270,000 m^3	(L/C = 1.35)		
101 (G)	Road Filling	85,700 m^3	Sandy soil	480,200 m^3	
102	Sub-base Course	2,850 m^3	Sand	2,000 m^3	
			Pea gravel	2,000 m^3	
103	Base Course	1,560 m^3	Pea gravel	630 m^3	
			Shingle	1,100 m^3	
			Pit sand	470 m^3	
	Asphalt Concrete	(4,880 ton)	Pea gravel	1,360 m^3	
104 (G)	Asphalt Surface	2,210 ton	Sand	1,340 m^3	
105	Bridge Surface	1,290 ton	Pit sand	610 m^3	
600 (G)	Traffic Maintenance	1,380 ton	Cement	150 ton	
			Asphalt	370 ton	
	Concrete Class A	(9,320 m^3)			
108	Box Culvert	280 m^3	Cement	3,140 ton	
110	Slope Protection	390 m^3	Sand	2,160 m^3	
111	Back Abutment slab	52 m^3	Pit sand	2,160 m^3	
112 (G)	Drainage, etc.	120 m^3	Shingle	3,660 m^3	
202 (G)302	Footing Concrete	5,520 m^3	Crushed Stone	3,660 m^3	
205 (G)303	Pier & Abutment Concrete	2,460 m^3			
301	Precast Concrete Pile	410 m^3	Plasticiser	9.3 ton	
504	Pier Protection	80 m^3			
	Concrete Class X	(20,450 m^3)			
201 (G)	Reverse Circulation Pile	18,270 m^3	Cement	7,950 ton	
203 (G)	Seal Concrete	2,180 m^3	Sand	4,790 m^3	
			Pit sand	4,790 m^3	
			Shingle	7,180 m^3	
			Crushed stone	7,180 m^3	
			Plasticiser	20.5 ton	
	Concrete Class P		Cement	5,300 ton	
207 (G)	PC Box Concrete	12,930 m^3	Sand	2,710 m^3	
			Pit sand	2,710 m^3	
			Shingle	4,900 m^3	
			Crushed stone	4,900 m^3	
			Plasticiser	12.9 ton	

Remarks :

Total Cement & Aggregate for Approach Road and Bridge

Cement	16,540 ton
Sand	13,000 m^3
Pea gravel	3,990 m^3
Shingle	16,840 m^3
Pit sand	10,740 m^3
Crushed stone	15,740 m^3

AP. TABLE 5-2 CONSTRUCTION MATERIALS OF MEGHNA-GUMTI BRIDGE (2)

Item No.	Work Item	(Volume)	Materials required	Quantities required	Remarks
	TORSTEEL	(3,680 ton)			
108	Box Culvert	30 ton			
111	Back Abutment Slab	6 ton			
201 (G)	Reverse Circulation pile	2,750 ton	TORSTEEL Bar	3,680 ton	
206 (G)	TORSTEEL Bar	700 ton			
210	Railing	108 ton			
212	Footpath & Kerb	20 ton			
301	Precast Concrete Pile	65 ton			
	Deformed Bar				
208 (G)	Deformed Bar of PC Box	1,480 ton	* Deformed Bar	1,480 ton	
	High Tensile Bar				
209 (G)	PC Cable Stressing	760 ton	* High Tensile Bar	760 ton	
	Fabricated Steel Goods	(100 ton)			
211	Expansion Joint	50 ton			
213	Centre Hinge	36 ton	* Fabricated Steel and Cast Iron	100 ton	
214	Bearing Shoe	2 ton			
109	Guard Rail	12 ton			
	Shape Steels	(10,810 ton)			
201 (G)	Reverse Circulation Pile	1,950 ton			
202 (G)	Excavation in River	4,260 ton	* Shaped Steels	10,810 ton	
401 (G)	Temporary Staging	3,130 ton			
403	Temporary Quay	1,230 ton			
504	Pier Protection	70 ton			
600 (G)	Traffic Maintenance	170 ton			

* Note : Imported Material
(G): Items for Meghna-Gumti Bridge only

Source: The Study Team

AP. NOTE 6–1 PCE: PASSENGER CAR EQUIVALENT

バングラデシュは下記のように交通車輌の台数を表すのに国連アジア太平洋経済社会委員会が示唆したと同じ乗用車換算係数を使用している。

Type of Vehicles	PCE Factor
1. Trucks	3.0
2. Buses and coaches	3.0
3. Other medium and heavy commercial vehicles	3.0
4. Cars, jeeps, pick-ups, station wagons, microbuses, etc.	1.0
5. Light commercial vehicles	1.0
6. Auto-rickshaws	1.0
7. Motorcycles	0.5
8. Animal drawn or push carts	3.0
9. Rickshaws	0.5
10. Bicycles	0.25

Source: Roads & Highways Department

AP. TABLE 6-1 COMPARISON OF LOADING SPECIFICATIONS FOR HIGHWAY BRIDGES

DESCRIPTION	AASHTO (American Association of State Highway and Transportation Officials)	IRC (Indian Road Congress)	J.R.A (Japan Road Association)	Adopted to Meghna & Meghna-Gumti Bridge Project	Remarks
Live Load	HS 20 - 44 (MS 18)	90% of CLASS "A" (For 2-Lane Bridge)	TL - 20	HS 20 - 44 (MS 18)	
Impact Fraction	$i = \frac{15.24}{L + 30} \leq 30\%$	$i = \frac{4.5}{6 + L} \leq 50\%$	$i = \frac{20}{50 + L}$ (For T-Load.) $i = \frac{10}{25 + L}$ (For L-Load.)	$i = \frac{15.24}{L + 30} \leq 30\%$	L: Span Length in Meters
Sidewalk Loading	415 kg/m^2	400 kg/m^2	350 kg/m^2 (For $L \leq 80$) 430-L (For $80 < L \leq 130$) 300 (For $L > 130$)	415 kg/m^2	L: Span Length in Meters
Kerb Loading	744 kg/m	750 kg/m	--	744 kg/m	Lateral Force
Railing Loading	74.4 kg/m	150 kg/m	250 kg/m	74.4 kg/m	Lateral Force
Longitudinal Forces	5% of Live Load	20% of the first train load plus 10% of the succeeding train load		5% of Live Load	
Wind Load	V = 100 m.p/h (160.9 km/h) W = 244 kg/m^2 (For Girder and Beam) W = 195 kg/m^2 (For Sub-structure)	$V_h = 20 = 2 \times 136$ km/h $= 272$ km/h	V = 55 m/s (198 km/h) W = 300 kg/m^2 (For PC Girder and Beam) W = 300 kg/m^2 (For Sub-structure)	V = 140 m.p.h (225.3 km/h) W = 479 kg/m^2 (For Girder and Beam) W = 383 kg/m^2 (For Sub-structure)	
Earthquake Load	- Equivalent Static Force Method - Response Spectrum Method	E = 0.05 W W: Dead Load (t)	- Modified Static Force Method - Response Spectrum Method	E = 0.05 W W: Dead Load (t)	
Thermal Forces	Rise 16.7°C Fall 22.2°C	± 17°C	± 15°C	26°C ± 17°C	
Stream Current Forces	$P = 515\ k \cdot V^2$ V: Velocity of Water $K = 1 \cdot \frac{3}{8}$ (For Square End) $K = \frac{1}{2}$ (For Angle End, $\leq 30°$) $K = \frac{2}{3}$ (For Circular Pier)	$P = 52\ k \cdot V^2$ V: Velocity of Water K = 1.5 (For Square End) K = 0.66 (For Circular Pier) K = 0.5 (For Triangular cut, Angle $\leq 30°$)	$P = k \cdot v^2$ v: Maximum Water Velocity k = 0.07 (For Square End) k = 0.04 (For Circular Pier) k = 0.02 (For Streamline Pier)	As specified in the IRC standard	
Centrifugal Forces	$C = \frac{0.79}{R} \cdot S^2$ S: Design Speed (km/h) R: Radius of Curve (m)	$C = \frac{WV^2}{127\ R}$ V: Design Speed (km/h) R: Radius of Curve (m) W: Vehicle Weight (t)	C = 0.08 x W W: Vehicle Weight (t)	$C = \frac{0.79}{R} \cdot S^2$ S: Design Speed (km/h) R: Radius of Curve (m)	
Earth Pressure	Rankine's Formula	Coulomb's Formula	Coulomb's Formula	Coulomb's Formula	

AP. NOTE 6-2 SEISMIC LOAD

1. 前置き

橋梁の設計や建設に配慮されるべき地震による影響要素は、主として対象地域の地震活動の特性と地震時の地盤の挙動特性、さらに対象とする構造物の動態特性によって決められる。

地震活動は主としてその地域の地殻構造に影響されるもので、過去における地震のおきた頻度と震度、その震源地からの距離にもとづいて推定される。

地震時の地盤の挙動は、地震の起因機構（メカニズム）、震源地より計画中の現場への地震波の伝達路の特性、さらに地形および地質状況を含む現場の状況によって性格づけがなされる。

構造物の動態特性は、土質構造の相互作用を考慮して、構造物自体によって決定されるもので、現場における地震活動および地震時における地盤の挙動特性に調整しうるものである。

2. バングラデシュの地震環境

バングラデシュには１８９７年に大地震が起こり、大被害を受けており、１９１８年のスリマンガル地震と１８８５年のベンガル地震では震源地近くで局部的被害が発生した事実があるが、バングラデシュ国内には地震要因となる活断層はないようにみえる。しかしながら、起因性の断層と高頻度の地震地帯は、バングラデシュの北方のインドと東方のビルマに存在し、この地域における地震が近接するバングラデシュに影響しているものといえる。

バングラデシュでは"震害防止に関する専門家委員会"が包括的研究を行い、１９７９年１１月に"バングラデシュの地震強度地域別分布図と構造物の耐震設計に関する指針"について報告書を作成した。この分布図によると、メグナ、メグナ・グムティ橋の架橋地点は第Ⅱ地区に位置し、０.０５の水平震度を配慮すべきであるとしている。

