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ABBREVIATIONS USED

IN

BASIC DESIGN STUDY REPORT

A. Authorities and Agencies

JICA	:	Japan International Cooperation Agency
RHD	:	Roads and Highway Department, Roads and Road Transport Division, Ministry of Communications
RRTD	:	Roads and Road Transportation Division, Ministry of Communications
MOC	:	Ministry of Communications
PWD	:	Public Works Department
ERD	:	External Resources Division, Ministry of Finance
BBS	:	Bangladesh Bureau of Statistics
ADB	:	Asian Development Bank
IDA	:	International Development Association
UNDP	:	United Nations Development Programme

B. Other Abbreviations

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society for Testing and Material
B/D	:	Basic Design
BS	:	British Standards
D/D	:	Detailed Design
EL	:	Elevation
E/N	:	Exchange of Notes
F/S	:	Feasibility Study
GDP	:	Gross Domestic Product

GNP	:	Gross National Product
Government	:	The People's Republic of Bangladesh
HHWL	:	Highest High Water Levels
IRC	:	Indian Road Congress
JIS	:	Japan Industrial Standard
LL	:	Liquid Limit
LLWL	:	Lowest Low Water Levels
LWL	:	Low Water Levels
MSL	:	Mean Sea level
MWL	:	Mean Water Level
N	:	N-Value
NP	:	None Plastic
OD	:	Origin and Destination
PC	:	Prestressed Concrete
PL	:	Plastic Limit
RC	:	Reinforced Concrete
RCD	:	Reverse Circulation Drill
rd	:	Dry Density
rt	:	Wet Density
SHWL	:	Standard High Water Levels
STA	:	Station
UK	:	United Kingdom

GNP	:	Gross National Product
Government	:	The People's Republic of Bangladesh
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IRC	:	Indian Road Congress
JIS	:	Japan Industrial Standard
LL	:	Liquid Limit
LLWL	:	Lowest Low Water Levels
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MSL	:	Mean Sea level
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RC	:	Reinforced Concrete
RCD	:	Reverse Circulation Drill
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rt	:	Wet Density
SHWL	:	Standard High Water Levels
STA	:	Station
UK	:	United Kingdom

CHAPTER 1 : INTRODUCTION

CHAPTER 1 INTRODUCTION

In response to the request of the Government of the People's Republic of Bangladesh (hereinafter called the "Government"), the Government of Japan decided to conduct a basic design study on the project for Constructing Meghna-Gumti Bridge (hereinafter called the "Project"), and entrusted the study to the Japan International Cooperation Agency (hereinafter called "JICA").

JICA sent a basic design study team (hereinafter called the "Study Team") headed by Mr. Masaaki Tatsumi, Director, First Design Division, Design Department, Honshu-Shikoku Bridge Authority to Bangladesh from May 17 to June 30, 1990 (refer to Appendix 1.1) to carry out the Study.

In Bangladesh the Study Team had a series of discussions on the Project with the officials concerned of the Government and conducted a field survey at the Project Site.

As a result of the Study in Bangladesh, both parties agreed to recommend to their respective governments that the major points of understanding reached between them (refer to Appendix 1.2), should be examined toward the realisation of the Project.

Consecutive studies were carried out in Japan on the design features of the bridge, the estimated preliminary construction cost and the construction schedule, after which the draft final report on the Study was compiled.

CHAPTER 2 : BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 Background of the Project

The Dhaka-Chittagon National Road (hereinafter called the "Dhaka-Chittagong Highway") with a total length of about 260 km connects Dhaka City, the capital and centre of social and economic activities of Bangladesh, with Chittagong City, the country's second largest city which has an industrial area and the country's largest port.

The development of Dhaka-Chittagong Highway is viewed as being of the highest priority. This is due to the large share of population and GRP (both about 30% of the nation's total) within the highway's catchment area and to the corridor's important role in the movement of passengers and cargo in Bangladesh.

The Dhaka-Chittagong Highway crosses the Meghna River and the Meghna-Gumti River at about 25 km and 40 km southeast of Dhaka, respectively, where the Roads and Highways Department (hereinafter called the "RHD") provides ferry services. As the waiting time of vehicles for the ferries has increased, RHD has increased the number of ferry vessels and expanded ferry facilities to accommodate the increased traffic demand. However, it is anticipated that the economic loss by time consuming ferry crossings will increase drastically in the future as a result of rapid traffic growth.

The Meghna Bridge has been opened to the public since June 1990. The improvement of the Daudkandi-Feni Section of the Dhaka-Chittagong Highway is presently under construction with completion scheduled for the middle of 1991. The improvement of the remaining sections of the Dhaka-Chittagong Highway is in the project formation stage with the completion of construction scheduled for the end of 1995. Under such circumstances there is an urgency to construct the Meghna-Gumti Bridge since the interrupted road transport at the Meghna-Gumti River could become a major problem in the very near future and the usage of the improved Dhaka-Chittagong Highway is restricted unless the problem of no ferry crossing is completely solved.

2-2 Outline of the Request

The outline of the request is based on the result of the "Feasibility Study on Meghna, Meghna-Gumti Bridges Construction Project" and the Project was named the "Project for Constructing Meghna-Gumti Bridge". The Roads and Highways Department (RHD), Roads and Road Transport Division, the Ministry of Communications is the government agency responsible for the implementation of the Project.

The proposed bridge is located upstream of the existing Meghna-Gumti ferry ghats. RHD has confirmed that necessary land acquisition and property compensation will be completed prior to the start of the construction.

CHAPTER 3 : OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3-1 Objectives

The objectives of the Project are to construct the bridge over the Meghna-Gumti River, replacing the bottleneck created by the present ferry crossing, to provide for uninterrupted road transport between Dhaka and Chittagong and to contribute toward the enhancement of the nation's economic activities.

3-2 Study and Examination of the Request

The basic design study team went to Bangladesh and stayed there from May 17, 1990 to June 30, 1990, and discussed the present status of the road network system and the related problems with the officials concerned at the Transportation Centre, where data was obtained and the request of the client were received during the many discussion held there.

(1) The Project and Its Role

The mode of traffic over the past 10 years for the transport of people has increased dramatically for road and inland water transport at an average of 7% and 8%, respectively, whereas it has decreased by 5% for the railways and is very low. The share of passenger transportation in 1989 for roads, inland water and railway transportation was 54%, 23% and 23%. In terms of freight, the share between roads, inland water and railway transportation was 49%, 34%, 17% and the miserable state of the railways is reflected in this standing. The share of investment in the 3rd 5 Year Plan will be 42%, 23% and 35%.

The role of inland water transportation has been large and been an important characteristic due to the existence of large rivers in Bangladesh. However, the rivers have become heavily silted and rising water has become frequent due to the felling of forests and the construction of dams.

For this reason, the length of navigable river waters has been reduced by the year, and whereas the rivers could be navigated the year around for approximately 8,000 to 9,000 km, this has now been reduced to approximately 8,400 km in the rainy season, and 5,200 km in the dry season. When compared to other modes of transportation it is generally accepted that the availability of transport in the inland waters will become further reduced in future years. This has lowered the share of investment for inland water transportation (the share has changed from the 1st thru the 3rd 5 Year Plan in the order of 41%, 26% and 23%).

The relation of large rivers and the ferry crossings is one of the characteristics of the road systems in Bangladesh, and is also the constant source of transport problems.

Ferry crossings take up much time to make the crossing, and with the recent increase in the road traffic, it will take even more time to cross the rivers. In addition to this the ferry boat is subject to changes in the weather conditions, and it must tackle the silting of the river bed, and dredging cannot be performed as required due to shortage of funds, creating operational problems and curtailment in the number of trips.

The 3rd 5 Year Plan (1985/90) has been given top priority to the improvement of existing trunk road network in the Road Sector Programme. The Dhaka-Chittagong Road has the heaviest of road traffic of all trunk roads, and is the most important road which contributes to the social and economic activities of Bangladesh, and for this reason the improvement work has been started ahead of the other roads. There are many other trunk roads with ferry crossings, and the ferries are planned to be replaced with bridges in the order of their priority, and with the completion of the Meghna Bridge presently close at hand, the Meghna-Gumti Bridge will be given the next highest priority.

(2) Other Similar Projects and Their Relation with International Financing Institutions

There are other road improvement projects (including bridges) in the East Bangladesh Region which are as described in pars. 2.(2) v), 3.(2), and 3.(3), in Chapter 2. The project which is most closely related to this project is the Dhaka-Chittagong Road, and the project is divided into 2 phases, and it is a project that will be financed by the Asia Development Bank (ADB).

This bridge project has been handled as a Grant-in Aid project from its beginning, and no other country outside of Japan has offered to take on this project. However, for the access roads for this bridge on the Comilla side it will connect to the 1st Phase Improvement of the Dhaka-Chittagong Road (presently under construction), and on the Dhaka-side it will connect to the 2nd Phase Improvement (Feasibility Study currently being prepared) of the same Dhaka-Chittagong Road. An investigation has revealed that there is a section approximately 1,200 m long which will not be provided with improvements by either project, and so the Bangladesh Road and Highway Department. Road and Road Transport Division, Ministry of Construction, has agreed to construct this missing section of road at their responsibility.

(3) <u>The Main Components of This Project</u>

(a) <u>Bridge Centreline</u>

The Project Site was inspected by the Study Team through field reconnaissance and the bridge centreline was finalized. A straightline which connects a point 30 m upstream of the Dhaka side ferry ghat (centre of the north pontoon) with a point 85 m upstream of the Comilla side ferry ghat (centre of the north pontoon), is the final alignment of the Meghna-Gumti Bridge. This site will not conflict with the present ferry operations, and will not require relocation of the shops on both shores. A straight bridge has resulted in an aesthetically pleasing setting with the surrounding river banks.

(b) <u>Bridge Length</u>

The hydrological survey and the on-the-ground topographical survey was carried out by the Study Team to determine the final bridge length. Following are the major findings of the surveys and analyses:

- River courses of the Meghna Branch and Gumti Tributary have been stable over the past 50 years;

- No signs of scouring of riverbanks is identified near the bridge alignment. However, the lowest point of the river bed (i.e. a gut of river) is close to the Dhaka side riverbank located upstream of the Meghna Branch; and

- A sign of siltation was found at the Comilla side riverbank between the existing ferry ghats and the Daudkandi market area.

Based on the above findings, the location of the Dhaka side abutment is kept the same as that recommended in the Feasibility Study, and the Comilla side abutment was shifted toward the west to meet the existing reiverbank slope. The final bridge length arrived at is 1,410 m.

(c) Approach Roads

The on-the-ground topographical survey, including the precise traverse survey, centreline survey and leveling, was conducted by the Study Team to fix the exact length of each approach road.

i) Dhaka Side Approach Road

As a result of the road alignment study, the length of the Dhaka side approach road is fixed at 870 m.

ii) Comilla Side Approach Road

The distance between the Comilla side abutment and the Daudkandi terminus of Contract No.1 of the ongoing Road Improvement Project is the length of the Comilla side approach road. The Daudkandi side terminus (chainage 0 + 00) is situated on the extension of the bridge centreline. The length of the Comilla side approach road is measured as 470 m.

(d) Superstructure and Substructure

Concrete structures are adopted. The superstructure is prestressed to allow for a long span bridge. Pier columns are reinforced with steel bars to meet structural requirements. The adoption of a concrete structure is aimed at keeping it free of maintenance and to encourage the utilisation of local materials, i.e., materials produced in Bangladesh.

(e) Foundations

Cast-in-place reinforced concrete piles are adopted. Since the soil layers that are to support the concrete piles exist in the deep subsurface and the foundation work must be done in the water, the construction of cast-in-place reinforced concrete piles with drilling is the only practical method to employ at the present time.

(f) Number of Lanes of Bridge and Approach Roads

The bridge and approach roads are 2-lane 2-way design. The result of 24-hour traffic count survey justified this selection.

(g) Lane Width of Bridge and Approach Roads

Lane width is related to the width of the design vehicle, and the lateral clearance compatible with design speed. The Government standard specifies that the pavement width of a 2-lane 2-way road shall be 6.7 m (22 feet) in case of 80 km/hour design speed of vehicles.

On the bridge, a side lateral distance should be provided between the carriageway and the sidewalk. A minimum distance of 0.25 m is provided in general design practice.

Based on the above clarification, the lane width of the bridge and approach road is decided upon as follows:

- Lane width of the bridge : 3.35 m + 0.25m = 3.60m
- Lane width of the approach road : 6.7m ÷ 2 + 0.03 side strip = 3.65m

(h) Sidewalks on the Bridge

A 1.0 m wide sidewalk is provided on each side of the bridge carriageway for the convenience and safety of pedestrians. Each sidewalk has a capacity to handle 750 persons per hour, i.e., average walking speed of 0.8 m per second for older people and higher service level. Many pedestrians consider themselves outside the law in traffic matters and in many cases pedestrian regulations are not fully enforced. However, it is recommended that these sidewalks be 1-way use to achieve safe and orderly pedestrian movement.

(i) Navigation Clearance

The navigation clearance of 75 m width and 7.5m height was adopted in the Feasibility Study for both the Meghna Branch and the Gumti Tributary. Bangladesh Inland Water Transport Authority (hereinafter called the "BIWTA") once requested a vertical navigation clearance of 12 m (40 feet) for the Gumti Tributary but soon after withdrew its claim.

The Study Team identified the following factual data on the hydrological situation of the Meghna Branch and the Gumiti Tributary within 1.0 km upstream of the planned bridge:

- Lower river-bed elevations of Meghna Branch and Gumti Tributary are approximately -8 and 3 (PWD datum, in metre) respectively;
- The Gumti Tributary forks right and left about 1.0 km from the planned bridge;
- The riverbed elevation of the right waterway is approximately -0.5 (PWD datum, in metre) and the Daudkandi riverside is silted up; and
- The riverbed elevation of the left waterway is somewhat lower. However, the width of the channel keeping a 2.0 m depth from PWD datum is only about 5 m (June 1990).

3-3 Project Description

(1) Project Site Location and Conditions

i) Project Site Location

The Meghna-Gumti River (approximately 1,350 m wide) crosses the Dhaka-Chittagong Highway at a point some 40 km southeast of Dhaka. RHD provides ferry services at this location. The Project site is in this vicinity and the Project's bridge construction site is about 150 m further upstream from the ferry crossing.

ii) Topography of the Project Site

The topography of the Project site and its surrounding area is a floodplain having elevations of lower than +6m. During rainy season high water periods, the entire floodplain, except for the major roads and villages, becomes inundated.

iii) River Condition at the Bridge Construction Site

No riverbank erosion is noticeable in the vicinity of the bridge construction site and the gut of the river is comparatively stable.

The Meghna-Gumti River's design flood discharge at the construction site is approximately 12,400 m^3/s (100-year probability). The river's 100-year probability design high water and low water levels are +6.65 m and +0.64 m respectively.

iv) Geology and soils at the Bridge Construction Site

The floodplain consists of sediment materials transported from the continent by the river. The main characteristic of the floodplain is the excessive deposit of silt material on its surface. A gravel layer exists underneath the silt layer which contains clayey-sand and silty-sand layers.

Soils at the site are mainly fine sand, silt, and sand up to -30 m (based on PWD's datum having ±0 at Mean Sea Level) and sandy silt is predominant below -30 m. Possible bearing strata for the piling foundations are about -60 m near the right bank on the Dhaka side of the river and about -70 m near the left bank of the Comilla side of the river.

v) Traffic Volume

To investigate the traffic volume at the Project site a 24-hour traffic volume survey was conducted on the Dhaka-Chittagong Highway at the Comilla side of the site from June 5 (Tuesday) through June 6 (Wednesday), 1990. The survey results are shown in Table 3-1.

Table 3-1 24-hour Traffic Volume by Vehicle Type

Vehicle Type	Traffic Volume
Truck, Tanker, and Tractor	1,671
Bus	773
Small Bus (Minibus)	127
Microbus, Jeep, Station Wagon	168
Passenger Car	249
Small Motor-tricycle, Motorcycle	47
TOTAL	3,035

The traffic characteristics obtained by the survey are as follows:

Peak Hour: 17:00 to 18:00
Ratio of daytime traffic to nighttime traffic: 62.0%
Peak Ratio: 7.3%

(2) Project Implementation Agency

The Roads and Highways (RHD), Roads and Road Transport division (RRTD), the Ministry of Communication (MOC) is the agency responsible for Project implementation.

i) RHD

RHD is the Government's agency fully responsible for the administration, planning, construction, management, operation, and maintenance of the country's major road networks (national roads, provincial roads, and Class A rural roads). The head of RHD is the Chief Engineer. Under the Chief Engineer there are eleven Additional Chief Engineers of whom three are in charge of foreign aid schemes, five are in charge of provincial roads, and the remaining three are in charge of administrative, planning and development work and ferry service matters at the Dhaka office.

RHD has 600 civil and mechanical engineers, 624 engineers in other fields and 21,713 technicians and general clerks. RHD's organizational chart is shown in Fig. 3-1.

