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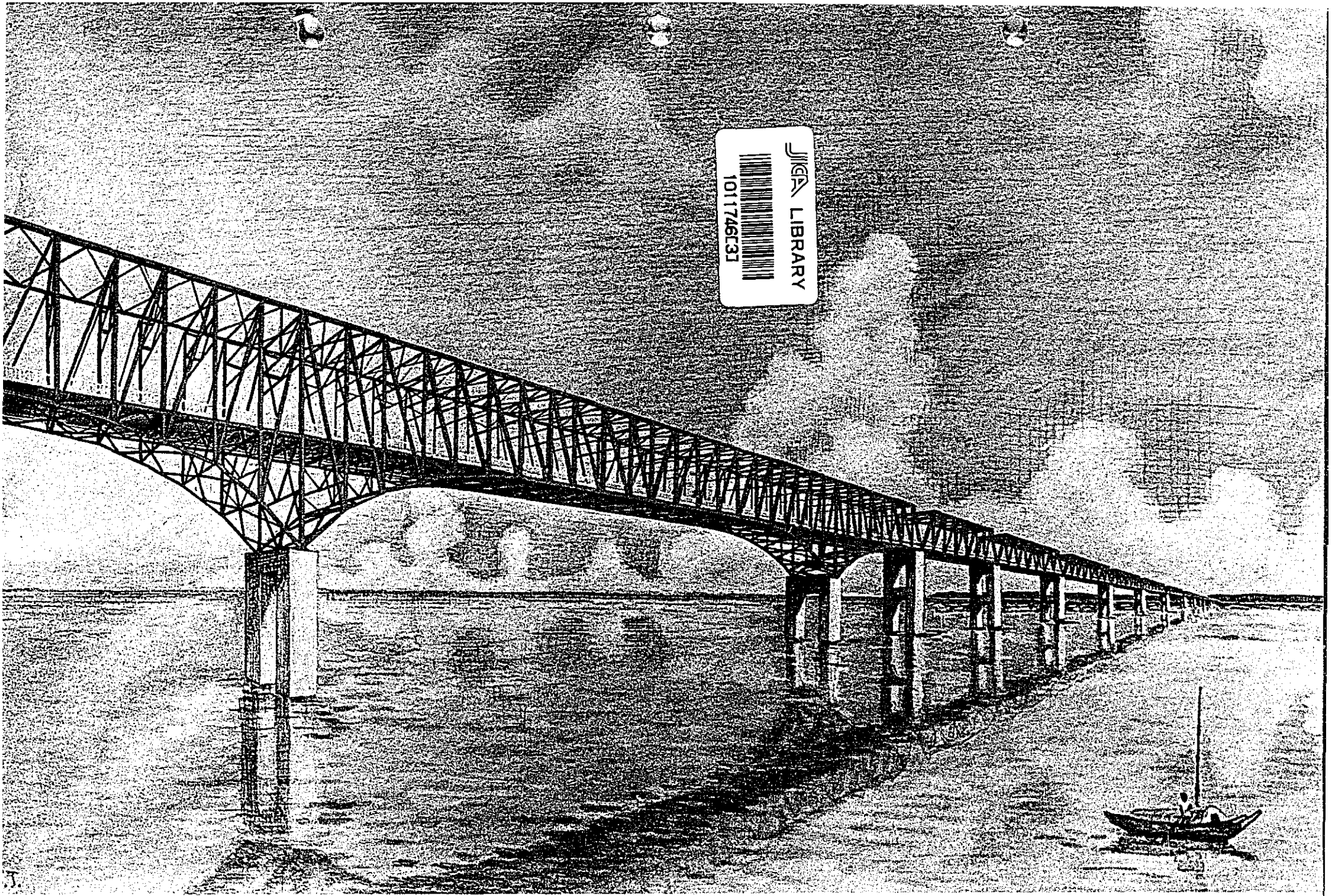