その報告書のAppendix Ⅱには、１９７１年7月より１９８３年8月までにバングラデシュの国内およびその附近で発生した２１５の地震を発生時点、震源地、震度等の資料とともに記録している。

報告書は、バングラデシュ国を3つのゾーンに区分している。Zone Ⅰは東北部で最も地震活動の多い地区、Zone Ⅱは西北から南東に向って同国の中央部、Zone Ⅲは同国の南西部で地震活動の最も少ない地区としている（Ap.Fig. 6－1参照）。同報告書はZone Ⅰおよび Ⅱでは修正震度階（Modified Mercalli Scale）のⅣおよびⅧは起り得るとし、Zone Ⅲでは震度階Ⅶは超えないとしている。同報告書はZone Ⅰ、Ⅱ、Ⅲにはそれぞれ水平地震係数0.08、0.05、0.04を示唆している。メグナ、メグナ・グムティ橋の架橋地点はZone Ⅱにあたる。

3. 過去の地震にもとづく地盤加速度の推定

調査団は先に述べた報告書の地震目録より、その震源地が北緯21°－26°6 東径88°－92°6に囲まれる地域にある地震を摘出しAp.Fig.6－2に示した。

摘出された地震の発生した日時、震源地、震度を、メグナおよびメグナ・グムティ橋架橋地点までの震源地からの距離と合せてAp.Table 6－2に示した。震源地から架橋予定地点までの距離は地図上から求めた。なお、このTableには報告書の地震目録にはその震源地が示されていないが、1897年の大地震も参考のため示した。

地震の震度および震源地からの距離から地盤加速度を推定する方法がある。震源地からの距離が短かくても長くても、よく合致している。

震源地からの距離が100Kmを超す場合には次の地盤加速度を求める公式が適用される。

$$A = 40.3 \times 10^{0.2621 M} \times (d + 30)^{-1.208}$$

where A = estimated maximum ground acceleration in % of g
M = magnitude of earthquake
d = epicentral distance in km

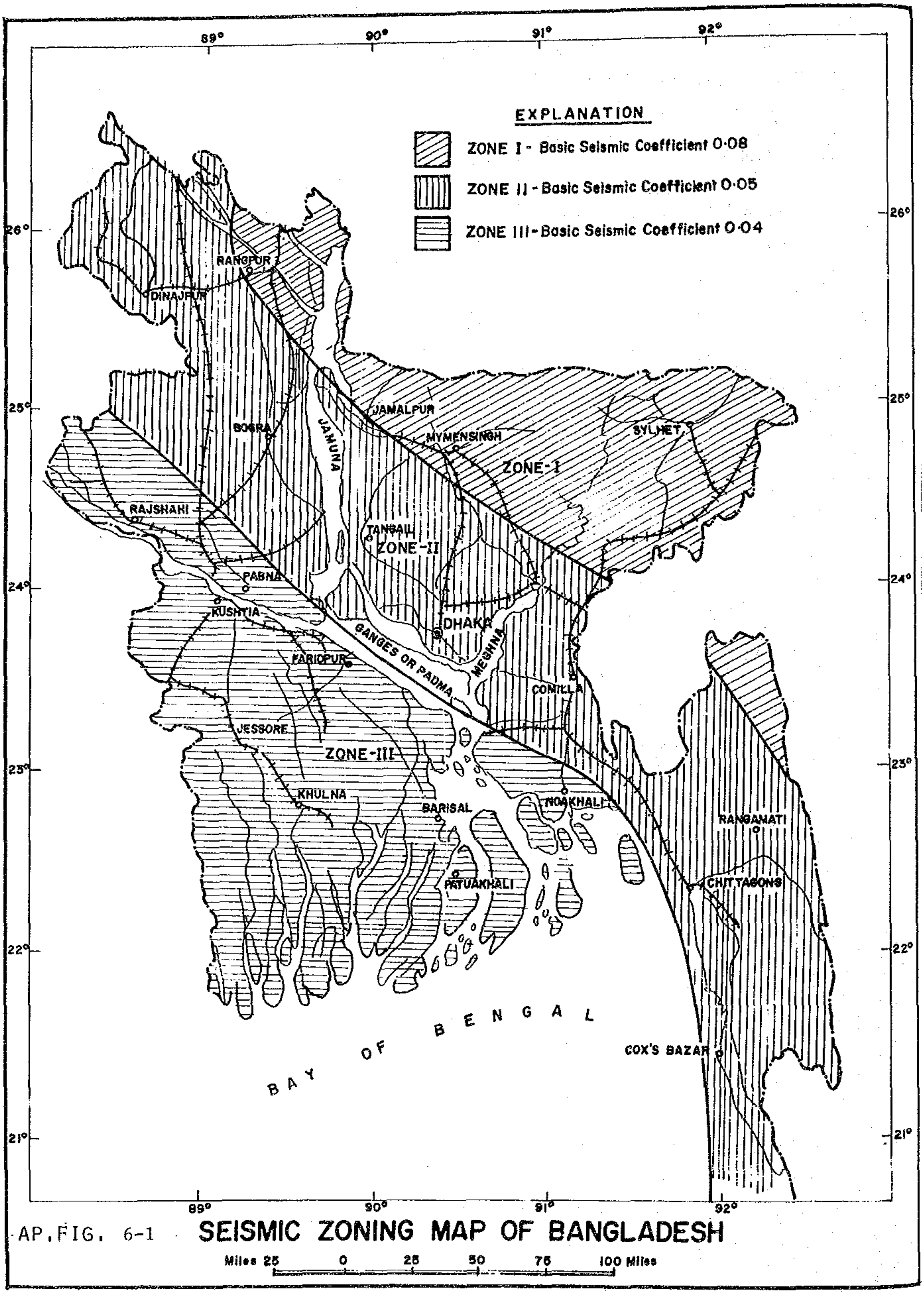
それぞれの地震について計算された地盤加速度をAp.Table6－2に示した。同表より、1869年1月10日および1918年7月8日の地震の場合を除き、ほとんどが5％gを超えていない。この2つの地震については以前に発生したことであり、不確実なことが多い。

したがって構造物の設計にあたっては、最大地盤加速度は配慮する必要がないといえる。例えば、1971年のサンフェルナンド地震の場合、パコイマダムにおいて14％gという最大の地盤加速度が観測されたにもかかわらず、当時誰一人としてこの加速度に対する設計を配慮しなかった。調査団はAp.Table 6－2において1869年の5.9％g

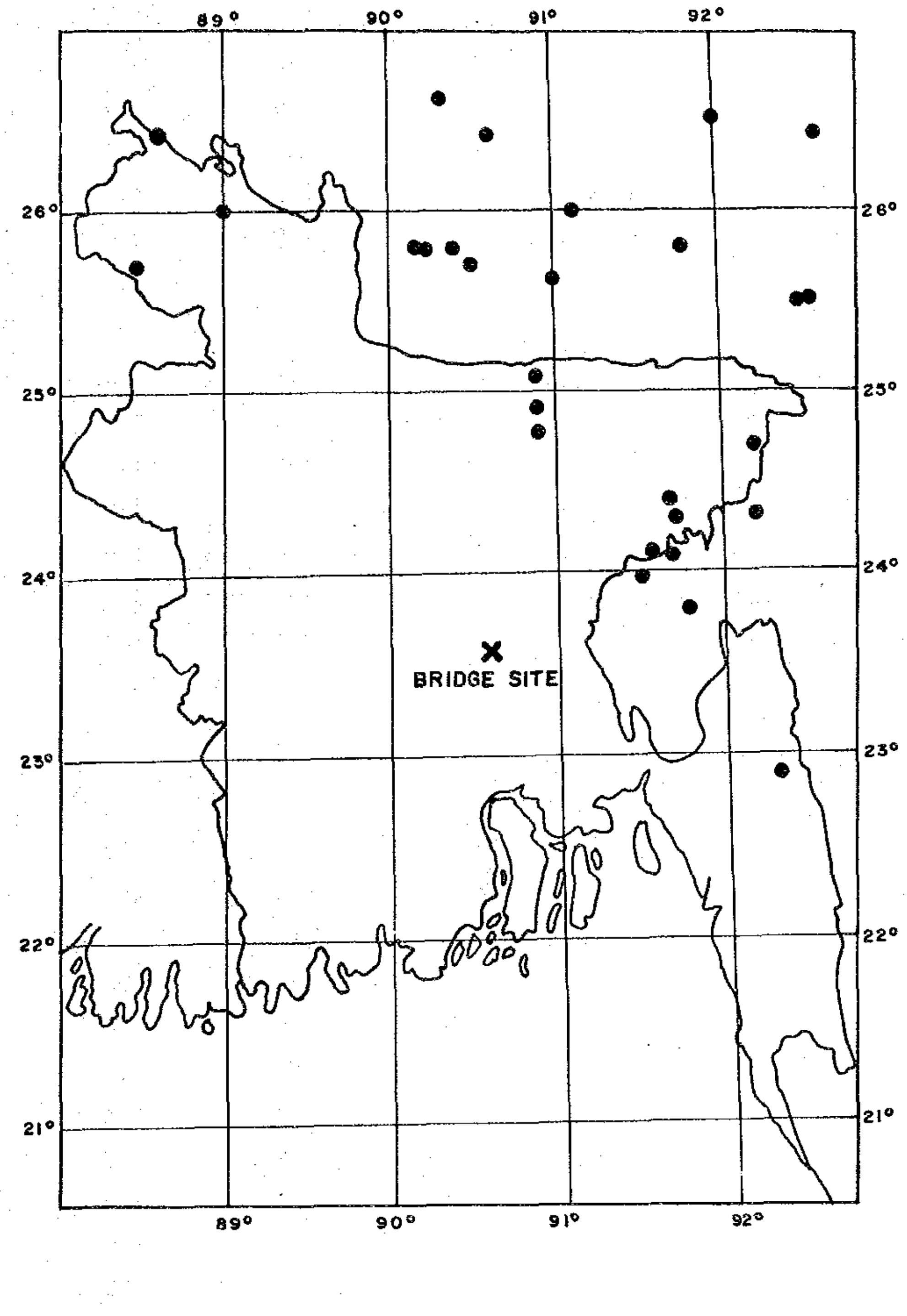
と１９１８年の8.４％ｇだけが５％ｇを超えているが、これらの記録が不明確なことと合せてこれを無視することとした。