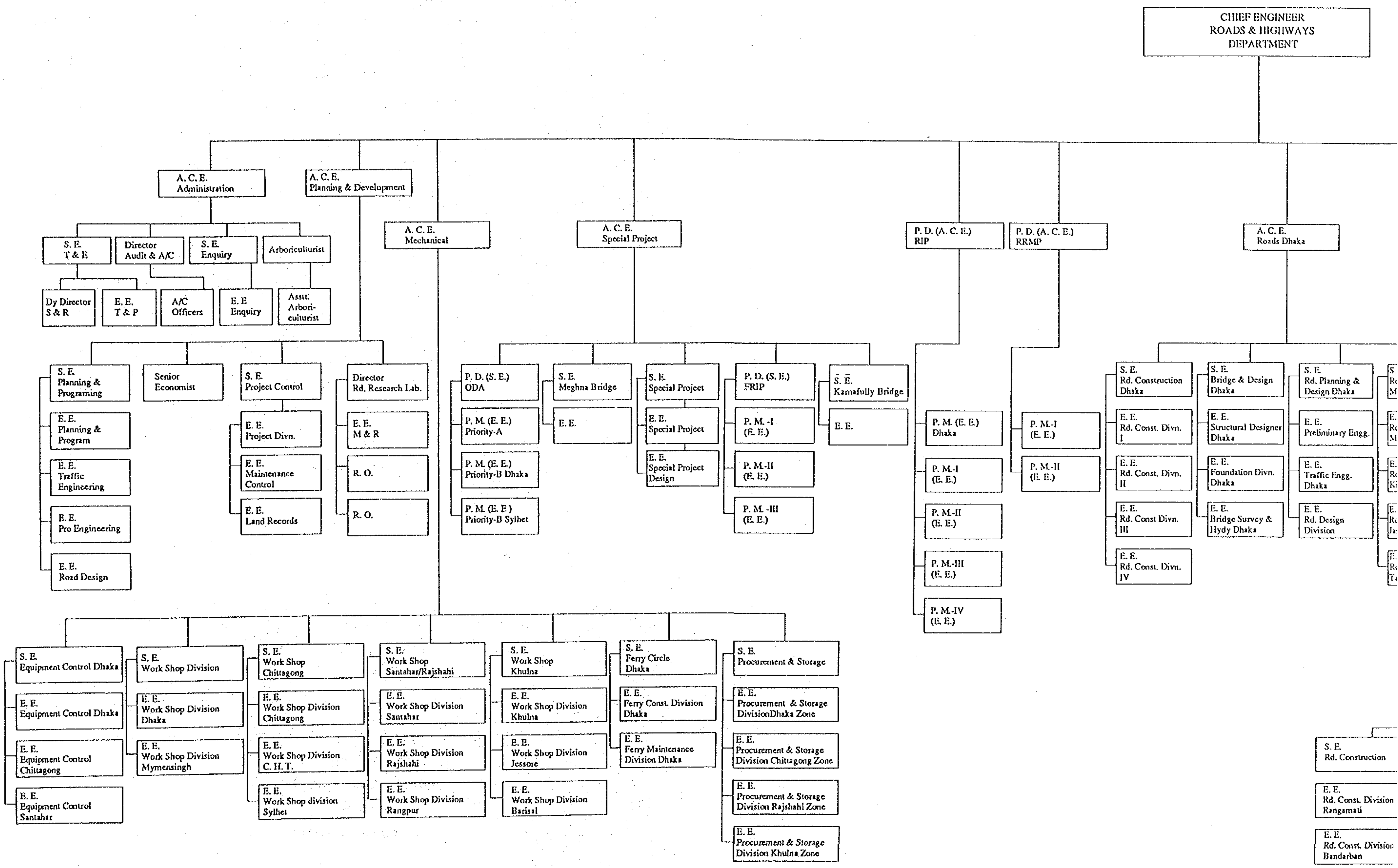
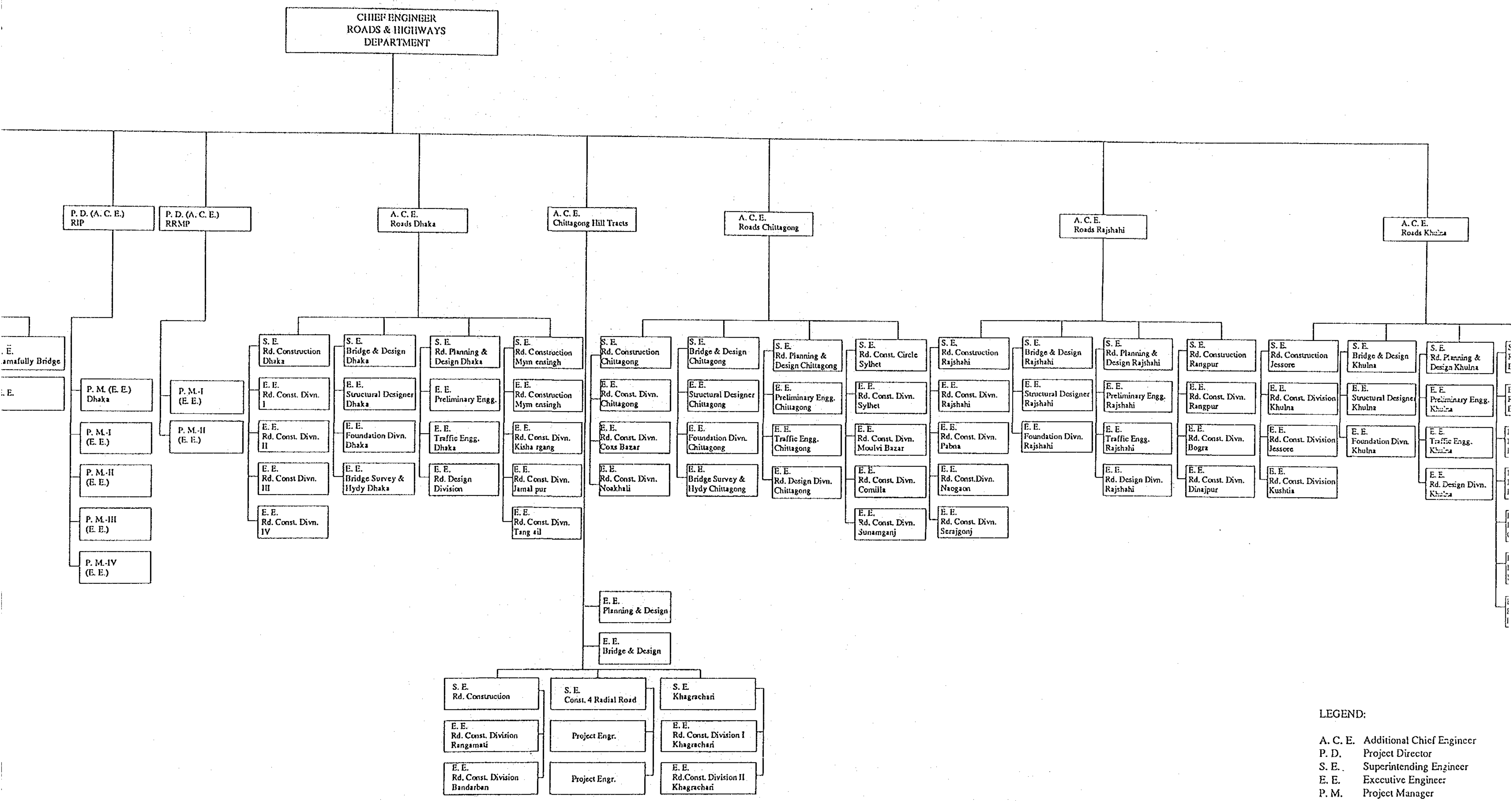


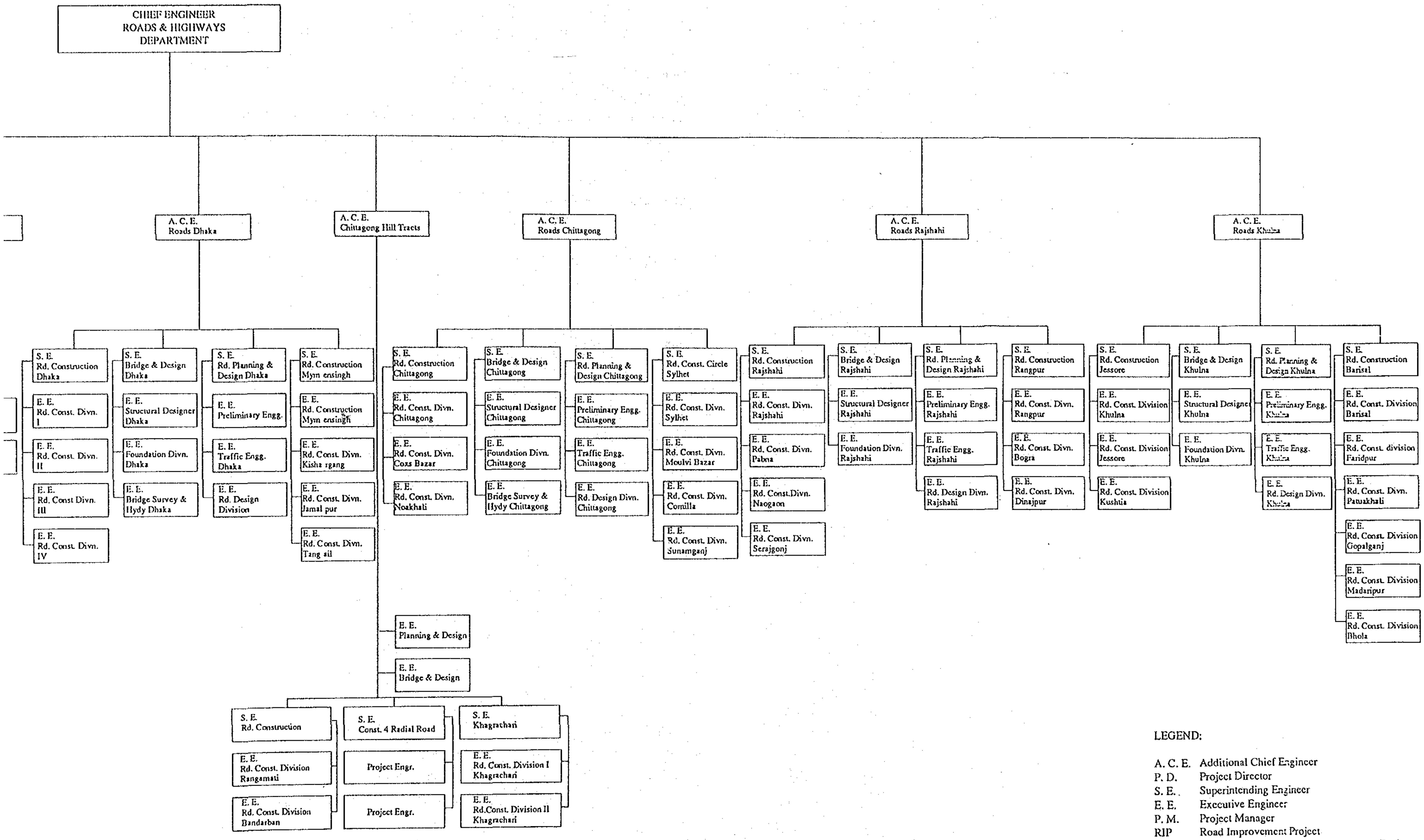
Fig. 3-1 RHD's ORGANIZATIONA



LEGEND:

A. C. E.	Additional Chief Engineer
P. D.	Project Director
S. E.	Superintending Engineer
E. E.	Executive Engineer
P. M.	Project Manager
RIP	Road Improvement Project
RRMP	Road Rehabilitqation and Mainter
FRIP	Feeder Road Improvement Admin
ODA	Overseas Development Administr

Fig. 3-1 RHD's ORGANIZATIONAL CHART



LEGEND:

A. C. E. Additional Chief Engineer
P. D. Project Director
S. E. Superintending Engineer
E. E. Executive Engineer
P. M. Project Manager
RIP Road Improvement Project
RRMP Road Rehabilitqation and Maintenance Project
FRIP Feeder Road Improvement Administration
ODA Overseas Development Administration

1 RHD's ORGANIZATIONAL CHART

ii) RHD's Management, Operation, and Maintenance System

The purpose of the Project is to construct an unusually long-span bridge. But, after the bridge is built, the management, operation, and maintenance of the bridge structures, approach roads, riverbank protection, and other related facilities will become a very important matter.

The following aspects were clarified as a result of discussions held with RHD officials during the survey period in Bangladesh.

- A road management, operation, and maintenance system for all the road networks in Bangladesh will be established under the direct supervision of RHD.

- A subdivision dedicated to the management, operation, and maintenance of the Meghna and Meghna-Gumti bridges will be established.

- Special precautions will be taken to prevent the scouring of the riverbank protection in the vicinity of the bridges and bridge foundations.

3-4 Technical Cooperation

Implementation of the Project will be carried out based on the similar methodology which has been employed for constructing Meghna Bridge. One of important objectives of the Project is to maintain Bangladesh counterparts and the Government officials touching with the Project and the technical transfer will be made as a priority matter.

The implementation of the Project will, therefore, be a good chance to examine the result of technical transfer attained in the previous Meghna Bridge construction project. However, after the Meghna and Meghna-Gumti Bridges are built the management, operation and maintenance of these unusual bridge structures will become a very important matter.

RHD presently does not possess enough experience and know-how in this field. It is recommended that the Government will be provided with training course for maintenance of the long-span bridges in Japan under certain Japanese official programme.

CHAPTER 4: PROJECT SITE CONDITION

CHAPTER 4 PROJECT SITE CONDITIONS

4-1 Topography

The project site is located on a flat lowland in the vicinity of the confluence of the Meghna Branch and the Gumti Tributary. Its geographical location is N23°31' 39" and E90°42'15". The river width at the confluence varies depending upon the river stage. At the river stage of MWL +2m, the width between the Meghna Branch's right bank and the Gumti Tributary's left bank is approximately 1,300 m. At this point, the Meghna Branch is approximately 600 m wide and the Gumti Tributary is approximately 300 m wide. There is an approximately 400 m wide sand bar between the two rivers.

The sand bar is approximately +2.5 m but it becomes completely submerged during the rainy season. The deepest point of the Meghna Branch is -6.4 m. The riverbed of the Gumti Tributary is almost flat and has an elevation of about -2.2 m.

The river courses at the Project site have not changed significantly since 1984 when the Feasibility Study was made. However, the Gumti Tributary's riverbed elevation that at one time was about the same as the Meghna Branch's has become approximately 3 m shallower as a result of sediment deposits. The elevation on the Dhaka side riverbank is +2 to +3 m. The Comilla side riverbank is about +4 m. During the rainy season both riverbanks become inundated except for the Dhaka-Chittagong Highway (+6 m in elevation) connecting to the existing ferry ghats.

The Dhaka side riverbank is a swamp where, during the dry season, rice farming is conducted. The Comilla side riverbank is grassland that is used mostly for pastures. A part of the area upstream from the ferry terminal is presently being used as a stockyard for ongoing road construction work; gravel and coal stockpiles (3 or 4 m high) can be seen there.

4-2 Geology

River deposits consisting mainly of sand and silt thickly underlies the Project site. The top 20 m thick layer down to an elevation of about -20 m is dominated by sand. The upper two thirds of the sand dominant layer is loose and is considered to be either alluvium or Holocene. The lower one third is dense and is either diluvium or Pleistocene.

The next 40 m thick layer (approximately -2 m to -60 in elevation) is dominated by stiff silt. At a depth of approximately -60 m to -80 m in elevation there is dense sand belonging to the Pleistocene era.

While the boundaries of the above layers undulate somewhat, they lie almost horizontally and continue widely up to the Meghna Bridge that spans the main stream.

For the basic Design Study four test borings were made on the centerline of the proposed Project bridge: two in the Meghna Branch; one on the sandbar and one at the site of the Comilla side approach. The locations of the test borings are shown in Fig. 4-1. Nos. 3, 4, 5, and 6 are the borings carried out in the Study. MG1, MG1-A, and MG2 are the boring locations made for the 1984 Feasibility Study.

The results of the geotechnical investigation are shown as the boring logs and the geological profile in Fig. 4-2. As shown in the Figure, the unconsolidated deposits above EL -80 m are classified in four layers, i.e., upper silt, upper sand, lower silt, and lower sand in descending order. For the foundation structure (pile foundation) of the Project bridge, the lower sand layer would be the most reliable bearing strata. The facies, physical property, and mechanical property of each layer are described hereunder.

