PEOPLE'S REPUBLIC OF BANGLADESH

JAMUNA RIVER BRIDGE CONSTRUCTION PROJECT

FEASIBILITY STUDY REPORT

VOLUME V

ROAD LINKS

AUGUST 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

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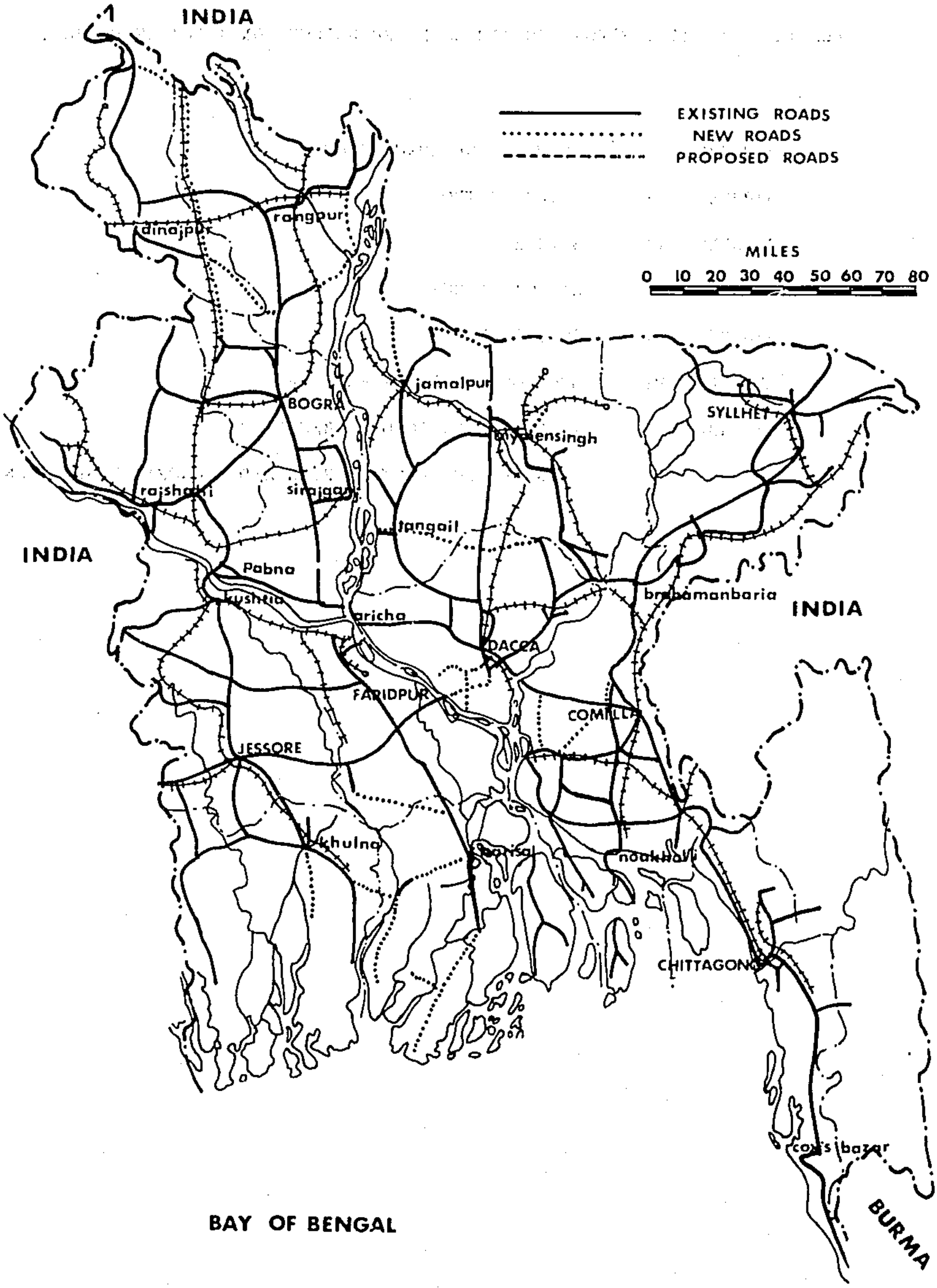
ROAD MAP OF BANGLADESH

ROAD NETWORK



ABBREVIATIONS, DEFINITIONS AND UNITS

Bangladesh	The People's Republic of Bangladesh.
MOC	Ministry of Communications.
IWTA	Inland Water Transport Authority.
BWDB	Bangladesh Water Development Board.
R & H	Roads and Highways Directorate of the Ministry of Communications.
WAPDA	Water and Power Development Authority.
JICA	Japan International Cooperation Agency, Government of Japan.
OTCA	Former name of JICA.
Jamuna River	The Brahmaputra-Jamuna River.
Jamuna Bridge Project	Jamuna River Bridge Construction Project.
Jamuna Bridge	Tentative name of the bridge in the present project.
Preliminary Study Report	Preliminary Report on the Jamuna River Bridge Construction Project prepared by the Preliminary Study Team of OTCA, Mar., 1973 (Written in Japanese).
Inception Report	Inception Report on Feasibility Study of Jamuna River Bridge Construction Project submitted by OTCA.
Interim Report	Interim Report on Feasibility Study of Jamuna River Bridge Construction Project submitted by JICA.
Feasibility Report Volume I	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume I Summary and Conclusions.
Feasibility Report Volume II	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume II River Control.

Feasibility Report Volume III	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume III Bridge.
Feasibility Report Volume IV	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume IV Railway Links.
Feasibility Report Volume V	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume V Road Links.
Feasibility Report Volume VI	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume VI Geology and Stone.
Feasibility Report Volume VII	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume VII Traffic and Economic Benefits.
Feasibility Report Volume VIII	Feasibility Study Report on Jamuna River Bridge Construction Project, Volume VIII Overall Construction Plan and Economic Analysis.
Project	Main Works and Construction works, including railways and road links.
Main works	Jamuna Bridge construction works comprising Jamuna Bridge, approaches and treatment of the Dhaleswari River.
Approach	Railway and/or road between an abutment of the bridge and a point at which it descends to the normal formation.
railway links	Railway between an end of the approach and a connection point on the existing railway.
road links	Road between the end of an approach and a connecting point on the existing road.
Guide bank	Dike built to guide the river flow.

Cross dike	Dike built crosswise in the river to check the river flow
Causeway	Raised path built over wet ground and/or river
DHWL	Design high water level
DHFL	Design high flood level
HWL	High water level
PWD	Public Works Department Datum
GTS	Great Trigonometrical Survey
PH	Proposed height
H	Water depth
v	Velocity
JIS	Japanese Industrial Standard
ASTM	American Society for Testing Materials
BS	British Standard
c	Cohesion of soil
ϕ	Internal friction angle of soil
C	Clay
M	Silt in case of soil classification
S	Sand
γt	Wet density
γd	Dry density
m	meter
s,sec	second
cm	centimeter
mm	millimeter
km	kilometer
g. gr.	gram

kg	kilogram
lb	pound
t, ton	ton (metric)
f, ft, (')	foot
m^3/s	cubic meter per second
cfs	cubic foot per second
gal	gallon
F	Fine in case of grain size
M	Medium
in, (")	inch
yd	yard
mi	mile
ac	acre
hr	hour
mon	month
yr	year
sq	square
cu	cubic
max.	maximum
min.	minimum

TO CONVERT	TO	Multiply by	
inches (in.)	millimeters (mm)		25.40
inches (in.)	centimeters (cm)		2.540
inches (in.)	meters (m)		0.0254
feet (ft)	meters (m)		0.3048
miles (ml)	kilometers (km)		1.609
yards (yd)	meters (m)		0.91
square inches (squ.in)	square centimeters (cm^2)		6.45
square feet (sq ft)	square meters (m^2)		0.093
square yards (sq yd)	square meters (m^2)		0.836
acres (ac)	square meters (m^2)		4047.
square miles (sq ml)	square kilometers (km^2)		2.59
cubic inches (cu in)	cubic centimeters (cm^3)		16.4
cubic feet (cu ft.)	cubic meters (m^3)		0.0283
cubic yards (cu yd)	cubic meters (m^3)		0.765
pounds (lb)	kilograms (kg)		0.453
tons (ton)	kilograms (kg)		907.2
one pound force (lbf)	newtons (N)		4.45
one kilogram force (kgf)	newtons (N)		9.81
pounds per square foot (pst)	newtons per square meter (N/m^2)		47.9
pounds per square inch (psi)	kilonewtons per square meter (KG/m^2)		6.9
gallons (gal)	cubic meters (m^3)		0.0038
gallons (gal)	liter (c/m^3)		3.8
acre-feet (ac-fe)	cubic - meters (m^3)		1233.
gallons per minuts (spg)	cubic meter/minute (m^3/min)		0.0038
gallons per second (gps)	cubic meter/second		0.00063
TAKA (TK)	YEN (Used in the preliminary design)		36
US$	TAKA		13
TAKA (TK)	YEN		13

C O N T E N T S

FIGURES

TABLES

CHAPTER I

INTRODUCTION

1. Objective of the Study.

At the request of the Government of the People's Republic of Bangladesh, the Government of Japan decided to conduct a feasibility study for the construction of a bridge over the Brahmaputra-Jamuna River as its international economic assistance contribution.

The objective of the present study is the planning of road links between all-weather roads on both sides of the Jamuna River and the proposed sites for bridge construction, from upstream to downstream on the Jamuna River, the Bahadurabad site, the Gabargaon site, the Sirajganj site and the Nagarbari site, from the viewpoint of road engineering.

First, in Phase I study, designs and initial costs estimation were carried out for the road links at every four proposed sites to connect the Jamuna Bridge with the existing all-weather roads including the Tangail - Bhuapur - Gopalgonj Road and the Sirajganj - Hatikumrul Road, on both sides of the Jamuna.

Second, next to the selection of the most suitable site for bridge construction, in Phase II designs and estimates of construction and maintenance costs for a two-lane undivided highway at the Sirajganj site have been made.

This report gives the results of the study made by the Road Link Study Team during the period from January 1974 to March 1976 in accordance with the Inception Report which was submitted by the Japan International Cooperation Agency to the government of the People's Republic of Bangladesh in August 1973.

2. Progress of the Study.

When the Preliminary Study Team for the Jamuna River Bridge Construction Project was dispatched in December 1972 by the Overseas Technical Cooperation Agency, one of the Japanese governmental executing agencies, the Government of Japan proposed four candidate sites for Jamuna Bridge construction from upstream to downstream; namely, downstream from Bahadurabad, near Gabargaon, about 10 km downstream of Sirajganj and about 20 km upstream from Aricha. For the purposes of reconnoitering the existing road on both sides of the Jamuna River and collecting data necessary to the study of the above-mentioned four sites, H. Nishikawa and K. Ohashi, road engineers, were sent to Bangladesh from January 18, 1974 to February 22, 1974.

During the stage of compiling the Interim draft report, a meeting was held in Tokyo from August 31, 1974 to September 13, 1974 in order to discuss the selection of the most suitable site for bridge crossing and some problems in each field of the study team. The further discussion meeting was held in Dacca from October 28, 1974 to November 6, 1974. In that meeting, the Sirajganj site was chosen as the most suitable for the Jamuna bridge construction.

During the stay of the Japanese delegation in Dacca from November 29, 1974 to December 14, 1974 the Interim Report was submitted to the Ministry of Communications and the location of bridge axis in the Sirajganj site was determined on the basis of aerial photographs newly taken by the Japanese Survey Team in November 1974.

Soil investigation and the main river cross section survey on the road link at the Sirajganj site were also carried out by the Japanese Survey Team in the 1974/1975 dry season.

Based upon the survey results and additional flood data in 1974, the road link study plan has been completed.

3. Members of the Road Links Study Team.

The study was undertaken by Mitsui Consultants Company, Ltd. Tokyo key members who were engaged in the study were:

Kunimura Nagashima	Team Leader
Harumi Nishikawa	Road Engineer
Kunio Ohashi	Road Engineer

4. Acknowledgement.

The Study Team wishes to extend its great appreciation for the cooperation offered by the authorities of the Government of the People's Republic of Bangladesh, especially its wholehearted gratitude to the members of the counterpart team; and the Study Team wishes to express its gratitude to the Embassy of Japan in Dacca for their kind cooperation and encouragement.

CHAPTER II

THE AREA FOR ROAD LINK PLANNING

1. General.

1.1. Topography.

Generally speaking the ground slopes towards the south, and most of the land of the project area lies between the 20 ft. and 60 ft. contourlines above the Survey of Bangladesh level. All of the land elevations described in this report are in terms of the Great Trigonometrical Survey (G.T.S.) data of the Survey of Bangladesh. To put G.T.S. data in terms of PWD data, 1.509 feet (0.46 m) is to be added. The land in the Western part of the Jamuna is generally higher than the eastern part of the project area.

The land level map is shown in Fig. 2-1.

1.2. Geology.

The project area is entirely a part of the Bengal Basin which is filled with alluvium gradually deposited by the Jamuna and its numerous tributaries in the quarternary geological age. The alluvial deposits typically range from silt and clay to sand. All alluvial deposits in the Basin comprise Pleistocene and recent sediments. The Jamuna sediments are characterised by a higher percentage of fine materials and a typically red-brown colour. The project area consists of the flood plains of the Jamuna, its numerous tributaries and distributaries.

The geological map is shown in Fig. 2-2.

1.3. Climate.

Climatically, the country has two distinct seasons, a dry season from October to May and a wet season from June to September. Over 80% of the annual rainfall occurs during the wet monsoon or rainy season when flood invariably occurs as well. The normal annual rainfall varies from approximately 70 in. to 80 in. in the project area. In addition the project area is the flooded area of the Jamuna. The recent maximum flood occured in the year 1974, which reportedly corresponds to 50 year flood.

1.4. Population.

The population of Bangladesh, now estimated at 76 million, is growing at an annual rate of over 3%. This adds more than 2 million people each year to a land whose population density is already one of the highest in the world. The population map which was made by the U.N. is shown in Fig. 2-3.

Fig. 2 – 1 LAND LEVELS MAP

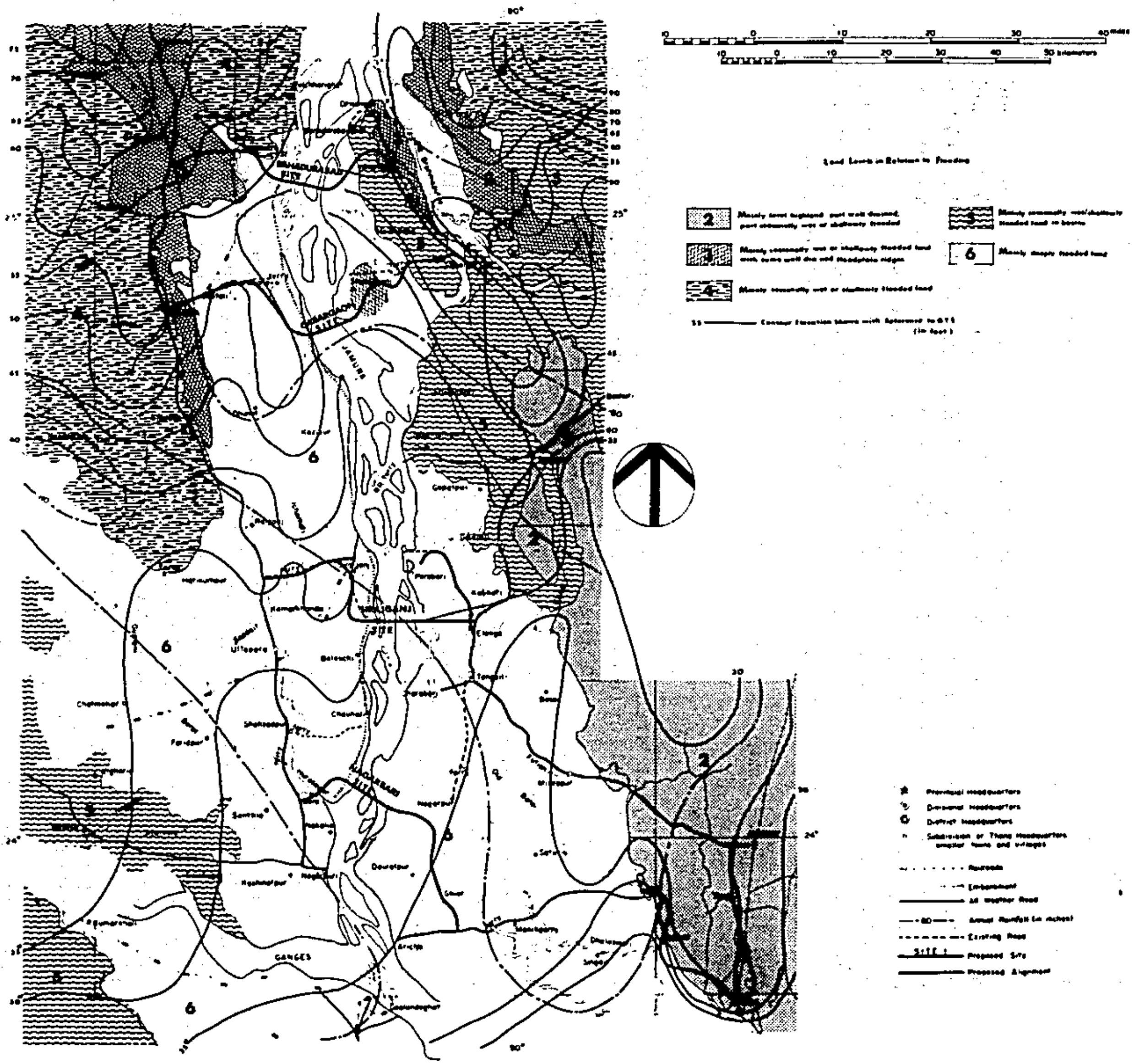
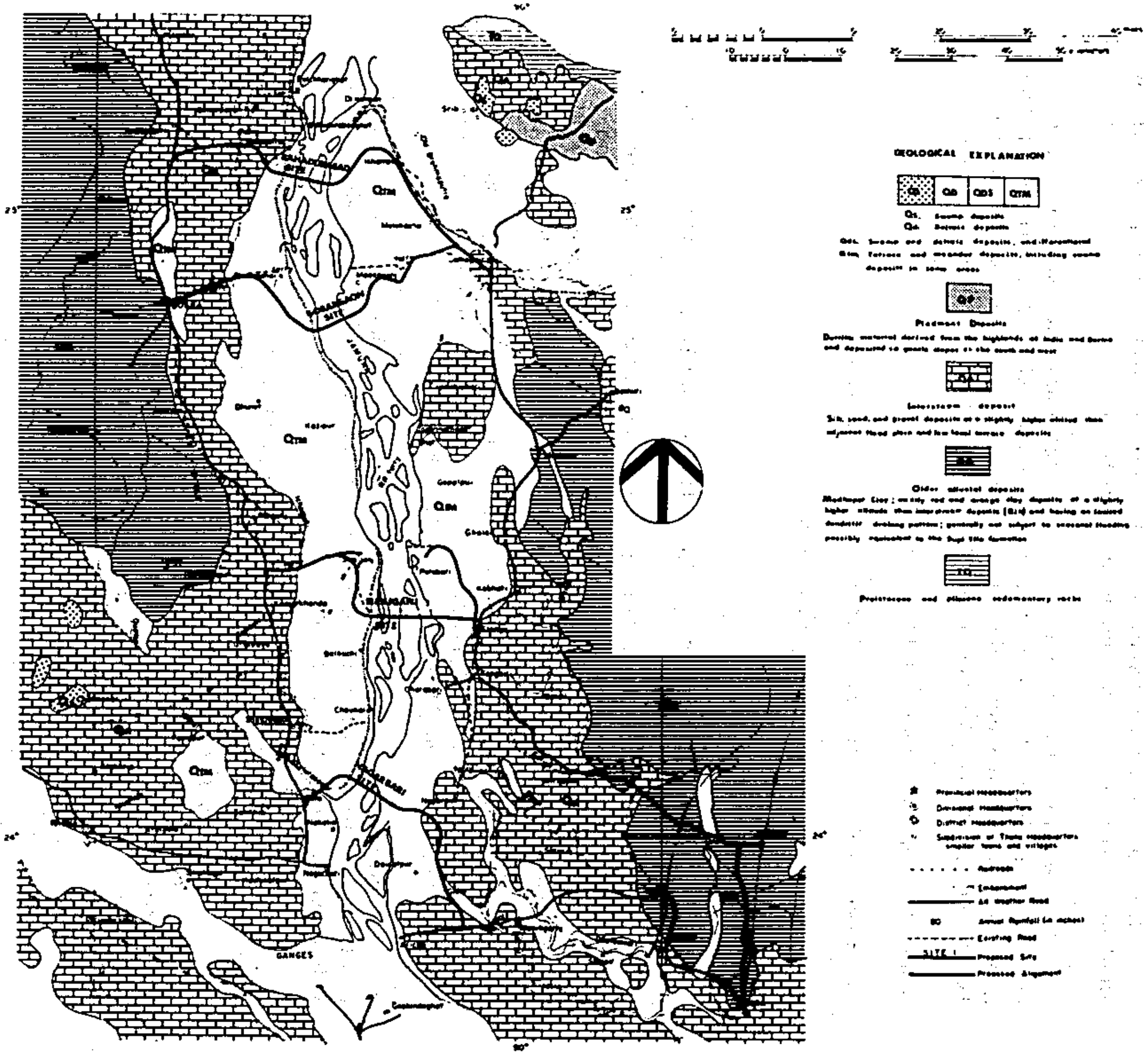


Fig. 2 - 2 GOLOGICAL MAP



1.5. Land Use.

Land use in Bangladesh is generally intensive, involving rotation of two or more crops per year on the same piece of land. It is also well adjusted to the environmetal conditions, especially to land levels in relation to the flooding.

Various kinds of paddy may be grown on different parts of the land depending on flood depth and duration.

The economy is dominated by the agricultural sector which contributes, directly and indirectly, more than two-thirds of the gross domestic product, absorbs the bulk of the employed labour force and provides the only source of foreign exchange earnings.

Land use map is shown in Fig. 2-4.

2. Inventory of Existing Roads and Facilities.

Road map is shown in Fig. 2-5.

2.1. All weather road.

2.1.1. DACCA-ARICH SECTION (ASIAN HIGHWAY ROUTE A-1, ROUTE A-2).

Asian Highway Routes A-1 and A-2 constitute this Section. Works are under way for improving and widening it to a 2-lane pavement over 90 kilometers long. It runs mostly over paddy fields except for a hilly portion on the Dacca side of Nayarhat.

Three R & H ferries have operated within this Section at the Buriganga, Bangsh and Kaliganga rivers but at each of these sites bridge construction is in progress under U.S. AID.

At Mirpur the road crosses the Buriganga by a 1-lane truss bridge but this bridge is used only by light vehicles, while heavy vehicles use the R & H ferry.

2.1.2. NAGARBARI - SHAZADPUR - ULLAPARA SECTION.

This is a section of about 50 kilometers, the portion of Asian Highway Route A-2 (395 kilometer from Tetsuria on the Indian border to Nagarbari). This is a 1-lane paved road. This area is in the vicinity of the confluence of the Ganges and the Jamuna and the road runs on an embankment of several meters high.

One R & H ferry operates at the Bangari within this Section.

2.1.3. ULLAPARA - BOGRA - GOBINDGANJ SECTION.

This Section of about 100 kilometers is also a portion of Asian Highway Route A-2 and has a 1-lane pavement for most of its length. Around Bogra, however, it has a paved width of about 2-lanes. From Ullapara to Sherpur the high embankment continues but from there the road runs over rolling terrain.