4. 架橋地点における基本的水平地震係数

以上の検討により、調査団は橋の設計にあたり、基本的水平震度として0.０５を採用することとした。



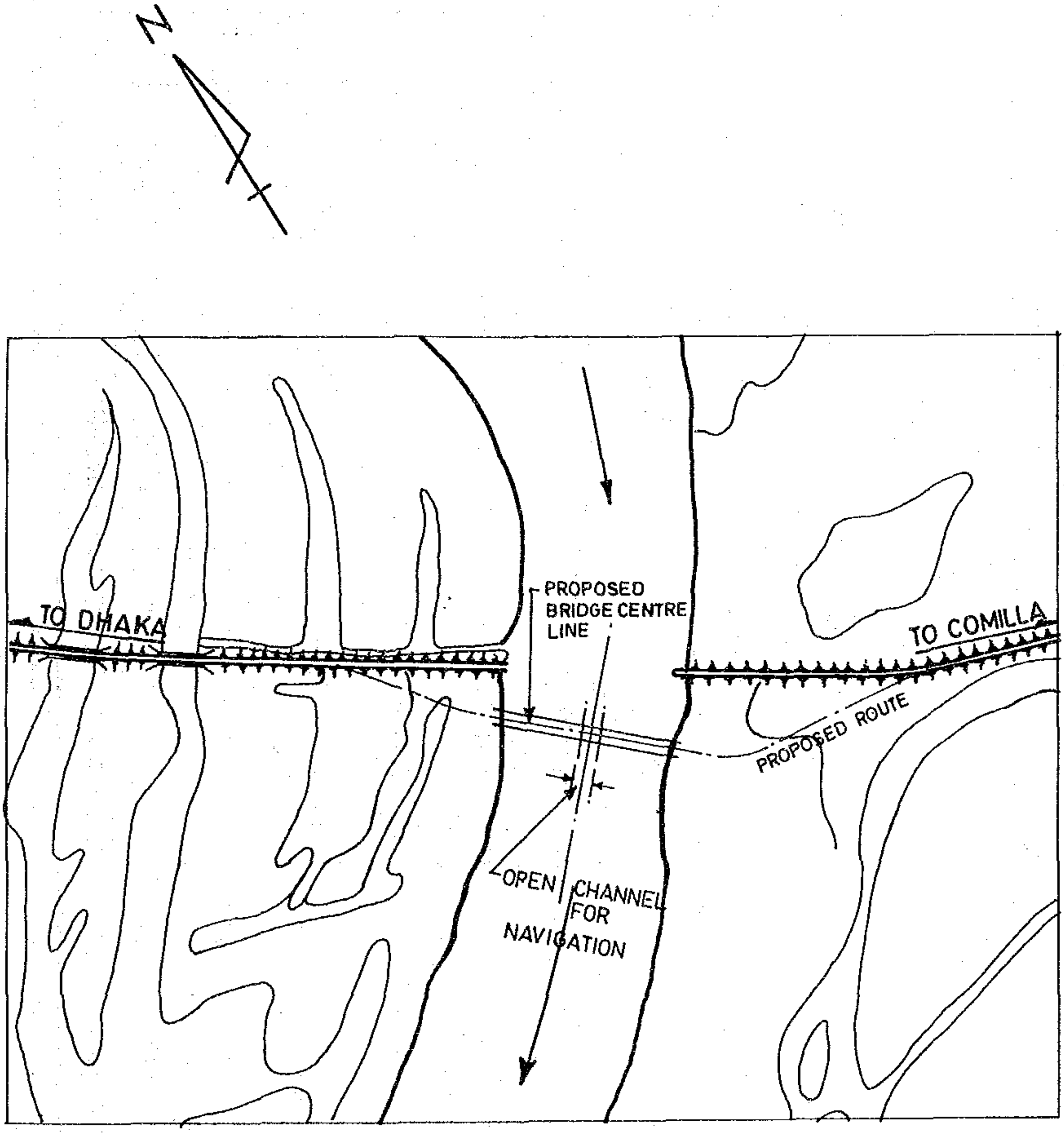
AP.FIG. 6-1 **SEISMIC ZONING MAP OF BANGLADESH**



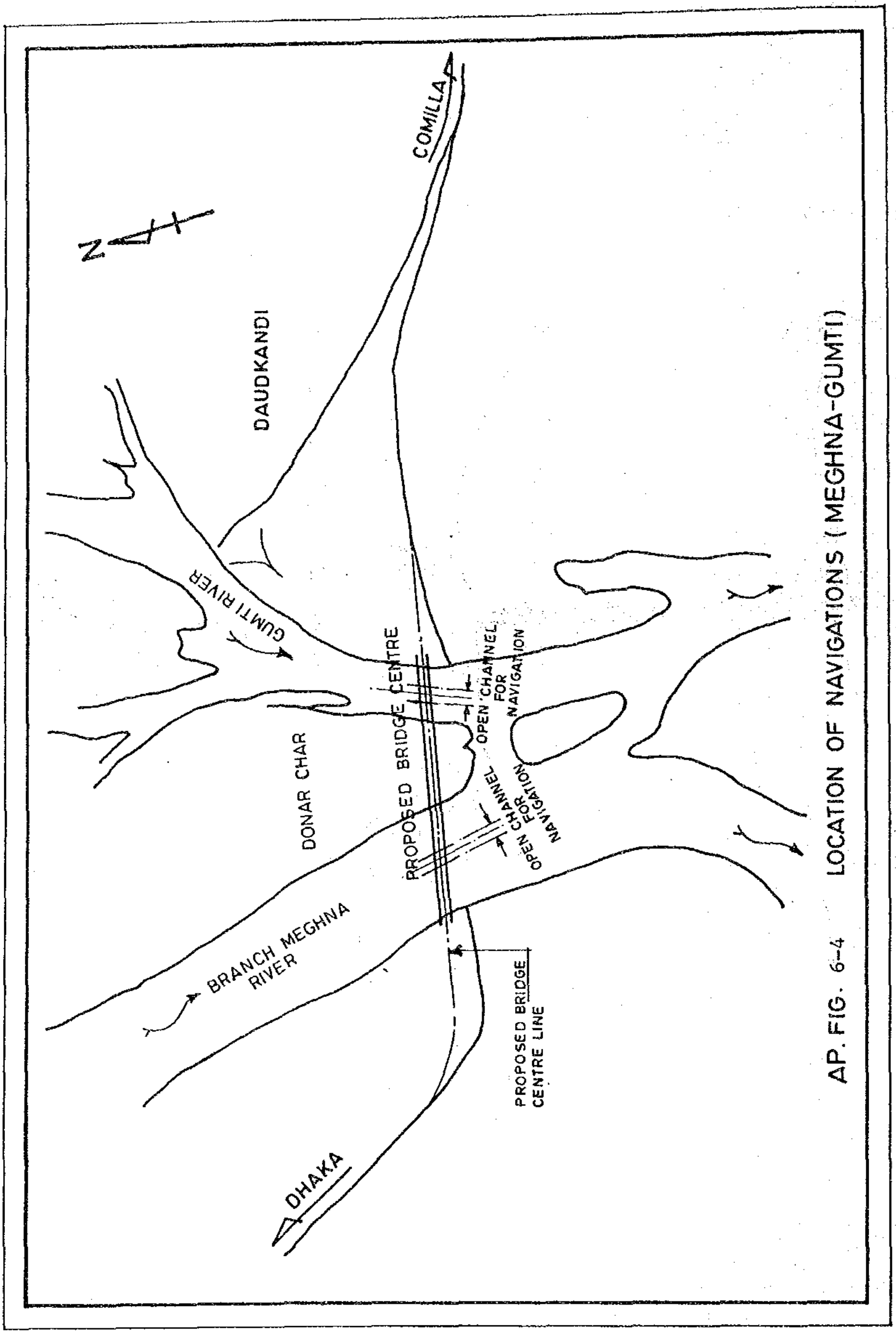
AP.FIG. 6-2 **LOCATION OF EPICENTERS IN AND NEAR BANGLADESH (1833-1971)**

Ap.Table 6-2 Estimation of Ground Accelerations Caused by Past Earthquakes

No.	Date of Occurrence Year	Month	Day	Epicentre N(o)	E(o)	Magnitude M	Epicentral Distance d (km)	Estimated Accelaration (% g)	Remarks
1	1869	1	10	24.3	92.2	7.5	178	5.9	
2	1897	6	12			8.5	500	3.9	d:Approx. Estimation
3	1918	7	8	24.3	91.7	7.6	134	8.4	
4	1923	9	9	25 ¼	91	7.1	189	4.4	
5	1930	7	2	25.8	90.2	7.1	250	3.2	Six major after shocks of M 5-6 took place
6	1932	3	6	25.5	92.5	5	284	0.8	
7	"	3	24	25.8	90.2	5-6	189	2.2	
8	"	3	27	25.5	92.5	"	284	1.5	
9	"	11	9	26.5	92.0	"	352	1.0	
10	1933	3	6	25.7	90.5	5.8	236	1.6	
11	1936	6	18	26.6	90.3	5.6	336	1.2	
12	1944	12	24	24.7	92.2	6	201	2.1	
13	1945	5	19	25.1	90.9	6	171	2.5	
14	1946	3	16	26.4	92.6	6	368	1.1	
15	1949	12	10	26.0	89.0	6	316	1.3	
16	1950	12	24	24.4	91.7	6.3	142	3.6	
17	1951	4	7	25.8	90.4	6.8	247	2.7	
18	1956	6	12	24.8	90.9	6	139	3.1	
19	1958	2	9	24.9	90.9	5.0	150	1.6	
20	1960	8	21	26.4	88.6		376	0.8	
21	1967	9	6	24.1	91.7	5.0	123	1.9	
22	"	11	14	24.0	91.5	5.1	101	2.4	
23	1968	6	12	26.0	91.1	5.5	273	1.1	
24	"	8	18	26.4	90.6	5.2	312	0.8	
25	"	12	27	24.1	91.6	5.2	114	2.2	
26	1969	1	25	22.9	92.3	5.4	186	1.6	
27	"		1	25.8	91.8	5.0	273	0.8	
28	1970	7	25	25.7	88.5	5.2	321	0.7	
29	1971	2	2	23.8	91.8	4.5	121	1.9	