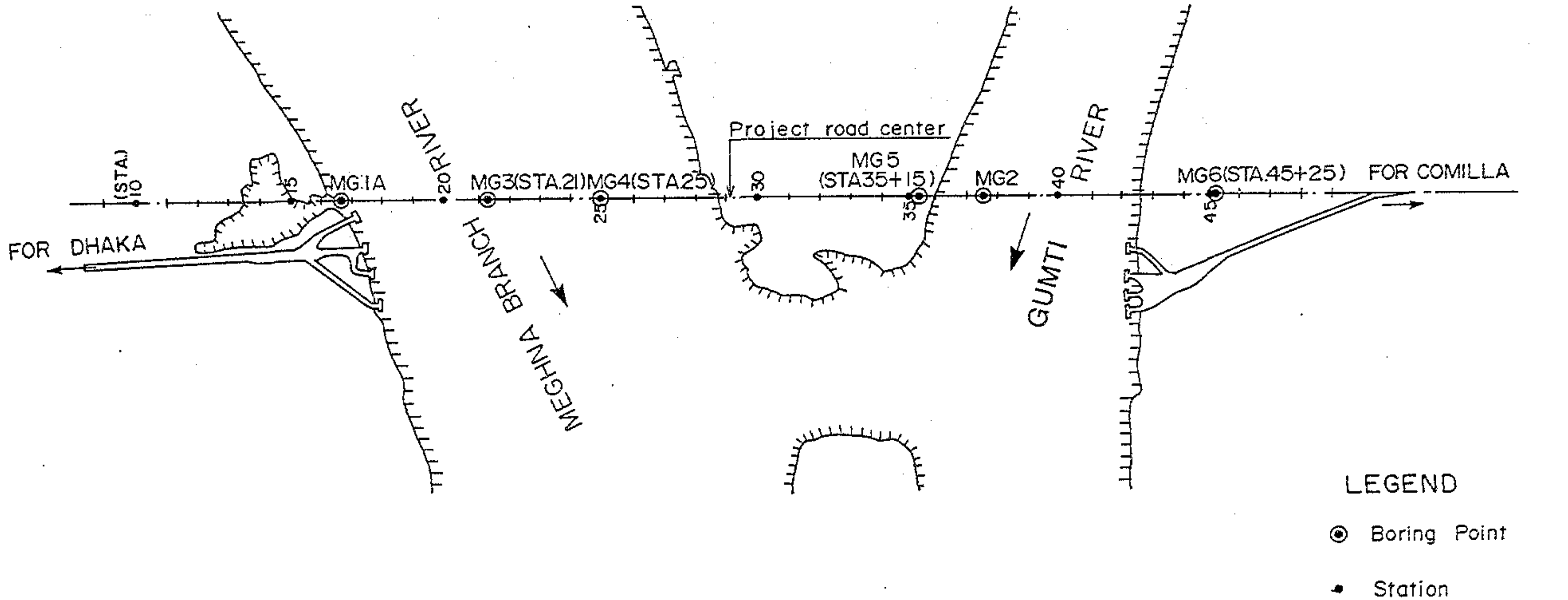


Fig. 4.-1 Location of Borings

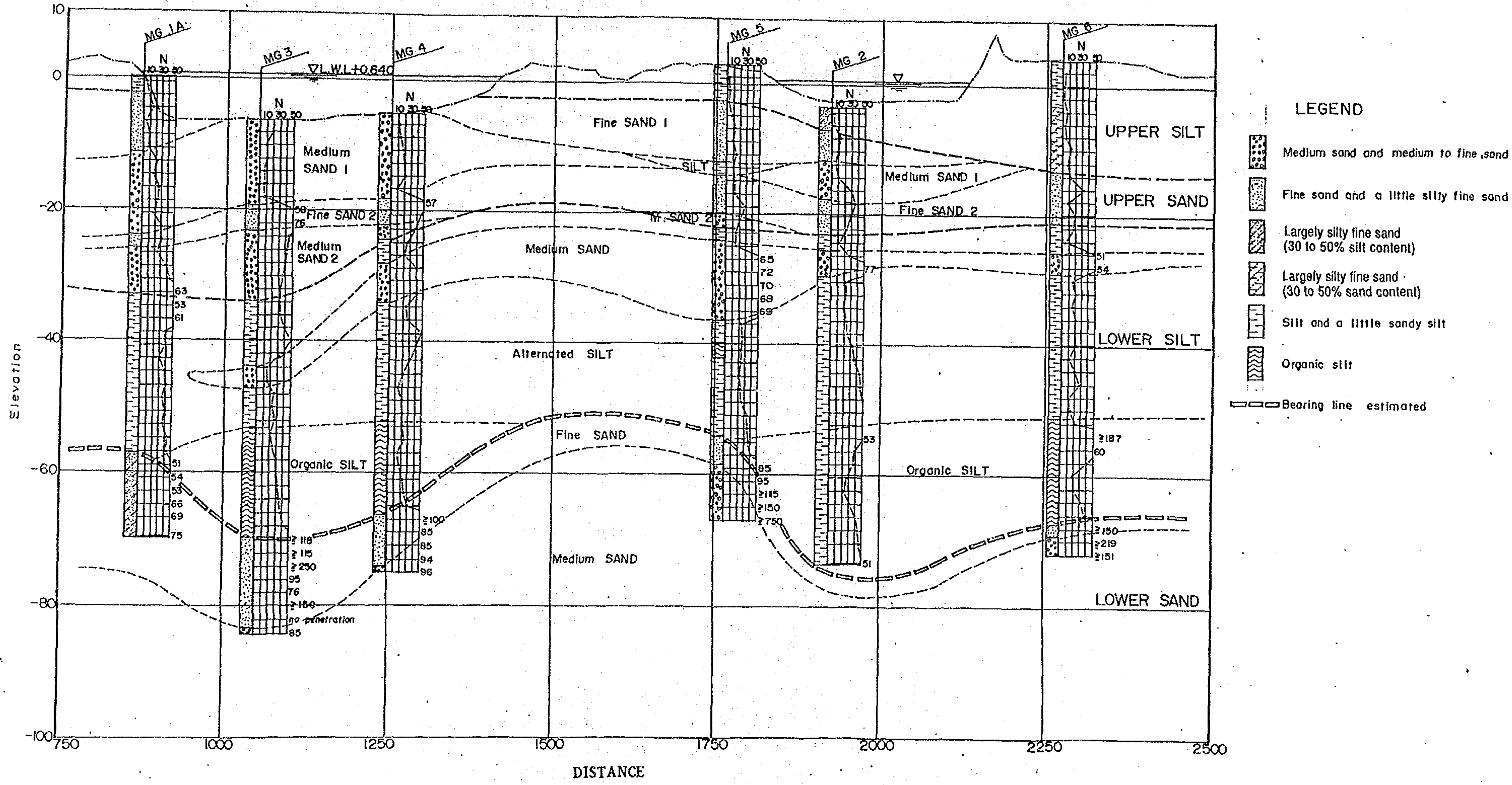


Fig. 4-2 Boring Logs and Geological Profile

(1) Upper Silt Layer

The upper silt layer lies on the right bank of the Meghna Branch and the sandbar. It is about 5 m thick and becomes thicker towards the left bank of the Gumti Tributary where it is about 10 m thick. The top 5 m thick sub-layer of the upper silt layer is sandy silt which lies almost horizontally from the right bank of the Meghna Branch to the left bank of the Gumti Tributary. This sub-layer consists of about 70% silt and 30% fine sand.

Another sub-layer underlies the top sub-layer increasing its thickness towards the left bank of the Gumti Tributary. This sub-layer contains nearly 60% fine sand.

The average N-value of the upper silt layer is less than 5 which indicates soft soil.

(2) Upper Sand Layer

The upper sand layer lies below the upper silt layer. It is about 25 m thick at the right bank of the Meghna Branch, about 15 m thick at the sandbar, and about 10 m thick at the left bank of the Gumti Tributary. The upper sand layer is formed mainly of alternating beds of fine sand and medium sand, and it partly intercalates the 2 to 3 m thick silt-bed lenticularly.

The fine sand and medium sand below the right bank of the Meghna Branch are mostly pure -- they contain less than 5% silt -- and tend to become more silty towards the left bank of the Gumti Tributary. The lenticular silt-bed contains about 30% fine sand below the Gumti Tributary and about 20% medium sand below the sandbar.

The grain size distribution of the fine sand and the medium sand is very uniform (in the range of 0.1 to 0.3 mm). The sand is very micaceous.

(3) Lower Silt Layer

The lower silt layer lies at a depth between approximately EL -22 m and EL -80 m. This layer intercalates a 2 to 10 m thick medium sand bed at a depth of about EL -20 m to EL -30 m. The boundary between the lower silt layer and its lower horizon (the lower sand layer) undulates largely having depressions below both the Meghna Branch and the Gumti Tributary.

A major part of this silt layer is made up of clayey silt and micaceous fine sand.

The intercalated medium sand bed in the upper portion of the lower silt layer is very pure. It is the same as the medium sand intercalated in the upper sand layer. Below the elevation of about RL -50 m organic silt is deposited. The organic silt contains slightly carbonized pieces of wood.

(4) Lower Sand Layer

The lower sand layer is composed of fine sand (2 to 10 m thick) in the upper portion and medium sand in the lower portion. No clay component is found in the fine and medium sand. The sand is ill-graded -- grain size ranges mostly from 0.02 to 0.2 mm. In this range, the grain size of the fine sand is slightly on the silty side. The lower sand layer is micaceous and bluish gray in color. The color turns brownish in the air after sampling.

The physical property and N-value of each layer are evaluated as shown in Table 4-1.

Table 4-1 Physical Property and N-value of Each Soil Layer

Type of Layer	Natural Water Content	Specific Gravity	Atterberg Limits (%)	Density (g/cm3)	N-Value
Upper silt			PL:40	rt:1.8	
- Top 5m	35	2.67	LL:20	rd:1.2	2-5
				rt:1.9	
- Other Part	35	2.66	N.P.	rd:1.4	5-10
Upper sand				rt:1.8-1.9	
- Upper half	35	2.66-2.69	N.P.	rd:1.4	10
				rt:1.9	
- Lower half	25	2.67-2.68	N.P.	rd:1.45	30
Lower silt			PL:40	rt:1.8	
- Major part	35	2.6	LL:25	rd:1.3	20
- Medium sand	25	2.68	N.P.	-	50
			PL:30	rt:1.9	
- Organic silt	30	2.58	LL:20	rd:1.4	20-30
Lower sand	20-30	2.67-2.68	N.P.	Unknown	>50

4-3 River

(1) Meghna Branch and Gumti Tributary

The Meghna River has a catchment area of approximately 77,00 km^2. The river course is about 880 km. 63% of the catchment area is in Bangladesh. The river course meanders frequently. In particular, the course downstream from the Project site splits and merges repeatedly in a complicated pattern. The Gumti Tributary originates in the Tripra State of India. The Gumti Tributary is the most downstream of the Meghna Branch. The triburary has a catchment area of approximately 2,700 km^2 and has a river course about 180 km long.

(2) Discharge

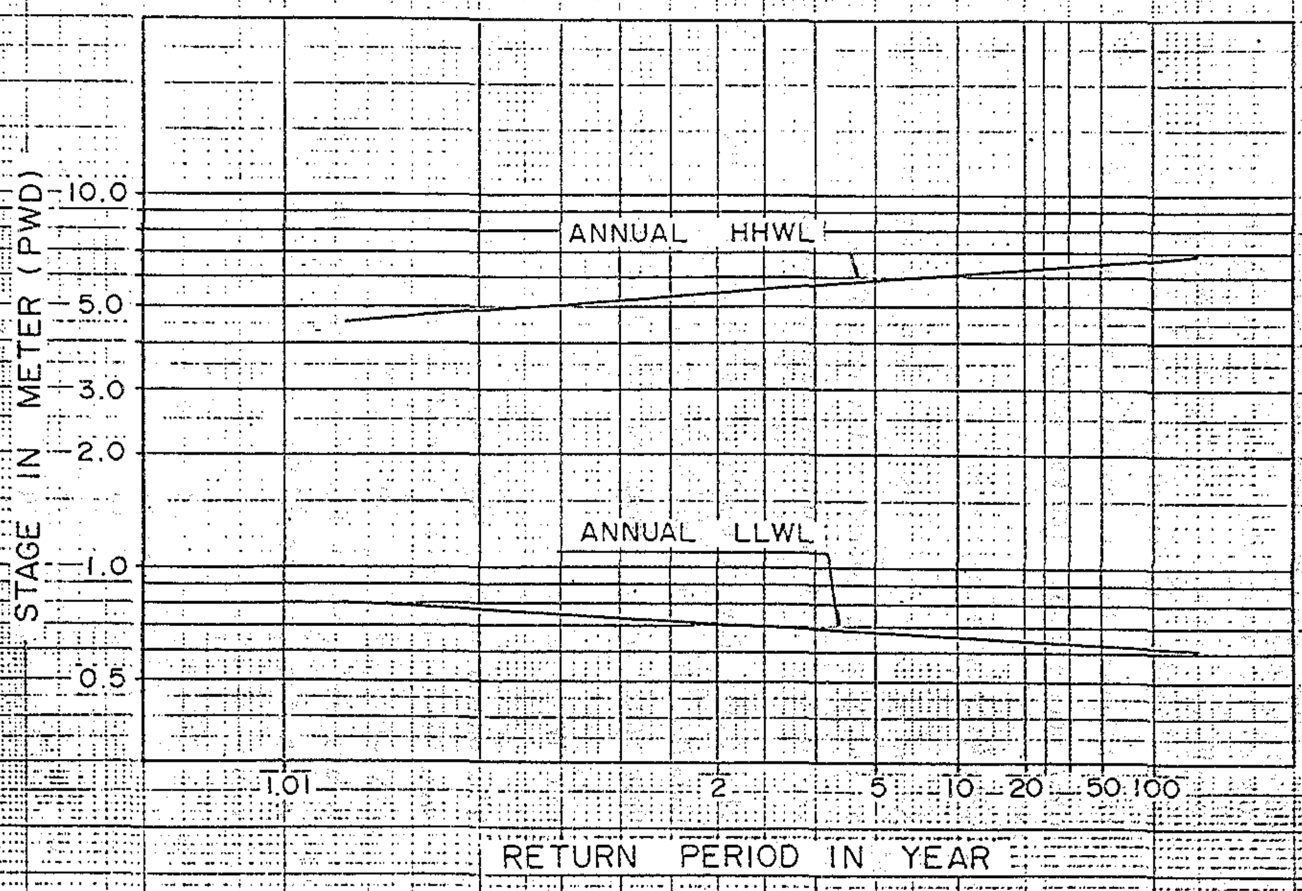
According to JICA's 1985 Feasibility Study, the discharge at the confluence of the Meghna Branch and Gumti Tributary that is at the Project site is 12,400 m^3/s with a 100-year return period.

The Gumti River's discharge is observed at the two gauging stations near Comilla. Its yearly maximum value is several hundred cubic meters. It is a very small amount compared to that of the discharge at the confluence.

(3) Water Level

The annual highest high water levels (HHWL) and the annual lowest low water levels (LLWL) observed at the Daudkandi Observation Station (located upstream from the Project site on the left bank) were analyzed and the results are shown in Fig. 4-3. From the figure the HHWL was determined to be +6.65 m and the LLWL was determined to be +0.64 m with a 100-year return period.

Fig. 4-3 FREQUENCY CURVE FOR HHWL AND LLWL LEVELS
(AT DAUDKANDI STATION)



(4) Water Level Variations

Variations of the annual average water levels recorded at the Daudkandi Observation Station over a five year period (1973-1977) are shown in Fig. 4-4. From the figure it is evident that the water levels observed at the station are affected by the tides. The 5-year average of the daily maximum water level differences is 0.6 m during the low water period and 0.1 m during the high water period.

The 5-year average of the daily highest water levels is +5.28 m in August. The 5-year average of the daily lowest water levels is +1.04 m in February. The annual maximum water level difference is 4.24 m.

(5) Riverbank Conditions

The Dhaka side riverbank upstream of the Project site is slightly scoured from wave action. The downstream portion of the sandbar is scoured by flood waters. However, both the banks and riverbeds are comparatively stable. Thus, the condition of the riverbanks will not pose a problem for the Project bridge construction.

The riverbank conditions are summarized as follows:

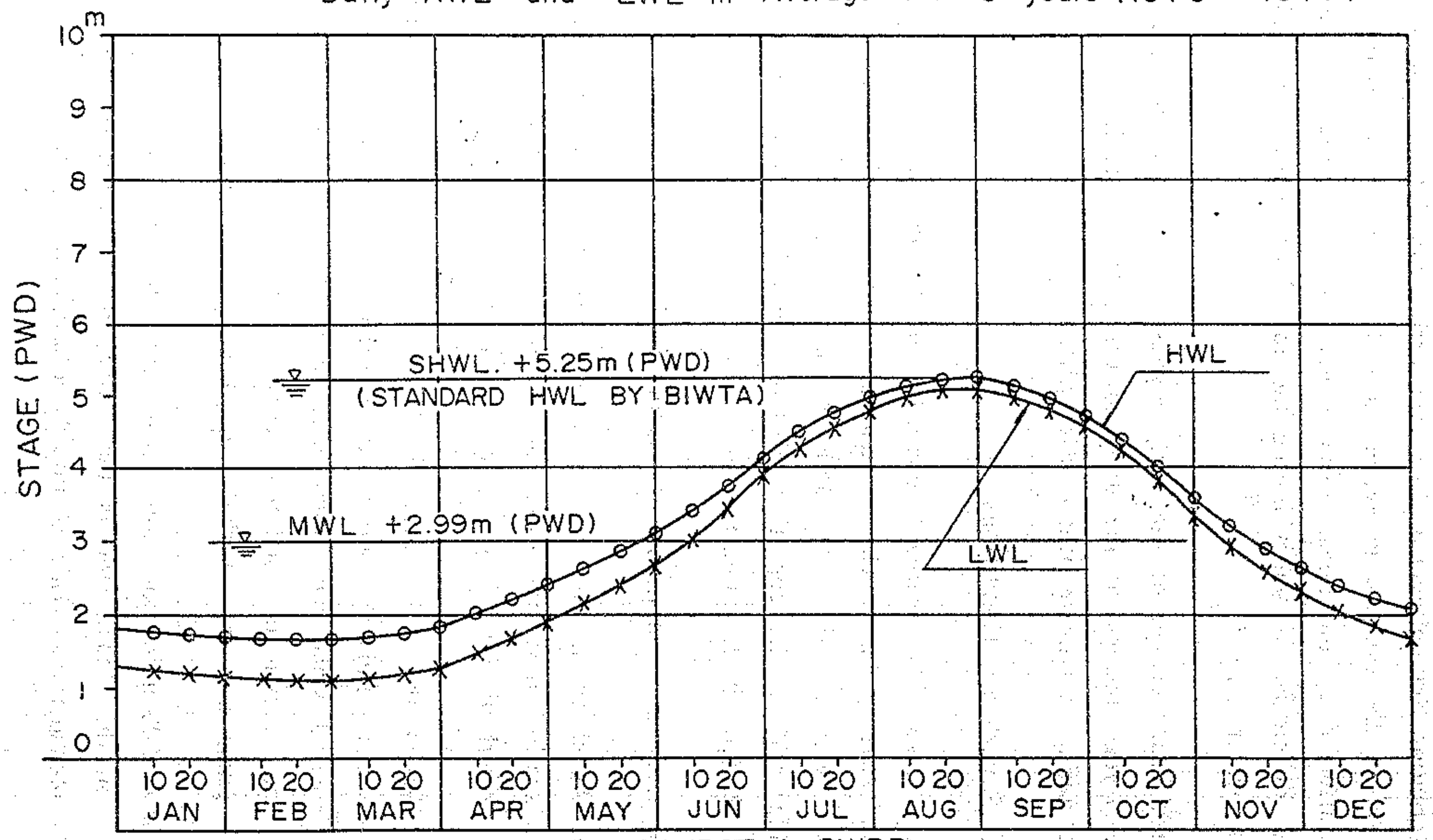
i). As shown in Fig. 4-5, the deepest part of the Meghna Branch in a 2 km section upstream from the Project site is located close to the right riverbank (the Dhaka side) which has a steep slope.