Fig. 2 - 3 POPULATION MAP

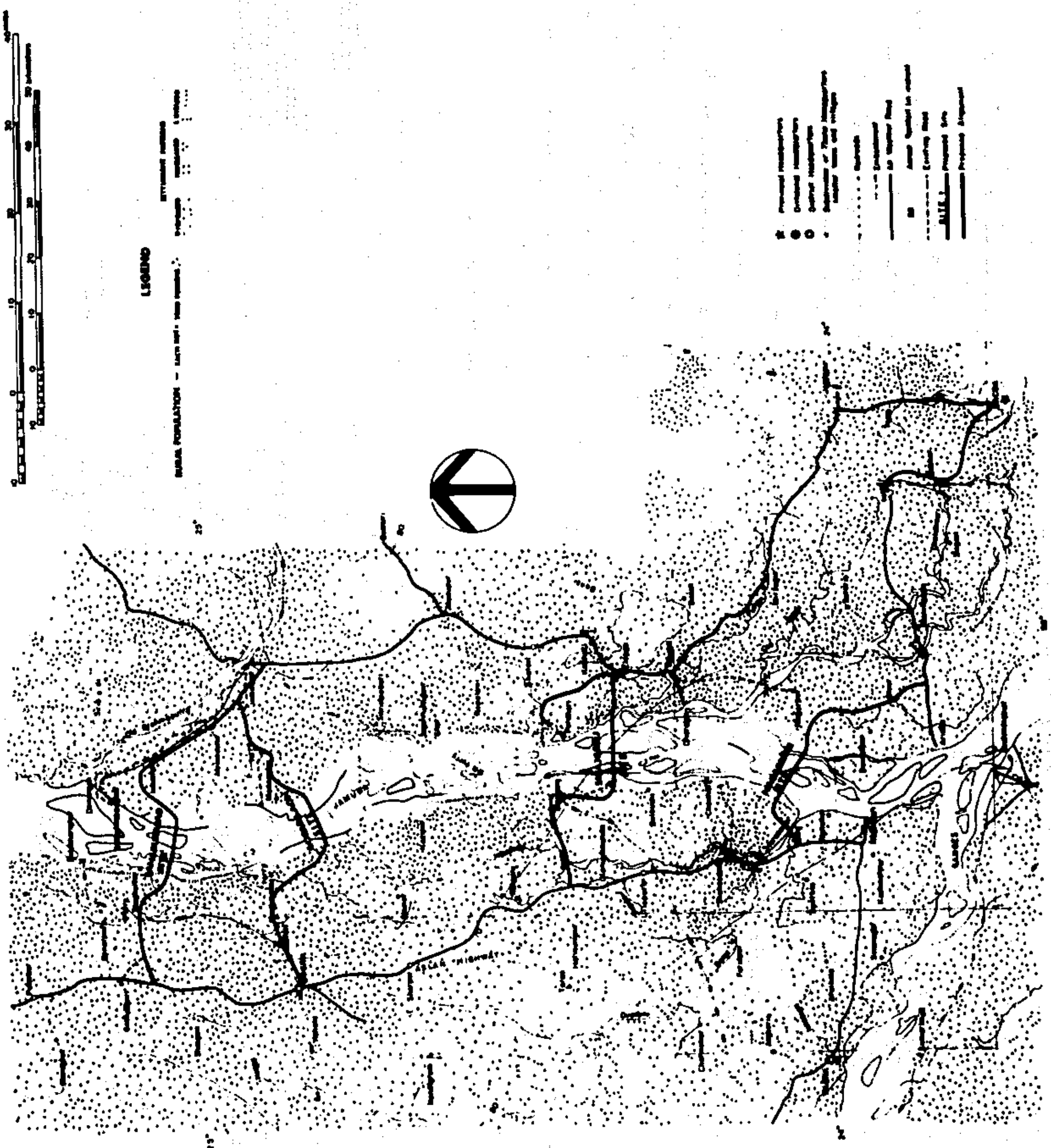


Fig. 2 – 4 LAND USE MAP

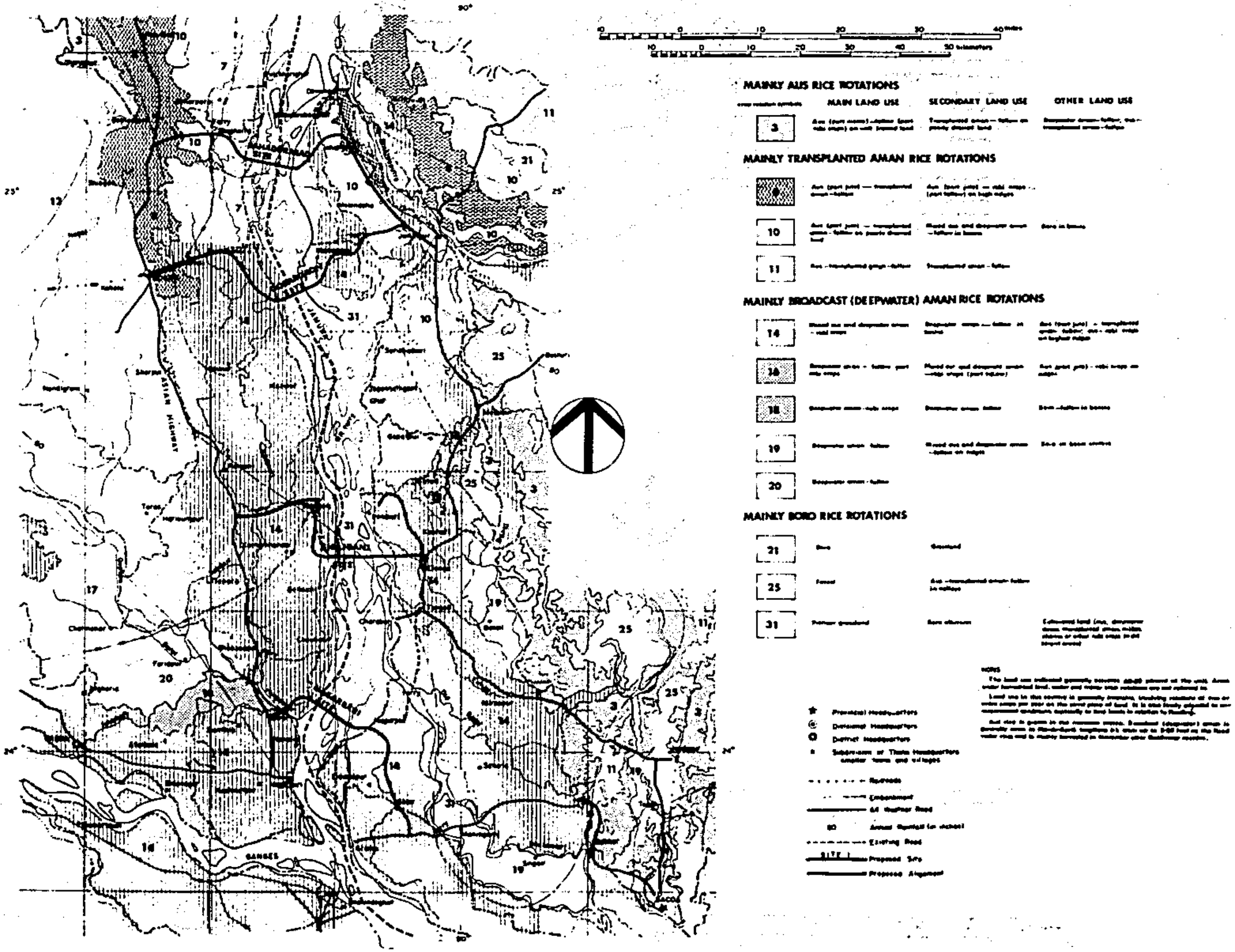
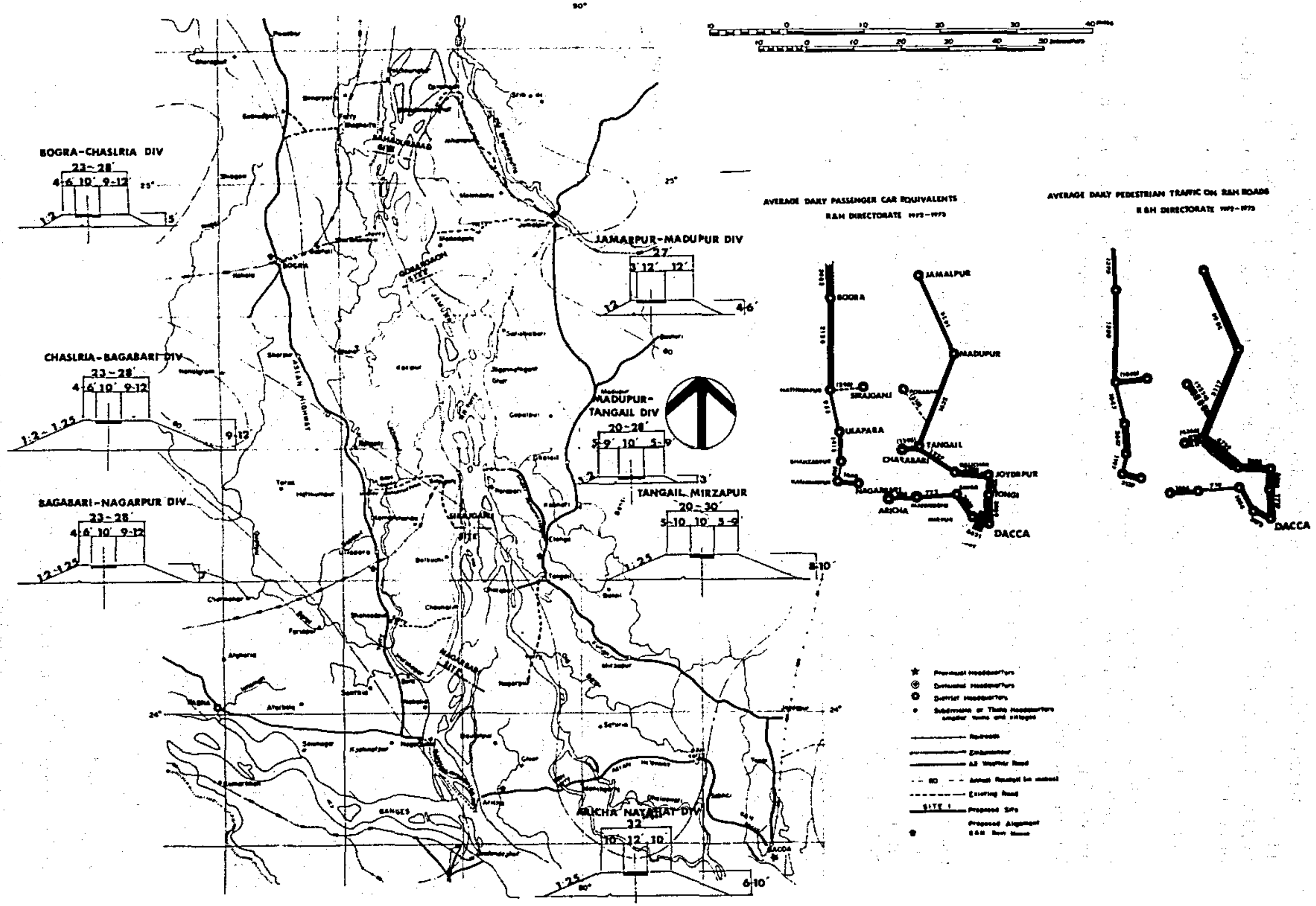


Fig. 2-5 ROAD MAP



Within this Section the bridges damaged during the War of liberation were particularly noticeable. Those bridges have been replaced by Bailey Bridges but they are still deemed to be the bottleneck to traffic.

2.1.4. HAYARHAT - KALIAKUR BYPASS.

This road, which was constructed in 1972, runs over rolling terrain for the most part with fair horizontal alignment. It has one paved lane but at the portion around the structures it actually has a 2-lane paved width.

2.1.5. DACCA - JOYDEBPUR SECTION.

This road runs about 30 kilometers from Dacca to Joydebpur. It has a 4-lane divided highway section for about 6 kilometers from the point of intersection with the railway near Dacca Airport to where it again intersects with the railway near the New Kurmitola Dacca Airport. This Section is topographically hilly.

From Tongi the roadway becomes a undivided 2-lane road up to Joydebpur.

Most of this Section is on a low embankment.

2.1.6. JOYDEBPUR - TANGAIL SECTION.

The Joydebpur - Tangail section is a 1-lane paved road of about 60 kilometers in length.

From Joydebpur to Mirzapur the road runs over rolling terrain for about 25 kilometers and from Mirzapur to Tangail the embankment section continues for about 35 kilometers. Conspicuous within this embankment section are the bridges damaged during the War of liberation and a sharply curved portion with poor horizontal and vertical alignment between Kaliakur and Karatia.

2.1.7. TANGAIL - JAMALPUR SECTION.

This section, from Tangail to Jamalpur via Madhupur, of about 85 kilometers in length, with poor horizontal alignment that does not permit comfortable driving or safe overtaking. There is hilly terrain around Tangail but the rest of the road passes paddy fields for the most part. The broad shoulder on the left toward Jamalpur, made wider than the other side for use by ox-carts, is a characteristic of this 1-lane paved road.

2.2. Road approaching to the Jamuna.

Inventory table is shown in Table 2-1.

2.2.1. Left side.

L-1) JAMALPUR - BAHADURABAD SECTION

The existing road from Jamalpur to Bahadurabad the railway ghat, is about 40 kilometes in length.

This road runs keeping almost parallel to the Jamalpur - Bahadurabad Railway and the Brahmaputra, also called Old Jamuna. There are four railway stations between Jamalpur and Bahadurabad and the road is paved with brick near the stations, but most of the rest is kacha road.

The driving time by jeep for this section is three and a half hours.

L-2) JAMALPUR - GABARGAON SECTION

This existing approach road is about 30 kilometers in length and it runs almost straight westward from Jamalpur to Gabargaon.

During the rainy season two private ferries have been operating on this section. They are merely contrivances consisting of two barges bound together with bamboo platforms laid between and which can hardly carry a jeep. During the survey of this section the jeep was trapped in an ox-cart but from which it was freed with much difficulty with the help of its winch.

The driving time by jeep for this section is three hours.

L-3) ELENGA - GOPALGONJ SECTION (T.B.G. Road)

The approximately 25 kilometers of this road, from Elenga to the left bank of the Jamuna via Bhuapur, is now under reconstruction. The initial section of 19 kilometers from Elenga to Bhuapur consists of improvement and widening of the existing road and the section of 6 kilometers from Bhuapur to the left bank of the Jamuna is new road construction. It will be opened in 1977.

a) The Aricha - Nagarbari Road Ferry Ghat is the only existing highway link between Dacca and northern districts of the country. Nevertheless the present overcrowded ferry can no longer function as an effective link between Dadca and northern districts. A new road ferry ghat which would be able to navigate to the north of Aricha during the dry season is therefore required.

b) On the right side there is a road under reconstruction between Hatikumrul on the Asian Highway and Sirajganj where there is a passenger ferry ghat at present. On the left side also there is a road under reconstruction between Elenga, about 8 kilometers to the north of Tangail on Tangail - Mymensingh Road, and Bhuapur. Not much new road construction is therefore needed for either route. Between Gopalgonj and Sirajganj the ferry can operate even during the dry season.

   Under the above circumstances and in compliance with requirements, the T.B.G. Road, Sirajganj - Hatikumrul Route was planned as a road link between Dacca and northern districts. The Gopalgonj Road Ferry Ghat was planned at first for use during the rainy and dry seasons but the plan was later changed on 27th January in 1974 to make it available for the dry season only.

Table. 2-1 INVENTORY OF ROAD FACILITIES

EXISTING APPROACH ROADS

ROUTE & SECTION	DISTANCE	ALL-WEATHER ROAD		FAIR WEATHER	NO	STRUCTURE		FERRY	FORD	LINIOR-METER-OF-SPILLWAY
		1 LANE PAVEMENT	GRAVEL SURFACED	JEEPABLE	ACCESS	BOX-CUL	SPILLWAY BRIDGE	CLOSSING		OPENING-PER-KILOMETER
BAHADURABAD SITE										
JAMALPUR — BAHADURABAD	42.0^{km}				42.0^{km}	6	9		1	$89^m / 42.0^{km} = 0.002$
GOBINDGANJ — BAHADURABAD SITE	20.0^{km}	16.5^{km}			3.5^{km}	3	7	PRIVATE 1		$92^m / 16.5^{km} = 0.006$
GABARGAON SITE										
JAMALPUR — GABARGAON	32.5^{km}				32.5^{km}	4	2	PRIVATE 2		$22.5^m / 32.5^{km} = 0.001$
BOGRA — GABARGAON SITE.	20.5^{km}	BRICK 9.2^{km}			11.3^{km}		17	PRIVATE 1	1	$313^m / 20.5^{km} = 0.015$
SERAJGANJ SITE										
ELENGA — GOPALGONJ	26.0^{km}			UNDER CONST 19.0^{km}	7.0^{km}	5	12		2	$358^m / 19.0^{km} = 0.019$ INCLUDING TWO FORDS
TANGAIL — CHARABARI	6.0^{km}	1.6^{km}		UNDER CONST 4.4^{km}			5			$75^m / 6.0^{km} = 0.013$
HATIKAMPUL — SIRAJGANJ	17.0^{km}			UNDER CONST 17.0^{km}		6	4	R&H 1	4	$92^m / 17.0^{km} = 0.005$
SIRAJGANJ — SIRAJGANJ	13.8^{km}	9.0^{km}	2.8^{km}		RIGHT EMB'T 2.0^{km}				1	$24^m / 11.8^{km} = 0.002$
NAGARBARI SITE										
TANGAIL — NAGARPUR (NAGARBARI SITE)	19.5^{km}	BRICK 5.8^{km}		13.7^{km}				PRIVATE 1		$264^m / 19.5^{km} = 0.013$
ULAPARA — NAGARBARI SITE	21.0^{km}			16.0^{km}	RIGHT EMB'T 5.0^{km}	2	7	PRIVATE 1	8	$111^m / 16.0^{km} = 0.007$

L-4) TANGAIL - CHARABARI SECTION

This section is about 4.5 kilometers from Tangail to Charabari where there is a rainy season ferry ghat at present. On January 27, 1974 R & H changed the road ferry ghat for the rainy season, which was first planned for Gopalgonj, to Charabari.

Works on this section are under way by R & H for improvement and widening.

L-5) TANGAIL - NAGARPUR SECTION

The existing road from Tangail to Nagarpur is about 20 kilometers long. Two private ferries operate in this Section.

The road is 1-lane and paved with brick for about 6 kilometers from Tangail to the first ferry site but most of the rest of the section is kacha road. This initial section now has heavier ox-cart traffic and horse-cart traffic than other approach roads on the left side. The first ferry site from Tangail is in shallow water that a jeep could drive through.

The second ferry site is located on the Dhaleswari river, about 1 kilometer wide, with a steep right bank and a sand beach on the left bank. Its width in the dry season is reduced to about 100 meters. The section from Nagarpur to the left bank of the Jamuna was not passable by jeep due to the erosion of the road.

The driving time between Tangail and Nagarpur is three hours.

2.2.2. Right side.

R-1) GOBINDGANJ - BAHADURABAD SITE

This existing road is about 30 kilometers long, from Gobindganj, about 30 kilometers to the north of Bogra, to Shaghatta, of which the last section of 10 kilometers was not passable by jeep due to erosion of the existing road. For about 17 kilometers from Gobindganj to Gapalpur, where there is a sugar mill, the road is 1-lane and paved with concrete but many cracks are observed.

In the last section from Capalpur to the Right Flood Embankment are destroyed by flood.

R-2) BOGRA - SHARIAKANDI SECTION

From Bogra to the private ferry site of Shariakandi, about 20 kilometers, the road passes over comparatively rolling terrain. For 9 kilometers from Bogra to Gabtali, the road is 1-lane, paved with bricks and runs parallel to the railway. At present a light public bus is servicing between Bogra and Gabtali. From Gabtali to Shariakandi, 10 kilometers, the route is a kacha road.

The driving time by jeep from Bogra to Shariakandi is one and a half hours.

R-3)

a) HATIKUMRUL - SIRAJGANJ TOWN SECTION

About 17 kilometers of road from Hatikumrul on the Asian Highway to Sirajganj is now under construction. At present the R & H ferry and a private ferry operate at a point of 5 kilometers from Hatikumrul.

The driving time by jeep from Hatikumrul to Sirajganj Town is one and a half hours.

b) SIRAJGANJ TOWN - SIRAJGANJ SITE SECTION

This section extends from Sirajganj town straight southward for about 12 kilometers to the Right Embankment. For about 9 kilometers from Sirajganj the road is 1-lane, paved with concrete. Thenceforth kacha road extends for 3 kilometers to the Right Embankment of the Jamuna. On the latter route there was the Hurasagar river with 100 m dried river bed.

The driving time by jeep from Shirajganj town to the Right Embankment is 45 minutes.

R-4) SHAHADPUR - NAGARBARI SITE

From Shahadpur to the Right Embankment of the Jamuna the length of the road is 14 kilometers long and from the Right Flood Embankment to the right bank of the Jamuna the length is 16 kilometers. Both are kacha roads totalling 16 kilometers in length.

The shortest route mentioned on the topographic map of 1:50,000 scale, from Shahadpur to the Right Embankment, has a private ferry only on the Karatoya river but none on the other tributaries. It is considered possible to drive from Sirajganj to the Nagarbari site by way of the Right Flood Embankment crest, which has a width of about 5 m.

The driving time by jeep from Shahadpur to Nagarbari site is two and a half hours.

CHAPTER III

PRELIMINARY DESIGN

1. Geometric Design Standard.

For geometric design standards in Phase I, the "Geometric Design Standards of Rural Road in Bangladesh" shown in Appendix B were adopted as they were.

With regard to road width a total road width of 40 feet for primary road stipulated in the above standards were adopted with due considerations given to the result of the future traffic forecast in Phase I.

Table 3-1 shows the geometric design standards.

Table 3-1 GEOMETRIC DESIGN STANDARDS

		2-LINE TWO-WAY HIGHWAY	
ROADBED		12.200 m	(40'-0")
LANE		3.355 m	(11'-0")
SHOULDER		2.440 m	(8'-0")
EARTHBERM		0.305 m	(1'-0")
DESIGN SPEEDS	RURAL	96.5 km	(60 mph)
	URBAN	80.5 km	(50 mph)
RUNNING SPEEDS	RURAL	72.5 km	(45 mph)
	URBAN	64.5 km	(40 mph)
RADIUS OF CURVATURE	60 mph	350 m	(1,146')
	50 mph	230 m	(754')
GRADES		3.0% MAX	
PASSING SIGHT DISTANCE	60 mph	610 m	(2,000')
	50 mph	520 m	(1,700')
STOPPING SIGHT DISTANCE	60 mph	145 m	(475')
	50 mph	107 m	(350')
SUPERELEVATION		8.0% MAX	

2. Design Elements.

2.1. Major bridge and necessary openings.

Topographic surveys and inland waterway investigations were not carried out in the Phase I study. Therefore, the study team divided the structure design into two types, one for the bridge longer than 100 m and the other for the spillway and the bridge shorter than 100 m because of the accuracy of the 1:50,000 Photo-mosaic and Topographic map.

The study team made preparations for the site selection for the major bridges, which are longer than 100 m, according to the study data collected at sites and 1:50,000 photo-mosaic. In relation to spillways and a bridge openings shorter than 100m, the study team adopted the value of 4% of openings shorter than 100 m, the study team adopted the value of 4% of opening ratio "linear-meter-of-spillway-and-bridge-shorter-than-100 m-opening-per-kilometer" of the structure to total road length, is taken from the data of Aricha-Kaliganga Road inventory, which is the only all-weather road in Bangladesh at right angles to the Jamuna. The calculated figure is shown in Table 3-2.

Table 3-2 SPILLWAY & BRIDGE OPENINGS
KALIGANGA RIVER - ARICHA ROAD

DISTANCE	EXISTING & PROPOSED STRUCTURE LENGTH		
	SPILLWAY & BRIDGE L 100 m		
0 - 1.6 km	FERRY CROSSING		666.0 m UNDER CONSTRUCTION KALIGANGA BRIDGE
"	18.3 m	TEE - BM	
1.6 - 3.2 km	24.4 m	2 SPAN TEE - BM	
3.2 - 4.8 km	36.6 m	3 SPAN TEE - BM	
"	24.4 m	MULTI-SPAN BOX CUL	
"	90.0 m		PROPOSED SINGLE UNIT "OVERLAND FLOW"
4.8 - 6.4 km	24.4 m	2 SPAN TEE - BM	
"	30.5 m	MULTI-SPAN BOX CUL	
6.4 - 8.0 km	18.3 m	TEE - BM	
8.0 - 9.6 km	50.0 m	3" SPAN TEE-BM	PROPOSED SINGLE UNIT "OVERLAND FLOW"
"	90.0 m		
9.6 - 11.2 km	18.3 m	TEE - BM	
"	36.6 m	MULTI-SPAN BOX CUL	
11.2 - 12.8 km	50.0 m	3 SPAN TEE - BM	
12.8 - 14.4 km	18.3 m	TEE - BM	
14.4 - 16.0 km	50.0 m	3 SPAN TEE - BM	
16.0 - 17.6 km	42.7 m	MULTI-SPAN BOX CUL	
"	18.3 m	TEE-BM	
17.6 - 19.2 km	30.0 m	MULTI-SPAN BOX CUL	
"	50.0 m	3 SPAN TEE - B	
"	24.3 m	MULTI-SPAN BOX OIL	
TOTAL	745.4 m		

$$\frac{745.4 \text{ m}}{19.2 \text{ km}} = 0.039 \approx 4\%$$

2.2. Embankment.

It is recommended that the whole alignment will be built with a minimum free-board of three feet above the design high flood level. This is considered necessary because the maximum benefits to be derived from the road can be realized if it is passable throughout the year. In other words, three feet free-board has been provided to keep the moisture content of the subgrade within an allowable level by preventing saturation during the flood season, and spillway openings have been provided to preventing the rapid deterioration of the pavement and embankment.

Soil investigation were not carried out for Phase I study. On the other hand, a 1:2 embankment side slope is standard for roads in Bangladesh. For the purpose of the cost estimate, therefore, a 1:2 embankment side slope was adopted for all proposed roads.

Turfing will be required to maintain the normal height embankment side slope without sloughing. Enchased brick rivetment in the high approaches of bridge and spillway will be required to keep the embankment side slope from sloughing and to prevent erosion at the bridge abutments.

A soil in Bangladesh vary from sandy clay to silty clay. They are usually not suitable materials for embankment and have low stabilization quality. Road embankment and bridge approaches will be constructed by spreading and compacting the borrowed earth from the road sides. The ground surface of all embankment borrowpits and embankment foundations should, therefore, be stripped to remove organic materials. However, where a bad soil is encounters with the top layer of subgrade of 2 feet thick, this is to be adequately mixed with sand and duly compacted. Earth moving and compacting equipment will be used in conjunction with handbasket labor to distribute the embankment materials and ensure a uniform embankment section. The moisture content control will be achieved by use of compaction equipment.

For the purpose of cost estimates, embankment earth work quantities are to be increased by 10% to allow for settling.

2.3. Pavement.

From practical experience in this country, a flexible pavement is considered the best to ensure against any possible settling of the embankment.