AP. FIG. 6-3 LOCATION OF NAVIGATION (MEGHNA)

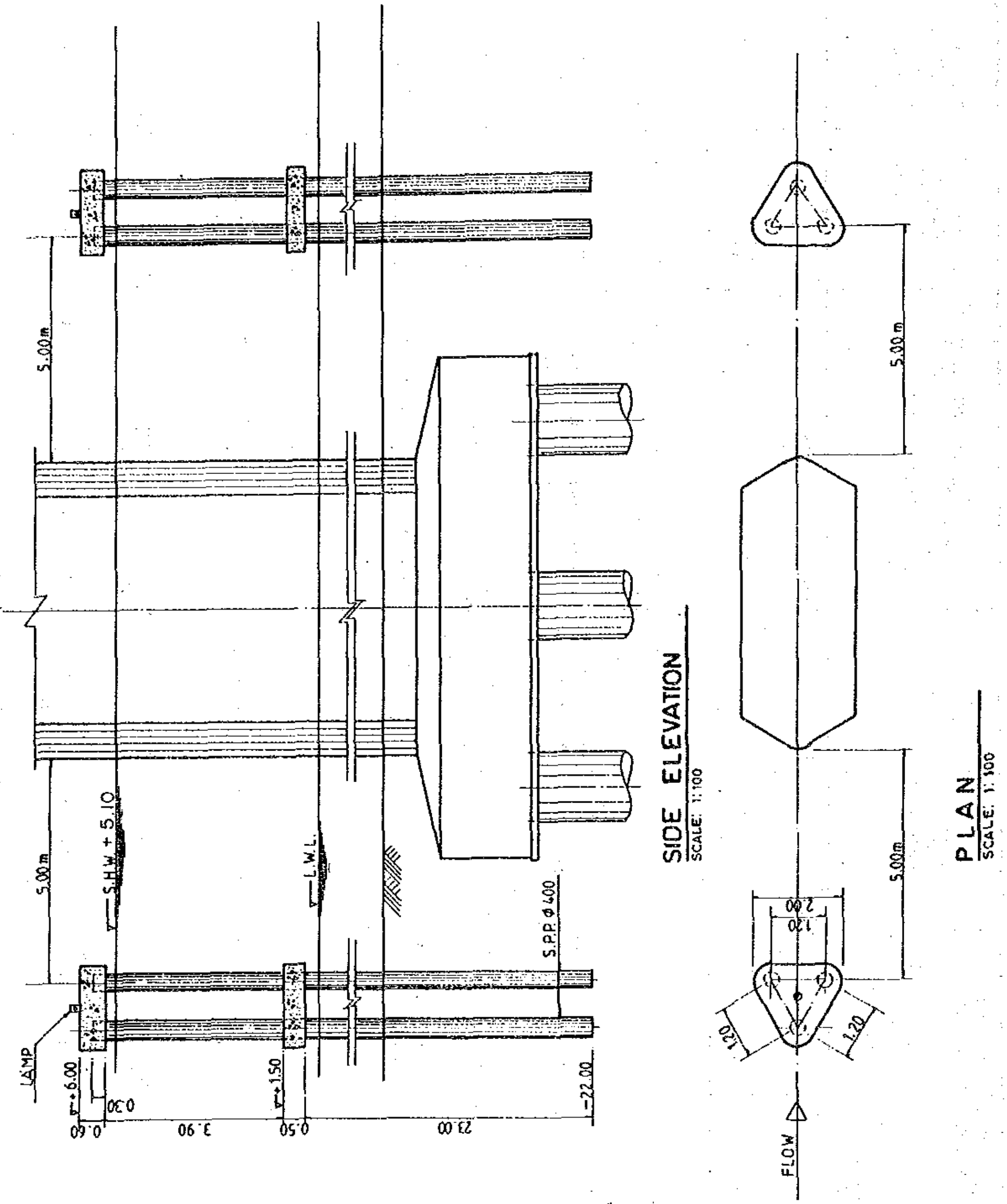


AP. FIG. 6-4 LOCATION OF NAVIGATIONS (MEGHNA-GUMTI)

AP. TABLE 7-1 COMPARISON OF ALTERNATIVE ROUTES OF THE MEGHNA BRIDGE

SUBJECTS STUDIED / ALTERNATIVE ROUTES	HORIZONTAL ALIGNMENT OF THE BRIDGES AND APPROACHES	COST OF APPROACH ROAD	LAND REQUIRED FOR THE PROJECT	REPLACEMENT OF EXISTING FERRY	COMPENSATION FOR SHOPS TO BE REPLACED	SCOPE OF COUNTERMEASURE AGAINST LEFT BANK EROSION	INFLUENCE OF UP STREAM SANDBAR IN NEAR FUTURE
X ROUTE A	◎ Straight line	◎ The minimum cost	◎ Required only for temporary use	△ Required	△ Required	X Large scope required	△ Affected
X ROUTE B	△ Large curve in bridge structure	△ Large cost due to a canal bridge required on right approach	○ 33,000 SQ. M. be required	○ Not required	○ Not required	X Large scope required	X Much affected
△ ROUTE C-1	△ Flat curve in bridge structure	○ Not so large	○ 33,000 SQ. M. be required	○ Not required	○ Not required	△ Small scope required	△ Less affected
○ ROUTE C-2	○ Straight line is possible in the bridge	○ Not so large	○ 36,000 SQ.M. be required	○ Not required	○ Not required	△ Required for adjacent eroded bank	◎ Free
○ ROUTE C-3	○ Straight line is possible in the bridge	△ Large cost due to the longest approach	△ The largest; 42,000 SQ. M. be required	○ Not required	○ Not required	○ Not required	◎ Free

Legend : ◎: Excellent ○: Good △: Poor X: Bad



AP. FIG. 7-1 PIER PROTECTION AGAINST SHIP COLLISION

AP. NOTE 7–1 SPAN ARRANGEMENTS SELECTED

Alternatives	Span Arrangement (Towards Dhaka → Towards Comilla)	No. of Piers
A	40m + 55m + 7 @ 90m + 55m + 2 @ 40m	11
B	40m + 2 @ 45m + 55m + 5 @ 90m + 55m + 2 @ 45m + 2 @ 40m	13
C	40m + 4 @ 45m + 55m + 3 @ 90m + 55m + 4 @ 45m + 2 @ 40m	15
D	40m + 6 @ 45m + 55m + 90m + 55m + 6 @ 45m + 2 @ 40m	17
E	30m + 2 @ 40m + 6 @ 120m + 30m	9

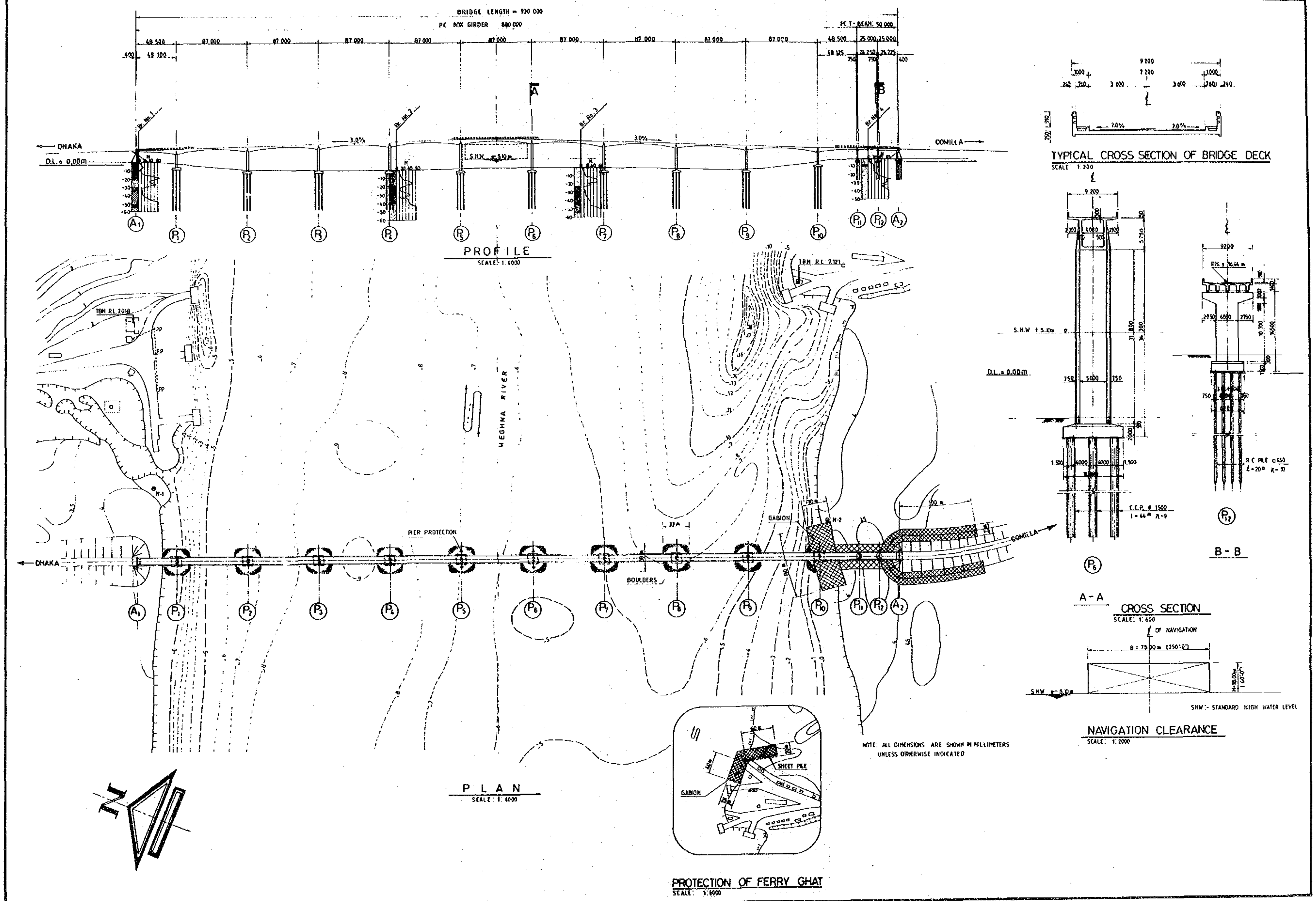
Alternative A: Spans in the river have minimum length of 90 m and side spans near the banks have economical lengths.