When the water level is lower than the riverbank crown, the river water tends to scour the riverbank. However, during the 28-year period since the Dhaka side ferry facilities were constructed in 1962, no erosion nor sediment deposit problems have occurred at the ferry ghats and the riverbank has been quite stable.

A 500 m section downstream from the Project bridge construction site on the Dhaka side is the inward bend portion of the Meghna Branch's meandering. This section is a sediment depositing area.

Fig. 4-4 VARIATION OF WATER LEVEL (AT DAUDKANDI STATION)

Daily HWL and LWL in Average for 5 years (1973 - 1977)



SOURCE : BWDB

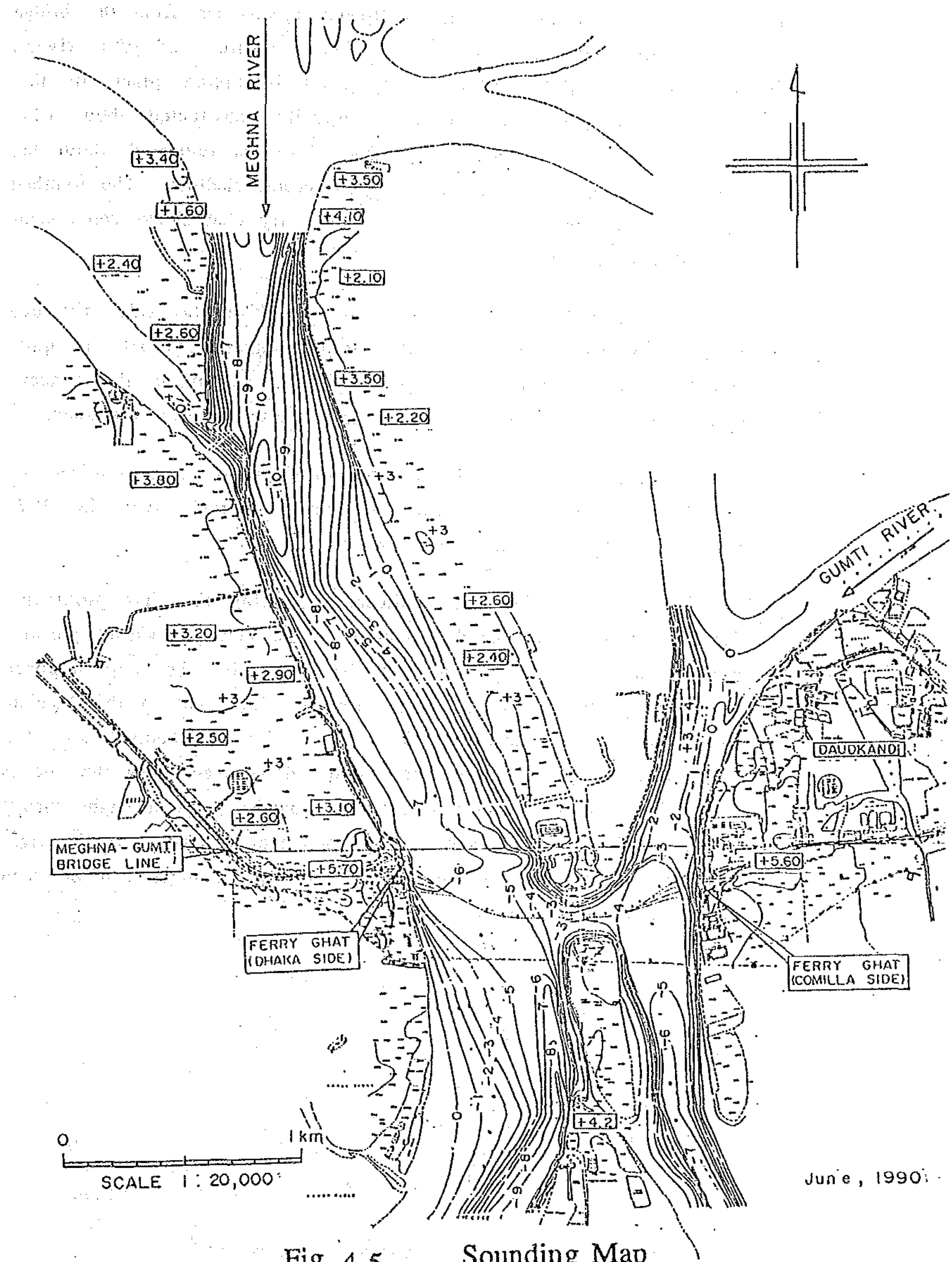


Fig. 4-5 Sounding Map

ii) The Comilla side of the Meghna Branch downstream from the bridge construction site is the inward bend portion of the river's meandering. Slight sediment depositing is taking place in this section. An old ferry ghat was originally constructed about 1 km upstream from the present ferry ghat. It was relocated about ten years ago because that part of the river became shallow. The riverbed portion downstream from the Comilla side ferry ghat shows some signs of sediment deposit.

An approximately 2 km section of the Comilla side riverbed immediately downstream from the bridge construction site is quite stable. 2 km further downstream from this section is the concave section of the river's meandering; it may cause scouring problems.

iii) The scouring and the sediment depositing areas were analised by superimposing a 1989 Landsat Satellite photograph over the 1972 Landsat Satellite photograph as shown in Fig. 4-6.

The riverbank scouring and sediment depositing that has progressed for more than several hundred meters at the most significant portions during the 17-year period can be seen in the superimposed photograph. In particular, the progress is significant in the Meghna Branch about 8 km upstream from the bridge construction site and the profile change of the sandbar located downstream from the site is remarkable. In the vicinity of the site, however, only a slight change of the sandbar's profile and a small sediment deposit near the right bank are noticeable. No significant riverbank changes can be seen on the upstream side of the site.

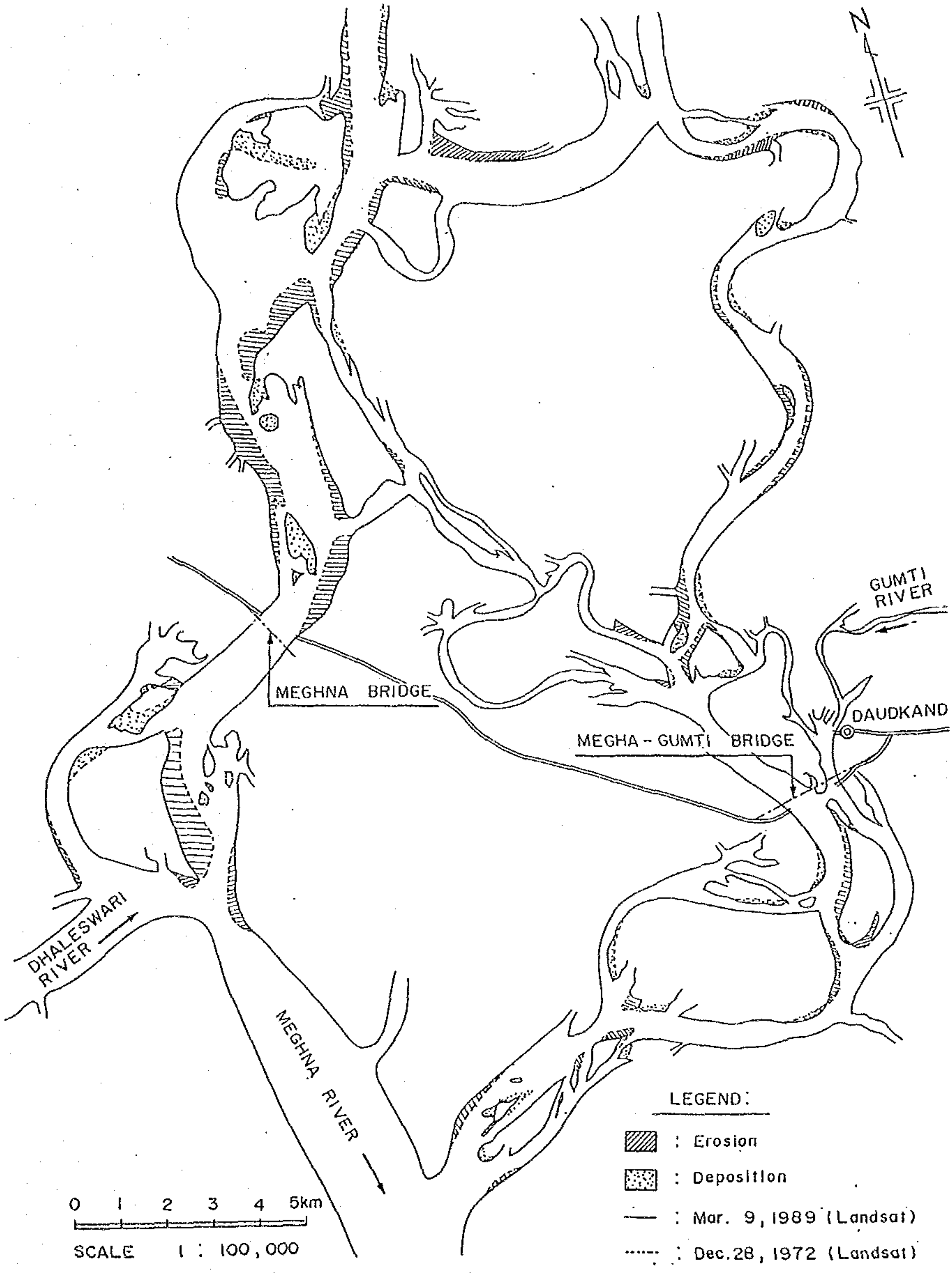


Fig. 4-6 Erosion and Deposition Area

CHAPTER 5 : BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5-1 Design Policies

The Basic Design was prepared to ensure the most appropriate scheme based on the data and information obtained during field surveys and the confirmations obtained through discussions with RHD officials. The Basic Design drawings are listed at the end of this chapter.

5-2 Study and Examination of the Design Criteria

(1) Road Design Criteria

i) Geometrical Design Criteria

RHD has geometrical design standards for road construction and improvement. The standard for Class A national road is adopted. For design criteria not covered by RHD standards, Japanese standards were adopted for the Basic Design. .

Table 5-1 shows the Basic Design's major geometric design criteria. The cross sections of the Bridge and the approach road are shown in Fig.5-1.

ii) Pavement Design Criteria

Based on Road Note 29 of the British Standards, the road pavement is to be asphalt concrete having a 10-year service life.

Table 5-1 Geometric Design Standard for Approach Road

Item	Unit	Standard
Design Speed	km/h	80
Horizontal Curve		
Minimum radius	m	230
Maximum crossfall	%	6
*Transition Curve (Clothed)		
Minimum parameter, A	m	100
Vertical Curve		
Min. length of sag curve	m	50
Min. radius of sag curve	m	3,300
Min. length of crest curve	m	200
Min. radius of crest curve	m	3,300
Maximum Gradient	%	3.0
Crossfall of Carriageway in Normal Crown	%	2.0
Min. Stopping Sight Distance	m	120
Min. Passing Sight Distance	m	470
Crest Width	m	12.20
Carriageway Width	m	6.70
Shoulder Width	m	2.75

Note: *Indicates the item that is not shown in the RHD Standard.

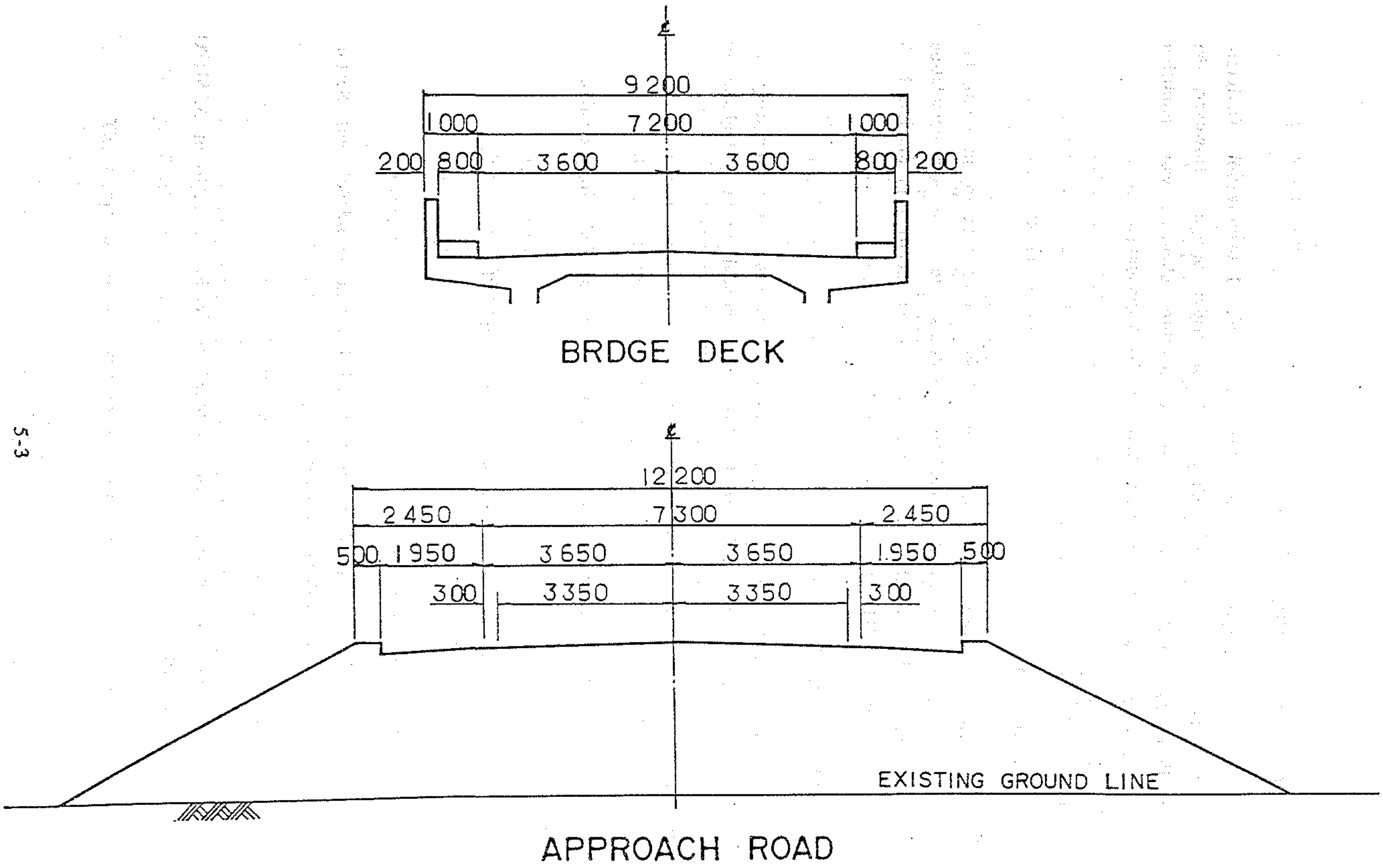


Fig.5-1. TYPICAL CROSS SECTION

(2) Structure Design Criteria

American Association of State Highway and Transportation Officials (AASHTO) standards were mainly used for bridge design. However, the criteria for winds, earthquakes, and temperature changes, were modified in accordance with Indian Road Congress (IRC) standards.

i) Load Criteria

a. Dead Load

The dead load is the total weight of the bridge structure including the carriageway, sidewalks, guardrails, handrails, etc. For the calculation of the dead weight, the material unit weights specified in Section 1.2.3 of the AASHTO standards were adopted.

b. Live Load

The Live load is the weight of pedestrians and vehicles crossing the bridge. AASHTO's HS 20-44 (MS18) was adopted for the calculation of the live load.

c. Impact Coefficient

The impact coefficient was calculated using the following equation:

$$I = \frac{15.28}{L + 38}$$

where, I: Impact coefficient (maximum 30%)

L: Span length in meters

d. Weight of Sidewalks

The weight of the sidewalks was calculated in accordance with Section 1.2.11(A) of AASHTO standards.

e. Curbstone Weight

Curbstone Weight was calculated based on Section 1.2.11(B) of AASHTO standards.

f. Wind Load

Design wind speed: 140 miles per hour (225.8 km/hr)

Basic wind speed: 100 miles per hour (160.9 km/hr)

Wind load intensities specified in Section 1.12.14 of AASHTO standards increase at the rate of the squares of the design wind speed and the basic wind speed. Thus, horizontally distributed wind load intensities were calculated as follows:

Truss and arch structures:	718 kg/m^2
Girders and beams:	479 kg/km^2
Piers and abutments:	888 kg/m^2

g. Seismic Force

The horizontal seismic force of 0.05W (W = dead weight) was adopted.

h. Effects of Temperature Changes

The range of temperature change 26 $\pm$ 17°C was adopted. 26°C is the average temperature in Dhaka and Comilla. The range of change was determined based on IRC standards.

i. Current Force

The current force acting on bridge piers was calculated in accordance with the equation shown in IRC standards as follows:

$$P = 52.K.V^2$$

where, P = current force (kg/m^2)

V = flow velocity (m/s)

V = 2.6 m/s for piers

V = 1.5 m/s for temporary structures

K = coefficient specified in Section 218 of IRC standards

j. Earth Pressure

The Coulomb equation was used to calculate earth pressure.

ii) Major Materials

a. Structural Steel

Allowable tensile stress: Fs = 2,100 kg/m²

The structural steel material must be in conformity with ASTM A633 (C, D, E) or JIS 3106 (SM50A, SM50Y, SM53).

b. Concrete

The compressive strength of concrete must be as follows:

Prestressed concrete:	fc' $\geq$ 350 kg/cm²
Slab concrete for steel bridges:	fc' $\geq$ 270 kg/cm²
Concrete for cast-in-place concrete piles:	fc' $\geq$ 300 kg/cm²
Concrete for piers, abutments, and foundations:	fc' $\geq$ 210 kg/cm²

where, fc' is compressive strength at 28 days.

c. Reinforcing Bars

The allowable tensile strength for reinforcing bar should be as follows:

Deformed bars: Fs $\geq$ 1,800kg/cm²

Reinforcing bar materials must be in conformance with JIS G3112 (SD30).

d. Tendon Wires for Prestressing

The allowable tensile stress for tendon wires must be calculated in accordance with Section 1.6.1 of AASHTO standards.