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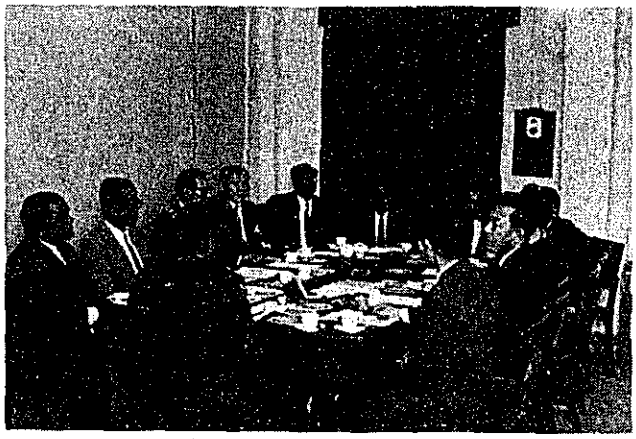
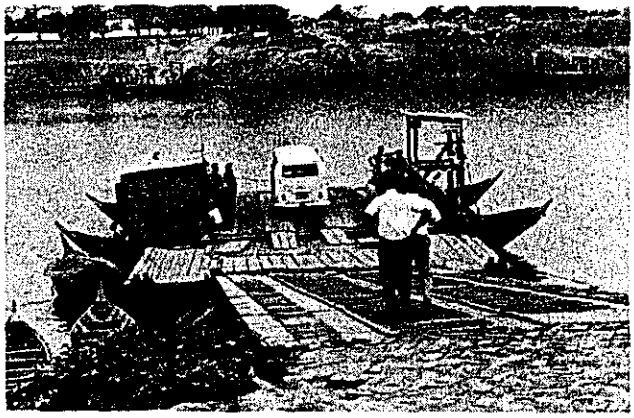
PERSPECTIVE VIEW OF PADMA RIVER BRIDGE

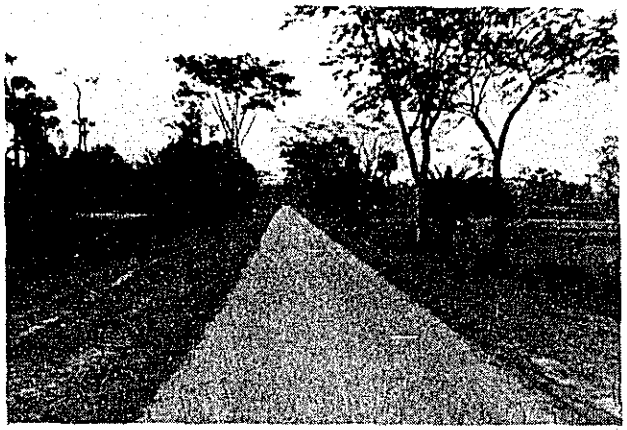


Discussion among survey team and the governmental officials about the fundamental scope of the survey

Survey team and government engineers at Faridpur Inspection Bungalow



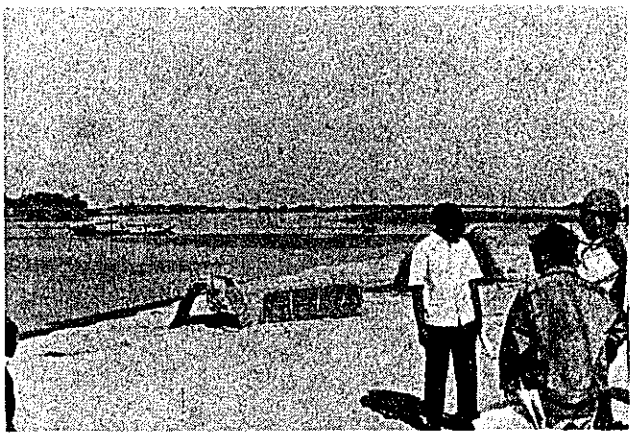
Ferry boats near Madaripur



Typical rural highway near Jessore

Technical discussion about the proposed Dacca-Faridpur road (in Roads and Highways Office)