From practical experience in this country, it has been observed that a 3 inch layer of brick flat soling under a 9 inch crushed brick water bound macadam, with a 2 inch bituminous macadam or concrete surface, for a total thickness of 14 inches, is suitable for this kind of Project Area. The sub-base is provided for the distribution of the load on the subgrade and it also aids in drainage. The road links study team adopted the value of 6 inches for the sub-base, being the minimum value for drainage.

2.4. Navigation clearance.

The classified waterway clearance is determined by local requirement and need. BIWTA set the clearance classification, but the waterways which the proposed alignment would cross have not been officially classified.

For the purpose of cost estimates, the study team determined the navigation clearance classification, for waterways that were not classified, from the NEDECO report and BIWTA's clearance classification method.

The determined clearance classification is shown in Table 3-3.

Table 3-3 CLEARANCE CLASSIFICATION

WATERWAY TRAFFIC DESCRIPTION	CLASS	VERTICAL CLEARANCE ON H.F.L.	RECOMMENDED CLASSIFICATION
LARGEST VESSELS - RIVER STEAMERS 6 feet DRAUGHT - GROUP	A	40 feet	
LARGEST VESSELS - CARGO BARGES & CARGO SAIL BOATS 4.5 feet DRAUGHT - GROUP	B	25 feet	HURASAGAR RIVER
LARGEST VESSELS - COUNTRY BOATS 3 feet DRAUGHT - GROUP	C	12 feet	BANGALI RIVER KARATOYA RIVER CJATA: RIVER
	OTHER	6 feet	OTHER MINOR CHANNELS

3. Route Location.

3.1. Horizontal location.

3.1.1. Primary elements of horizontal alignment.

(1) The definition of Road Links proposed by the study team are the linking all-weather roads to the proposed Jamuna Bridge sites from existing all-weather roads, including the Tangail-Bhuapur-Gopalgonj and Sirajganj-Htaikumrul roads, on the both sides of the Jamuna.

All-weather Road on Left Side	Proposed Bridge site	All-weather Road on Right Side
Jamapul Madhupur Road	Bahadurabad Site	Nagarbari-Saidpur Road (Asian Highway A-2)
Jamapul-Madhupur Road	Gabangaon Site	Nagarbari-Saidpur Road
Tangail-Bhuapur-Gopalgonj Road & Tangail-Madhupur Road	Sirajganj Site	Sirajganj-Hatikumrul Road
Dacca-Aricha Road (Asian Highway A-1, A-2)	Nagarbari Site	Nagarbari-Saidpur Road

(2) Taking into account the results of the field survey and regional speciality of Bangladesh, the study team planned the horizontal alignment, giving priority to the (1) reconstruction of existing roads (2) stable river crossings (3) shortest distance. The proposed alignment passes through principal villages because of the above.

Besides, there are many marshes in the project area. Therefore the road links study team designed the route with detours and curves so as to keep away from the marshes on the left side of Bahadurabad and Gabargaon.

3.1.2. Proposed route.

Road Link Type B: Dist. bew. guide banks 4.2 km
Type C: Dist. bew. guide banks 5.2 - 5.6 km

(1) Bahadurabad Site B = 67,500 m, C = 67,000 m

Right side B,C = 25,000 m

The proposed route follows the existing kacha road, with improving and widening the section from Kamar on the Asian Highway to Shahapur where there is a sugar mill at present, and the existing brick road for the section from Shahapur to Mahimaganj. Thereafter it turns south following the existing road from Gobaripara to Muhammadpur, which will be widened and improved.

Left Side B = 42,500 m, C = 42,000 m

From Jamalpur to northwest up to Dharmakara the proposed road link was planned on the left side of Jamalpur - Bahadurabad Railway and in parallel thereto and to Old Jamuna. Westward from Dharmakura to Ghilabari the present route will be followed, with improving and widening the existing kacha road. The new alignment was planned southward from Ghilabari the proposed bridge site at Rajapur.

Due to the low and marshy ground in this area, it was necessary to lead the route in a large round-about curve to the north.

Proposed Road Links Route Location is shown in Fig. 3-1.

(2) Gabargaon Site B, C = 65,100 m
Right side B, C = 31,100 m

The proposed route followed the existing brick paved road from Bogra on the Asian Highway eastward to Gabtali, and the present kacha road from Gabtali to Phurbari improving and widening them. The new alignment was planned from Phurbari southeast to the proposed bridge site at Chandanbaisa.

Left side B, C = 34,000 m

The proposed route goes westward from Kochagar, about 5 kilometers to the south of Jamalpur, crossing the Chatal River up to the proposed bridge site. As there are many marshes and river crossing in this area, like the left bank area of Bahadurabad, almost the whole route is new construction except for the portion between Kochgar and the Chatal River where the existing kacha road is improved and widened.

Proposed Road Links Route Location is shown in Fig. 3-2.

(3) Sirajganj Site B, C = 29,750 m
Right side B, C = 15,500 m

From Hatikumrul on the Asian Highway to Slalkal, the Hatikumrul-Sirajganj Highway, now under re-construction for completion in 1978 is wholly used. From Slalkol the new road was planned toward southeast, passing the railway and bypassing Sirajganj Town, up to Banbaria. From Banbaria the route turns southward following the existing partly paved 1-lane road, with widening it, up to Tengrail. From Tengrail the new alignment follows the shortest route to the proposed bridge site.

Left side B, C = 14,250 m

The proposed road goes westwards straight by the use of the existing road from Parima on the Tangail-Bhuapur-Gopalgonj Road, to the end of the existing road.

Thence, it goes southwestwards, crossing the Dhaleswari River, to the proposed site.

Proposed Road Links Route Location is shown in Fig. 3-3.

(4) Nagarbari Site B, C = 35,250 m
Right side B, C = 6,500 m

To northeast from Bangram on the Asian Highway to the Hurasagar River, the existing road was followed and widened, and henceforth the new alignment follows the shortest route to the proposed bridge site.

Left side B, C = 28,750 m

The proposed route starts from Mahadebpur, about 10 kilometers from Aricha on the Dacca-Aricha Road, and extends northwards to Tebaria, with widening and improving the existing kacha road now badly eroded. From there on the new alignment was planned to go westward from Tebaria to the proposed bridge site via Haparikatra.

Proposed Road Links Route Location is shown in Fig. 3-4.

3.2. Vertical location.

3.2.1. Design high flood level.

Flood height is of vital importance for planning of highways in Bangladesh.

Left side

The study team adopted the maximum flood height from the Jamuna river section survey which was recorded at the end of July, 1970. And it is also reported that the year 1970 recorded the largest floods in the recent years.

River section survey map is shown in Fig. 3-5.
Left side D.H.F.L. is shown in Fig. 3-6.

Right side

The study team decided the D.H.F.L. by consultation at the sites for the Bahadurabad (Gobindganj) and Gabargaon (Bogra) sites; because the Nagarbari-Saidpur Road has not been built with a minimum free board above high flood level, and the study team decided the D.H.F.L., from the Stream Gaging Data and 100 year probability for the Right Embankment Project at Sirajganj (Ullapara gage) and Nagarbari (Bagabari gage) sites.

Sirajganj: The 100 year flood elevation at Ullapara was used as the design water profile for the Right Embankment. Therefore, the study team adopted the above figure for Sirajganj site.

Nagarbari: The 100 year flood elevation at Bagabari was not used directly in establishment of design water profile for the Right Embankment. On the other hand, the highest record was observed on August 15, 1955 and was equal to the 1970 Jamuna Record. Therefore, the study team adopted the 1955 figure for the Nagarbari site.

Right side D.H.F.L. is shown in Fig. 3-7.

Fig.3-1 BAHADURABAD SITE

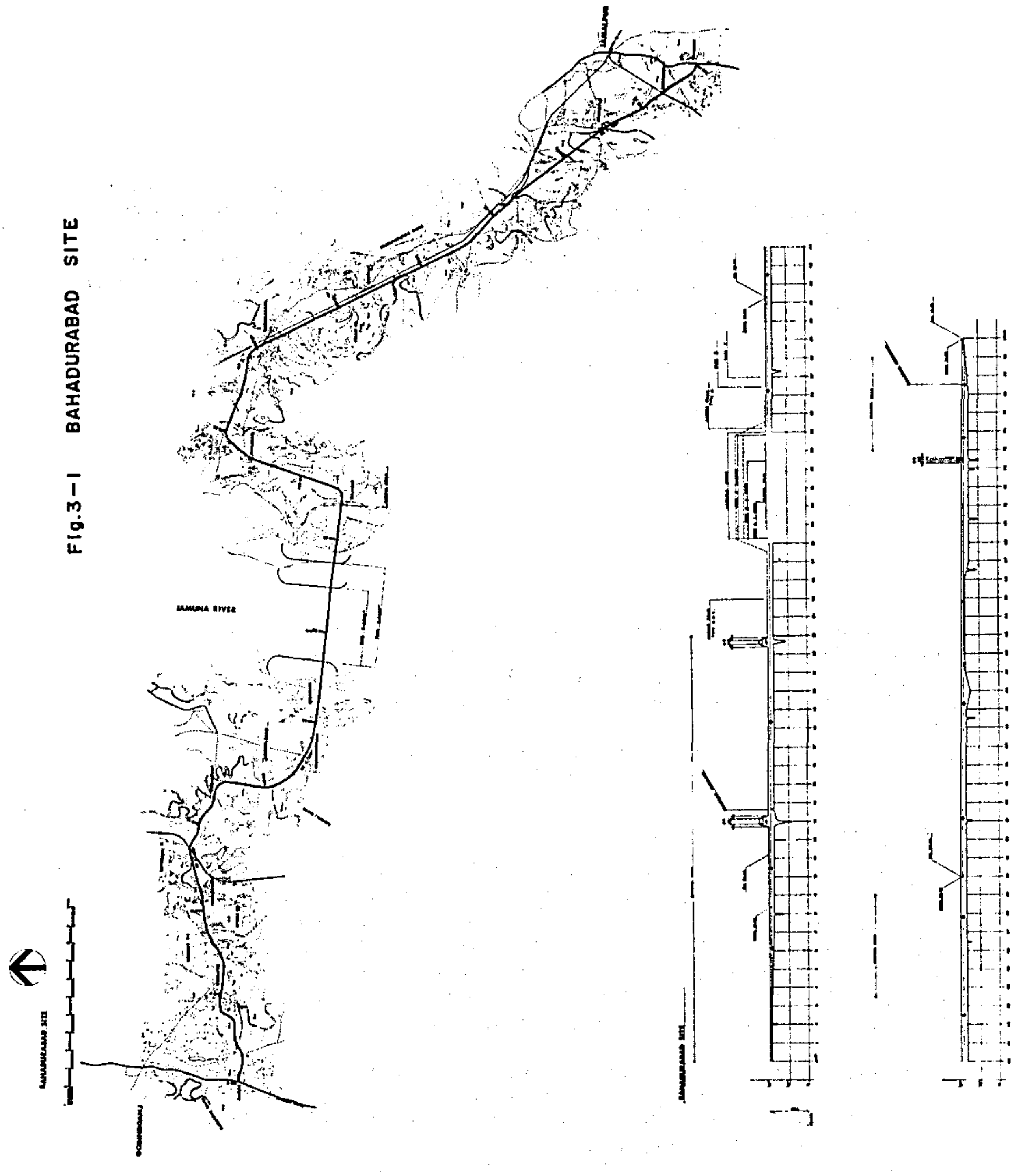


Fig.3-2 GABARGAON SITE

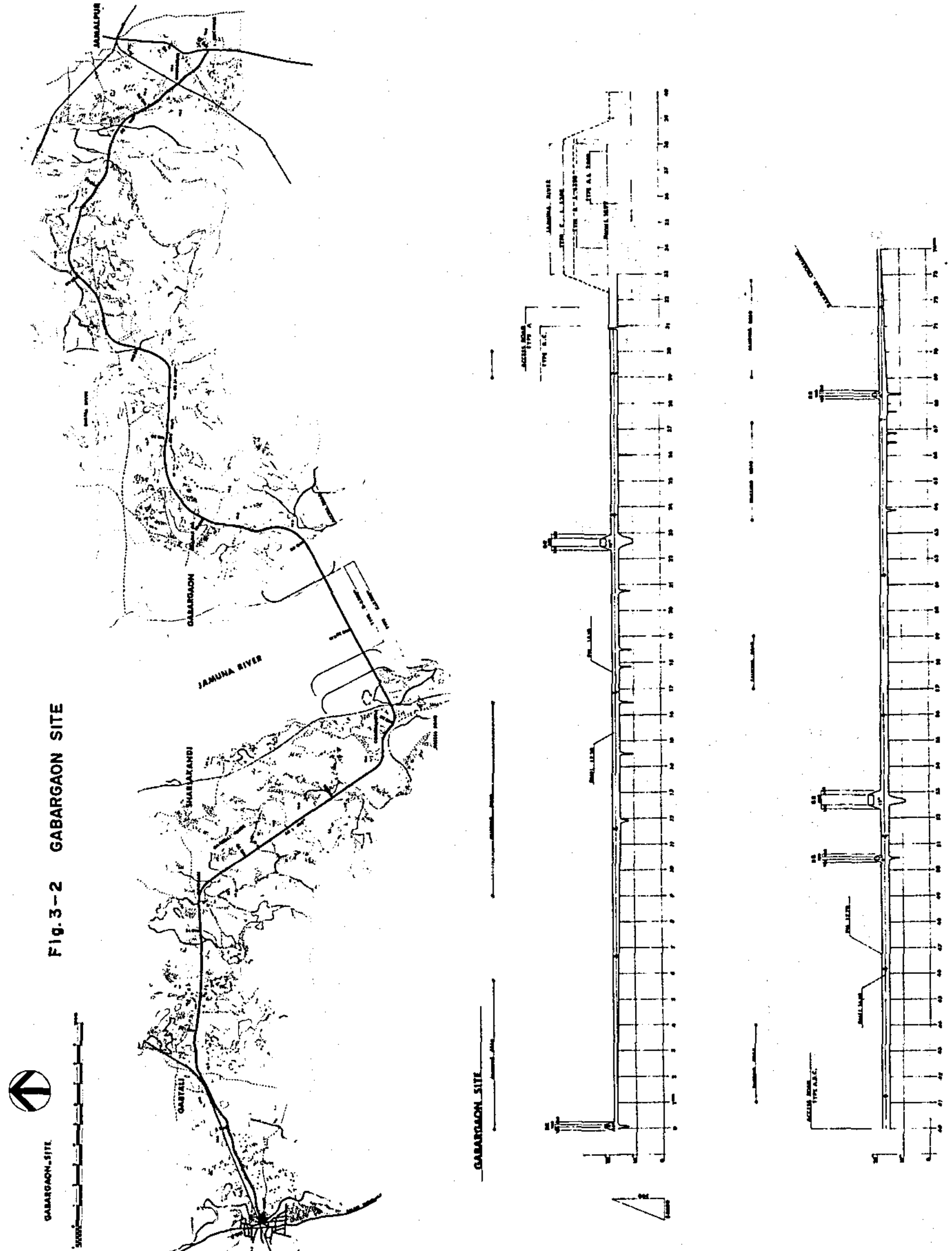


Fig. 3-3 SIRAJGANJ SITE

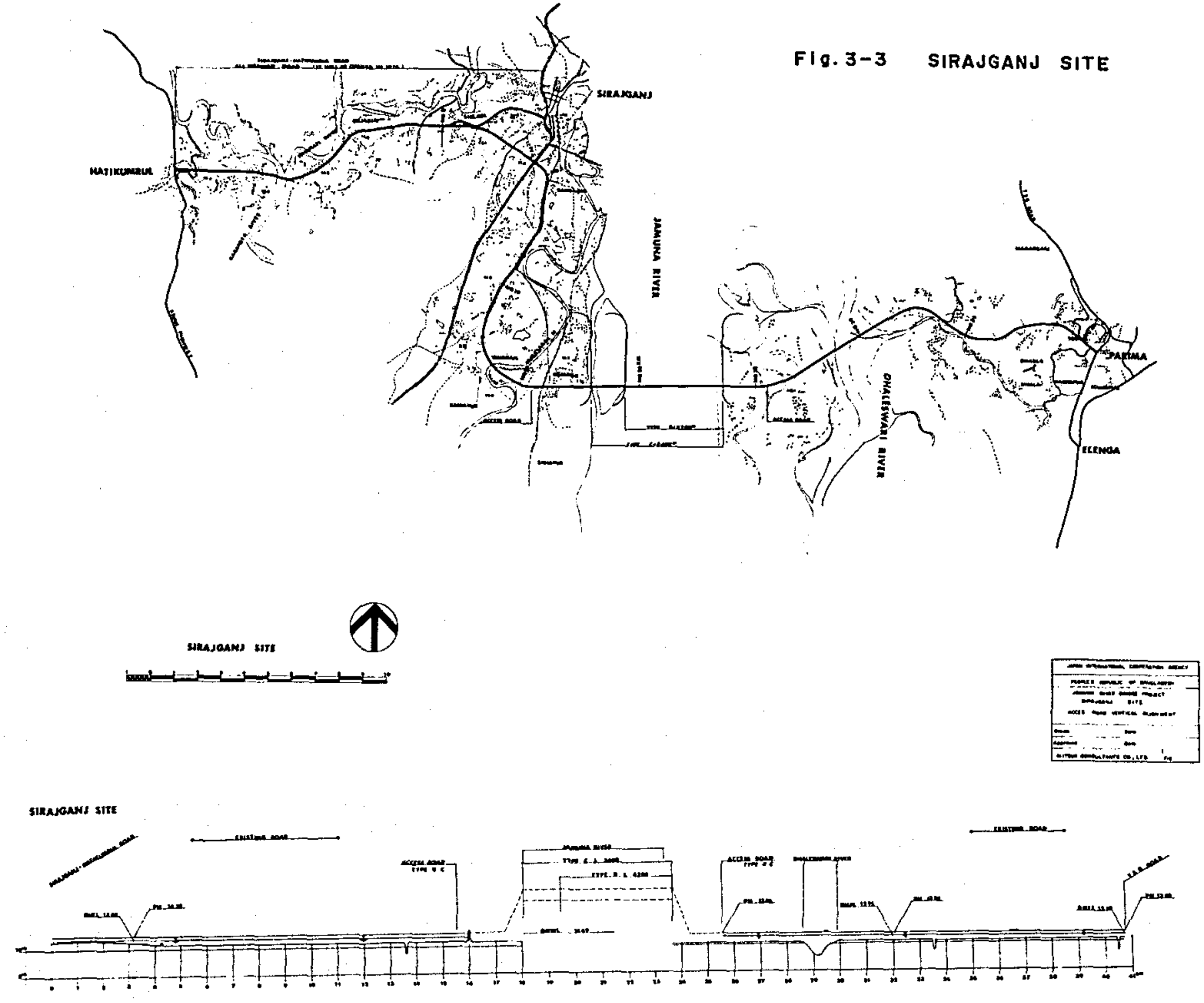
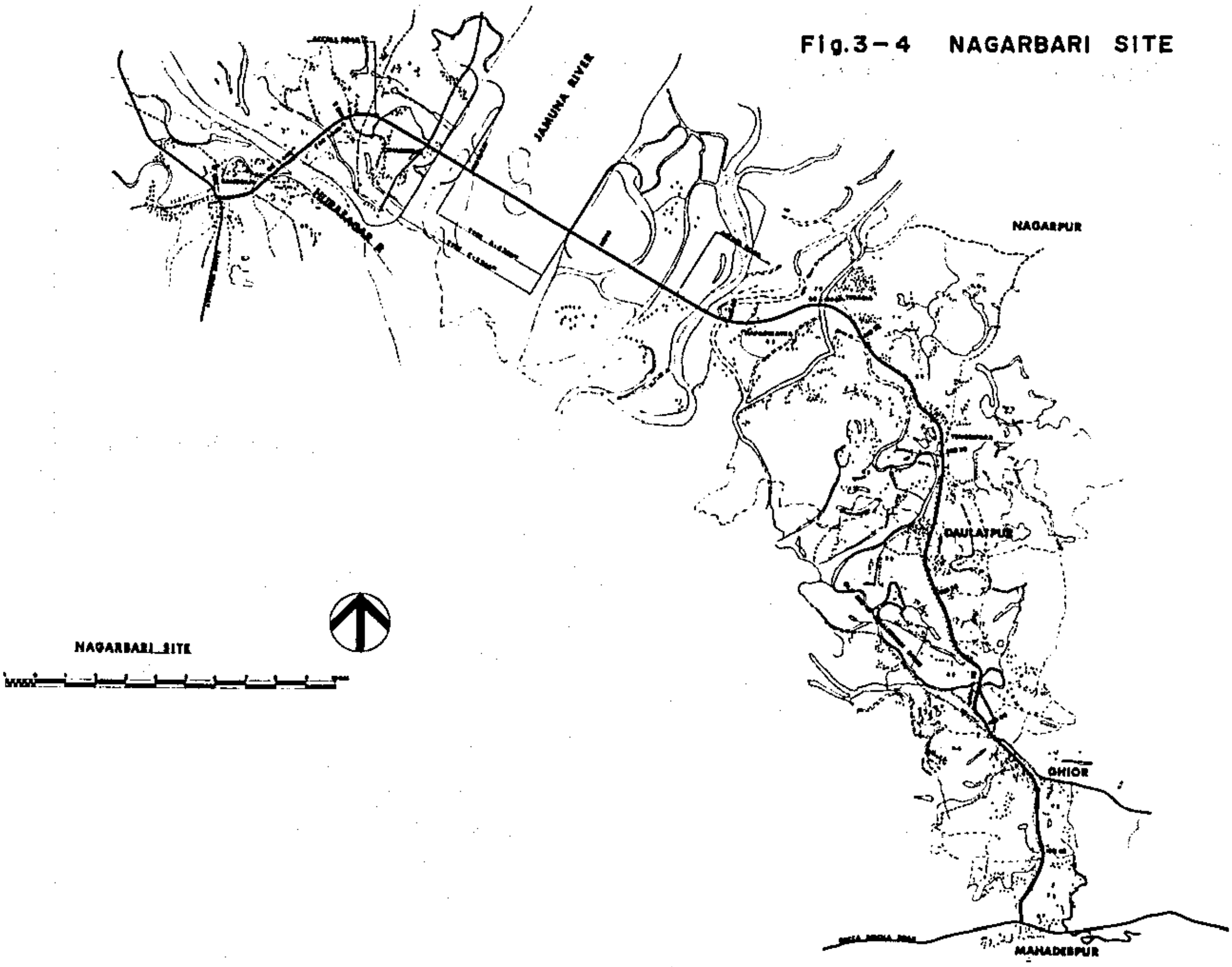