Alternative B, C, D: To compare the total cost of superstructure and substructure three kinds of side span arrangement which are all modified from Alternative A were selected.

Alternative E: To compare the cost between span lengths of 90 m and 120 m the latter of which is the maximum span length of road bridge in Bangladesh this arrangement was selected.

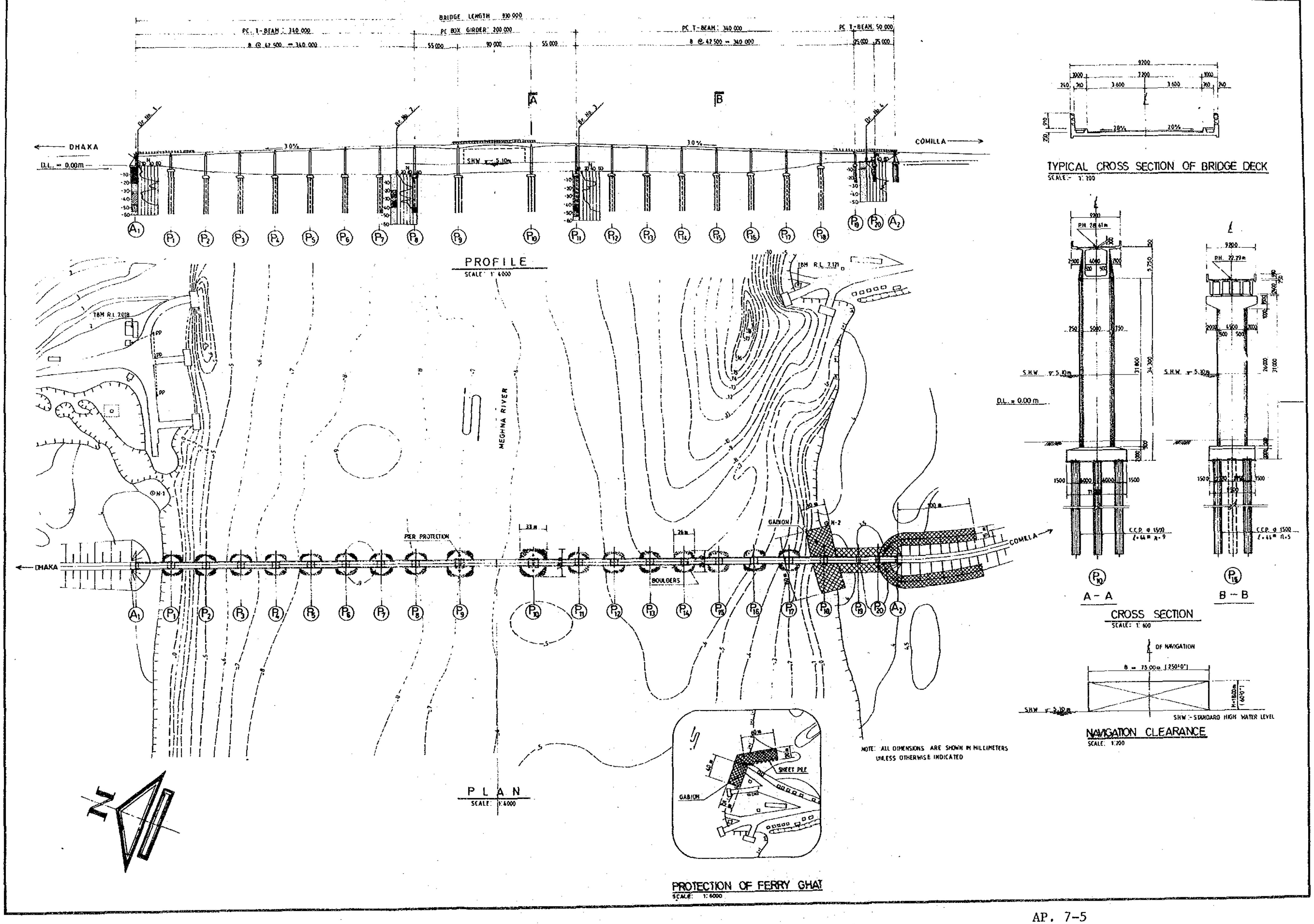
AP.FIG. 7-2

GENERAL VIEW
ALTERNATIVE: CASE-a1, a2



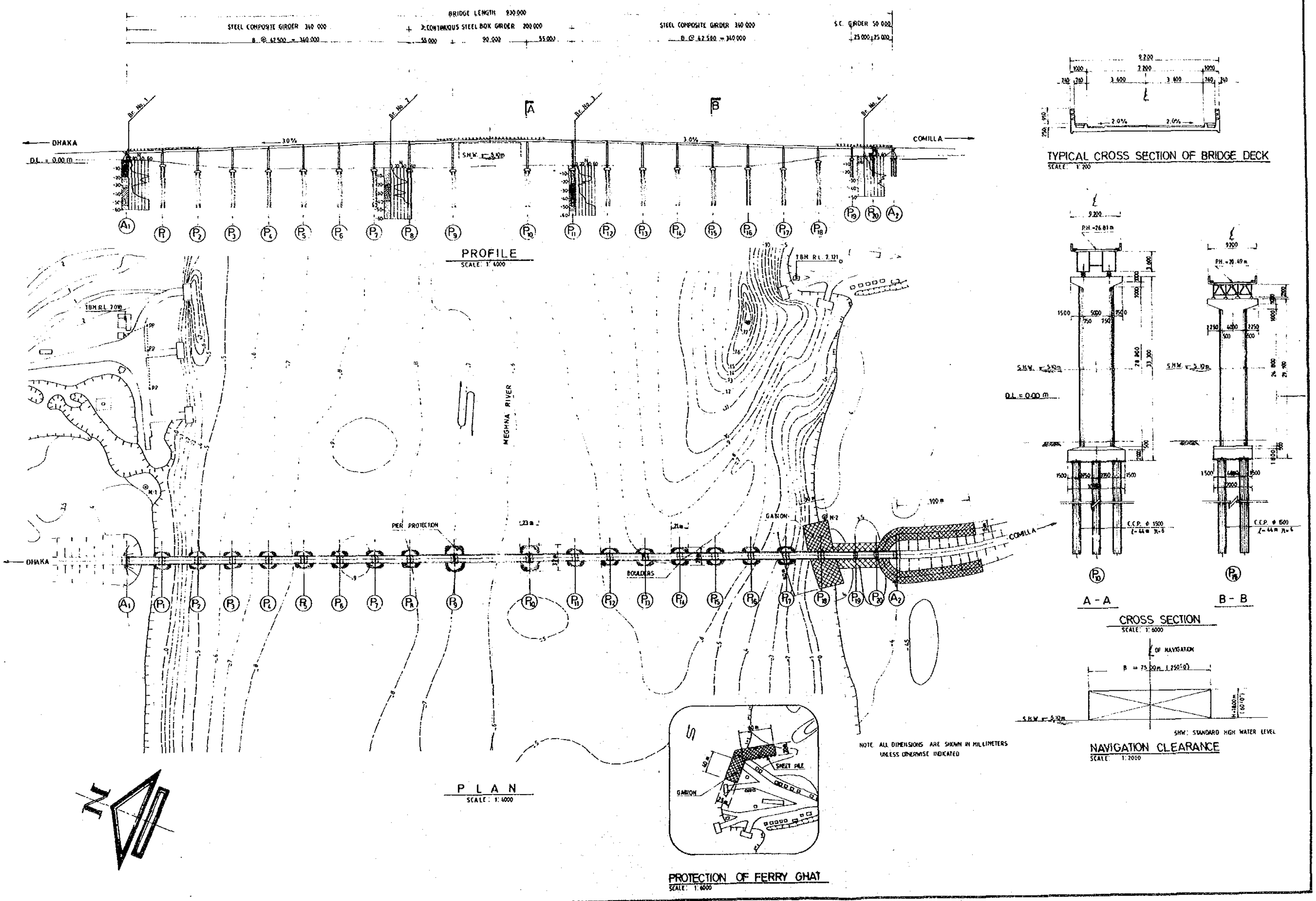
AP.FIG. 7-3

GENERAL VIEW
ALTERNATIVE: CASE-b_1, b_2



AP.FIG. 7-4

GENERAL VIEW
ALTERNATIVE: CASE-b3



AP.TABLE 7-2 COST OF CASE-a1 PC BOX CAST-IN-SITU

(TK)