5-3 Alignment Plan

(1) Horizontal Alignment

The horizontal alignment of the Project bridge route was dedicated upon to run in a straight line between a point about 30 m upstream from the Dahka side ferry ghat to a point about 85 m upstream from the Comilla side ferry ghat in order to stay clear of the ferry ghat facilities.

The Dhaka side approach between the bridge and the existing road is planned to have a 400 m radius curve and a 200 m transition curve for the comfort on persons driving vehicles.

Since the Comilla side approach between the bridge and the existing road has an intersection angle of approximately 3°, the angle appears smaller to drivers than the actual curve. Thus, an alignment is planned to have an 3,000 m radius curve to make the curved section as long as possible.

For the above reasons, the bridge route section is planned to be a straight line.

(2) Vertical Alignment

The vertical alignment was decided upon by taking into account the following conditions:

a. The navigation clearance height of 7.5 must be maintained for both the Meghna Branch and the Gumti Tributary.

b. The embankment sections must be higher than the annual highest high water levels +6.65 m (100-year return period).

The vertical alignment of the bridge section was decided upon to maintain the navigation clearance at the deepest point of the river on the Dhaka side (-6.00 m near Sta. No. 20) and at the Comilla side river portion having a riverbed elevation of -2.00 near Sta. No. 40. The embankment sections were decided upon to have an elevation of +7.00 m.

For the above reason, the profile of the vertical alignment of the Project bridge route became convex.

The vertical alignment of both approach sections (the Dhaka and Comilla sides) was decided upon to be a flat level to allow smooth connections to the existing roads. However, it is planned to have vertical curves with a maximum gradient of 3.0% near the bridge abutments (A1 and A2 abutments) in order to maintain the navigation clearance and minimize the amount of embankment material.

From an aesthetic viewpoint, the bridge section is planned to have a vertical slope of 0.3% which is the minimum required gradient for draining rainwater.

5-4 Bridge Length and Span

The river conditions are major factors for determining the length of the Meghna-Gumti Bridge. Appropriate span lengths must be determined by taking into account the substructure's and superstructure's economy, ease of construction, construction periods, etc.

The bridge and span lengths were decided upon based on the results of the field surveys and by reviewing the Feasibility Study.

(1) Confirmed Items As a Result of the Field Surveys

The bridge length proposed by the Feasibility Study Team is 1,480 m. As a result of the field surveys for the Basic Design Study, the following hydrological facts were found:

a. The courses of the Meghna Branch and Gumti Tributary in the vicinity of the Project site are very stable.

b. No scouring can be seen around the Comilla side ferry ghats, but slight siltation is taking place.

c. Slight siltation is taking place up to about 1 km upstream from the bridge site.

d. River traffic can operate beneath a bridge having a span of 87 m.

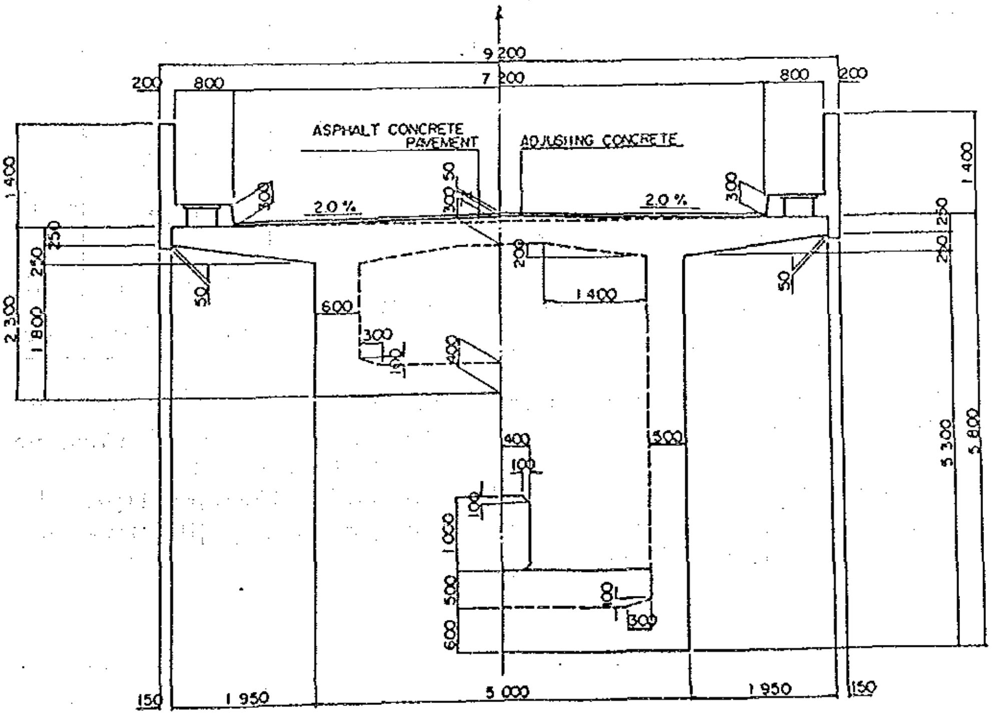
(2) Bridge and Span Lengths

Based on the results of the hydrological survey, the Basic Design Study Team revised the location of the Comilla side abutment proposed in the Feasibility Study towards the ferry ghats in order to shorten the bridge length. As a result, the length of the Meghna-Gumti Bridge was decided upon as being 87.0m x 15 + 52.5m x 2 = 1,410m (16 piers) by taking into account the present riverbank conditions and the protection work to be provided under the Project.

5-5 Superstructure

(1) Structure type

The bridge and span lengths were described in the above Section. The structure type for the superstructure was decided upon as being a cast-in-place prestressed concrete box type (cantilever erection method) by taking into account the results of the Feasibility Study and the detailed design of the Meghna Bridge. The standard cross section of the superstructure is shown below:



(2) Design

The 1,410 m long Project bridge is a 17-span continuous rigid-frame structure. The bridge's span lengths are 52.5 m + 87.0 m x 17 + 52.5 m. A high-speed computer was used to conduct the bridge structure's stress analyses. The analyses were made based on the criteria specified in Section 5.1.

The load combinations used and the increase rate of allowable stress are as follows:

a. Load Combinations and Increase Rates of Allowable Stress

Load Combination		Allowable Stress Increase Rate	Allowable Tensile Strength of Concrete (kg/cm^2)
Super-structure	Main Load (P) + Temperature Change (T)	1.15	18.5
	• Main Load (P) + Wind Load (W)	1.25	23.5
	• Main Load (P) + Temperature Change (T) + Wind Load (W)	1.35	23.5
	• Live Load + Main Load without Impacts + Earthquake Load (EQ)	1.50	-
Sub-structure	• Main Load (P) + Current Force	1.25	-
	• Main Load (P) + Wind Load (W)	1.25	-
		1.50	-
	• Live Load + Main Load without Impacts + Earthquake Load (EQ)	1.50	-
	• Load During Erection Period (ER)		

Note: Main Load P includes the following:

Dead Lad (D)
Live Load (L)
Impact (I)
Prestress (PS)
Creep of Concrete (PCR)
Drying Shrinkage of Concrete (PSH)
Earth Pressure (E)
Hydraulic Pressure (HP)
Buoyancy or Uplift (U)

b. Load Combinations for Structural Failure

• 1.3 x (Dead Load) + 2.5 x (Live Load + Impact) + Secondary Stresses Caused by Prestress
• 1.0 x (Dead Load) + 2.5 (Live Load + Impact) + Secondary Stresses Caused by Prestress
• 1.7 x (Dead Load + Live Load + Impact) + Secondary Stresses Caused by Prestress

Notes: Dead Load = Beam, Weight + All loads on the bridge
Live load = L-load + Pedestrian Load
Impact = Impact by Live Load

c. Adopted Specifications and Standards

The following specifications and standards were used for preparing the Basic Design:

- Specifications (and explanations) for Highway Bridges, Japan Road Association
  - I. Specification for Common Aspects
  - II. Specifications for Concrete Bridges
  - III. Specifications for Substructures of Highway Bridges

- Standard Specifications for Design and Construction of Concrete Structures, Japan Society of Civil Engineers

- Standard Specifications for Highway Bridges, AASHTO

- Standards for Freyssinet Method

(3) Erection

Construction of the cast-in-place prestressed concrete box type beams can be carried out as follows:

a. Top Portion of Pier

The superstructure portion near the pier is to be supported by brackets that are supported by anchor bolts imbedded in the pier.

b. Cantilever Portions

By using cantilever platform wagons, the cantilever portions are to be constructed symmetrically to the pier.

c. Center Closing Portion

The tips of the two facing cantilever portions are to be constructed on a suspended scaffold and will then be closed with a hinged joint.

(4) Bridge Appurtenances

a. Railings

0.9 m high (above the walkway surface) reinforced concrete posts at 1.5 m intervals and two horizontal aluminum pipes having 100 mm diameter were used for the railing of the Meghna Bridge. As shown in Fig. 5-2, by taking into account RHD's request to install higher railings, the Meghna-Gumti Bridge's railing is designed to have 1.1 m high reinforced concrete posts and four galvanized steel pipes.

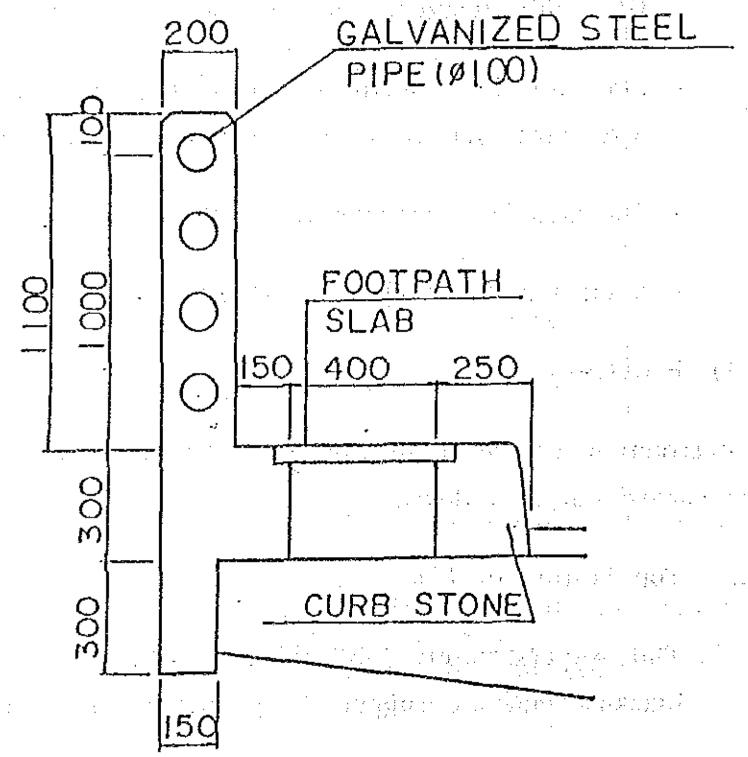


Fig. 5-2 BRIDGE RAILING DETAIL

b. Shoes

The same as for the Meghna Bridge, bearing shoes are adopted for the Meghna-Gumti Bridge.

c. Expansion Joint

In general, expansion joints become a bridge's weak points. Thus, a durable and easily maintainable type having unique shaped steel and rubber pieces is adopted (see Fig. 5-3).

d. Lighting Facility

The Project bridge is to be constructed as a part of a major national road route. Since the Project site is located in a rural area it is not necessary to install a lighting facility. However, electric light pole bases are incorporated in the design to allow for a future lighting facility to be installed if and when urbanization takes place in the Project area or if the area becomes a tourist attraction.

e. Drainage

The same as for the Meghna Bridge, a direct drainage system is adopted.

f. Future Addition

The same as for the Meghna Bridge, the design allows for the future installation of Electricity and telephone cables.

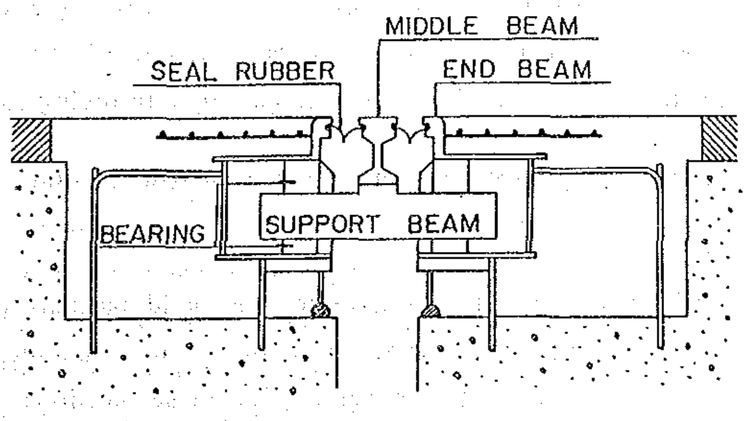


Fig. 5-3 Expansion Joint

5-6 Substructure

(1) Pier Design

i) Pier Shape

The centreline of the Project bridge intersects Meghna Branch's flow direction with an angle of about 75° right and the Gumti Triburary's flow direction with an angle of about 80° left. Since the bridge's superstructure and substructure are planned as one rigid-frame structure, the desirable pier shape is such that (1) its structural function will be symmetrical with respect to the bridge's centerline, (2) it will not create hydraulic problems for the river flows, and (3) the appearance of all piers will have an integrated beauty.

For these reasons, a circular shape is adopted for all of the Project bridge's piers.

ii) Cross Section of the Pier

In order to rigidly affix the superstructure to the substructure, the pier is planned as a reinforced concrete structure.
As described above, all of the piers are planned to be circular shaped. To reduce the volume of concrete material, the cross sections of the piers are hollow. However, the top portions of the piers are solid so that they can be attached rigidly to the superstructure.

The height of each pier varies in the range of approximately 8 to 13 m. by taking into account easy construction and from an aesthetic view, it was decided upon to use the same cross section (outer circle having a 4.9 m diameter) for all piers. Different cross sectional forces can be taken by changing the number of reinforcing bars.

The design strength of concrete for the hollow sections of the piers is to be $\sigma ck = 240 \text{ kg/cm}^2$.

Since PC tendons will be fixed in the top solid portions of the piers, the concrete must have the same strength as the concrete used for the superstructure. Thus, the concrete for these portions are planned to have the design strength of $\sigma ck = 350 \text{ kg/cm}^2$.

iii) Footing Position

The ground at the Project site is a deposit of soft, thick alluvium soil.

The pier foundations are planned to be the pile foundation type. Thus, the pier footings are practically pile caps. Footing positions can be selected at any elevation. If positions are selected above the river water level, the footings can easily be constructed without cofferdams. However, some foundation piles will stick out approximately 11 m above the riverbed. The piles will be subjected to scouring and become unstable. Furthermore, the piles will stand up high in the river and will therefore create an undesirable hydraulic condition.

As were the Meghna Bridge's footings, the footings of the Project bridge are to be constructed at elevations lower than the riverbed elevation.

Footings in the sandbars are to be constructed at elevations lower than the low water level in order to keep them below the water level even if the sandbars are washed away in the future.

(2) Foundation Design

i) Foundation Type'

As previously described, the ground at the Project site is a thick soft deposit of loose sand and unconsolidated silt layers. Thus, the reliable bearing ground for the large Project bridge is the lower sand layer beneath the soft deposit. The lower sand layer is up to EL-80 m at its deepest part and the foundation work should be extended to more than 70 m in depth. In general, pile foundation is used in this type of work.

Steel piles or cast-in-place reinforced concrete piles can be used for pile foundations. Steel piles should be driven by a heavy pile driver that is either mounted on a barge or on staging. Also, a great deal of in-situ welding work and a high level of quality control would be required if steel piles are used. For a bridge of this size, the foundation work would be very difficult.

For cast-in-place reinforced concrete piles, light equipment can be used if the reverse circulation drill method is adopted.

Further, pile construction work using 70 m or longer piles is within the range of past experience.

For the above reasons, cast-in-place reinforced concrete piles (the same type used for the Meghna Bridge's foundations) are adopted for the Project.

ii) Cast-in-place Reinforced Concrete Piles

In general, the cast-in-place reinforced concrete piles are planned to have 1.0 to 1.5 m diameters. For some large bridges, large piles having diameters of 2.0 to 3.0 m are considered to be more economical. From a design viewpoint, large diameter piles may be used for the Project. However, due to the limited capacity of continuous concrete placing work, large diameter piles were not adopted for the Project bridge.

70 m long piles having 2.0 m and 1.5 m diameters require 250 m3 and 140 m3 of concrete respectively. By assuming a concrete placing capacity of 35 m3/hour, it would take seven continuous hours to place concrete for a 2.0 m diameter pile and 4 continuous hours for a 1.5 m diameter piles. It is therefore preferable to use 1.5 m diameter piles.

For the above reason, 1.5 m diameter piles are adopted for the Project. This is the same size pile as described in the Feasibility Study.