Fig.3-4 NAGARBARI SITE



NAGARBARI SITE

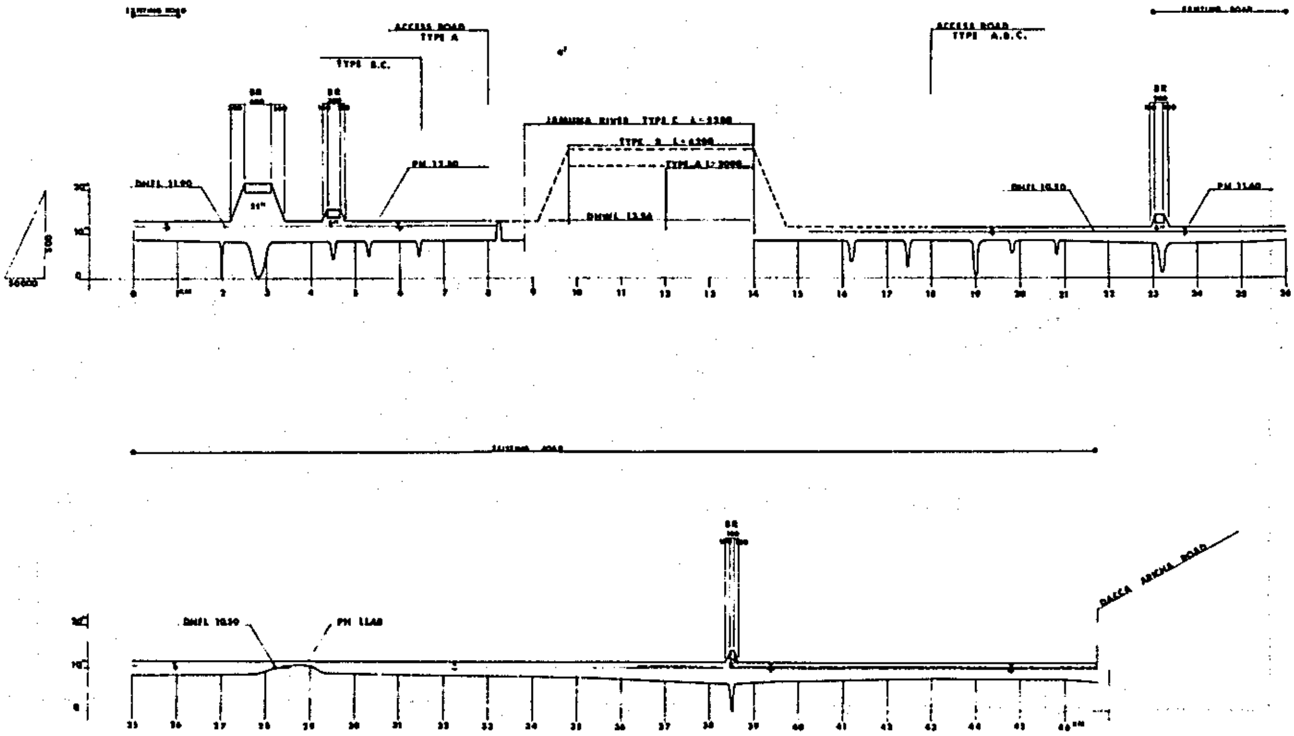


Fig. 3 - 5 RIVER SECTION SURVEY MAP

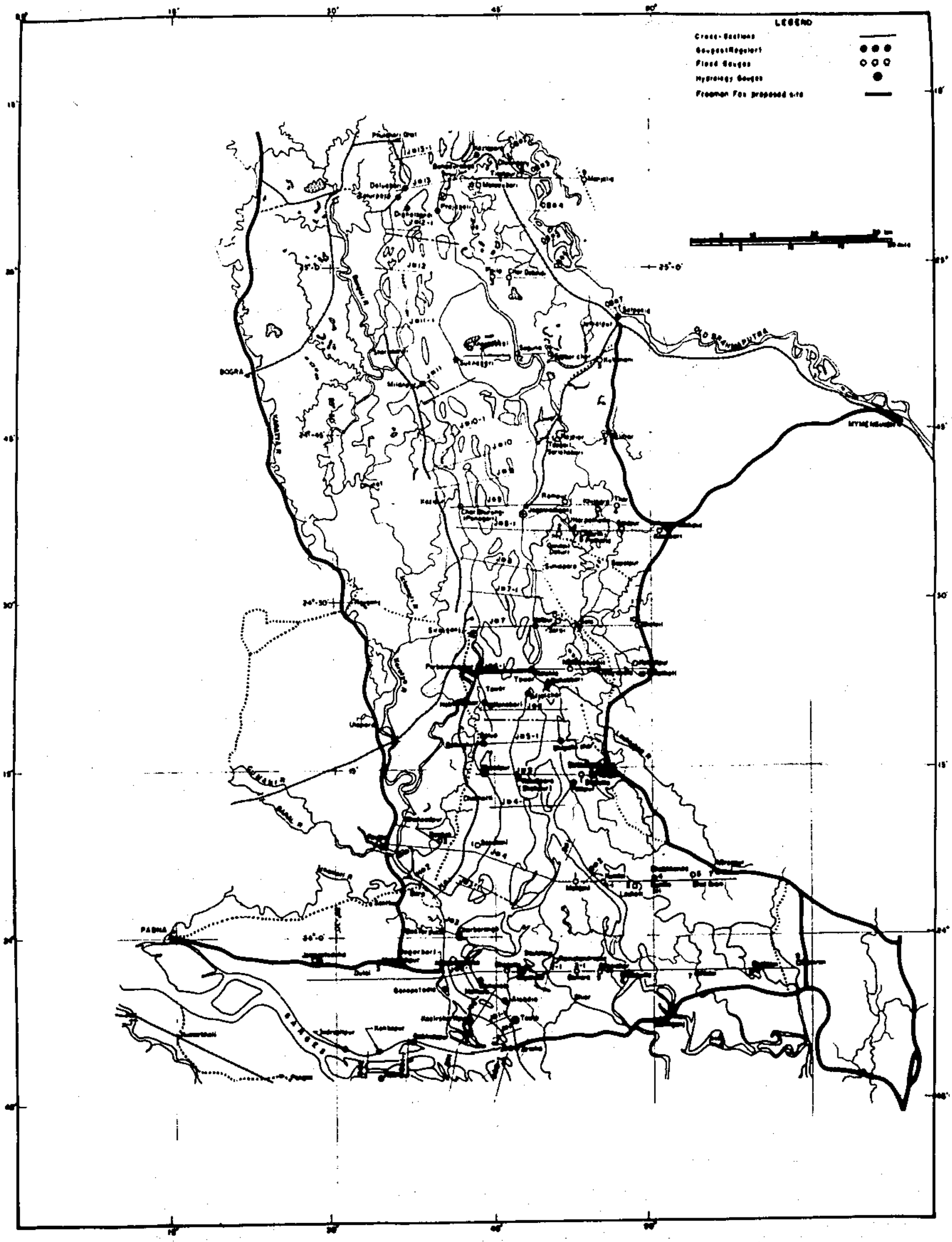
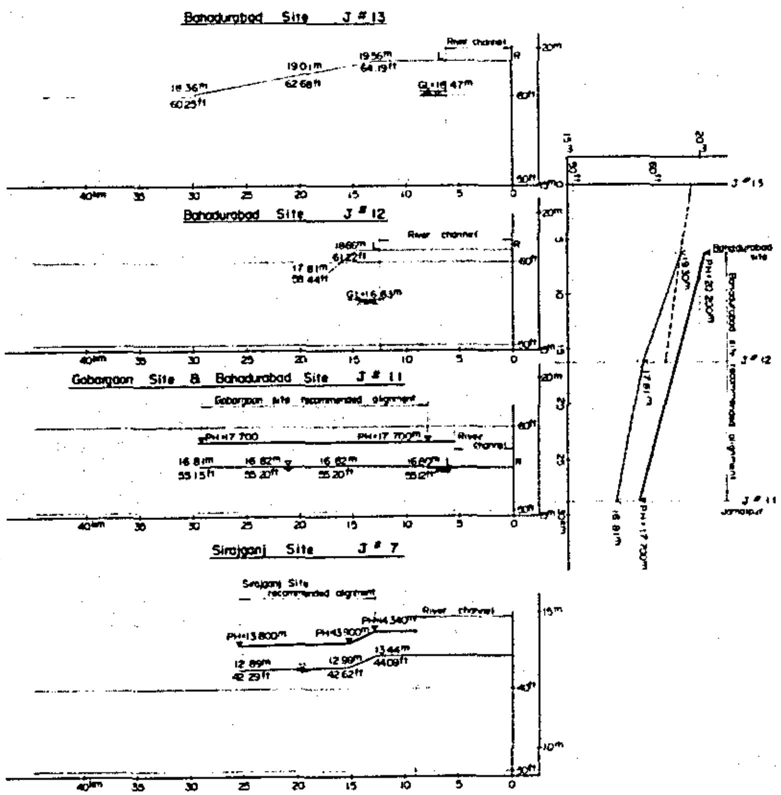


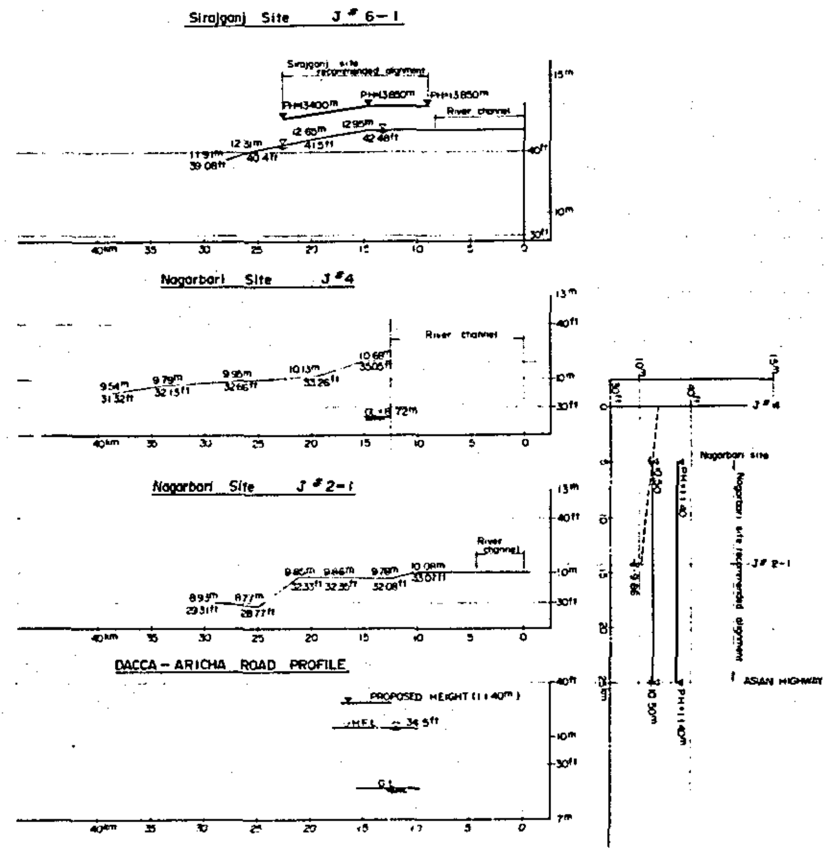
Fig. 3 − 6 Determination of Left Side High Flood Levels.

Left Side Inland High Water Level (July Aug. 1970)

Note : All elevation in this table refer to S.O.B. datum.



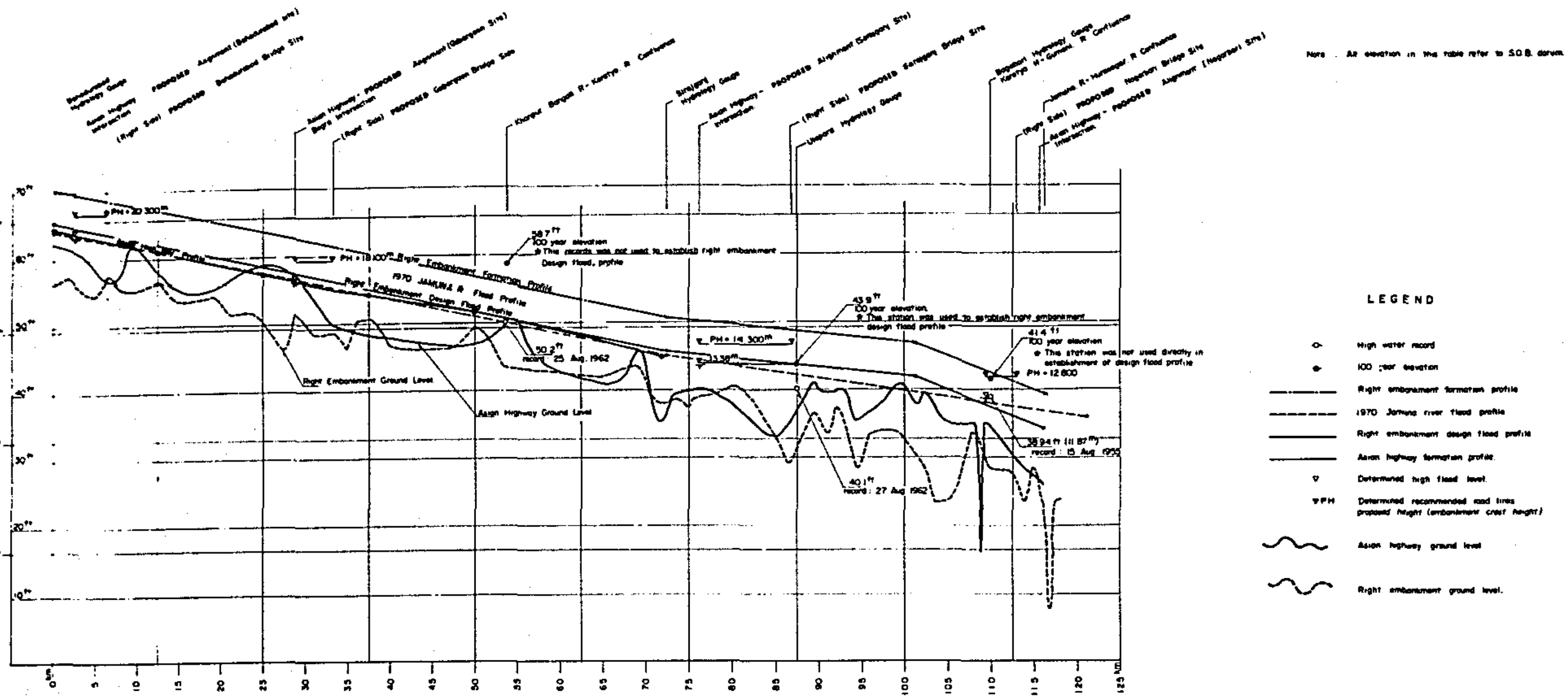
Left Side Inland High Water Level (July. Aug. 1970)



LEGEND

Determined high flood level

Fig. 3 – 7 Determination of Right Side High Flood Levels



CHAPTER IV

COMPARISON OF THE FOUR PROPOSED ROAD LINKS

1. Comparison of Construction Costs.

The purpose of Phase I work was to select the most suitable site for a bridge crossing among the four alternative sites. The study team, therefore undertook a comparison of the total construction costs in line with the total road links for the four sites.

From the study, it was made clear that the Sirajganj site is the shortest in length, with the lowest construction cost.

Table 4-1 shows the total length of each site, and Table 4-2, comparison of cost estimate for each site.

Table 4-1 TOTAL LENGTH

Unit : m

		B Type of Road Links			C Type of Road Links			Bridge Length
		Road Link	Embankment	Structure	Road Link	Embankment	Structure	longer than 100 m
Bahadurabad, site	Right side	25,000	23,520	1,480	25,000	23,520	1,480	500
	Left side	42,500	40,680	1,820	42,000	40,200	1,800	100
	Total	67,500	64,200	3,300	67,000	63,720	3,280	600
Gabargaon site	Right side	31,100	29,460	1,640	31,100	29,460	1,640	400
	Left side	34,000	32,000	1,960	34,000	32,040	1,960	600
	Total	65,100	61,500	3,600	65,100	65,100	3,600	1,000
Sirajganj site	Right side	15,500	14,800	620	15,500	14,880	620	-
	Left side	14,250	13,680	570	14,250	13,680	570	-
	Total	29,570	28,560	1,190	29,750	28,560	1,100	-
Nagarbari site	Right side	6,500	5,340	1,160	6,500	5,340	1,160	900
	Left side	28,750	27,300	1,450	28,750	27,300	1,450	300
	Total	35,250	32,640	2,610	35,250	12,600	2,610	1,200

Table 4-2 CONSTRUCTION COST IN PHASE I

B: Dist. bew. guide banks 4.2 km
C: Dist. bew. guide banks 5.2 - 5.6 km

Unit: million Taka

Site \ Article		Total Length of Road Links km (mile)	Earthwork & Land Acquisition	Bridge L 100m	Bridge & Spillway L 100m	Dhaleswari River Cross-dam	Pavement Work	Miscel-laneous	Total Amount
Bahadurabad site	B	67.500 (43.3)	77.5	16.1	75.0		53.6	5.6	227.8
	C	67.000 (41.6)	76.6	16.1	74.4		53.1	5.6	225.8
Gabargaon site	B	65.100 (40.4)	84.4	42.5	72.2		51.4	5.6	256.1
	C	65.100 (40.4)	84.4	42.5	72.2		51.4	5.6	256.1
Sirajganj site	B	29.750 (18.5)	46.7		33.1	175.0	23.9	2.5	281.1
	C	29.750 (18.5)	46.7		33.1	175.0	23.9	2.5	281.1
Nagarbari site	B	35.250 (21.9)	40.3	53.9	39.2		27.2	3.0	163.6
	C	35.250 (21.9)	40.3	53.9	39.2		27.2	3.0	163.6

2. Selection of the most Suitable Site for Bridge Crossing.

From the viewpoint of road transportation and in consideration of the geology, economy, traffic, and feasibility of a railway link, the Sirajganj Site is considered to be the most suitable site for Road-cum-Railway Bridge over the Jamuna River.

The Inception Report mentions that the selection of the most suitable site for bridge crossing must be made based on these criteria; (a) stability of river channel, (b) construction costs including river control works and (c) traffic volume.

As mentioned above, all four candidate sites, which have been proposed as bridge crossing points are certainly located at nodes of braiding, which suggests that any of them is favorable for spanning a bridge across the Jamuna River.

From the geomorphological point of view, the Sirajganj narrow is the most suitable among the four sites, the Gabargaon site comes closely next, the Bahadurabad site is comparatively unfavorable in comparison with the former two, and the Nagarbari site falls behind all the others.

From point of view of river morphology, the Nagarbari site is the worst one while the other three are almost equal judging from the fact that the banklines have shown little change since around 1860; but the Gabargaon site is the best and the Bahadurabad and Sirajganj sites are almost equal in view of the width between the banks.

Therefore, from both geomorphological and river-morphological points of view, there is nothing to choose between the Sirajganj and Gabargaon sites.

At the Sirajganj site, the bridge axis was chosen a little downstream from the Sirajganj narrow. This site lies under the protection of the narrow as well as the Sirajganj bank-protection works and has only one main stream with chars on both sides of the Jamuna River. This means that the site is very favorable for spanning a bridge. However, this site has two branch channels to the Dhaleswari River, one of which must be crossed by a cross-dam. Fortunately, the entrances to the two branch channels lie with the proposed bridge axis between them. Therefore, it is the best to close the upper inlet channel and improve the lower inlet channel to make it the main one to the Dhaleswari River.

The overall costs, including those of the river control work, the bridge building works, and access link construction works were compared on the A, B, C basis.

It was decided to take the Sirajganj site as the most suitable site for the bridge crossing based on the above-mentioned viewpoints.

CHAPTER V

ROAD CRITERIA AND DESIGN ELEMENTS AT THE SIRAJGANJ SITE

1. Lane Width.

The capacity and service volumes of a 2-lane highway are expressed in total vehicles per hour, regardless of the distribution of traffic by direction.

Furthermore, overtaking and passing maneuvers must be done on the traffic lane normally occupied by opposing traffic.

As far as the maintenance of a desired speed on a 2-lane highway requires passing maneuvers, the volume of traffic plus highway geometrics, which establish available passing sight distance, have much more significant effects on operation speeds than in the case of multi-lane roads.

Therefore, whenever service volumes are considered for 2-lane roads, the corresponding range of the available passing sight distance (1,500 ft or greater) must also be considered.

The width of the roadway on 2-lane highways, taking traffic volume, design speed, character of terrain, and economy into consideration may vary from 26 ft (18 feet pavement carriageway plus 4 feet shoulders) to about 44 ft (24 feet pavement carriageway plus 10-feet shoulders).

From the standpoint of driver's convenience, operation and safety, it is desirable to construct 2-lane highways with 12 feet lanes and with usable shoulders of 10 feet width. The "usable" width of the shoulder can be used when a driver makes an emergency stop.

In accordance with the above condition and analysis of the road capacity described hereunder, the access highway study team adopted the geometric standards of primary roads established by R & H Directorate in Bangladesh.

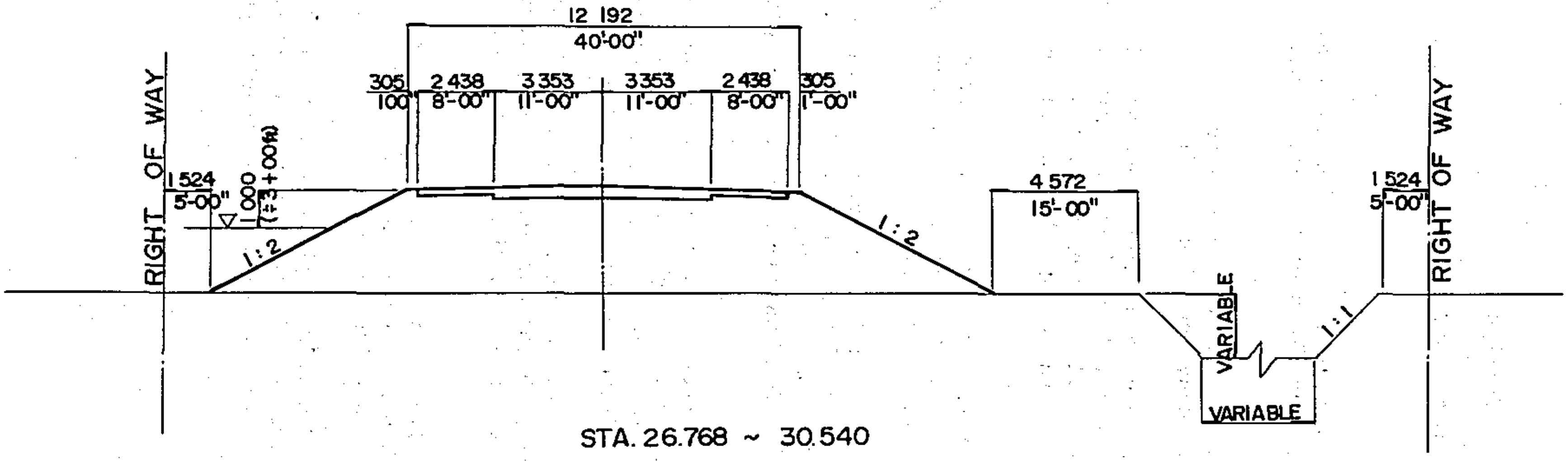
All the proposed road links have 22 feet flexible pavement, 11-feet wide carriageways with 8 feet paved shoulders, on a 40 feet embankment. A typical cross section is shown in Fig. 5-1.

The Government of the People's Republic of Bangladesh will take appropriate action to reserve sufficient land for two additional lanes for future extension on the other side of the borrowpit and the road.

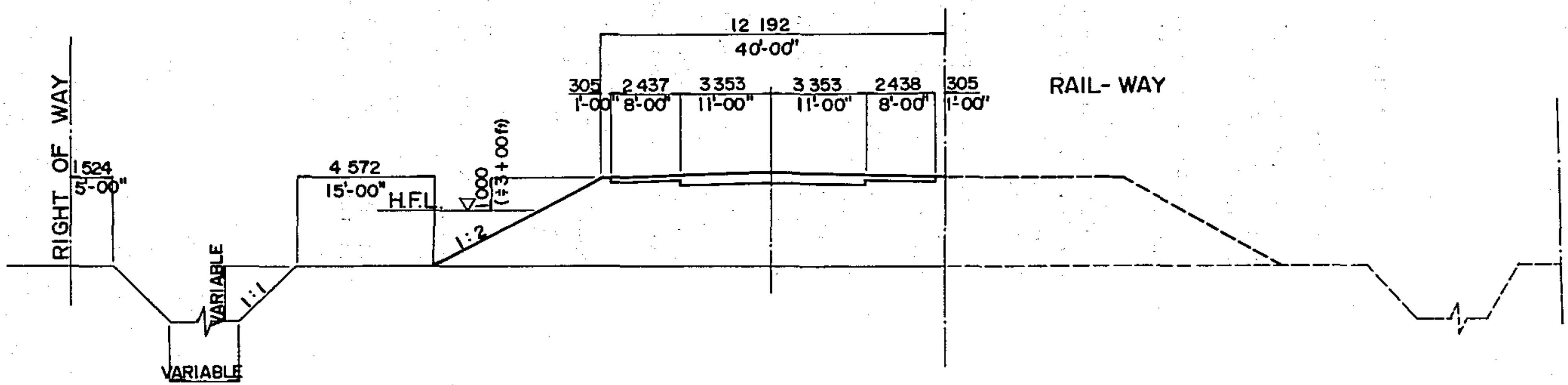
Fig. 5-1 TYPICAL CROSS — SECTION

SCALE 1/200

STA. 0.000 ~ 13.754
STA. 30.540 ~ 37.350



STA. 26.768 ~ 30.540



2. Analysis of the Road Capacity.

2.1. Traffic forecast.

The methods are described in Vol VII, TRAFFIC ECONOMIC BENEFITS, for the calculation of vehicle operating costs required as daily input capacity of a road in terms of equivalent passenger car units (p.c.u.'s). In the Vol VII report, the traffic forecast on the Sirajganj Site Road Links for key years are as follows.

Table 5-1 TRAFFIC FORECAST

Year	Passenger cars	Buses	Trucks	Total	Equivalent in passenger car units
1993	3,460	303	169	3,932	4,876
2020	5,495	480	552	6,527	8,591

* Passenger car equivalent of trucks and buses = 3

2.2. Road capacity.

The concept and methodology used to develop the highway capacity analysis of the proposed road links are based on the Highway Geometric Design Standard of Japan.

The capacity for proposed road links for uninterrupted flow under ideal conditions are summarized in Table 5-2.

Table 5-2 ROAD CAPACITY

Road type	Capacity (passenger cars per hour)
Two-lane, two-way	2,500 total, both directions

2.3. Design volume to capacity ratio.

Table 5-3 shows the methods used to determine volume/capacity ratios on the facility during the peak hours in a given year.

Table 5-3 DESIGN VOLUME - CAPACITY RATIO

Year	A. D. T. (p.c.u.'s)	Capacity 2,500×Wc×Ts=Capacity	DHV Design (p.c.u.'s) ADT × 12%	Volume to Capacity Ratio	Level of Service
1993	4,876	2,500×0.96×0.76=1,824	585	0.32	C
2020	8,591	2,500×0.96×0.76=1,824	1,030	0.56	D

p.c.u.'s = passenger car units

Wc = Adjustment for lane width and lateral clearance

E_T = Passenger car equivalents of trucks

E_B = Passenger car equivalents of buses

T_C = Truck factor at capacity = $\frac{100}{100-P_T+E_T \cdot P_T}$

T_B = Buses factor at capacity = $\frac{100}{100-P_B+E_B \cdot P_B}$

P_T = Percentage of trucks

P_B = Percentage of buses

2.4. Level of service.

Two-lane highway geometrics primarily affect operating speeds during the free flow representative level of service A, their effects becoming less significant by the time the maximum volume at this level is reached. Average speeds are most influenced by speed limits at this level also. At the limit of level of service C, still stable flow, operating speeds for uninterrupted flow on all two-lane highways are 40 mph or above, with total volume for both directions reaching 51 percent of capacity with or 930 passenger cars per hour, the condition of passing sight distance, under ideal conditions.

Unstable flow is approached as operating speeds fall to 35 mph and volumes carried, in both directions, may reach 67 percent of capacity with continuous passing sight distance, or 1,222 passenger cars per hour, under ideal conditions. This represents the limiting conditions for the level of service D, or the highest volume that can be maintained for short periods of time without a high probability of breakdown in flow.