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
A. Superstructure				
PC box (C) concrete (P)	CM	7,070	4,860	34,360,200
PC beam concrete (P)	CM	220	7,930	1,744,600
Deformed bar	T	837	21,600	18,079,200
PC cable stressing	T	429	70,440	30,218,760
Railing	LM	1,860	1,290	2,399,400
Footpath & kerb	LM	1,860	850	1,581,000
Expansion joint	EACH	13	110,000	1,430,000
Centre hinge	EACH	18	81,650	1,469,700
Bearing shoe	EACH	24	40,750	978,000
Indirect cost	LS	1		46,130,140
Subtotal				138,391,000
B. Substructure				
RCD pile ø1.5 m	LM	4,070	14,110	57,427,700
Precast concrete pile	LM	2,560	1,980	5,068,800
Excavation in river	CM	10,170	7,100	72,207,000
Seal concrete (X)	CM	1,350	1,810	2,443,500
Footing concrete (A)	CM	3,010	2,330	7,013,300
Pier concrete (A)	CM	4,500	2,890	13,005,000
TORSTEEL bar	T	692	22,190	15,355,480
Indirect cost	LS	1		86,260,220
Subtotal				258,781,000
Total A. + B.				397,172,000

Source: The Study Team

Note
(C): Cast-in-situ
(S): Segmental
(A): Class A concrete for box culvert, footing and piers
(P): Class P concrete for prestressed T-beam girder and box section bridge
(X): Class X concrete deposited in water and tremie concrete for cast-in-situ piles

AP.TABLE 7-3 COST OF CASE-a2 PC BOX SEGMENTAL

(TK)

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
A. Superstructure				
PC box (S) concrete (P)	CM	7,070	10,630	75,154,100
PC beam concrete (P)	CM	220	7,930	1,744,600
Deformed bar	T	837	15,550	13,015,350
PC cable stressing	T	429	70,420	30,210,180
Railing	LM	1,860	1,290	2,399,400
Footpath & kerb	LM	1,860	850	1,581,000
Expansion joint	EACH	13	110,000	1,430,000
Centre hinge	EACH	18	81,650	1,469,700
Bearing shoe	EACH	24	40,750	978,000
Indirect cost	LS	1		63,991,670
Subtotal				191,974,000
B. Substructure				
RCD pile ∅1.5 m	LM	4,070	14,110	57,427,700
Precast concrete pile	LM	2,560	1,980	5,068,800
Excavation in river	CM	10,170	7,100	72,207,000
Seal concrete (X)	CM	1,350	1,810	2,443,500
Footing concrete (A)	CM	3,010	2,330	7,013,300
Pier concrete (A)	CM	4,500	2,890	13,005,000
TORSTEEL bar	T	692	22,190	15,355,480
Indirect cost	LS	1		86,260,220
Subtotal				258,781,000
Total A. + B.				450,755,000

Source: The Study Team

AP.TABLE 7-4 COST OF CASE-b1 PC BOX (C) AND T-BEAM

(TK)

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
A. Superstructure				
PC box (C) concrete (P)	CM	1,600	6,050	9,680,000
PC beam concrete (P)	CM	4,180	7,930	33,147,400
Deforced bar (Box)	T	185	21,600	3,996,000
Deformed bar (Beam)	T	497	15,550	7,728,350
PC cable stressing (Box)	T	98	70,440	6,903,120
PC cable stressing (Beam)	T	139	56,100	7,797,900
Railing	LM	1,860	1,290	2,399,400
Footpath & kerb	LM	1,860	850	1,581,000
Expansion joint	EACH	21	110,000	2,310,000
Centre hinge	EACH	2	81,650	163,300
Bearing shoe (Box)	EACH	4	40,750	163,000
Bearing shoe (Beam)	EACH	180	30,300	5,454,000
Indirect cost	LS	1		40,661,530
Subtotal				121,985,000
B. Substructure				
RCD pile ∅1.5 m	LM	4,400	14,830	65,252,000
Precast concrete pile	LM	2,610	1,980	5,167,800
Excavation in river	CM	12,590	7,100	89,389,000
Seal concrete (X)	CM	1,680	1,810	3,040,800
Footing concrete (A)	CM	3,470	2,330	8,085,100
Pier concrete (A)	CM	6,020	2,890	17,397,800
TORSTEEL bar	T	940	22,190	20,858,600
Indirect cost	LS	1		104,595,900
Subtotal				313,787,000
Total A. + B.				434,772,000

Source: The Study Team

AP.TABLE 7-5 COST OF CASE-b2 PC BOX (S) AND T-BEAM

(TK)

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
A. Superstructure				
PC box (S) concrete (P)	CM	1,600	10,630	17,008,000
PC beam concrete (P)	CM	4,180	7,930	33,147,400
Deformed bar (Box)	T	185	15,550	2,876,750
Deformed bar (Beam)	T	497	15,550	7,728,350
PC cable stressing (Box)	T	98	70,420	6,901,160
PC cable stressing (Beam)	T	139	56,100	7,797,900
Railing	LM	1,860	1,290	2,399,400
Footpath & kerb	LM	1,860	850	1,581,000
Expansion joint	EACH	21	110,000	2,310,000
Centre hinge	EACH	2	81,650	163,300
Bearing shoe (Box)	EACH	4	40,750	163,000
Bearing shoe (Beam)	EACH	180	30,300	5,454,000
Indirect cost	LS	1		43,765,740
Subtotal				131,296,000
B. Substructure				
RCD pile ø1.5 m	LM	4,400	14,830	65,252,000
Precast concrete pile	LM	2,610	1,980	5,167,800
Excavation in river	CM	12,590	7,100	89,389,000
Seal concrete (X)	CM	1,680	1,810	3,040,800
Footing concrete (A)	CM	3,470	2,330	8,085,100
Pier concrete (A)	CM	6,020	2,890	17,397,800
TORSTEEL bar	T	940	22,190	20,858,600
Indirect cost	LS	1		104,595,900
Subtotal				313,787,000
Total A. + B.				445,083,000

Source: The Study Team

AP.TABLE 7-6 COST OF CASE-b3 STEEL BOX AND GIRDER

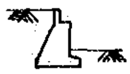
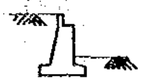
(TK)

ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
A. Superstructure				
Steel box fabrication	T	780	34,680	27,050,400
Steel box transport	T	780	8,290	6,466,200
Steel box erection	T	780	11,480	8,954,400
Steel girder fabrication	T	1,445	28,260	40,835,700
Steel girder transport	T	1,445	7,680	11,097,600
Steel girder erection	T	1,445	5,040	7,282,800
Slab concrete (B)	CM	2,180	3,070	6,692,600
Deformed bar	T	485	27,980	13,570,300
Railing	LM	1,860	1,290	2,399,400
Footpath & kerb	LM	1,860	850	1,581,000
Expansion joint	EACH	20	110,000	2,200,000
Bearing shoe	EACH	146	40,750	5,949,500
Indirect cost	LS	1		60,335,100
Subtotal				194,415,000
B. Substructure				
RCD pile ø1.5 m	LM	3,560	14,830	52,794,800
Precast concrete pile	LM	2,240	1,980	4,435,200
Excavation in river	CM	9,170	7,100	65,107,000
Seal concrete (X)	CM	1,230	1,810	2,226,300
Footing concrete (A)	CM	2,270	2,330	5,289,100
Pier concrete (A)	CM	5,150	2,890	14,883,500
TORSTEEL bar	T	745	22,190	16,531,550
Indirect cost	LS	1		80,633,550
Subtotal				241,901,000
Total A. + B.				436,316,000

Source: The Study Team

Note (B): Class B concrete for slab of steel bridges of alternative plans

AP. TABLE 7-7 GUIDE TO THE SELECTION OF ABUTMENT TYPE

Type	Height (m) 10 20	Remarks
Gravity	4	
Semi-Gravity	6	
Invert-T	6 12	
Buttress		
Rigid Frame	15	
Box	12	

AP. NOTE 7-2 PAVEMENT DESIGN

1. 交通調査と予測値

調査団によって予測された交通量を舗装設計の計算に使用した。設計年次１９９０、２０００、２０１０、２０２０における年平均日交通量は次の通り。

Year	1990	2000	2010	2020
Truck	1,410	2,360	3,470	5,150
Bus	780	1,180	1,700	2,390

上記の交通量は２車線に対してであるので、その交通量の半分が一方向の交通量と考える。

2. 軸荷重等価値および年間等価標準軸重

軸荷重等価値についてはコミラ・チャンディナ・バイパス道路の設計報告書(Vallentine, Laurie, Davies による)で報告されているように、１９７９年および１９８１年に調査された。雨季、乾期について下記の通りである。

Type of Heavy Vehicles	Monsoon Section	Dry Season
Truck	0.62	2.2
Bus	0.28	0.52

年間等価標準軸重の推定値は下記の通りである。

E.S.A at 1990

Truck : $150 \times 705 \times 2.2 + 215 \times 705 \times 0.62 = 327 \times 10^3$

Bus : $150 \times 390 \times 0.52 + 215 \times 390 \times 0.28 = 54 \times 10^3$

Subtotal : 381×10^3

E.S.A at 2000

Truck : $150 \times 1{,}180 \times 2.2 + 215 \times 1{,}180 \times 0.62 = 547 \times 10^3$

Bus : $150 \times 590 \times 0.52 + 215 \times 590 \times 0.28 = 82 \times 10^3$

Subtotal : 625×10^3

E.S.A at 2010

Truck : $150 \times 1{,}735 \times 2.2 + 215 \times 1{,}735 \times 0.62 = 804 \times 10^3$

Bus : $150 \times 850 \times 0.52 + 215 \times 850 \times 0.28 = 117 \times 10^3$