5-7 Approach Roads

(1) Embankment

In order to maintain the roads above the river's design high water level of +6.5 m to prevent them from being inundated, 5.0 m wide berms are planned on the embankment section at an elevation of +7.00 m.

Embankment slopes are planned as follows:

i) Slopes lower than berm: 1 or 3

ii) Slopes higher than berm: 1 or 2

(2) Pavement Works

The thickness of the asphalt pavement is to be the same as used for the Meghna Bridge project -- T = 50 cm at the carriageway and T = 30 cm at the shoulder (See Fig.5-4).

The bridge deck is planned to have 5 cm thick asphalt pavement as shown in Fig. 5-5. To maintain the pavement's side slopes, leveling concrete is to be used.

(3) Drainage Works

Drainage work for the embankment sections is planned at the following places:

i) L-shaped gutters on the shoulders of the roads are for preventing the slopes of the high embankment sections from being eroded by rainwater flowing from the road surfaces.

ii) U-shaped channels on berms.

iii) U-shaped channels at embankment slope toes.

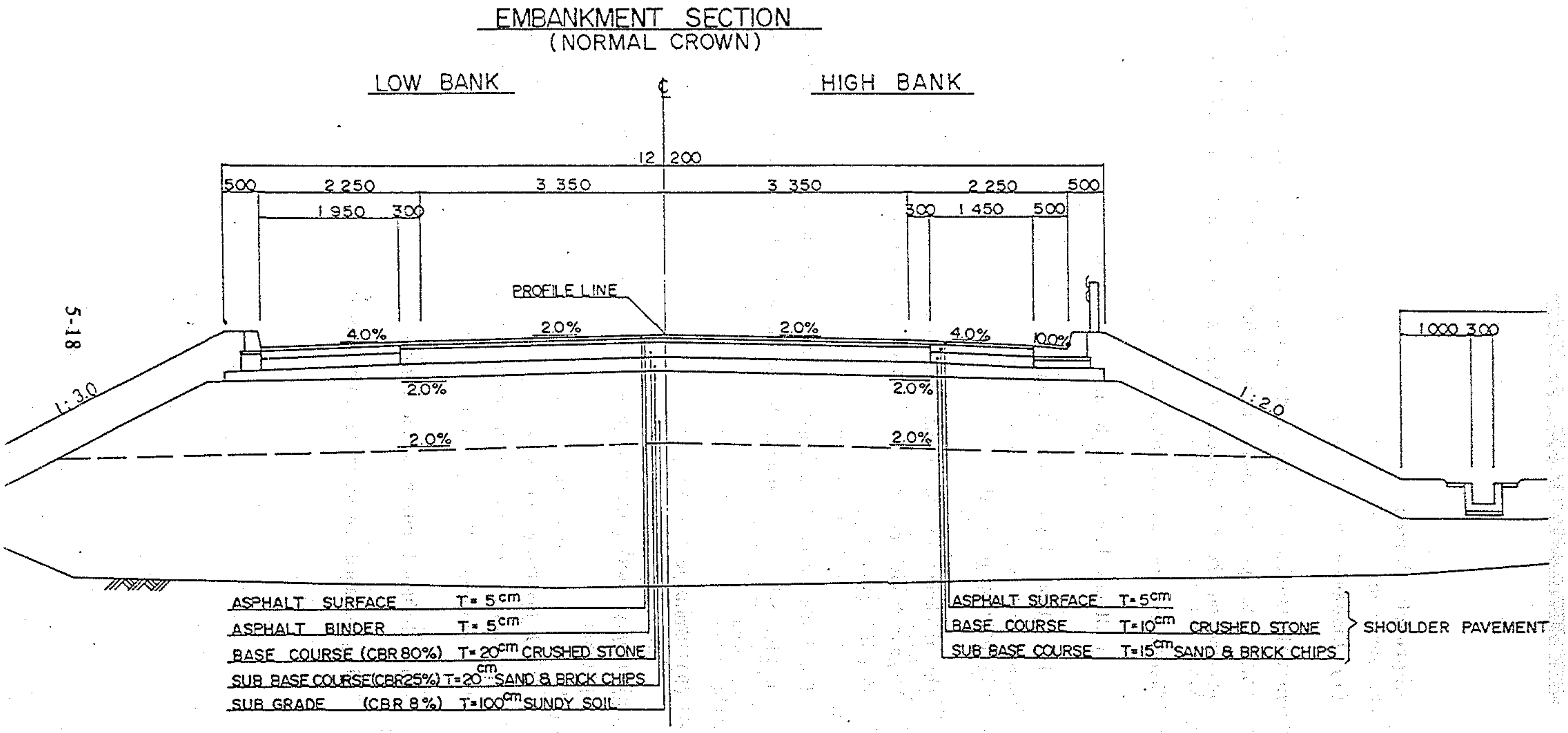


Fig. 5-4 Pavement Structures of Approach Road

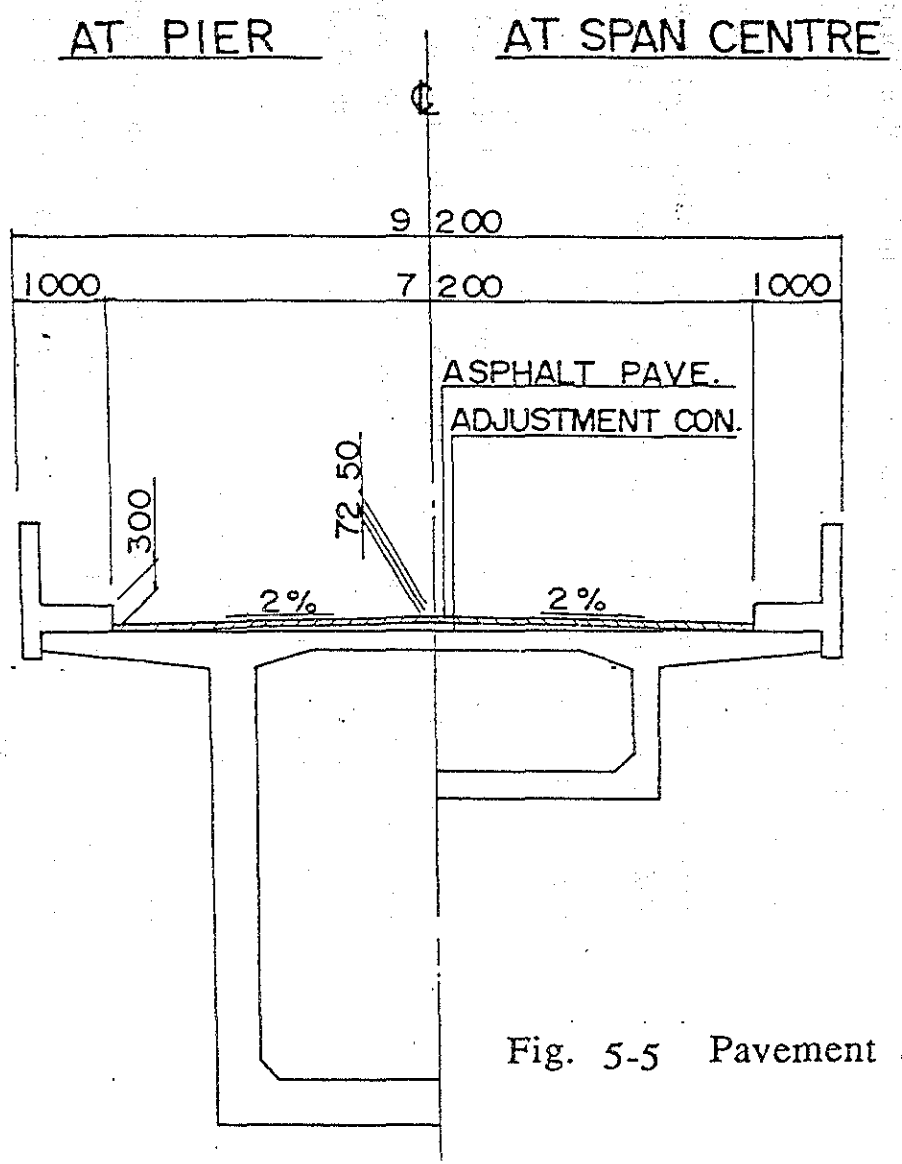


Fig. 5-5 Pavement Structures on Bridge

5-8 Ancillary Work

(1) Riverbank Protection Work

This work is planned to prevent the riverbanks from being scoured by wave actions at the following sections:

i) A 200 m section upstream of the pier in the construction yard on the Dhaka side riverbank.

ii) Around the Comilla side abutment up to 50 m upstream and downstream from the abutment.

(2) Pier Protection Work

Since the pier foundations in the river may receive local scouring, it is planned to place large sized round rock pieces around the piers.

(3) Construction Yard

A 1.6 ha construction yard will be required on the Dhaka side riverbank. It is planned to reclaim the yard by embanking to the elevation of +6.0 m - the same elevation as the existing road. The slopes of the embanked yard will be protected from erosion and scouring by concrete slope protection work and steel sheet-pile work

(4) Abutment Protection Work

The ground around the bridge abutments are planned to be protected from scouring during the high water period by placing concrete slope protection work, brick slope protection work, and steel sheet-pile protection work.

The sheet-pile protection work will be provided in areas that would have the tendency to receive scouring by wave action and to prevent the abutments and roads from damage.

(5) Guardrail Work

It is planned to install guadrails from a point immediately behind the bridge abutments to points where the berms start.

The guardrails will be installed on both sides of the abutments.

5-9 Basic Design Drawings

Basic Design Drawings for Meghna-Gumti Bridge are presented as follows:

(1) Centre Line & Survey Marks

(2) Plan of Approach Road and Bridge

(3) Profile of Approach Road and Bridge

(4) General View of Bridge

(5) Dimensions of Box Girder (1)

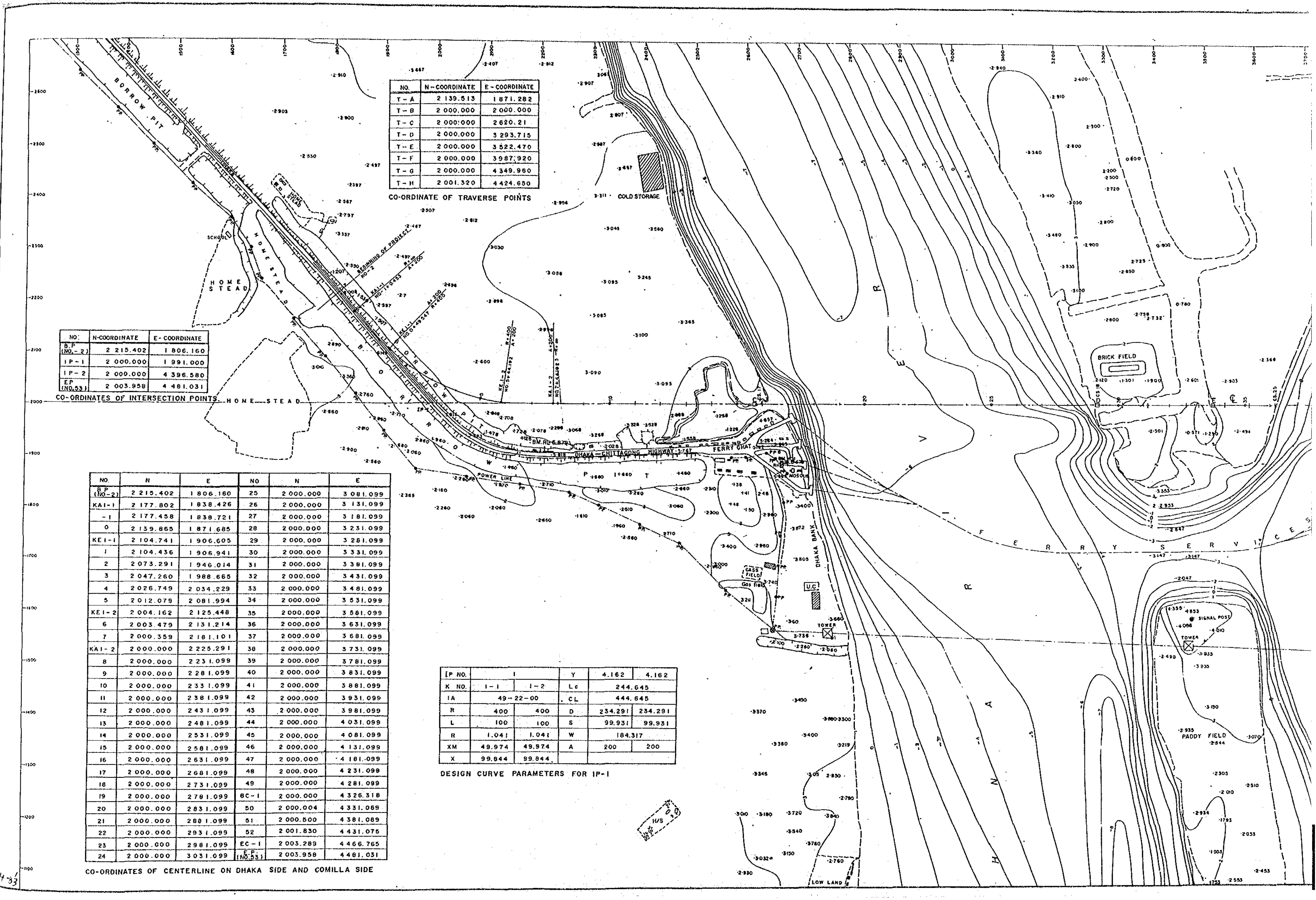
(6) Dimensions of Box Girder (2)

(7) Layout Plan of P.C. Cables (1)

(8) Layout Plan of P.C. Cables (2)

(9) P.C. Bar Arrangement of Pier Top Segment

(10) General Plan of Substructure



NO.	N-COORDINATE	E-COORDINATE
T-A	2 139.513	1 871.282
T-B	2 000.000	2 000.000
T-C	2 000.000	2620.21
T-D	2 000.000	3 293.715
T-E	2 000.000	3 522.470
T-F	2 000.000	3 987.920
T-G	2 000.000	4 349.960
T-H	2 001.320	4 424.650

CO-ORDINATE OF TRAVERSE POINTS

NO:	N-COORDINATE	E-COORDINATE
B.P (NO.-2)	2 215.402	1 806.160
IP-1	2 000.000	1 991.000
IP-2	2 000.000	4 396.580
EP (NO.53)	2 003.958	4 481.031

CO-ORDINATES OF INTERSECTION POINTS

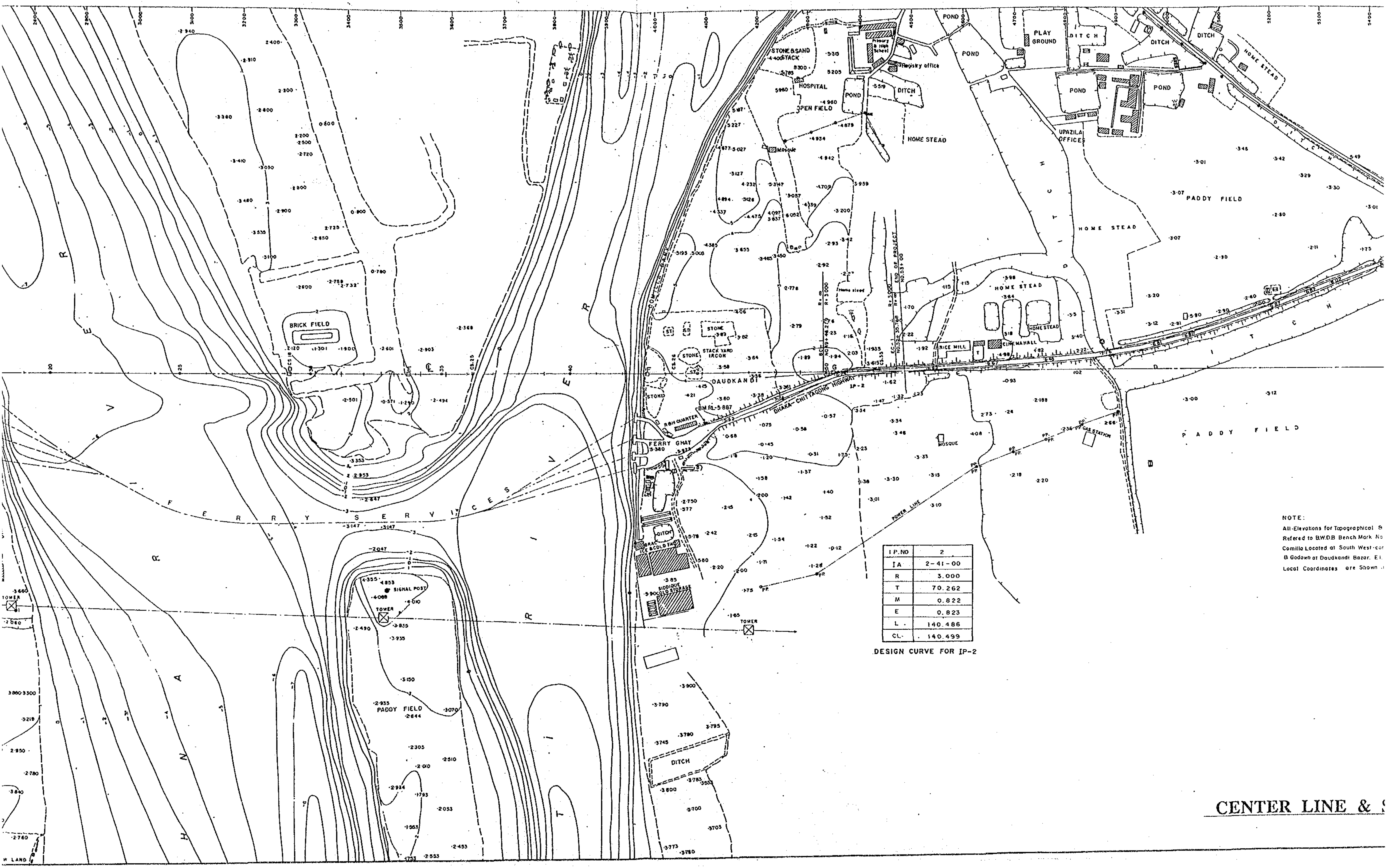
NO.	N	E	NO	N	E
B.P (NO-2)	2 215.402	1 806.160	25	2 000.000	3 081.099
KAI-1	2 177.802	1 838.426	26	2 000.000	3 131.099
-1	2 177.458	1 838.721	27	2 000.000	3 181.099
0	2 139.865	1 871.685	28	2 000.000	3 231.099
KEI-1	2 104.741	1 906.605	29	2 000.000	3 281.099
1	2 104.436	1 906.941	30	2 000.000	3 331.099
2	2 073.291	1 946.014	31	2 000.000	3 381.099
3	2 047.260	1 988.665	32	2 000.000	3 431.099
4	2 026.749	2 034.229	33	2 000.000	3 481.099
5	2 012.079	2 081.994	34	2 000.000	3 531.099
KEI-2	2 004.162	2 125.448	35	2 000.000	3 581.099
6	2 003.479	2 131.214	36	2 000.000	3 631.099
7	2 000.359	2 181.101	37	2 000.000	3 681.099
KAI-2	2 000.000	2 225.291	38	2 000.000	3 731.099
8	2 000.000	2 231.099	39	2 000.000	3 781.099
9	2 000.000	2 281.099	40	2 000.000	3 831.099
10	2 000.000	2 331.099	41	2 000.000	3 881.099
11	2 000.000	2 381.099	42	2 000.000	3 931.099
12	2 000.000	2 431.099	43	2 000.000	3 981.099
13	2 000.000	2 481.099	44	2 000.000	4 031.099
14	2 000.000	2 531.099	45	2 000.000	4 081.099
15	2 000.000	2 581.099	46	2 000.000	4 131.099
16	2 000.000	2 631.099	47	2 000.000	4 181.099
17	2 000.000	2 681.099	48	2 000.000	4 231.099
18	2 000.000	2 731.099	49	2 000.000	4 281.099
19	2 000.000	2 781.099	BC-1	2 000.000	4 326.318
20	2 000.000	2 831.099	50	2 000.004	4 331.089
21	2 000.000	2 881.099	51	2 000.500	4 381.089
22	2 000.000	2 931.099	52	2 001.830	4 431.075
23	2 000.000	2 981.099	EC-1	2 003.289	4 466.765
24	2 000.000	3 031.099	E.P. (NO.53)	2 003.958	4 481.031