3. Stability of Embankment.

Soil investigation was done during the 1975 dry season.

As already stated in the Volume VI, the predominant soil group throughout the route is sand containing silty soil (SM). Therefore the embankment material is proposed to be obtained by excavating soil above the ground water table as far as practicable along the proposed route. The above soil group classified as offering "fair" to good materials for embankments.

The main values are as follows.

	Ground soil	90% Modified AASHO Compaction soil
Unit weight	0.9 T/m^3	2.0 T/m^3
Angle of internal friction	13.0°	17.5°
Cohesion	1.0	1.0

Soil stability analyses were made for several typical conditions of side slope and embankment height in consideration of the surcharge on the embankment.

The results of the calculations are as follows.

Results of Slip-Circle Analysis

Slide Slope	Embankment height	Factor of Safety against Sliding
1:2	3 m	1.51
*1:2	4	1.32
1:2.5	4	1.39
1:2.5	5	1.28

The embankment height will not exceed 13 feet (4 m).

Therefore a 1:2 embankment side slope was adopted for the proposed road links.

The 4 meter height embankment Slip-Circle analysis is shown in Fig. 5-2.

4. Volume Change of Soil.

The volume of soil changes according to whether it is excavated and loosened, or compacted in banking.

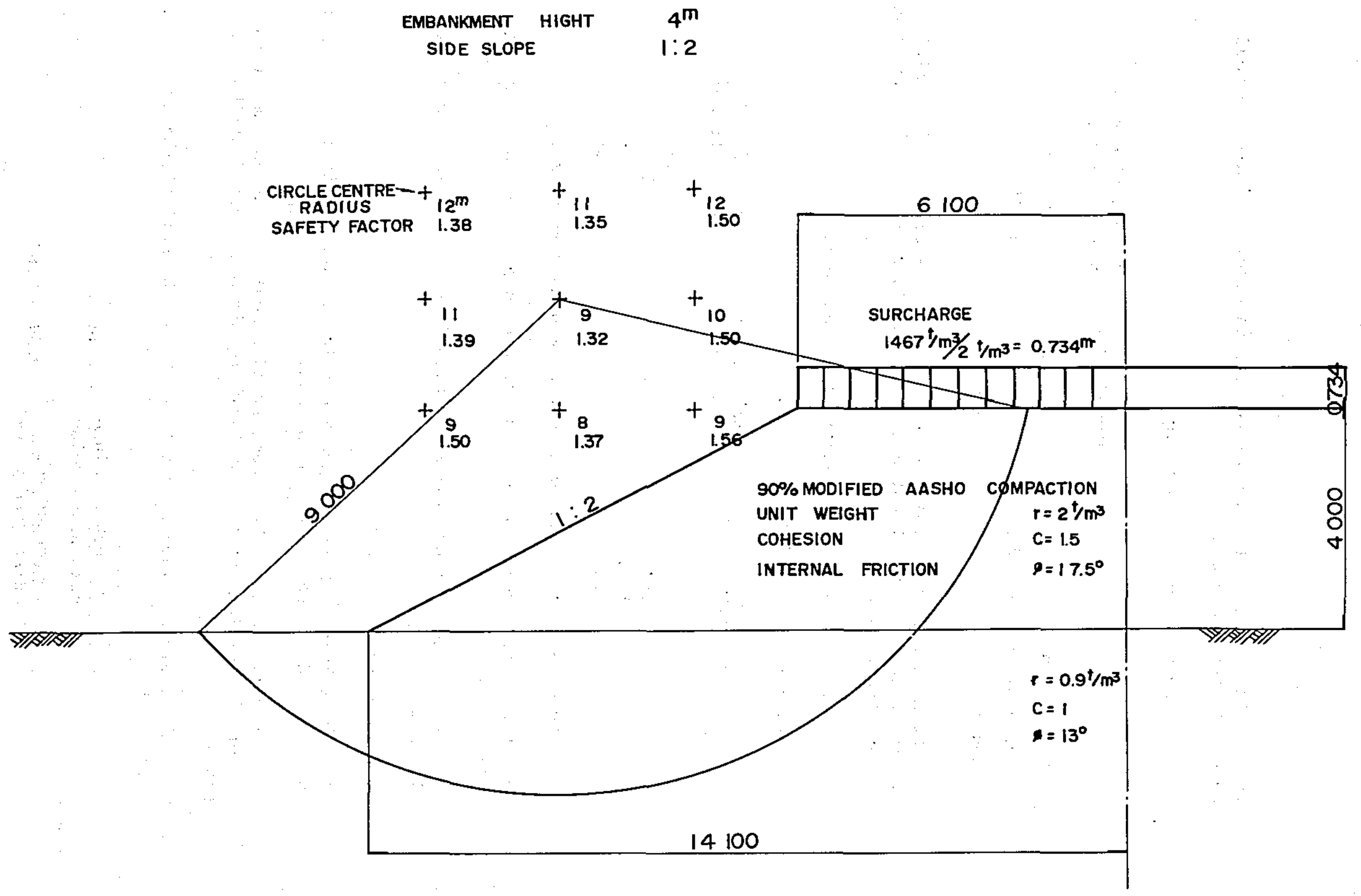
It will therefore be necessary to calculated the volume change factors in working out the earthwork requirements and distribution plans.

The average volume change factors for the soil of the area were found to be:

$$L = \frac{\text{Disturbed volume}}{\text{Undisturbed volume}} = 1.30$$

$$C = \frac{\text{Compacted volume}}{\text{Undisturbed volume}} = 0.89 - 0.87$$

Fig. 5-2 SLIP CIRCLE ANALYSIS



In calculation of required right-of-way, the volume change factor of fill has been set at C=0.85 . Earth work quantities, therefore, have been increased by 15% to allow for settling.

5. Free Board.

Freeboard should be provided in consideration of the variation of design high flood level and wind velocity, etc. Three feet freeboard was adopted in the case of the Tangail-Bhuapur-Gopalgonj Road and the Sirajganj-Hatikumrul Road. Therefore, it is judged that about a three feet (1.000 m) freeboard is sufficient also in this case. However, in order to make sure, the run-up height of wind wave was examined as follows.

Wind velocity for examination of the wave was determined at 9 m/s (20 mile/hr) which was taken in the case of the Right Flood Embankment of the Jamuna.

5 km fetch and 3 m (10 feet) depth were adopted in consideration of topographic features and design high flood level.

Wave height and period

Calculated by Bretschneidek theory on shallow waves (119B) under the conditions of: wind speed u_{10}=9m/s, fetch F=5km and water depth h=3m, the dimensions of the wave are as follows:

Wave height	$(H_{\frac{1}{3}})$	:	$gH_{\frac{1}{3}}/u_{10}^2=0.05$ $H_{\frac{1}{3}}=0.41m$
Wave period	$(T_{\frac{1}{3}})$	:	$T_{\frac{1}{3}}=3.86\sqrt{H_{\frac{1}{3}}}=2.48sec.$
Wave length	(L)	:	L=9.60m
Wave celerity	(C)	:	C=3.87m
Wave steepness	$(H_{\frac{1}{3}}/L)$	:	$H_{\frac{1}{3}}/L=0.042$

Run-up height.

The run-up height of the wave on the slope of the road embankment was estimated by Savil's study (119 GB). In case the slope gradient of the road-embankment is 1:2, the ratio of run-up height R to the wave height Ho of corresponding water depth is 1.8 for smooth slopes.

R = 1.8×0.41= 0.738m(2.42 feet) for significant waves in the case of smooth slopes.

6. Pavement.

From practical experience in this country, a flexible pavement is considered most suitable to ensure against any possible settling of the embankment.

The pavement thickness has been determined directly, using the lowest CBR value, from the Design Chart 2, page 25, Road Note 31,

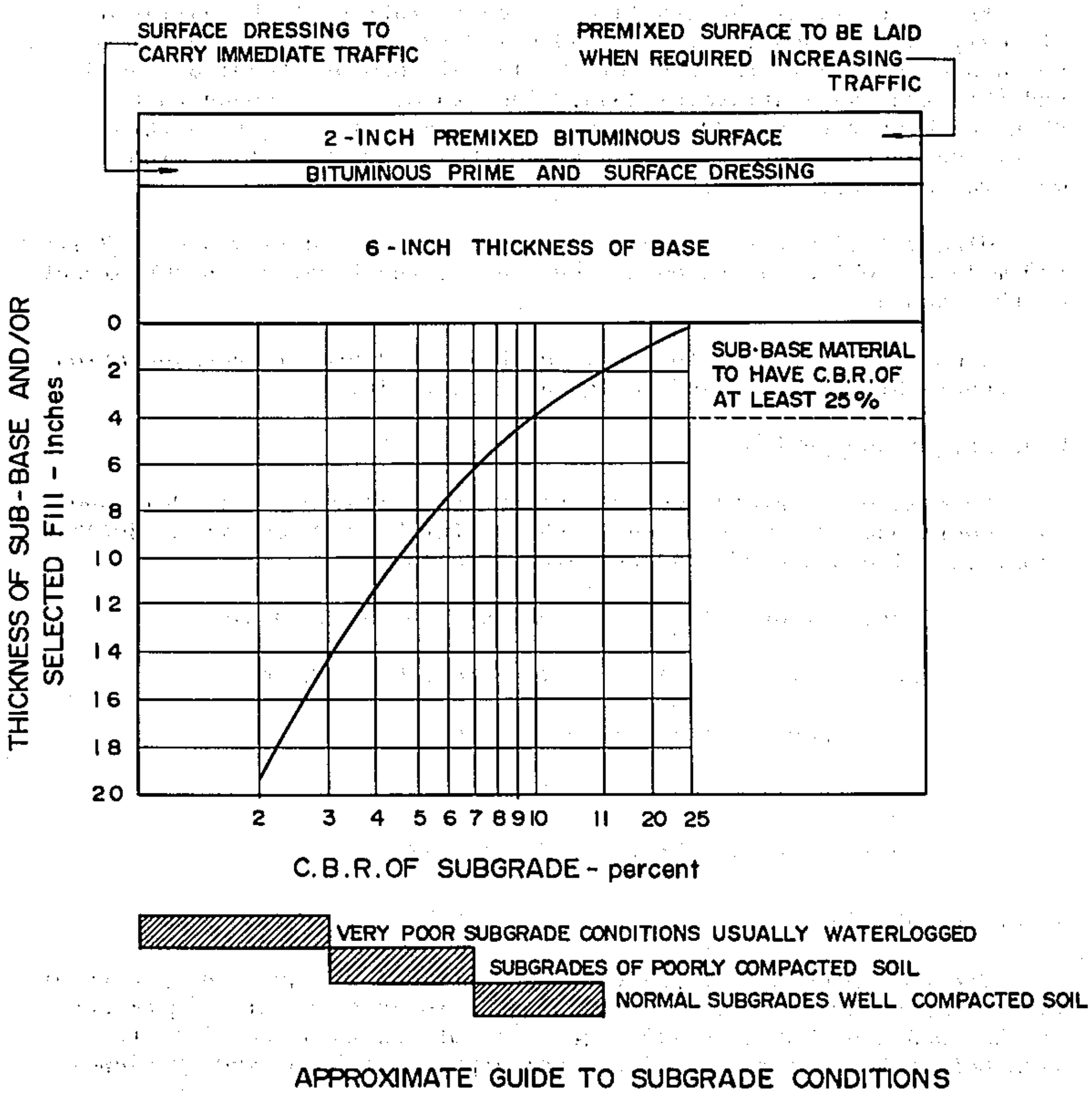


Fig. 5 - 3 DESIGN CHART - 2.

(150-1500 COMMERCIAL VEHICLES PER DAY)

Road Research Laboratory, Ministry of Transportation, UK. It is shown in Fig. 5-3.

CBR tests performed in soaked condition the showed a minimum value of 6.

Road Note 31 was produced for tropical and sub-tropical conditions and assumes a pavement life of only about ten years, with provision for adding strengthening layers. A limitation of Road Note 31, at present, is that design curves are for a maximum of 1,500 commercial vehicles per day and some roads in this country will carry more than that.

To use Road Note 29 for these cases would be certainly safe, and it is reasonable to assume that it would result in a pavement with a longer life.

CBR Design Curve is shown in Fig. 5-4.

The Pavement Section is shown in Fig. 5-5.

But from practical experience in this country, it has been observed that a 3 in. layer of brick flat soling under a 9 in. jama khoa consolidation is best. With a 2½ in. bituminus concrete, the total thickness comes to 14½ in. It is recommended to be placed over a plastic subgrade of sand in 6 inches thickness. This is considered adequate in light of the experience of the road engineers of Bangladesh and also conforms with the recommendation of the Road Research Laboratory.

Fig. 5-4 C.B.R. DESIGN CURVES

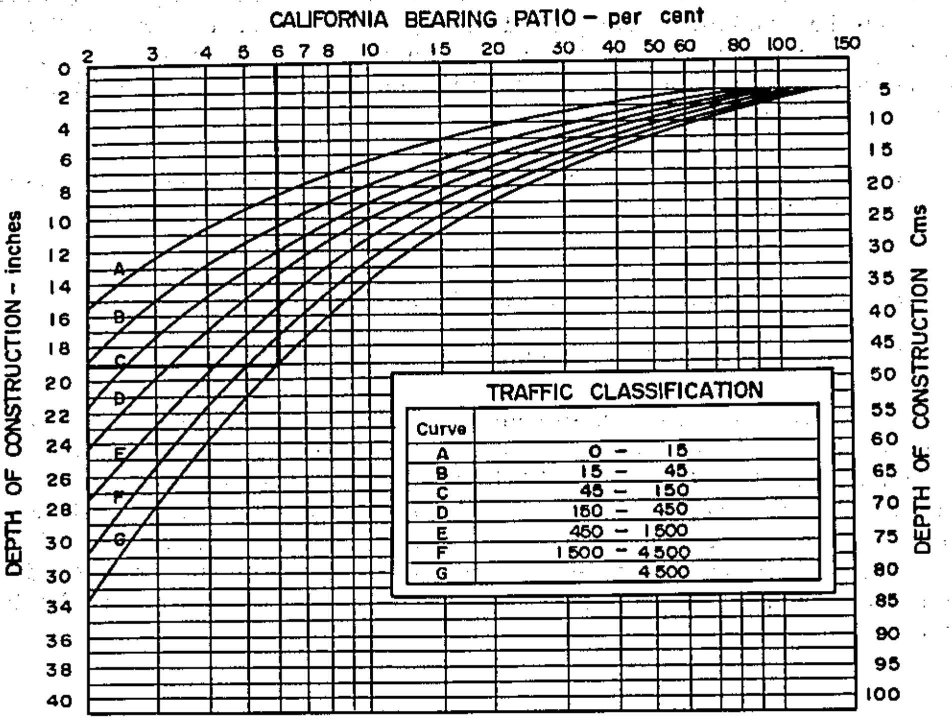
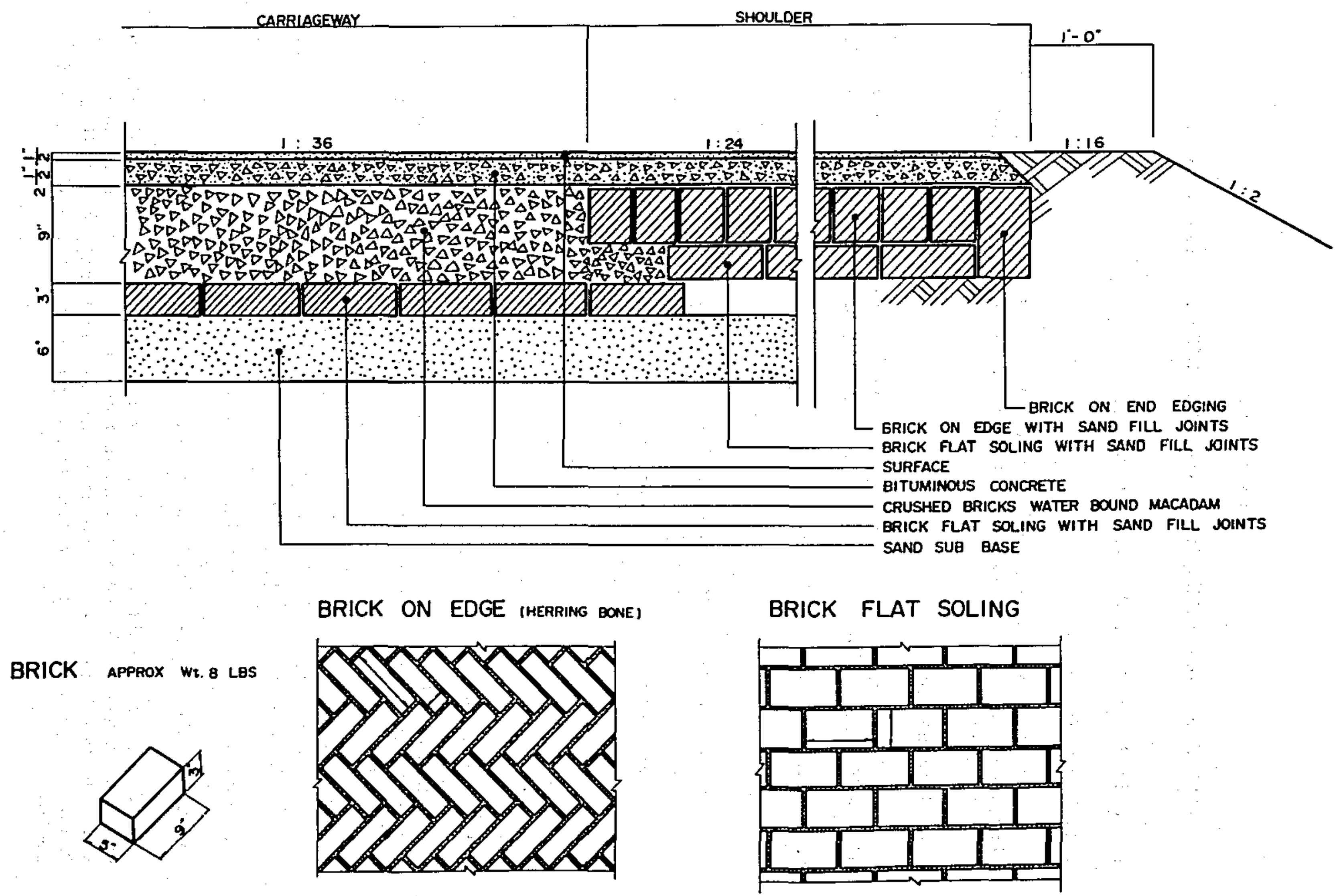


Fig. 5 - 5 TYPICAL PAVEMENT SECTION FOR ROAD LINKS



CHAPTER VI

DESIGN OF ROAD LINKS FOR BRIDGE CROSSING AT SIRAJGANJ SITE

1. Beginning Point and Terminal Point.

1.1. Beginning point.

The Road is planned to begin at Siakol, located 4 km west of Sirajganj, on the Sirajganj-Hatikumrul Road which is scheduled to open in 1978.

1.2. Terminal point.

It is planned to end at a point 500 m north to the intersection of the Tangail-Madupur Road and the Tangail-Bhuapur-Gopalgonj Road.

1.3. Length of the road links.

	Definition of Section	*Length (m)*
Right Bank	Beginning Point to Bridge Approach on the Right Bank	13,754
Left Bank	Bridge Approach on the Left Bank to Terminal Point	10,582
	Total	24,336

2. Route Location.

2.1. Right bank.

The road links on the right side of the Jamuna is planned in accordance with the discussion between Bangladesh and the JICA as follows:

(1) giving priority to the shortest approach to the Sirajganj-Hatikumrul Road which connect with Asian Highway A-2 (Nagarbari-Saidpur Road) at Hatikumrul,

(2) reconstruction of existing road and

(3) accesible to the Sirajganj town.

In order to make the traffic by-pass the town of Sirajganj, the study team has designed a straight route at the section between Sialkol, which is the beginning point on the Sirajganj-Hatikumrul Road, and a point south of the Raipur Railway Station (STA 0 to STA 2+650).

Railway traffic between Sirajganj town and the Jamuna bridge will be decreased after completion of the Jamuna bridge and the railway links. Intersection with railway at Raipur is planned as an atgrade intersection for the time being because of small railway traffic volume.

Between the point STA 4+850 and STA 5+600, the intersection of the Sirajganj-Halua Kandi Road and the Right Embankment rehabilitated in 1974, the road is designed as a straight route which parallel the Sirajganj Halua Kandi Road and close to the existing railway. And between the point STA 2+650 and STA 4+850, the Study Team designed a curving route with R=2,000 m.

Between the point STA 5+600 and STA 9+400, the existing Sirajganj-Halua Kandi Road is to be used, being widened and improved.

Between the point STA 9+400 and the end of the Right Embankment section, the road was designed as a curving route with R=2,250 m in order to connect with the bridge axis.

2.2. Left bank.

2.2.1. For the route location of the road link on the left bank, some revisions were made of the Phase I study because of the following reasons:

(1) In order to block the Dhaleswari River by the causeway, the road and the newly-planned railway are to use the same bridge approach designed as a straight line;

(2) Although the study team planned to use the existing road in Phase I, it is very unsuitable for use because of its heavy erosion; and

(3) The road is to reach the destination point over the shortest distance.

2.2.2. Between the point STA 26+768 where the bridge approach on the left bank ends and STA 30+540, the Road was designed as a straight route along the bridge axis on the same embankment.

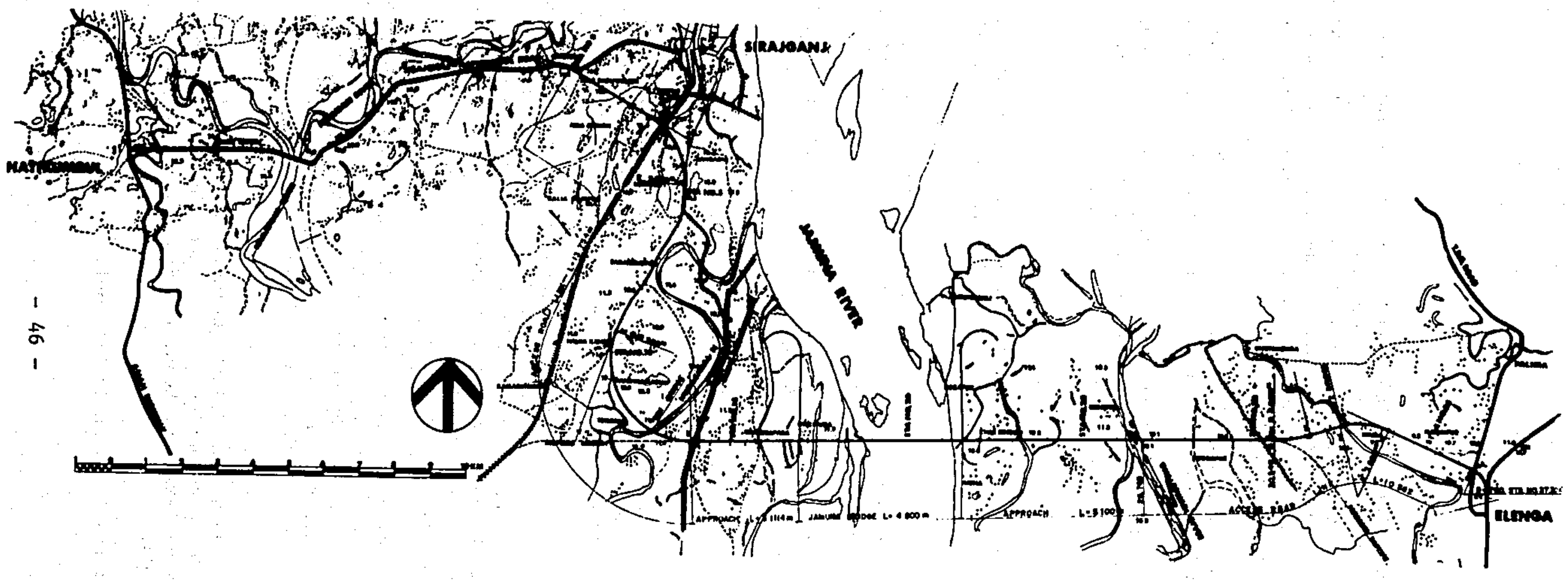
With an angle of 15° from the Jamuna bridge axis, going north-east to the river-crossing point of Bridge No. 2 the Study Team designed a curving route with R=4,000 m between the point STA 30+540 and STA 31+600. In addition, between the point STA 31+600 and STA 32+450 which is a beginning point of the sequent curving route, the road was designed as a staight route.

The study team designed the road with an angle of about 20° going south-east from the river-crossing point of Bridge No. 2 to avoid traffic interference by sunlight and with a straight route up to the Tangail-Bhuapur-Gopalganj Road. Between the point STA 32+450 and STA 34+850, the road was designed, sequently as a curving route with R=2,000m.

Between the point STA 36+500, which identifies the intersection of the Tangail-Bhuapur-Gopalgonj Roads, and STA 37+350, the terminal point of the Tangail-Madupur Road, the Study Team designed a curving route with R=750m.

Route Location is shown in Fig. 6-1.

Fig. 6-1 ROUTE LOCATION MAP



3. Vertical Alignment.

3.1. Design high flood level.

3.1.1. Design high flood level on the right bank.

At present, observations on the inland water level have been made at Ullapara on the right bank. The maximum water level was recorded at 11.46m (G.T.S.) at Ullapara in 1974, while the profile of the Jamuna River is 1/20,000. Therefore, the study team adopted the value which was adjusted to the design point by the 1/20,000 profile for the design high flood level on the right bank. In short, the values have been identified as 11.84m (G.T.S.) in the vicinity of the bridge axis and 12.34 m (G.T.S.) in the vicinity of Sirajganj.