Subtotal : 921×10^3

E.S.A at 2020

Truck : $150 \times 2{,}575 \times 2.2 + 215 \times 2{,}575 \times 0.62 = 1{,}193 \times 10^3$

Bus : $150 \times 1{,}195 \times 0.52 + 215 \times 1{,}195 \times 0.28 = 165 \times 10^3$

Subtotal : $1{,}358 \times 10^3$

Comulative Equivalent Standard Axles

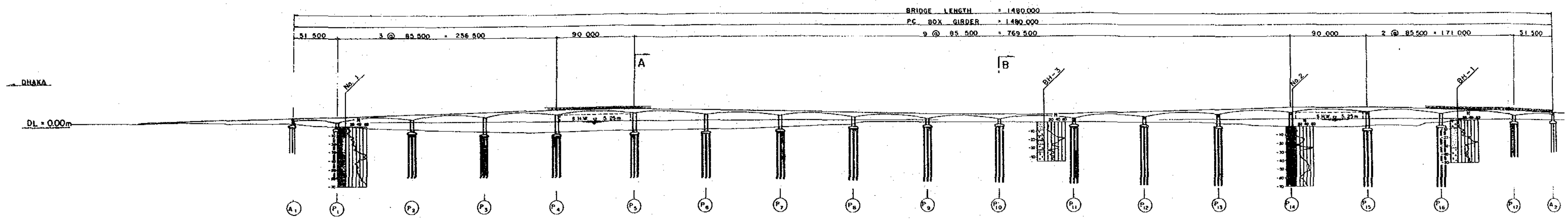
Year		E.S.A.
1990 – 2000	$(381 + 629)/2 \times 10^3 \times 10 = 5{,}050 \times 10^3$	$= 5.0 \times 10^6$
2000 – 2010	$(629 + 921)/2 \times 10^3 \times 10 = 7{,}750 \times 10^3$	$= 7.8 \times 10^6$
2010 – 2020	$(921 + 1{,}358)/2 \times 10^3 \times 10 = 11{,}395 \times 10^3$	$= 11.4 \times 10^6$

AP. TABLE. 7-8 ROUTE COMPARISON OF MEGHNA GUMTI BRIDGE

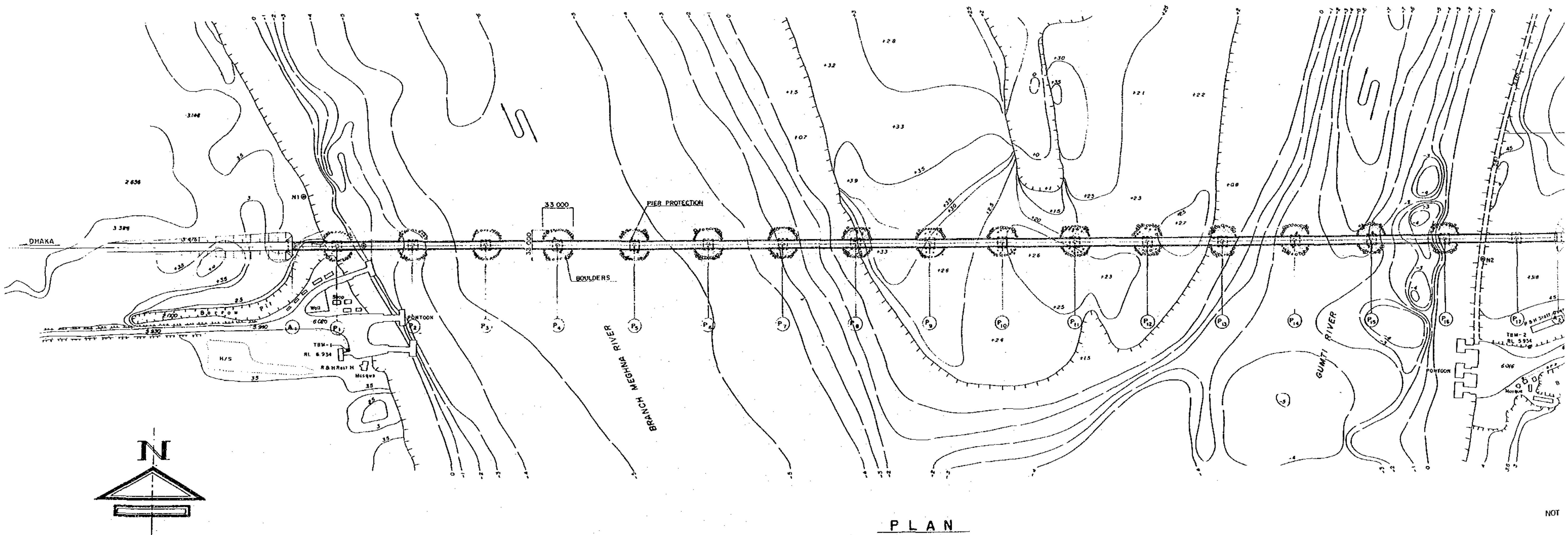
ROUTE	ROUTE ALIGNMENT	CROSSING ANGLE WITH RIVERS FLOW	WIDTH OF RIVERS UNDER BRIDGE (meters)	LENGTH OF NEW APPROACH ROADS (meters)	LAND ACQUISITION (sq.meters)	BRIDGE UNDER CONSTRUCTION: CROSSING WITH FERRY LINE	BRIDGE UNDER CONSTRUCTION: SHIFT OF ROADS, FERRY GHATS & SHOPS
△ A	◎ Bridge in a Straight line	△ 80°	△ 1320	X 1100	X 33,000	◎ Not Cross	◎ Not required
○ B	◎ Bridge in a Straight line	○ 83°	△ 1290	○ 750	◎ 12,000	△ Cross	△ Required only for a jetty in Dhaka side
△ C	△ Approach on Daudkandi Side in a curved line	△ 78°	○ 1280	○ 750 Profile of existing roads be changed to connect bridge profile	◎ 10,000	X Cross	X Required for Roads & Ferry Jetties: 2 for Dhaka & 2 for Comilla
X D	○ Approach on both sides in a curved line	◎ 90°	◎ 1230	○ 750	X 23,000	X Cross	X Required for Roads & Ferry Jetties: 3 for Dhaka & 2 for Comilla
X E	X Bridge in a large curved line	○ (85° on Shortest tangent line)	○ 1270	X 1050	X 32,000	◎ Not Cross	◎ Not required

LEGEND:

◎ Excellent ○ Good △ Poor X Bad



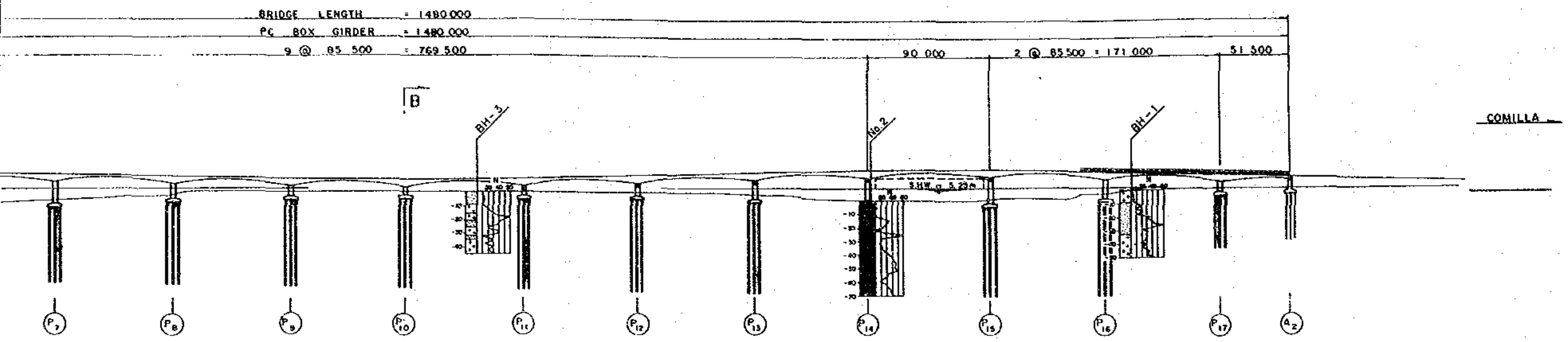
PROFILE
SCALE 1 : 4,000



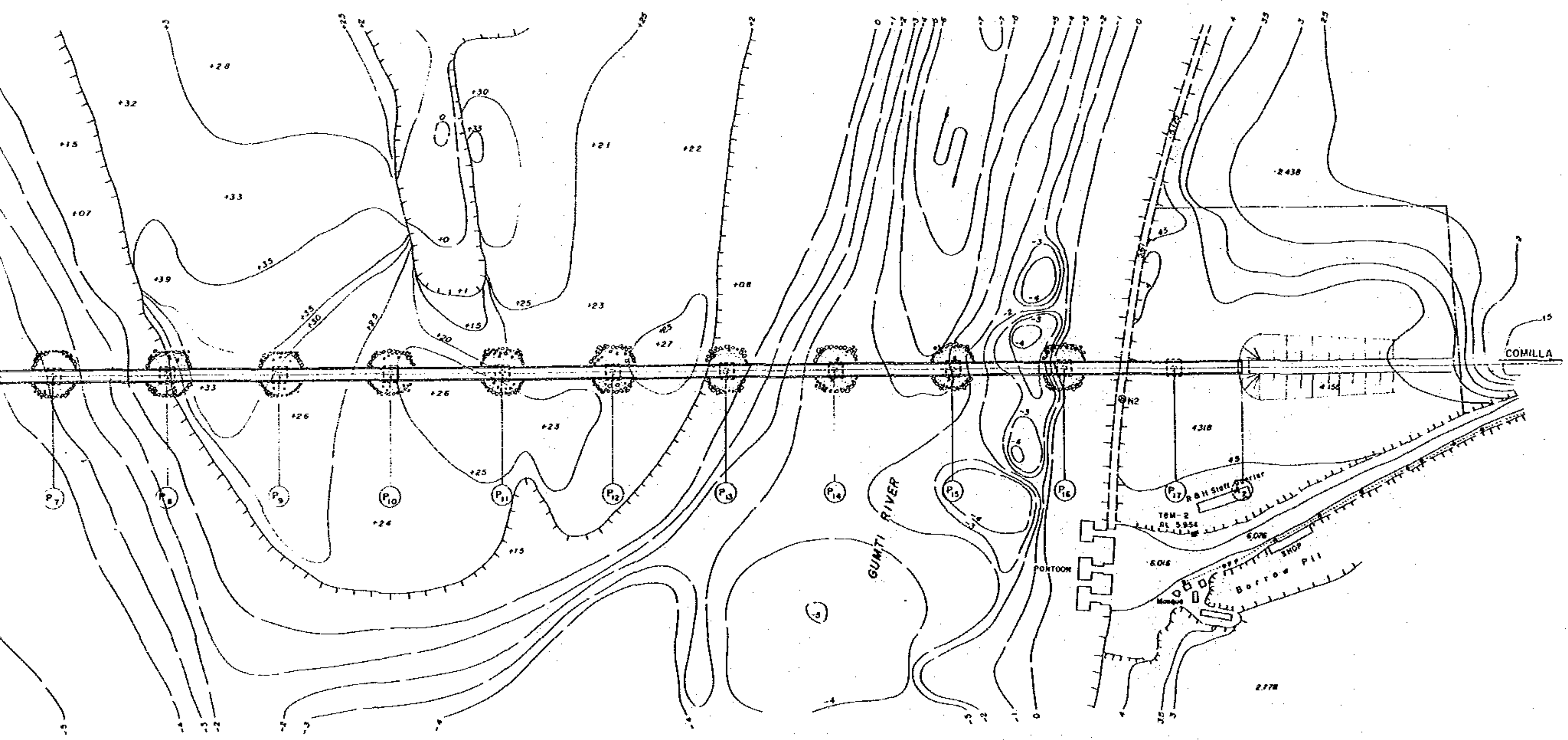
PLAN
SCALE 1 : 4,000

AP.FIG. 7-5

GENERAL VIEW
ALTERNATIVE : CASE - A

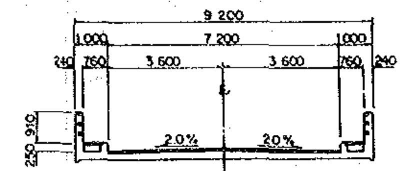


PROFILE
SCALE 1 : 4,000

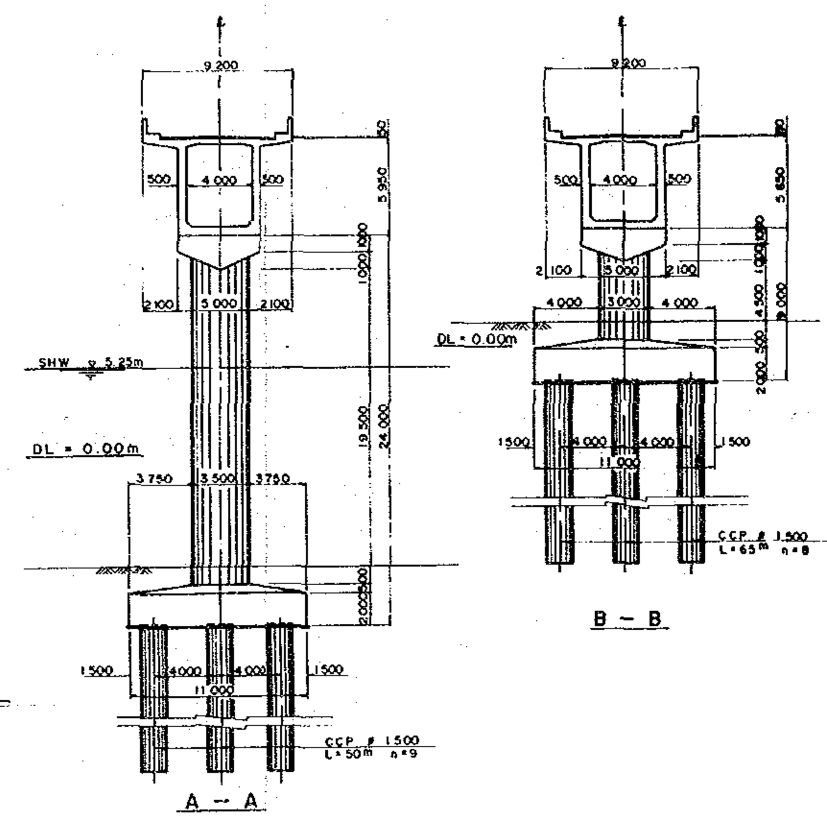


PLAN
SCALE 1 : 4,000

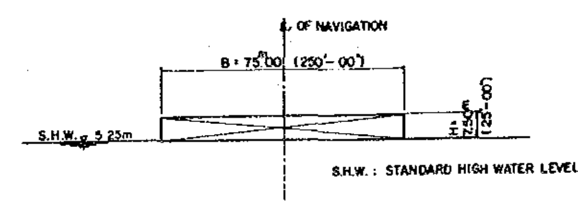
NOTE : ALL DIMENSIONS ARE SHOWN IN MILLIMETERS UNLESS OTHERWISE INDICATED



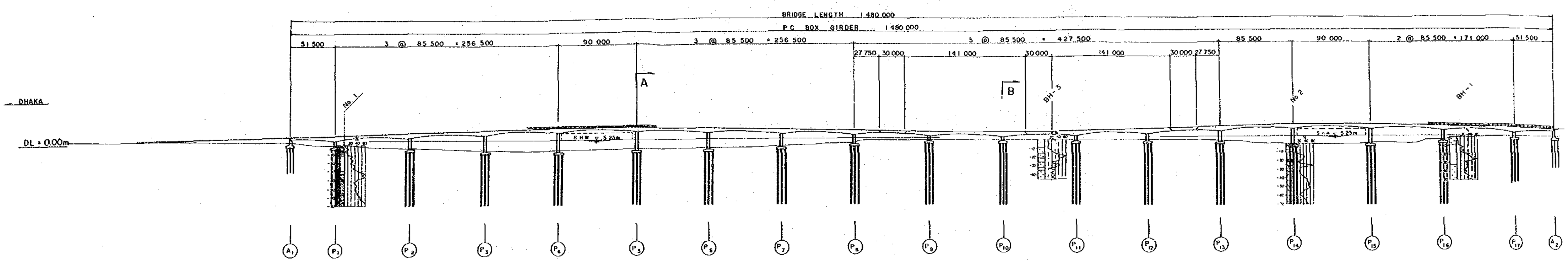
TYPICAL CROSS SECTION OF BRIDGE DECK
SCALE 1 : 200



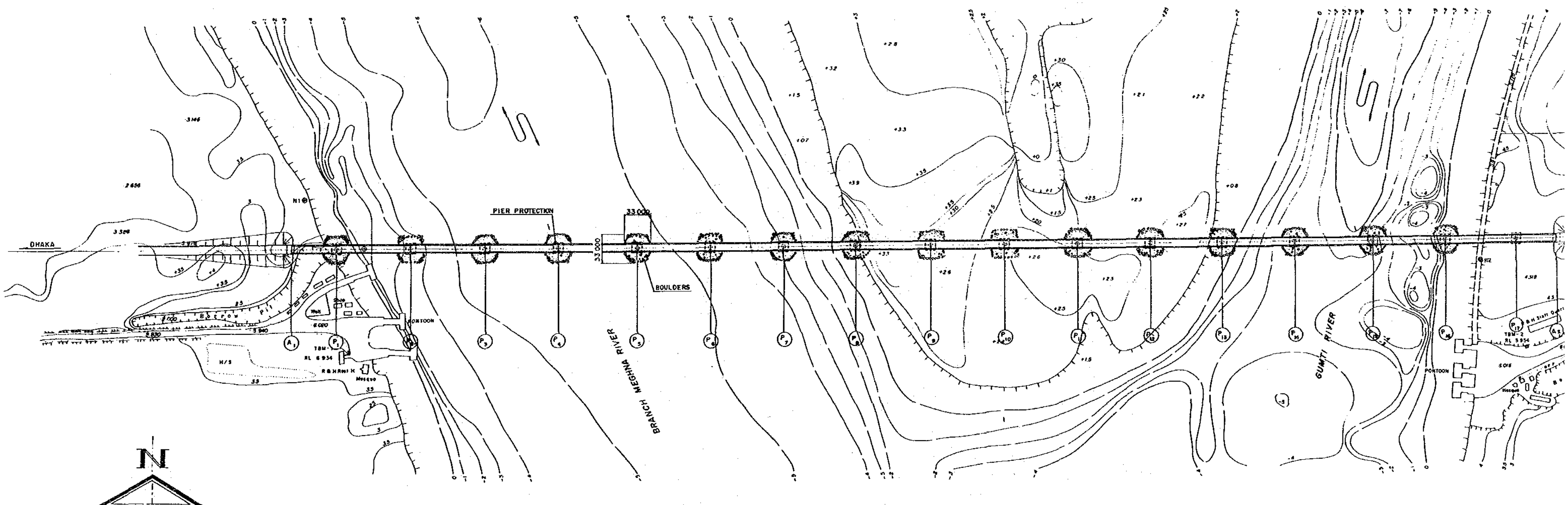
CROSS SECTION
SCALE 1 : 400



NAVIGATION CLEARANCE
SCALE 1 : 2,000



PROFILE
SCALE 1 : 4,000



NOTE

PLAN
SCALE 1 : 4,000

AP.FIG. 7-6

GENERAL VIEW
ALTERNATIVE: CASE- B