CO-ORDINATES OF CENTERLINE ON DHAKA SIDE AND COMILLA SIDE

IP NO.	1		Y	4.162	4.162
K NO.	1-1	1-2	Lc	244.645	
IA	49-22-00		CL	444.645	
R	400	400	D	234.291	234.291
L	100	100	S	99.931	99.931
R	1.041	1.041	W	184.317	
XM	49.974	49.974	A	200	200
X	99.844	99.844			

DESIGN CURVE PARAMETERS FOR IP-1

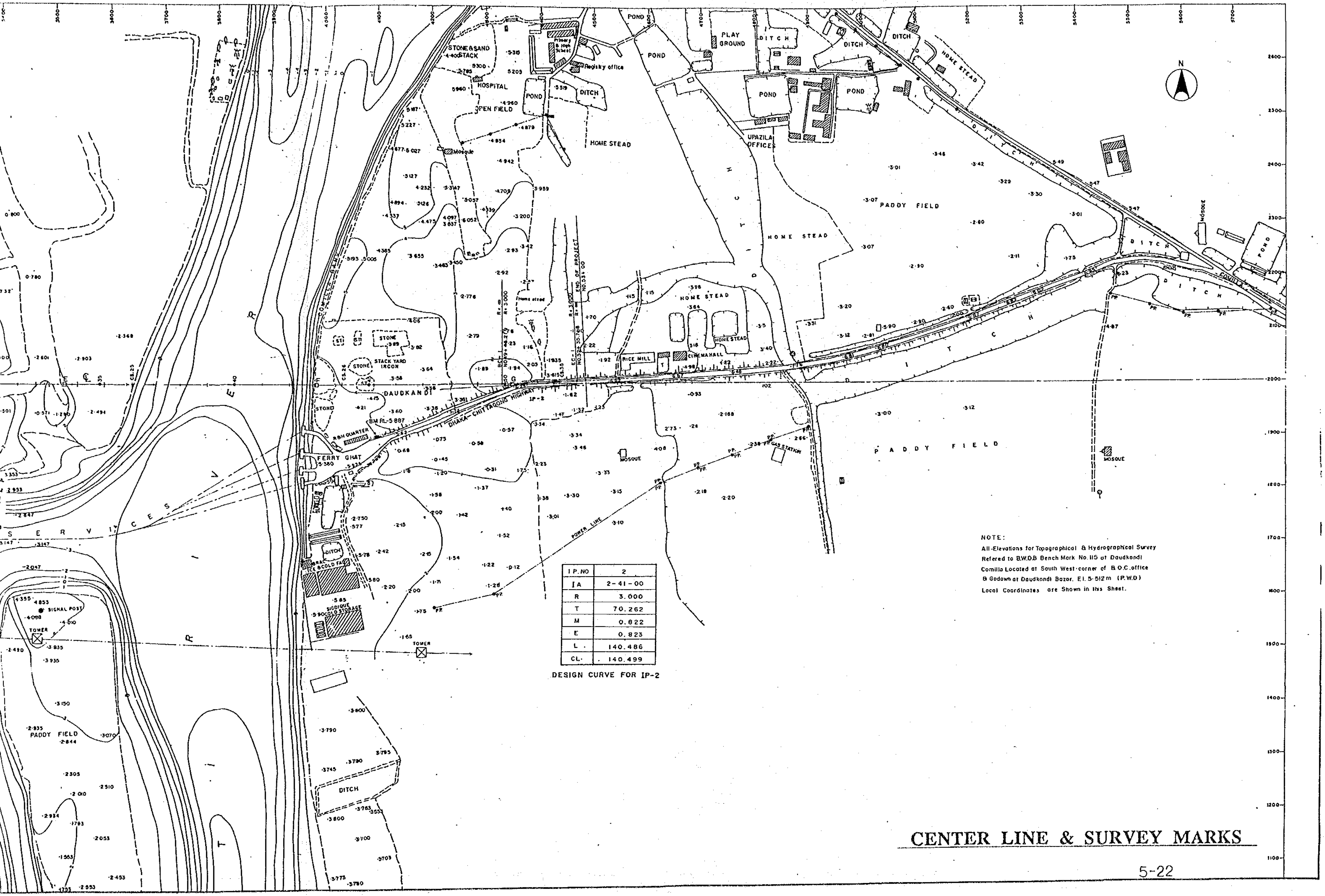
4-33



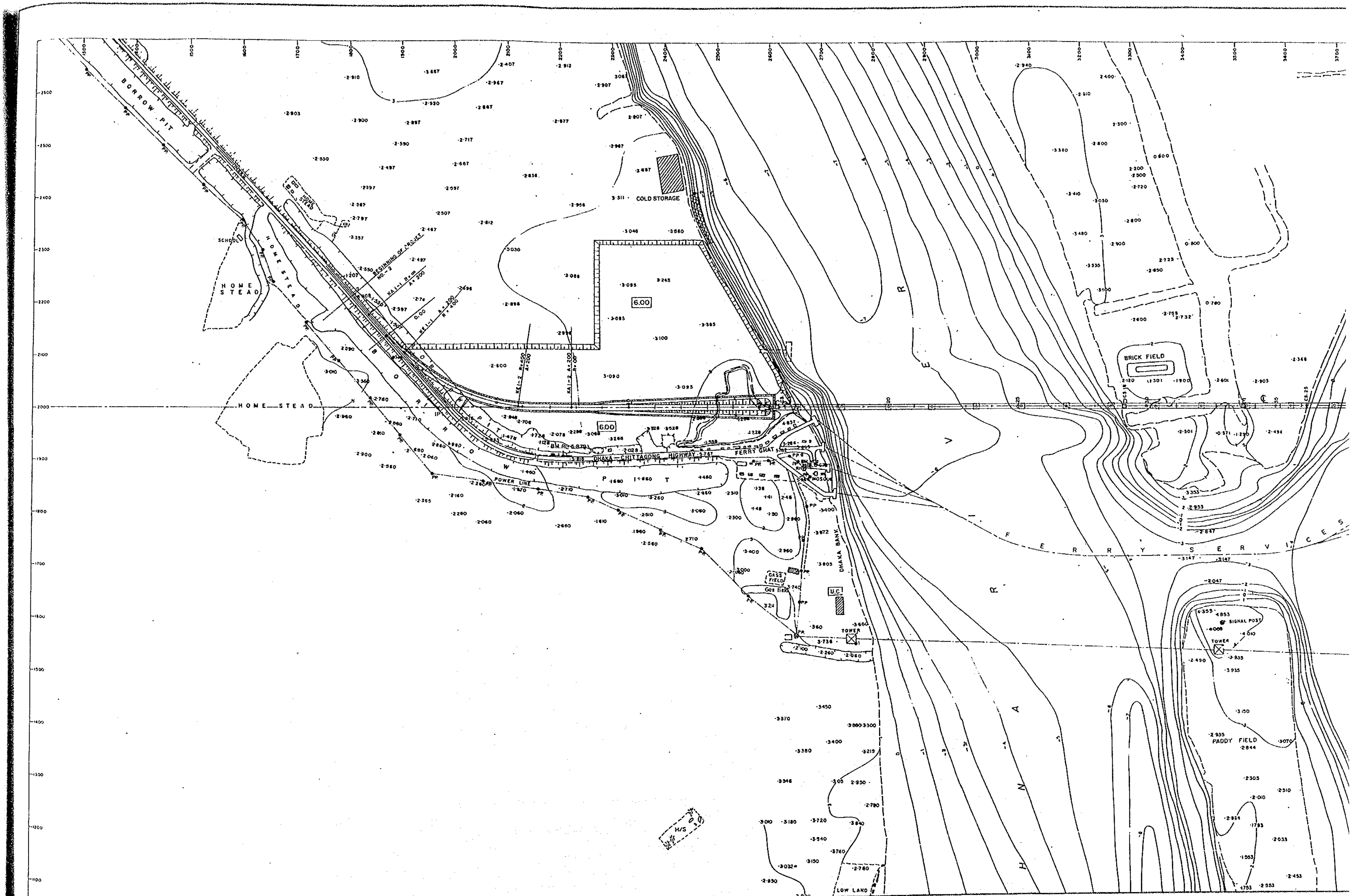
I.P. NO	2
IA	2-41-00
R	3.000
T	70.262
M	0.822
E	0.823
L	140.486
CL	140.499