3.1.2. Design high flood level on the left bank.

For the design high flood level on the left bank in close vicinity of the Dhaleswari River, the study team adopted 13.19m (G.T.S.) as the value, which was derived from the maximum water level of the Jamuna River that was observed at Sirajganj in 1974 and was adjusted to the point of the Jamuna bridge axis. In close proximity to the terminal point of the road, the observation on the inland water level was not done in 1974. Therefore, the value of 12.84m (G.T.S.), which was gotten by consultation when the Japanese Survey Team executed the river section survey was adopted.

3.2. Proposed height of the roads.

3.2.1. Right bank.

The Right Embankment in the vicinity of the proposed road link was collapsed over a distance of about 4 km south of Sirajganj by the flood in 1974. Recently, the new Right Embankment, connecting t the Right Embankment and the Siriganj-Halua Kandi Road, was constructed for the time being.

However, because of the connection with the Sirajganj-Halua Kandi Road, the new Right Embankment of the section has not ensured enough safety against flooding in comparison with the design height of the Right Embankment before collapse.

On the other hand, the section where almost all of the road link are located will be encircled by the existing railway and the high embankment of the proposed Railway Link.

Since the road link of the Jamuna Bridge is so fundamental, the road is to be used even in time of flood. Therefore, although the railway link has enough openings, from the viewpoint of road engineering the proposed road height of the section will not be based on the high flood level at Ullapara plus 1m, but the existing railway height designed before the completion of the Right Embankment will be adopted as the proposed height of the road link on the right bank.

The heights of the road are proposed to be at the level of high flood level plus 1.25m in the vicinity of Sirajganj and high flood level plus 1.75m in the vicinity of the bridge axis.

3.2.2. Left bank.

The value of the design high flood level plus 1m is adopted as the prooosed height of the Road Link on the left bank.

4. Quantity of the Works.

4.1. Running length.

o Total length of the road links

Right side	13,754 m
Left side	10,582 m
Total	24,336 m

o Major bridges length

Right side No.1 Bridge	100 m
Left side No.2 Bridge	135 m
Total	235 m

o Total pavement length of the road links

Right side	13,754 m - 100 m = 13,654 m
Left side	10,582 m - 135 m = 10,447 m
Total	24,101 m

o Total culvert length

Right side	13,654 m × 0.04 = 546.2 m
Left side	10,447 m × 0.04 = 417.9 m
Total	964.1 lm.

4.2. Area & volume.

o Land acquisition

Right side	483,847 m^2
Left side	611,118 m^2
Total	1,094,965 m^2

o Pavement area

6" Sand sub-base

o Right side	13,654 m × 13.716 m = 187,278 m^2
Left side	10,447 m × 13.716 m = 143,291 m^2
Total	330,569 m^2

4-1/2" Brick on edge

Right side	13,654 m × 4.877 m = 66,590 m^2
Left side	10,447 m × 4.877 m = 50,950 m^2
Total	117,540 m

9" Water bound mac'adam

Right side	13,654 m × 6.706 m = 91,564 m^2
Left side	10,447 m × 6.706 m = 70,058 m^2
Total	161,622 m^2

3" Brick flat, 2-1/2" Bituminous concrete
1/2" Surface

Right side	13,654 m × 11.582 m = 158,141 m^2
Left side	10,447 m × 11.582 m = 158,141 m^2
	279,138 m^2

o Shoulder protect area

Right side	124,001 m^2
Left side	117,587 m^2
Total	241,588 m^2

o Volume of culvert

Right side	3,048 m × 11.58 m × 546.2 m = 19,279 m^3
Left side	3,048 m × 11.58 m × 417.9 m = 14,750 m^3
Total	34,029 m^3

o Earth work volume

Right side including 15% extra volume = 255,398 m^3

255,398 - 19,279 (structure elimination) = 236,119 m^3

Left side including 15% extra volume = 380,387 m^3

380,387 - 14,750 (structure elimination) = 365,637 m^3

Total 601,756 m^3

CHAPTER VII

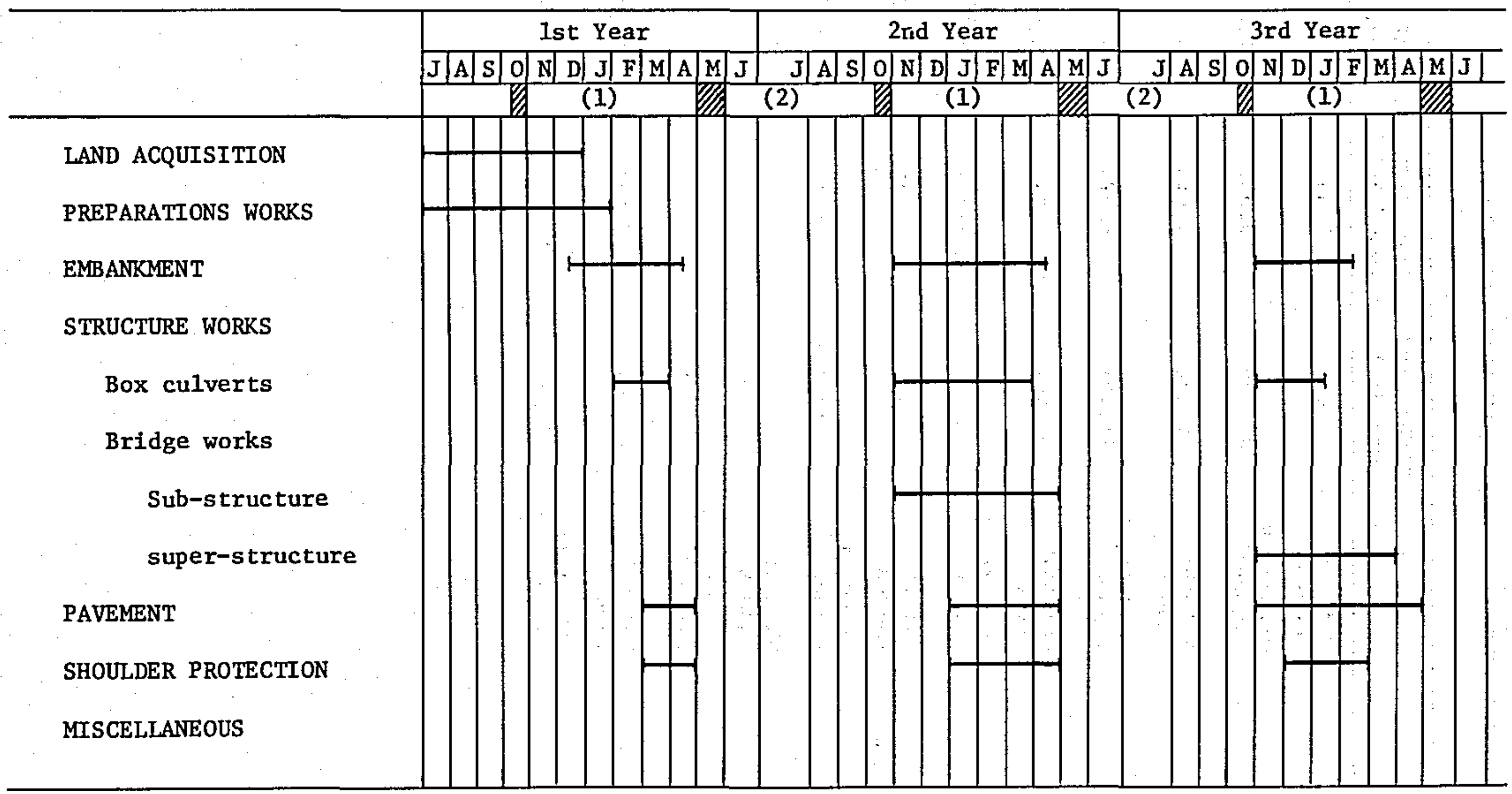
EXECUTION OF THE ROAD LINKS

Rainy season begins in June and continues through September in Bangladesh. The earthmoving from borrowpit will be performed by hand-basket labors. But in order to attain the desired percentage of moisture content by compaction, mechanical compacting equipments will be used for earth compaction. The construction of major bridges and culverts will be undertaken at the same time of the embankment. The bituminous concreting and surface course should be laid by modern mechanical methods in dry season only. Schedule of construction works is shown in Fig. 7-1. Quantity of labours, equipments, works and materials required for the road links are shown in Tables 7-1, 7-2, 7-3, 7-4, 7-5, 7-6 and 7-7.

Table 7-1 NUMBER OF LABOUR BY YEAR (TOTAL)

ITEM		RIGHT SIDE (man/day)	LEFT SIDE (man/day)	TOTAL (man/day)
EMBANKMENT	SKILLED LABOUR	685	1,061	1,746
	UN-SKILLED LABOUR	104,176	161,319	256,495
PAVEMENT	SKILLED LABOUR	46,942	35,917	82,859
	UN-SKILLED LABOUR	66,843	51,144	117,987
BOX CULVERT	SKILLED LABOUR	16,059	12,287	28,346
	UN-SKILLED LABOUR	39,928	30,549	70,477
SHOULDER PROTECT	SKILLED LABOUR	2,481	2,352	4,833
	UN-SKILLED LABOUR	9,921	9,407	19,328
MAJOR BRIDGES	SKILLED LABOUR	4,328	5,061	9,389
	UN-SKILLED LABOUR	5,328	7,782	13,110
TOTAL	SKILLED LABOUR	70,495	56,678	127,173
	UN-SKILLED LABOUR	226,196	260,201	486,397

Fig. 7-1 SCHEDULE OF CONSTRUCTION WORKS



Note: (1) Construction Season
(2) Flood Season

Table 7-2 NUMBER OF LABOUR BY YEAR (1st Year0

ITEM		RIGHT SIDE (man/day)	LEFT SIDE (man/day)	TOTAL (man/day)
EMBANKMENT	SKILLED LABOUR	211	326	537
	UN-SKILLED LABOUR	32,054	49,637	81,691
PAVEMENT	SKILLED LABOUR	7,824	5,986	13,810
	UN-SKILLED LABOUR	11,141	8,524	19,665
BOX CULVERT	SKILLED LABOUR	3,381	2,587	5,968
	UN-SKILLED LABOUR	8,406	6,431	14,837
SHOULDER PROTECT	SKILLED LABOUR	551	523	1,074
	UN-SKILLED LABOUR	2,205	2,090	4,295
MAJOR BRIDGES	SKILLED LABOUR	-	-	-
	UN-SKILLED LABOUR	-	-	-
TOTAL	SKILLED LBOUR	11,967	9,422	21,389
	UN-SKILLED LABOUR	53,806	66,682	120,488

Table 7-3 NUMBER OF LABOUR BY YEAR (2nd year)

ITEM		RIGHT SIDE (man/day)	LEFT SIDE (man/day)	TOTAL (man/day)
EMBANKMENT	SKILLED LABOUR	290	449	739
	UN-SKILLED LABOUR	44,074	68,250	112,324
PAVEMENT	SKILLED LABOUR	15,647	11,972	27,619
	UN-SKILLED LABOUR	22,281	17,048	39,329
BOX CULVERT	SKILLED LABOUR	8,452	6,467	14,919
	UN-SKILLED LABOUR	21,015	16,078	37,093
SHOULDER PROTECT	SKILLED LABOUR	1,103	1,045	2,148
	UN-SKILLED LABOUR	4,409	4,181	8,590
MAJOR BRIDGES	SKILLED LABOUR	1,229	1,438	2,667
	UN-SKILLED LABOUR	2,462	2,964	5,426
TOTAL	SKILLED LABOUR	26,721	21,371	48,092
	UN-SKILLED LABOUR	94,241	108,521	202,762

Table 7-4 NUMBER OF LABOUR BY YEAR (3rd year)

ITEM		RIGHT SIDE (man/day)	LEFT SIDE (man/day)	TOTAL (man/day)
EMBANKMENT	SKILLED LABOUR	184	286	470
	UN-SKILLED LABOUR	28,048	43,432	71,480
PAVEMENT	SKILLED LABOUR	23,471	17,959	41,430
	UN-SKILLED LABOUR	33,421	25,572	58,993
BOX CULVERT	SKILLED LABOUR	4,226	3,233	7,459
	UN-SKILLED LABOUR	10,507	8,040	18,547
SHOULDER PROTECT	SKILLED LABOUR	827	784	1,611
	UN-SKILLED LABOUR	3,307	3,136	6,443
MAJOR BRIDGES	SKILLED LABOUR	3,099	3,623	6,722
	UN-SKILLED LABOUR	2,866	4,818	7,684
TOTAL	SKILLED LABOUR	31,807	25,885	57,692
	UN-SKILLED LABOUR	78,149	84,998	163,147

Table 7-5 NUMBER OF CONSTRUCTION EQUIPMENT BY YEAR

(Unit: Number)

ITEM	1st year			2nd year			3rd year			TOTAL
	Right side	Left side	Total	Right side	Left side	Total	Right side	Left side	Total	
Tire roller	4	5	9	4	5	9	2	3	5	9
5 ton bull dozer	2	2	4	2	2	4	-	-	-	4
Motor grade 3.7m type	2	2	4	4	4	8	4	4	8	8
Water spray	2	2	4	2	2	4	2	2	4	4
5 ton dump track	-	-	-	5	5	10	5	5	10	10
Soil mixing plant	-	-	-	2	2	4	2	2	4	4
Hot mixing plant	-	-	-	1	1	2	1	1	2	2
Mac'adam roller	2	2	4	5	5	10	5	5	10	10
Concrete mixing	2	1	3	2	1	3	2	1	3	3

Table 7-6 QUANTITY OF WORKS BY YEAR

ITEM	UNIT		1st year	2nd year	3rd year	TOTAL
LAND ACQUISTION	m^2	Right Side	483,847			483,847
		Left Side	611,118			611,118
EMBANKMENT	m^3	Right Side	72,652	99,897	63,570	236,119
		Left Side	112,504	154,692	98,441	365,637
PAVEMENT						
6" Sand Sub-base	m^2	Right Side	31,213	62,426	93,639	187,278
		Left Side	23,882	47,764	71,645	143,291
9" Water bound Mac'adam	m^3	Right Side	15,261	30,521	45,782	91,564
		Left Side	11,676	23,353	35,029	70,058
4-1/2" Brick on Edge	m^2	Right Side	11,098	22,197	33,295	66,590
		Left Side	8,492	16,983	25,475	50,950
3" Brick Flat 2-1/2" Bituminous Concrete 1/2" Surface 3" Brick on End	m^2	Right Side	26,357	52,714	79,070	158,141
		Left Side	20,166	40,332	60,499	120,997
	R.m	Right Side	2,276	4,551	6,827	13,654
		Left Side	1,741	3,482	5,224	10,447
BOX CULVERT	R.m	Right Side	155	287.5	143.7	546.2
		Left Side	88	219.9	110	417.9
SHOULDER PROTECT	m^2	Right Side	27,556	55,112	41,333	124,001
		Left Side	26,130	52,261	39,196	117,587
MISCELLANEOUS	m	Right Side			13,654	13,654
		Left Side			10,447	10,447

Table 7-7-1 QUANTITY OF CONSTRUCTION MATERIALS

ITEM	UNIT	1st year	2nd year	3rd year	TOTAL
PAVEMENT					
Sand	m^3	14,970	29,950	44,930	89,850
Brick	nos	5,313,900	10,627,700	15,941,500	31,883,100
Stone chip	m^3	2,400	4,800	7,200	14,400
Bitumen	ton	483	967	1,450	2,900
Coal	ton	98	195	293	586
BOX CULVERT					
Sand	m^3	4,750	11,870	5,930	22,550
Brick	nos	55,900	135,700	69,800	265,400
Stone chip	m^3	205	512	256	973
Cement	ton	1,320	3,299	1,649	6,268
Reinforce rods	ton	733	1,832	916	3,481
SHOULDER PROTECT					
Sand	m^3	1,450	2,900	2,180	6,530
Brick	nos	87,200	174,300	130,700	392,200
NO. 1 BRIDGE					
Portlandcement	ton	-	360	90	450
Admixture	kg	-	760	420	1,180
Fine aggregate	cu.m	-	430	230	660
Coarse aggregate	cu.m	-	720	400	1,120
Form area	sq.m	-	780	2,860	3,640
Excavation for structure	cm.m	-	1,600	-	1,600
Deformed steel ber	ton	-	75	45	120
Brick	nos	-	32,000	-	32,000
H.E.S. cement	ton	-	-	150	150
Prestreeing tendon	ton	-	-	18	18
Erection work	ton	-	-	835	835

Table 7-7-2 QUANTITY OF CONSTRUCTION MATERIALS

ITEM	UNIT	1st year	2nd year	3rd year	TOTAL
NO. 2 BRIDGE					
Portland cement	ton	-	420	110	530
Admixture	kg	-	900	550	1,450
Fine aggregate	cu.m	-	510	310	820
Coarse aggregate	cu.m	-	840	530	1,370
Form area	sq.m	-	960	4,000	4,960
Excavation for structure	cm,m	-	2,000	-	2,000
Deformed steel ber	ton	-	91	63	154
Brick	nos	-	35,900	-	35,900
H.E.S. cement	ton	-	-	210	210
Prestressing tendon	ton	-	-	24	24
Erection work	ton	-	-	1,170	1,170

CHAPTER VIII

CONSTRUCTION COSTS & MAINTENANCE COSTS

1. Construction Costs.

Construction unit costs for each work are shown in Table 8-1 and estimated total construction cost and construction costs by year are shown in Tables 8-2, 8-3, 8-4 and 8-5.

Table 8-1 UNIT COSTS

ITEM	UNIT	UNIT COST
LAND ACQUISITION	TK/1 acre	33,000
EMBANKMENT		
Earth Work by Borrowed Earth	TK/100 m^3	785.1
Earth Work by Carted Earth	TK/100 m^3	1,391.65
PAVEMENT		
6" Sand Sub-Base	TK/100 m^2	925.5
3" Brick Flat	TK/100 m^2	2,170.1
9" Water Bound Mac'Adam	TK/100 m^2	7,128
2-1/2" Bituminous Concrete	TK/100 m^2	4,065.9
1/2" Surface	TK/100 m^2	964.1
4-1/2" Brick on Edge	TK/100 m^2	4,430.1
3" Brick on End	TK/100 m	1,362
SHOULDER PROTECT	TK/100 m^2	122
SURFACE PAINTING	TK/100 m^2	2,437.4
BOX CULVERT	R, M	23,459.9
MISCELLANEOUS	R, M	91,450.5

Table 8-2. TOTAL CONSTRUCTION COSTS OF THE ROAD LINKS

(NOTE) T,C,C, : Total construction cost
F,C, : Foreign currency
L,C, : Local currency
(10^3 KT)

W O R K S	RIGHT SIDE			LEFT SIDE			TOTAL		
	T,C,C	F,C	L,C	T,C,C	F,C	L,C	T,C,C	F,C	L,C
LAND ACQUISITION	3,945	-	3,945	4,983	-	4,983	8,928	-	8,928
EMBANKMENT	1,854	11	1,843	2,871	17	2,854	4,725	28	4,697
BOX CULVERT	12,814	9,785	3,029	9,804	7,486	2,318	22,618	17,271	5,347
BRIDGE WORKS Sub-structure	2,466	948	1,518	2,917	1,052	1,865	5,383	2,000	3,383
Super-structure	2,677	1,266	1,411	3,490	1,622	1,868	6,167	2,888	3,279
PAVEMENT	22,783	2,791	19,992	17,432	2,136	15,296	40,215	4,927	35,288
SHOULDER PROTECT	295	-	295	279	-	279	574	-	574
MISCELLANEOUS	1,249	-	1,249	955	-	955	2,204	-	2,204
TOTAL	48,083	14,801	33,282	42,731	12,313	30,418	90,814	27,114	63,700

Table 8-3 CONSTRUCTION COSTS OF THE ROAD LINKS BY YEAR

(1st year)

(NOTE) T,C,C, : Total construction cost
F,C, : Foreign currency
L,C, : Local currency
(10^3 TK)

WORKS	RIGHT SIDE			LEFT SIDE			TOTAL		
	T,C,C	F,C	L,C	T,C,C	F,C	L,C	T,C,C	F,C	L,C
LAND ACQUISITION	3,945	-	3,945	4,983	-	4,983	8,928	-	8,928
EMBANKMENT	571	3	568	883	5	878	1,454	8	1,446
BOX CULVERT	2,698	2,060	638	2,064	1,576	488	4,761	3,636	1,126
BRIDGE WORKS Sub-structure	-	-	-	-	-	-	-	-	-
Super-structure	-	-	-	-	-	-	-	-	-
PAVEMENT	3,797	465	3,332	2,905	356	2,549	6,702	821	5,881
SHOULDER PROTECT	66	-	66	62	-	62	128	-	128
MISCELLANEOUS	-	-	-	-	-	-	-	-	-
TOTAL	11,077	2,528	8,549	10,897	1,937	8,960	21,974	4,465	17,509

Table 8-4 CONSTRUCTION COSTS OF THE ROAD LINKS BY YEAR

(2nd Year)

(NOTE) T,C,C, : Total construction cost
F,C, : Foreign currency
L,C, : Local currency

(10^3 TK)

WORKS	RIGHT SIDE			LEFT SIDE			TOTAL		
	T,C,C	F,C	L,C	T,C,C	F,C	L,C	T,C,C	F,C	L,C
LAND ACQUISITION	-	-	-	-	-	-	-	-	-
EMBANKMENT	784	5	779	1,215	7	1,208	1,999	12	1,987
BOX CULVERT	6,744	5,150	1,594	5,160	3,940	1,220	11,904	9,090	2,814
BRIDGE WORKS Sub-structure	2,466	948	1,518	2,917	1,052	1,865	5,383	2,000	3,383
Super-structure	-	-	-	-	-	-	-	-	-
PAVEMENT	7,594	930	6,664	5,811	712	5,099	13,405	1,642	11,763
SHOULDER PROTECT	131	-	131	124	-	124	255	-	255
MISCELLANEOUS	-	-	-	-	-	-	-	-	-
TOTAL	17,719	7,033	10,686	15,227	5,711	9,516	32,946	12,744	20,202

Table 8-5 CONSTRUCTION COSTS OF THE ROAD LINKS BY YEAR

(3rd year)

(NOTE) T,C,C, : Total construction cost
F,C, : Foreign currency
L,C, : Local currency

(10^3 TK)

W O R K S	RIGHT SIDE			LEFT SIDE			TOTAL		
	T,C,C	F,C	L,C	T,C,C	F,C	L,C	T,C,C	F,C	L,C
LAND ACQUISITION	-	-	-	-	-	-	-	-	-
EMBANKMENT	499	3	496	773	5	768	1,272	8	1,264
BOX CULVERT	3,372	2,575	797	2,580	1,970	610	5,952	4,545	1,407
BEIDGE WORKS Sub-structure	-	-	-	-	-	-	-	-	-
Super-structure	2,677	1,266	1,411	3,490	1,622	1,868	6,167	2,888	3,279
PAVEMENT	11,392	1,396	9,996	8,716	1,068	7,648	20,108	2,464	17,644
SHOULDER PROTECT	98	-	98	93	-	93	191	-	191
MISCELLANEOUS	1,249	-	1,249	955	-	955	2,204	-	2,204
TOTAL	19,287	5,240	14,047	16,607	4,665	11,942	35,894	9,905	25,989

2. Maintenance Works and Their Costs.

2.1. Maintenance works.

The maintenance works classified as follows:

a) Surface painting works at intervals of 2 years,

b) Surface dressing works at intervals of 5 years, and

c) Repaving works at intervals of 10 years.

The maintenance works for the projected road links were assumed referring to those in the Khulna-Mongla Road Project.

Road Sections for maintenance works are 13,754 m for the right side road 10,582 m for the left side road, totaling 24,336 m.

Number of labours and quantity of materials required for the maintenance works are shown in Tables 8-6 and 8-7.

Table 8-6 NUMBER OF LABOURS

Unit: Man

Work items	man/km	Right side	Left side	Total
Surface Painting	497	6,836	5,259	12,095
Surface Dressing	746	10,260	7,894	18,154
Repaving	2,119	29,144	22,423	51,567

Table 8-7 QUANTITY OF MATERIALS FOR MAINTENANCE WORKS

Work items	Quantity/km	Unit	Right side	Left side	Total
Surface Painting					
Sand	70.4	m^3	968	745	1,713
Bitumen	7.15	ton	98	76	174
Coal	1.62	ton	22	17	39
Surface dressing					
Sand	176.0	m^3	2,400	1,862	4,282
Bitumen	17.71	ton	244	187	431
Coal	3.73	ton	51	39	90
Repaving					
Stone chips	424	m^3	5,831	4,487	10,318
Sand	274	m^3	3,397	2,613	6,010
Bitumen	59	ton	811	624	1,435
Coal	11.8	ton	162	125	287

2.2. Maintenance costs.

Unit costs of the maintenance works were calculated as shown in Table 8-8 based on the above mentioned maintenance works, number of labours, quantity of materials and the unit prices as of July 1975.

Table 8-8 Unist Cost

(TK)

Work items	Direct cost	General charge	Unit cost
Surface Painting	41,706.8	1,043.2	42,750
Surface Dressing	143,737.4	3,562.6	147,300
Repaving	439,076.4	10,973.6	450,050

Maintenance costs were thus estimated as shown in Table 8-9.

Table 8-9 Maintenance Costs

(10^3 TK)

Work items	Right side	Left side	Total
Surface Painting	588	452	1,040
Surface Dressing	2,026	1,559	3,585
Repaving	6,189	4,762	10,951

Miscellaneous costs for 30 years will be added to above maintenance cost.