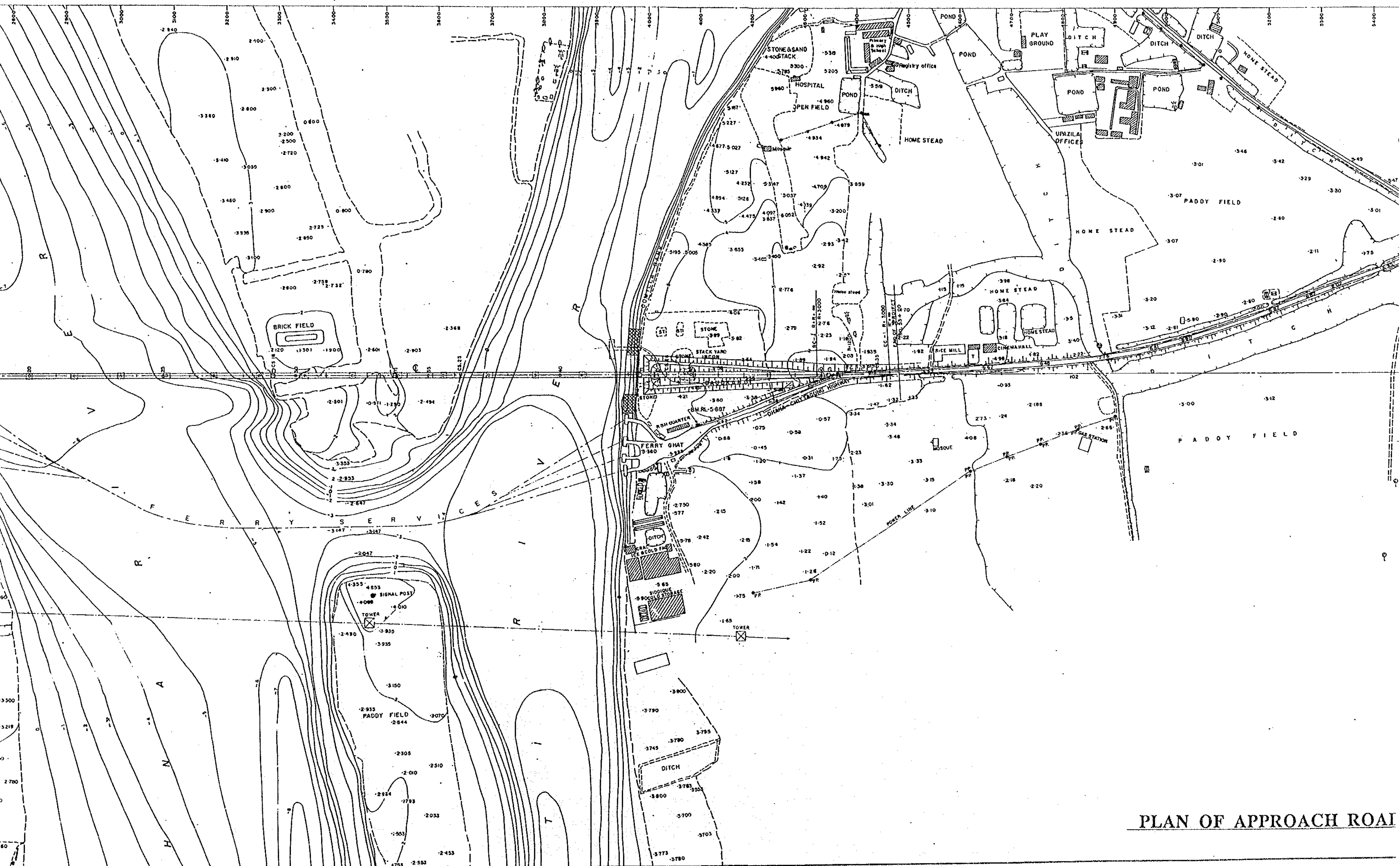
DESIGN CURVE FOR IP-2

CENTER LINE & S

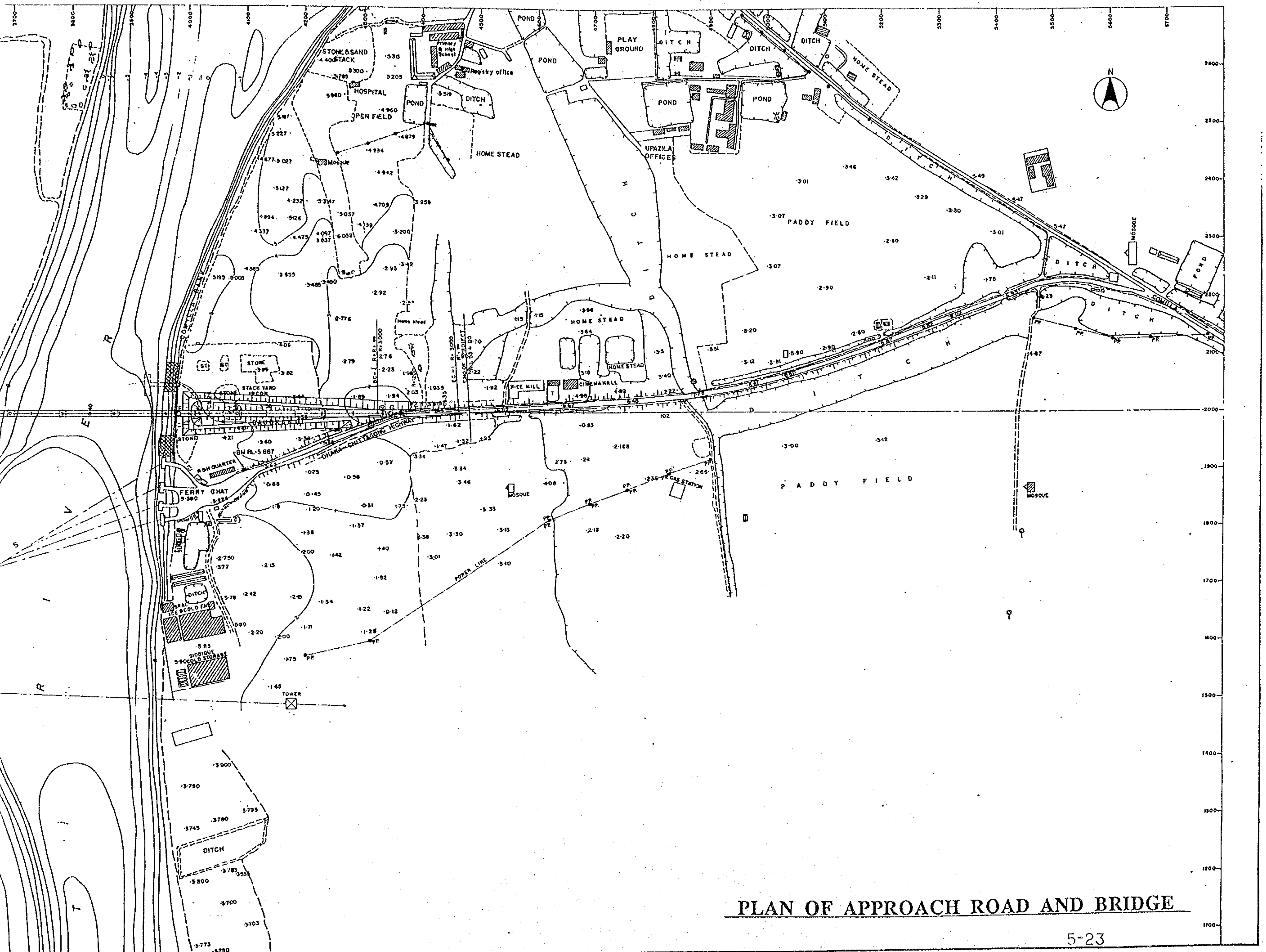


CENTER LINE & SURVEY MARKS

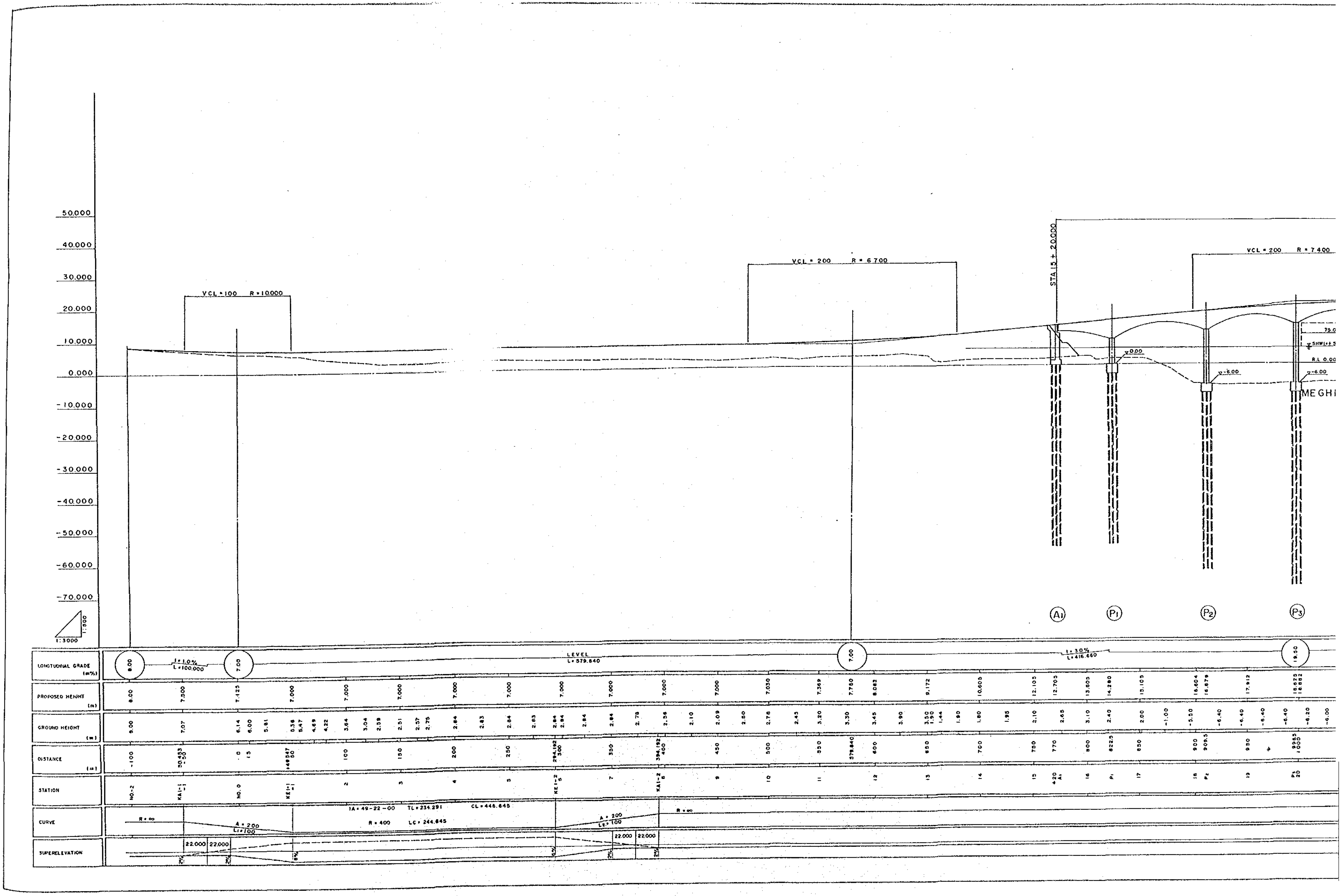

BORROW PIT
HOME STEAD
SCHOOL
COLD STORAGE
BEGINNING OF PROJECT NO.-2
6.00
DHAKA - CHITTAGONG HIGHWAY
FERRY GHAT
MOSQUE
POWER LINE
DHAKA BANK
GAS FIELD
U.C.
TOWER
LOW LAND
H/S
BRICK FIELD
SIGNAL POST
PADDY FIELD
FERRY SERVICES



PLAN OF APPROACH ROAI

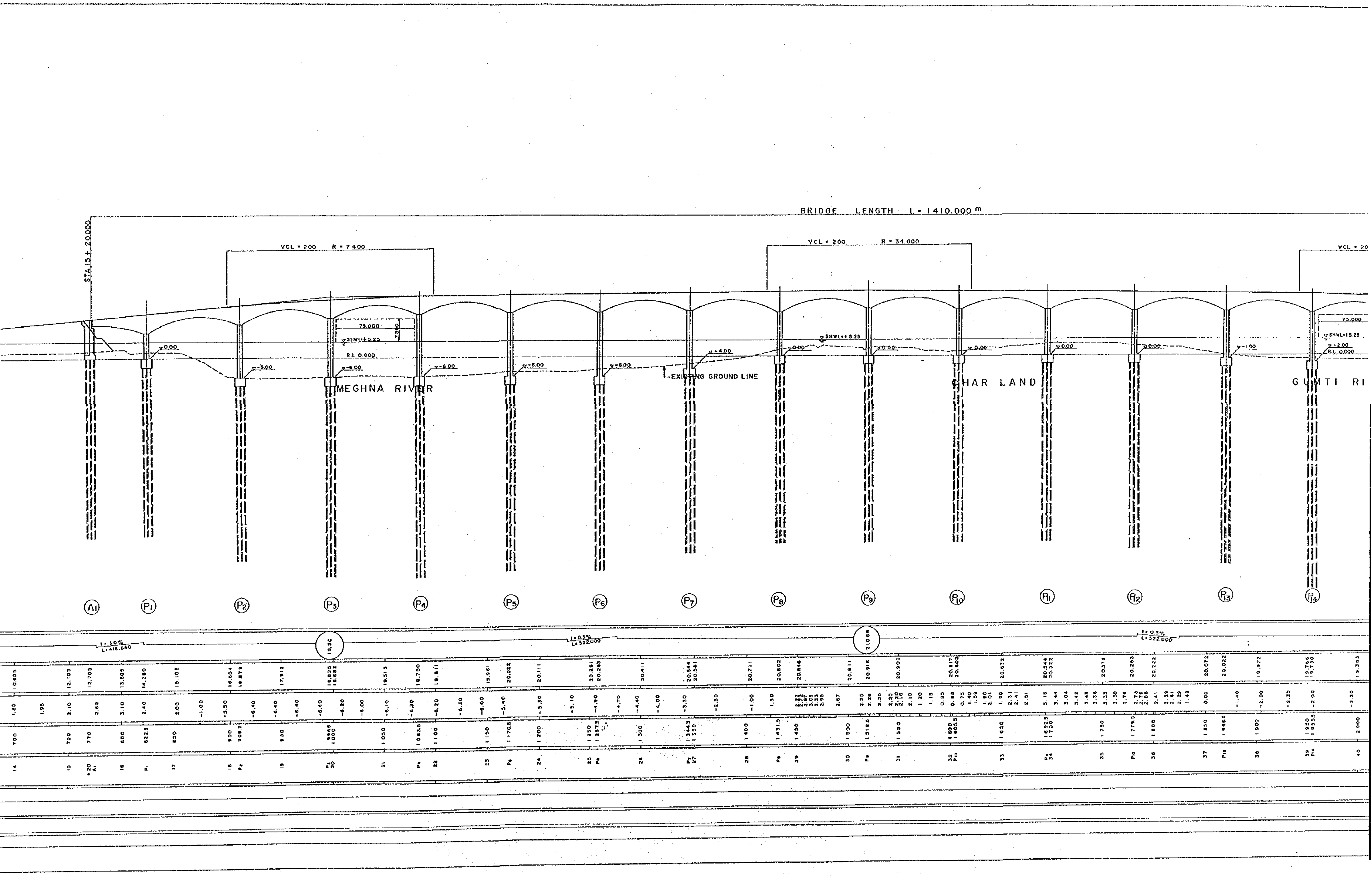


PLAN OF APPROACH ROAD AND BRIDGE

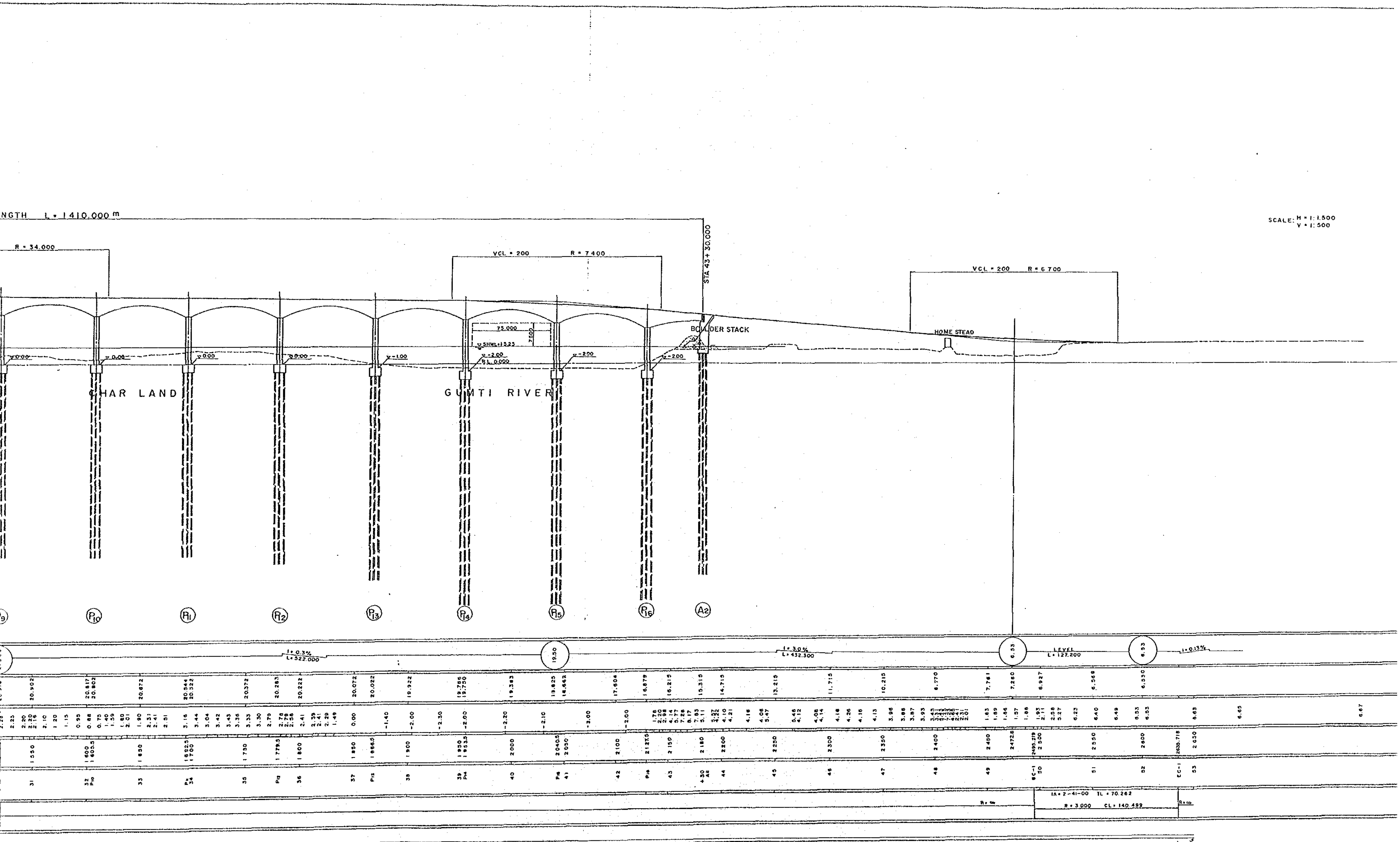


50.000
40.000
30.000
20.000
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
-60.000
-70.000
1:3000
1:500
VCL = 100 R = 10.000
VCL = 200 R = 6 700
STA 15 + 20.000
VCL = 200 R = 7 400
MEGHI
A1
P1
P2
P3
LONGITUDINAL GRADE (m%)
PROPOSED HEIGHT (m)
GROUND HEIGHT (m)
DISTANCE (m)
STATION
CURVE
SUPERELEVATION
LEVEL L = 579.840
I = 1.0% L = 100.000
I = 3.0% L = 416.660
IA = 49-22-00 TL = 234.291 CL = 446.645
R = 400 LC = 244.645
A = 200
22.000 22.000

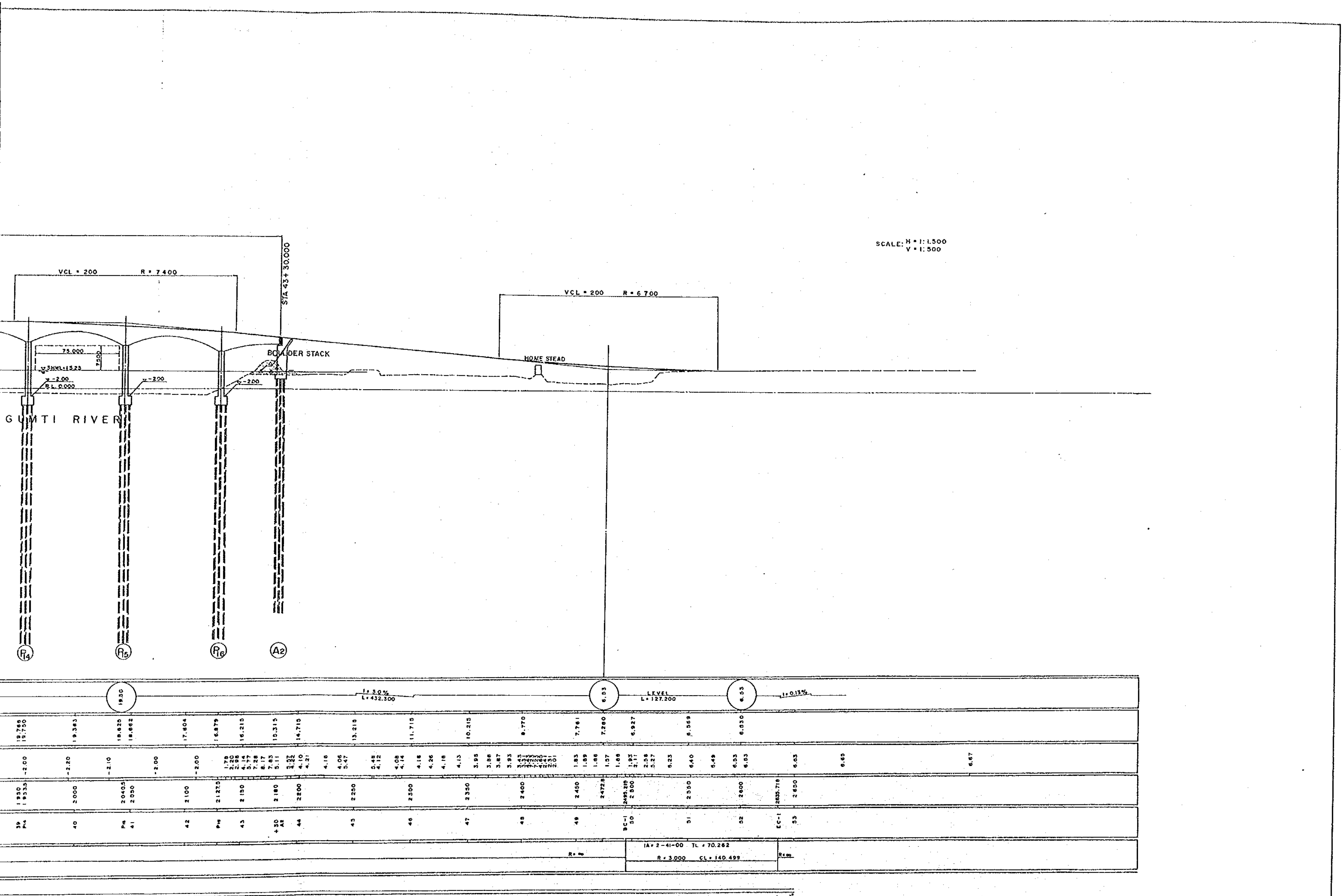
4-35



BRIDGE LENGTH L = 1410.000 m
STA 15 + 20.000
VCL = 200 R = 7400
VCL = 200 R = 34.000
VCL = 20
75.000
SHWL + 5.25
R.L 0.000
MEGHNA RIVER
EXISTING GROUND LINE
CHAR LAND
GUMTI RI
A1
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
i = 3.0%
L = 416.660
i = 0.5%
L = 522.000
i = 0.5%
L = 322.000
19.50
21.066



PROFILE OF APPI



PROFILE OF APPROACH ROAD AND BRIDGE