APPENDICES

APPENDIX A

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APPENDIX B

GEOMETRIC DESIGN STANDARDS OF RURAL ROADS IN BANGLADESH

1. Basic Principles.

The terrain of Bangladesh is mostly flat excepting some hilly areas in the east and south eastern part of the country. The plains get innundated by monsoon floods necessitating construction of high roadway embankments. These conditions greatly influence the design standards of roads in this country. Uniform application of design standards is most desirable here. In road planning the aim is to apply the minimum standards on short range basis since high level of standards the country cannot afford at this stage.

2. Classification of Roads.

The road system has been classified into three different categories in consideration of traffic service and importance. These classifications are as under:-

(a) Primary roads:-

Roads connecting the district HQs with the Metropolis come under this category. These roads have 40'ft wide roadway embankment and 22'ft wide hard crest with or without brick paved shoulders.

(b) Secondary roads:-

Roads connecting Sub-divisional HQs with district HQs or primary roads come under this category. The secondary roads have 32'ft wide roadway embankment and 18' ft wide pavement.

(c) Feeder roads:-

Roads connecting business centers, industrial centers, places of importance inaccessible areas etc. with primary and secondary roads come under this category. Feeder roads have 24'ft. wide roadway embankment and 12'ft wide pavement.

3. Design Speeds.

The design speed is 60 MPH for rural areas, 50 MPH for Urban and 40 MPH in special cases where existing structures control.

4. Running Speeds.

The running speeds are 45 MPH, 40 MPH and 34 MPH corresponding to design speeds, of 60 MPH, 50 MPH and 40 MPH respectively.

5. Radius of Curvature.

The radic of curvature are 1,146 ft, 754 ft and 430 ft corresponding to design speeds, of 60 MPH, 50 MPH and 40 MPH respectively.

6. Max$^{\underline{m}}$. Degree of Curvature.

The max$^{\underline{m}}$ degrees of curvature corresponding to the above noted radic of curvature are 5.0°, 7.6° and 12.4°.

7. Grades.

The grades provided to roads vary from 0% to 3.0% max$^{\underline{m}}$.

8. Passing Sight Distance.

Passing sight distances provided to roads are 2,000 ft., 1700 ft and 1,300 ft corresponding to design speeds of 60 MPH, 50 MPH and 40 MPH respectively.

9. Stopping Sight Distance.

The following stopping sight distances are provided assuming height of eye as 44 inches and height of object as 4 inches.

475	ft	for design	speed of	60 MPH
350	"	"	"	50 MPH
40	"	"	"	40 MPH

10. Cross Slope. -- 3/4" inch both ways with parabolic crown.

11. Extra with on Curves.

Over 11° only.

For 60 MPH - not rgd.
50 MPH - not required
40 MPH - 2'ft for R(520' ft)

12. Superelevation.

1. inch in one foot $(e = 0.8)_{max}\,\underline{m}$
No, crown for the stated design speeds.

13. Embankment side slopes

2 in 1

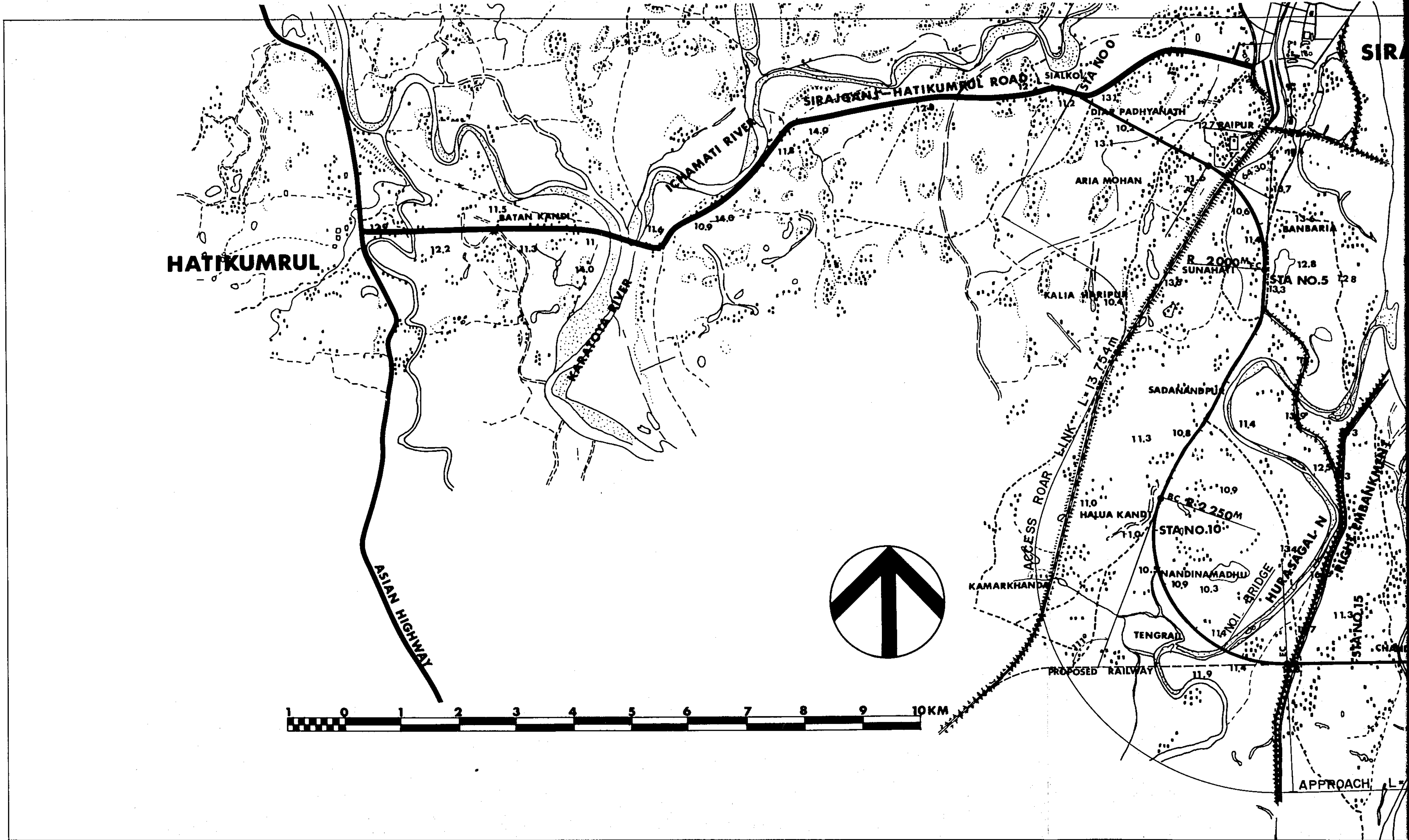
14. Embankment Slope Protection.

Turfing in normal cases and encased brick rivetment in high approaches of bridges and culverts.

Soil stabilisation Methods.

The soils in Bangladesh very from sandy clay to silty clay. These soils usually from a good embankment material and do not usually require stabilisation. However, where a bad soil is encountered th top layer of sub-grade of 2'ft in thickness is adequately mixed up with sand and duly compacted.

Superintending Engineer (R&H),
Road Planning Circle, Dacca.


HATIKUMRUL
SIRAJGANJ—HATIKUMRUL ROAD
ICHAMATI RIVER
KARATOYA RIVER
ASIAN HIGHWAY
BATAN KANDI
SIALKOL
STA NO 0
DIAR PADHYANATH
RAIPUR
ARIA MOHAN
BANBARIA
SUNAHATI
STA NO.5
R 2000M
KALIA HARIPUR
SADANANDPUR
ACCESS ROAR LINK L=13.754m
HALUA KANDI
STA NO.10
R 2250M
NANDINAMADHU
KAMARKHANDA
TENGRAIL
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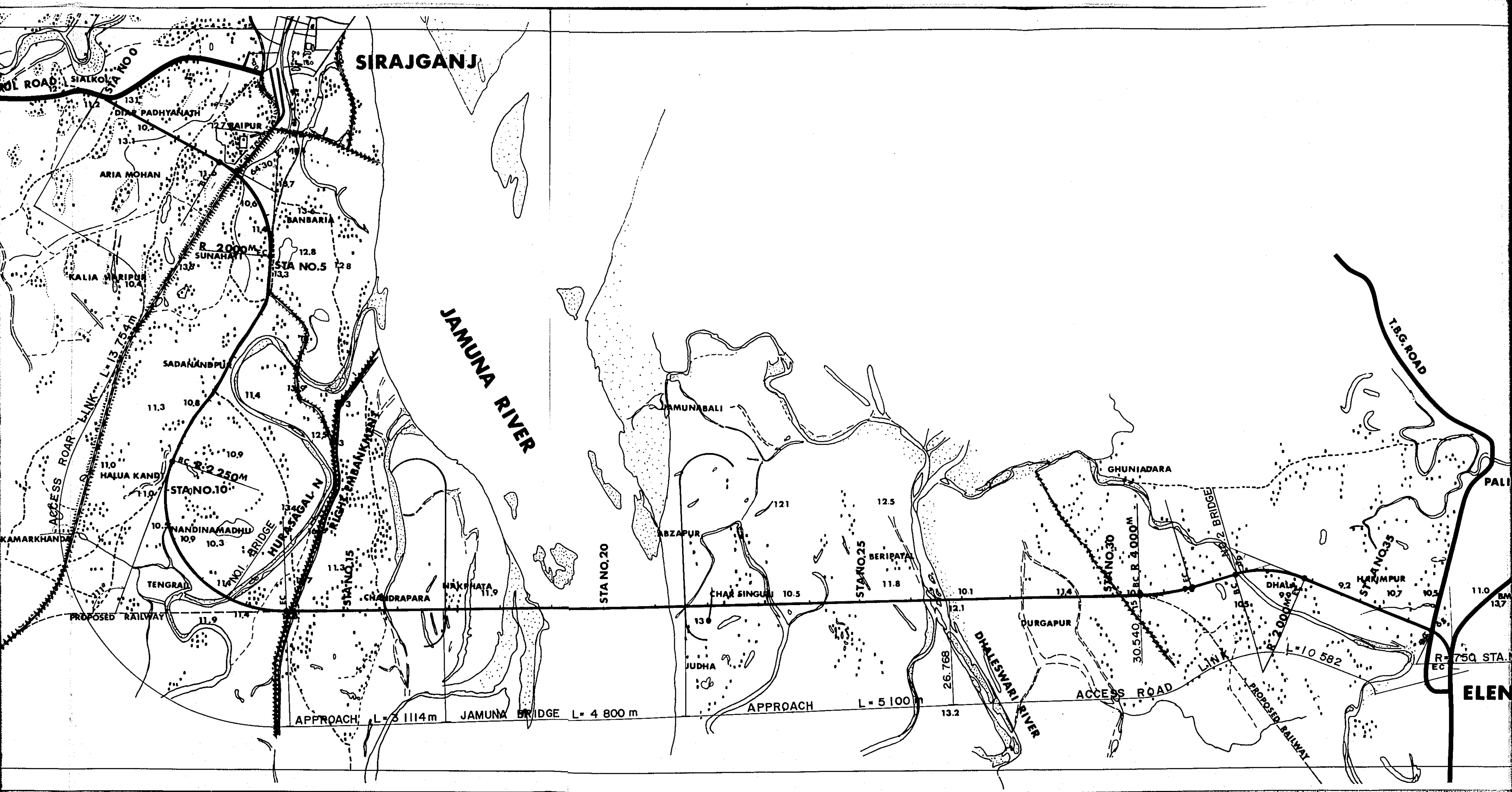
NOI BRIDGE
RIGHT EMBANKMENT
STA NO.15
PROPOSED RAILWAY
APPROACH
1 0 1 2 3 4 5 6 7 8 9 10KM


SIRAJGANJ
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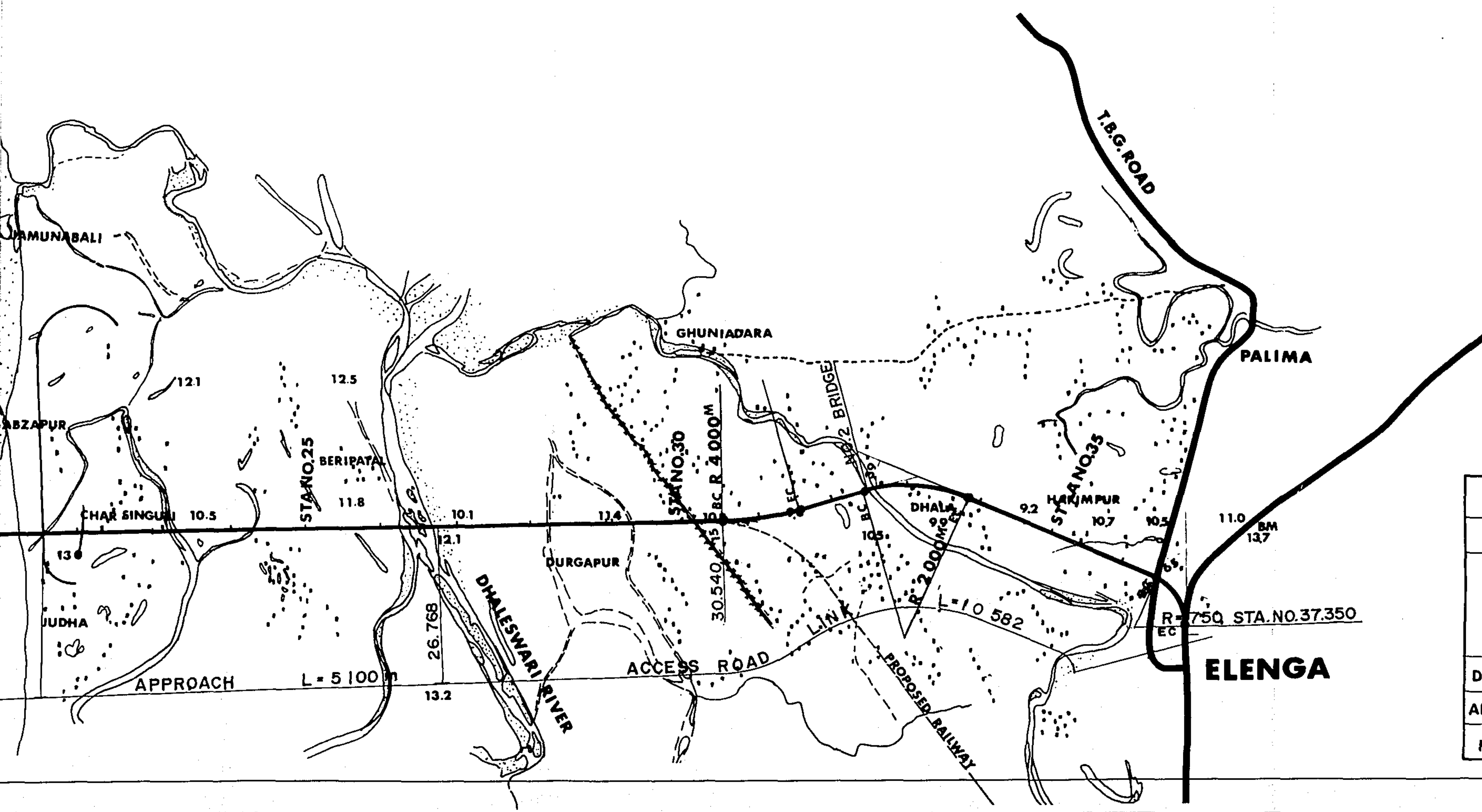
STA NO.5
KALIA HARIPUR
ACCESS ROAR LINK L=13 754m
SADANANDPUR
JAMUNA RIVER
RIGHT EMBANKMENT
HURASAGAL N
HALUA KANDI
R 2250M
STA NO.10
NANDINAMADHU
NO.1 BRIDGE
KAMARKHANDA
TENGRAIL
PROPOSED RAILWAY
STA NO.15
CHANDRAPARA
NAKPHATA
APPROACH L=3 1114m
JAMUNA BRIDGE L=4 800 m
STA NO.20
JAMUNABALI
ABZAPUR
CHAR SINGULI
JUDHA
STA NO.25
BERIPATAL
APPROACH L=5 100m
26.768
DHALESWARI RIVER
DURGAPUR
STA NO.30
30.540.15
R 4000M
GHUNIADARA
NO.2 BRIDGE
DHALA
R 2000M
HARIMPUR
STA NO.35
ACCESS ROAD LINK L=10 582
PROPOSED RAILWAY
T.B.G. ROAD
R=750 STA
ELEN
PALI



JAPAN INTERNATIONAL COOPERATION AGENCY	
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JAMUNA RIVER BRIDGE CONSTRUCTION PROJECT SIRAJGANJ SITE ACCES ROAD LINK HORIZONTAL ALIGNMENT	
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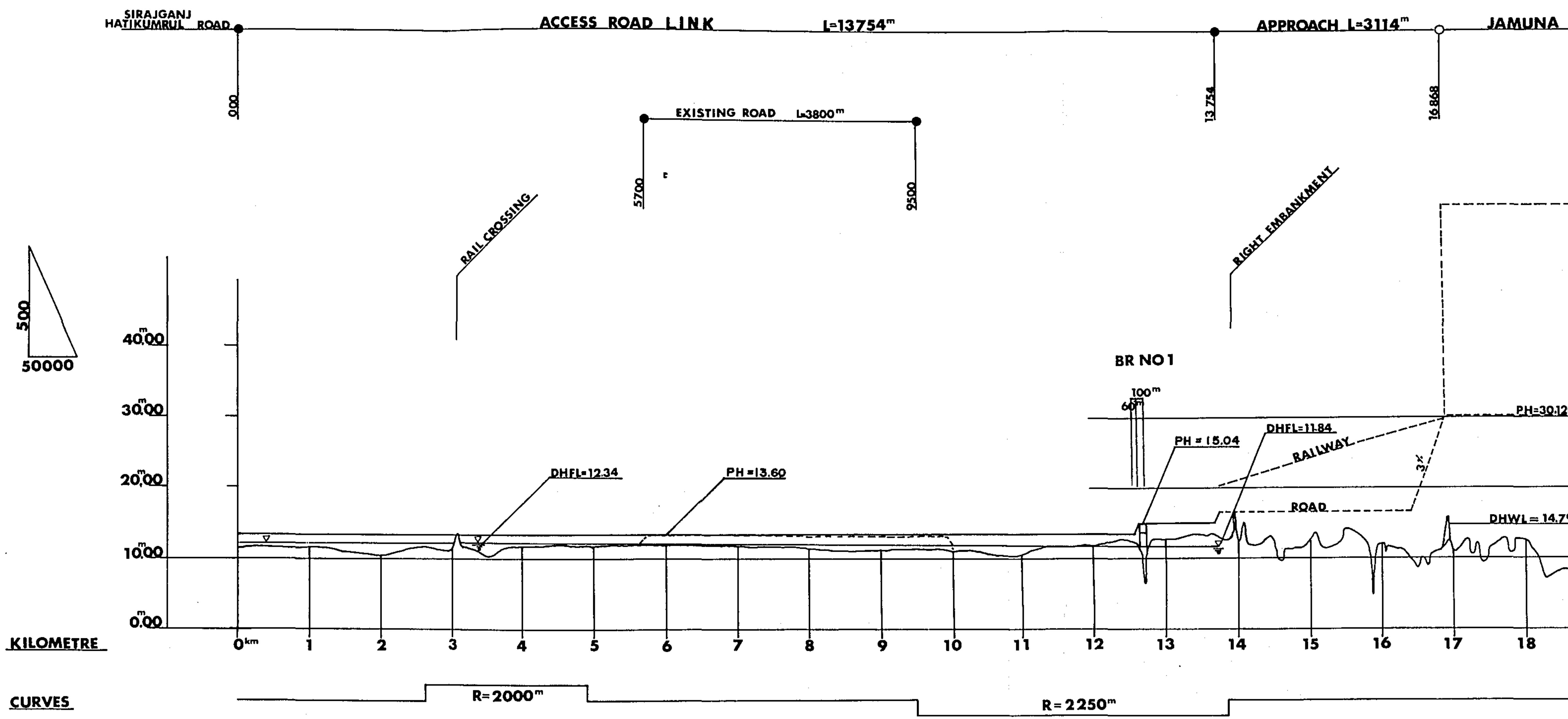
APPROVED	DATE
MITSUI CONSULTANTS CO., LTD.	FIG


SIRAJGANJ
HATIKUMRUL ROAD
ACCESS ROAD LINK
L=13754m
APPROACH L=3114m
JAMUNA
0.00
13.754
16.868
EXISTING ROAD L=3800m
5700
9500
RAIL CROSSING
RIGHT EMBANKMENT
500
50000
40.00
30.00
20.00
10.00
0.00
BR NO1
100m
60m
PH=30.12
PH = 15.04
DHFL=11.84
RAILWAY
3%
ROAD
DHWL = 14.79
DHFL=12.34
PH =13.60
KILOMETRE
0km
1
2
3
4
5
6
7
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13
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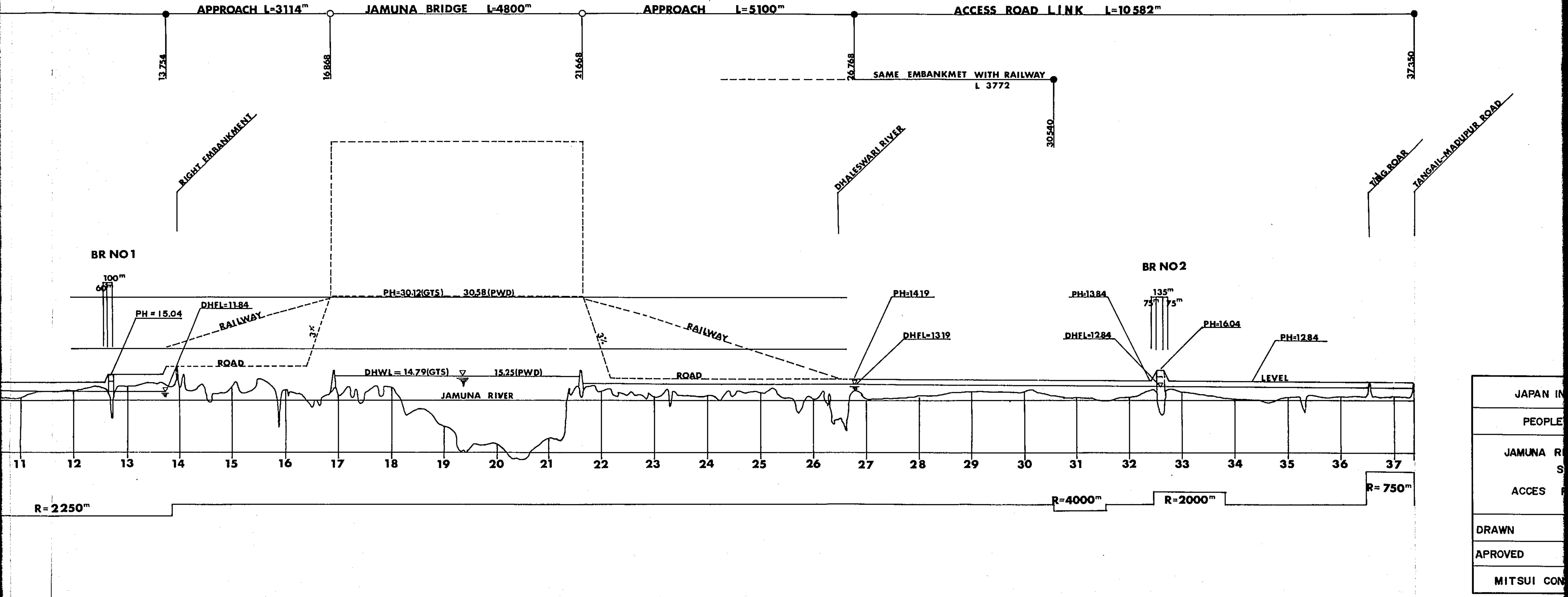

APPROACH L=3114m
JAMUNA BRIDGE L=4800m
APPROACH L=5100m
ACCESS ROAD LINK L=10582m
13754
16868
21668
26768
37350
SAME EMBANKMET WITH RAILWAY
L 3772
30540
RIGHT EMBANKMENT
DHALESWARI RIVER
TANGAIL-MADUPUR ROAD
BR NO1
100m
60m
PH=30.12(GTS) 30.58(PWD)
PH = 15.04
DHFL=11.84
RAILWAY
3%
ROAD
DHWL= 14.79(GTS) 15.25(PWD)
JAMUNA RIVER
RAILWAY
3%
ROAD
PH=1419
DHFL=1319
BR NO2
PH=1384
135m
75m 75m
DHFL=1284
PH=1604
PH=1284
LEVEL
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
R=2250m
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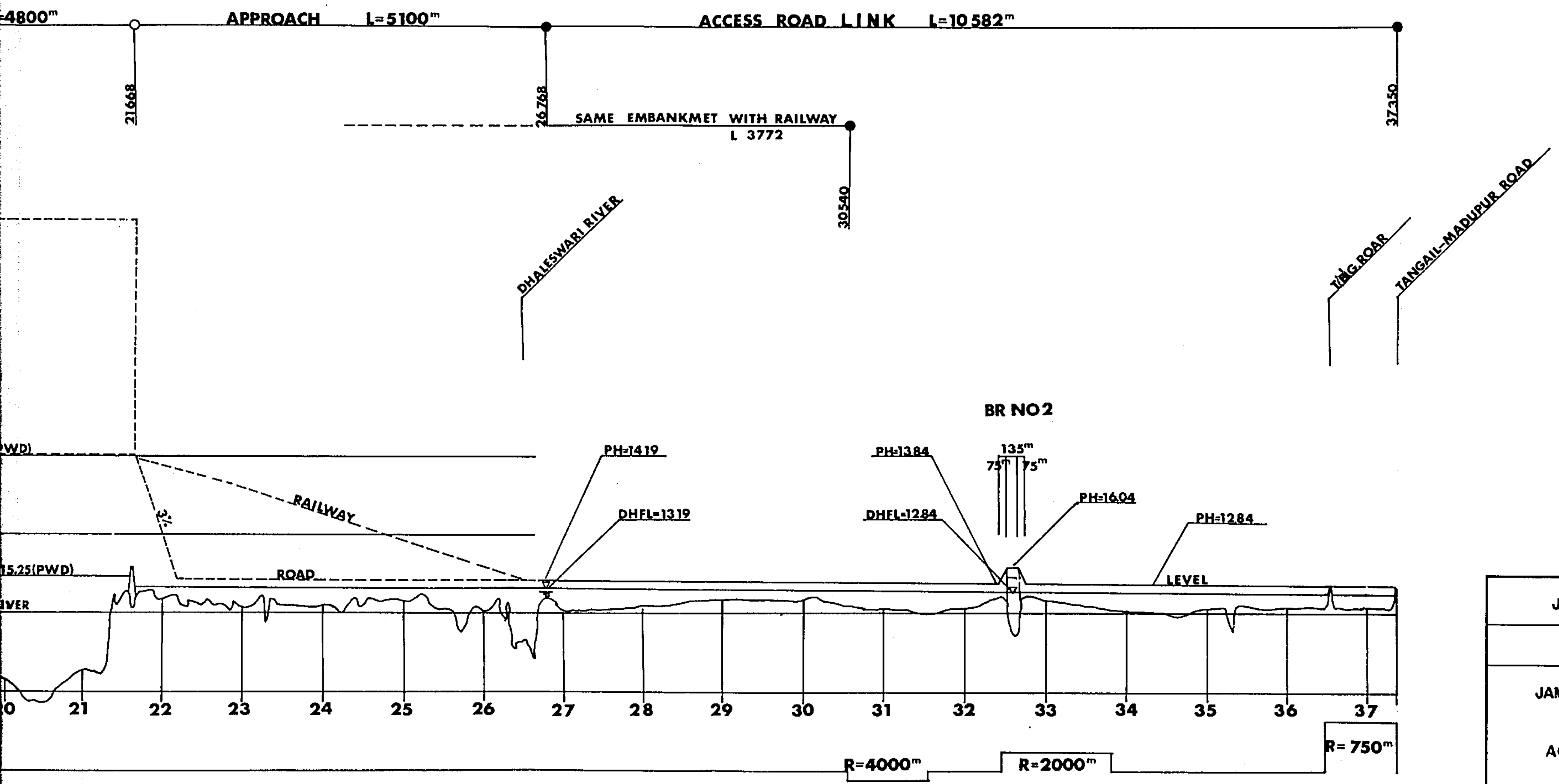

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APPENDIX D ROAD BRIDGE NO.1

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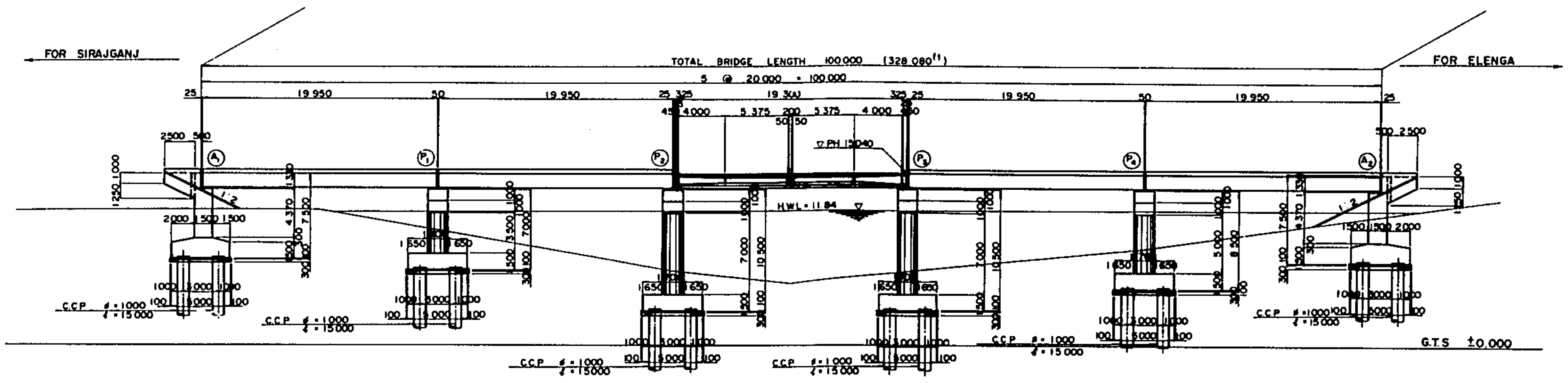

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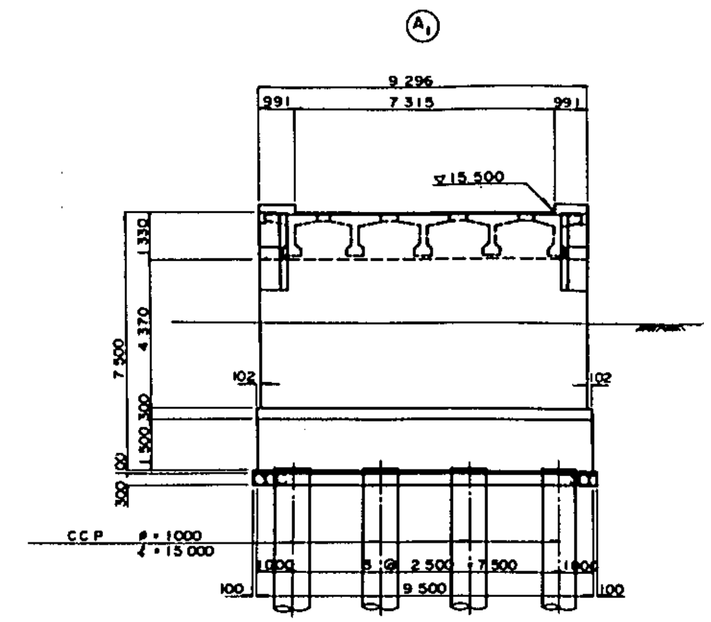

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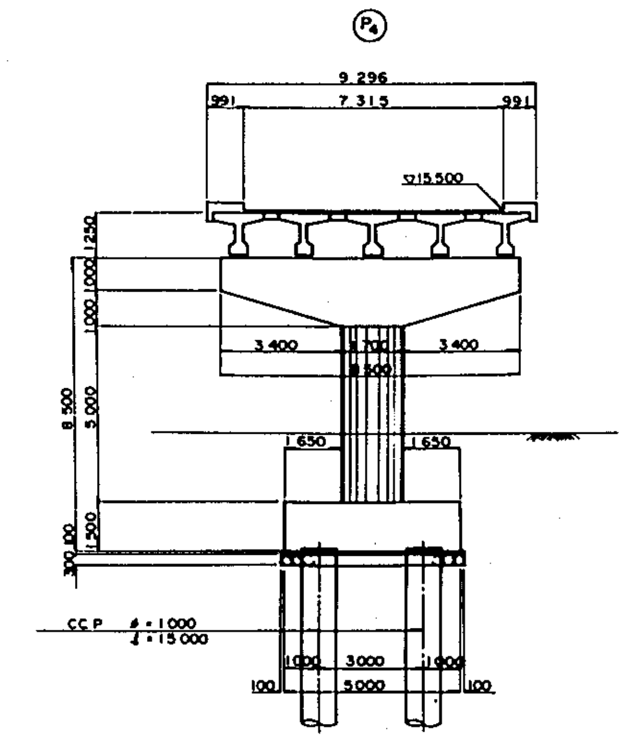

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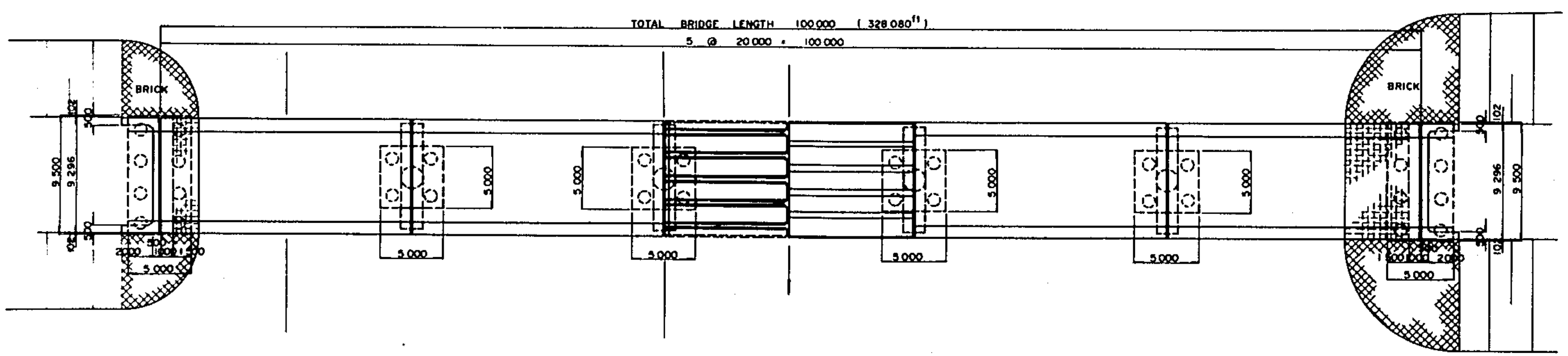

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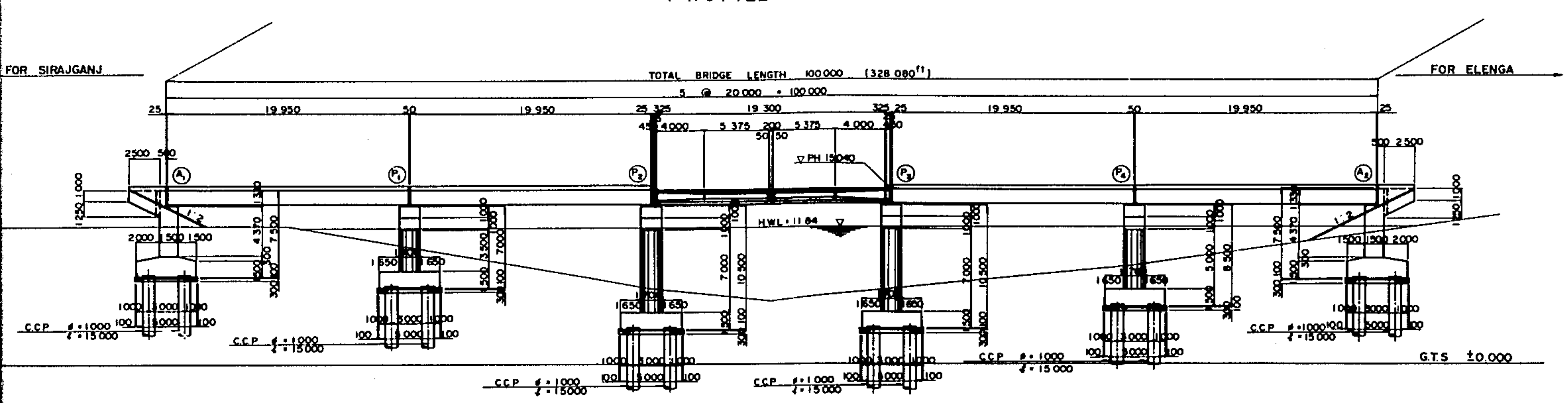

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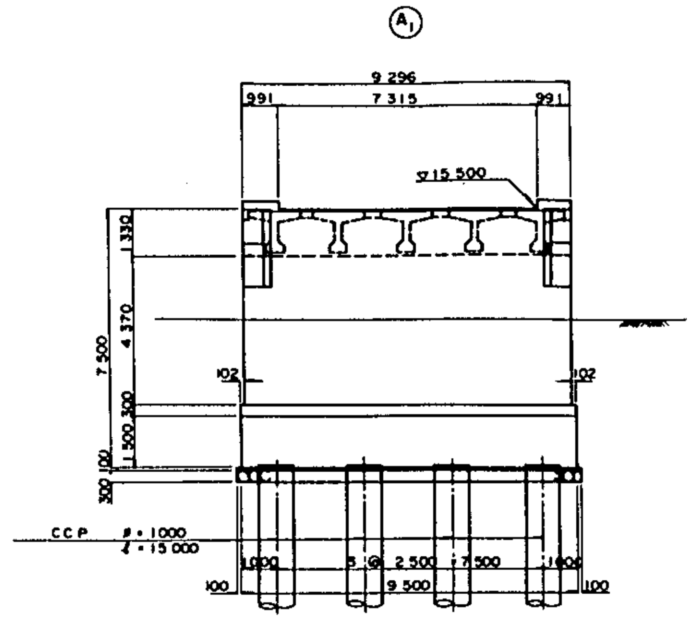

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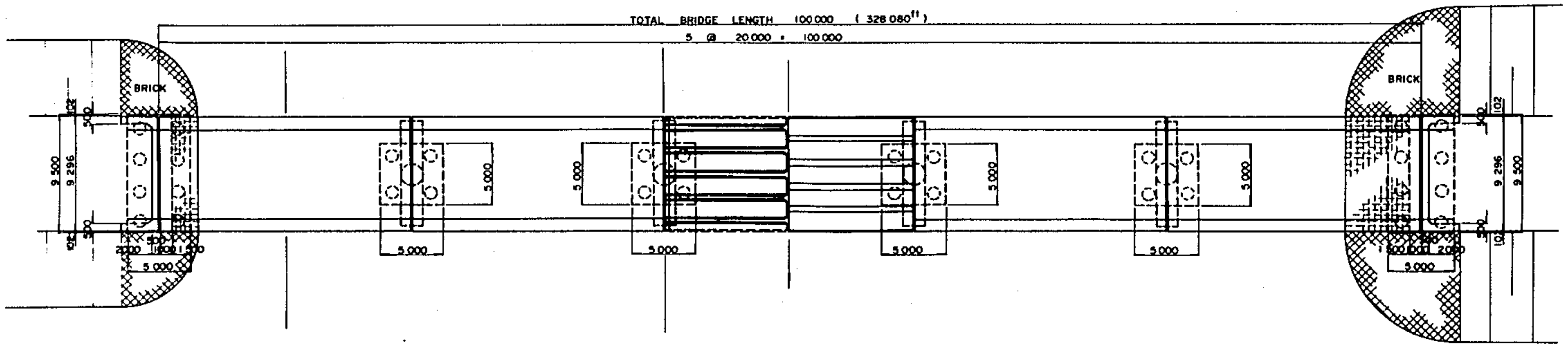

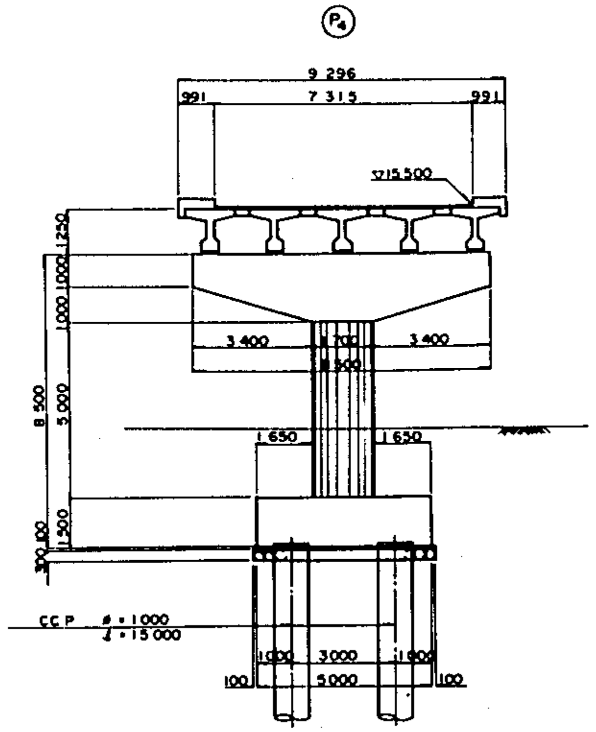

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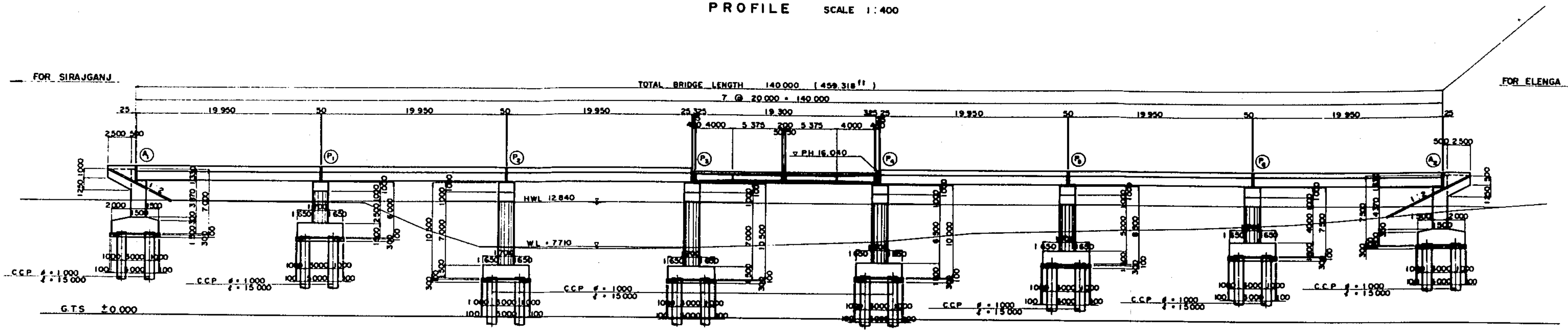

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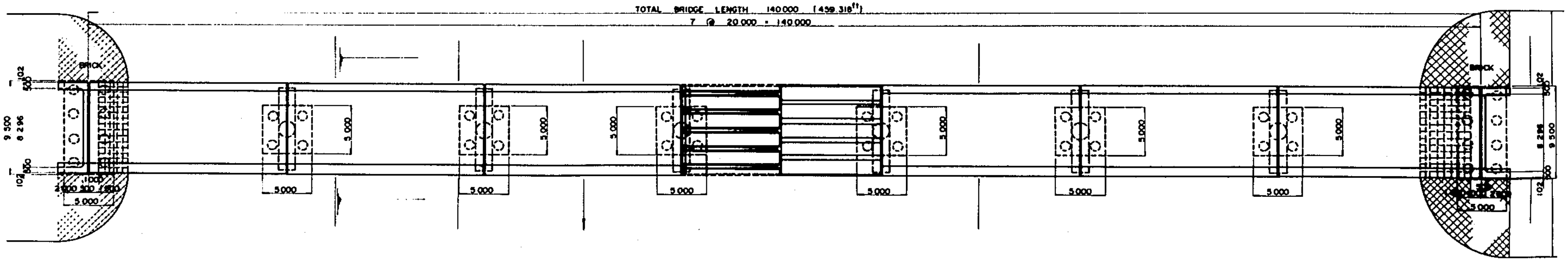

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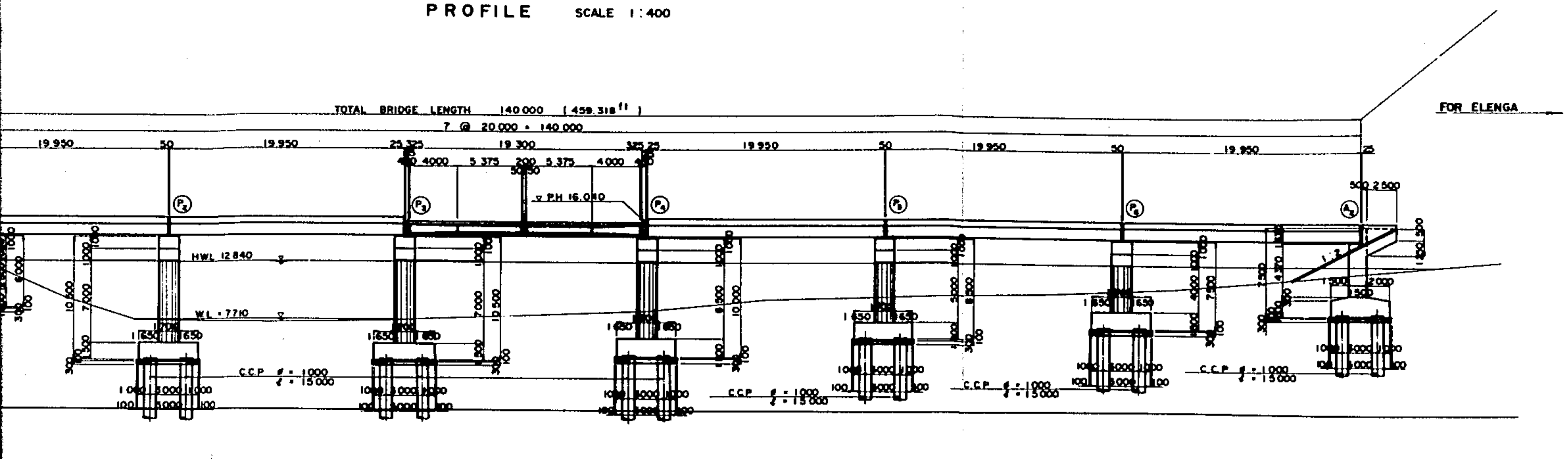

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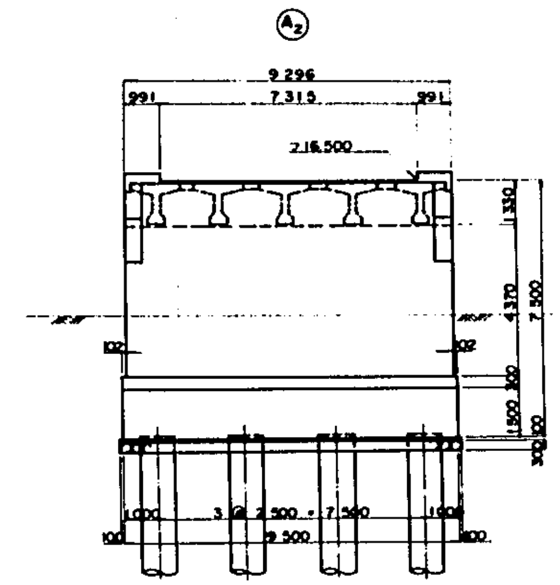

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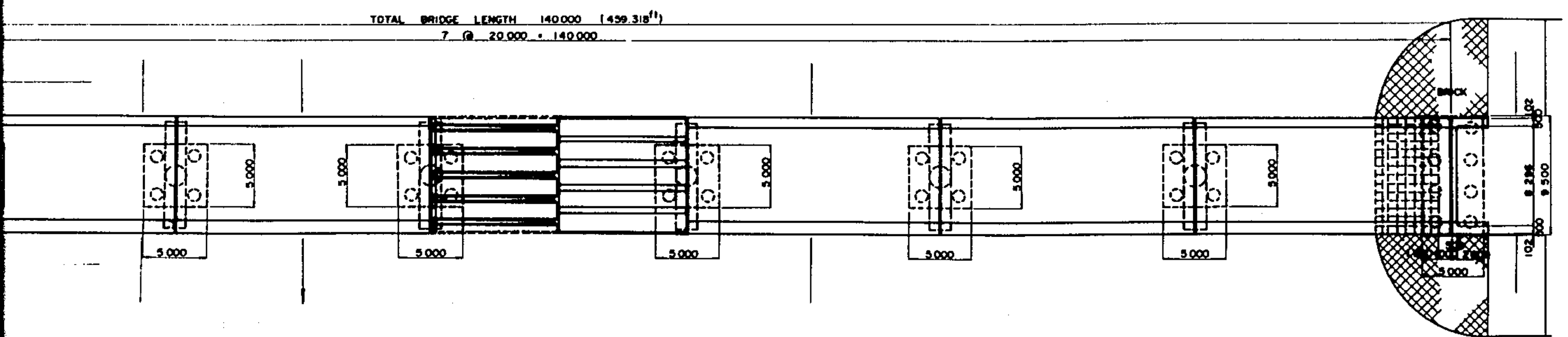

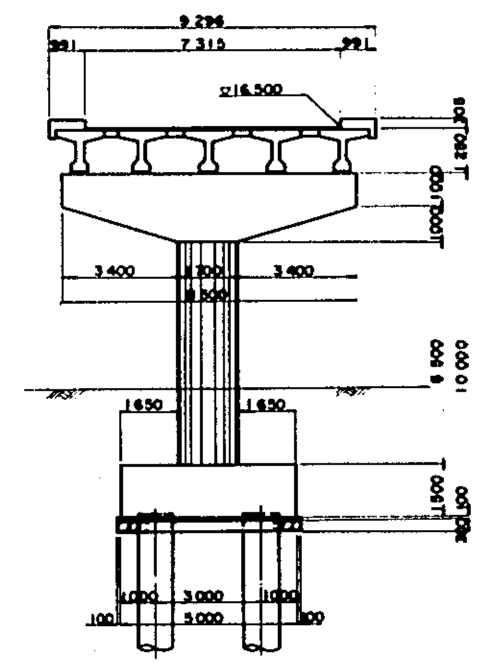

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