The right bank of the Padma river near Faridpur



The proposed bridge site of the Dhaleswari river

An existing cutcha road between the Padma and the Dhaleswari

C O N T E N T S

Preface

Part I. Outline of Survey 3
1. Background of the survey 3
2. Conclusions and recommendations 5
2-1. Significance of Dacca-Faridpur Road 5
2-2. Technical feasibility 6
2-3. Economic feasibility 7
2-4. Conclusions and recommendations 9
3. Members and schedule of the survey team 12

Part II. Details 19
1. Outline of the proposed road 19
1-1. Topography and traffic status 19
1-2. Significance of the proposed road 20
1-3. Alternative routes shown by the Government 22
2. Fundamental factors for planning 24
2-1. Geometric design standards 24
3. Route reconnaissance and works in East Pakistan 26
3-1. Collecting data 26
3-2. Route reconnaissance survey 27
3-3. Discussion with the government engineers 29
4. Route setting 30
4-1. Crossing point of the Padma river 30
4-2. Outline of the proposed route 31
4-3. Outline of the polder project 32
5. Technical features of the proposed route 33
5-1. Natural condition 33
5-2. Crossing facilities of the Padma river 41
5-3. Preliminary design 50
5-4. Estimation of construction cost 60
6. Economic characteristics of the route 72
6-1. Traffic condition of the existing route 72
6-2. Traffic volume of the new road 73

6-3. Benefit of the proposed road 78
6-4. Economic evaluation 82
7. General Assessment 94
7-1. Technical problems of crossing the Padma river 94
7-2. Road construction plan 94
7-3. Construction plan of the road directly connecting to Khulna 95
8. Plan of further study 98

App. 1. Technical study on the viaduct plan of North-South road in Dacca ... 99
App. 2. Design criteria 109
App. 3. Gravity model 119
App. 4. Estimation of Benefits 122
App. 5. Data list 131

Part III. Drawings

1. East Pakistan road map
2. Route location map of project area
3. Geological map of East Pakistan
4. Average annual precipitation
5. Polder project for road project area
6. Origin and destination traffic flow map
7. General plan
8. Plan and profile (No. 1 - 6)
9. Ganges or Padma river bridge, Plan and profile
10. Dhaleswari river bridge, Plan and profile
11. Arial Khan river bridge, Plan and profile
12. P.C. girder bridge
13. Typical cross section and pavement
14. Culvert details
15. Drain pipe details
16. Road cross section (No. 1 - 11)
17. Dacca North-South road plan
18. Dacca North-South road project, Type A
19. Dacca N-S road, Type B, Plan and profile
20. Dacca N-S road, Type B, General section
21. Dacca N-S road, Type C, Plan and profile
22. Dacca N-S road, Type C, General section

PREFACE

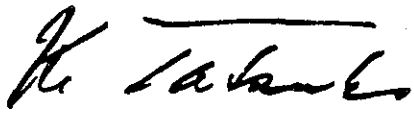
The government of Japan, in response to the request of the Government of Pakistan, entrusted the Overseas Technical Cooperation Agency with the study on Dacca-Faridpur Road Construction Project in East Pakistan.

The Agency, appreciating the necessity of the said road and its role as the Asian Highway, Route 1, despatched a survey team headed by Mr. Takahiko Hayanari, Chief of Maintenance and Facility Dept., Japan Highway Public Corporation, consisting of specialists respectively in road planning, design, geology and economy.

The Team conducted a thorough field investigations in East Pakistan over a period of a month in February and March 1970 in close cooperation with the Government of Pakistan and East Pakistan. The findings of the investigations are compiled in the report.

It will be the greatest pleasure to me if the present survey will serve to promote the development of Pakistan and the friendly relations between Pakistan and Japan.

September 1970



Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

PART I. OUTLINE OF SURVEY

Part I. Outline of Survey

1. Background of the survey

The government of Japan received a request in April, 1969 from the government of Pakistan to execute surveying on Dacca-Faridpur Road Project in East Pakistan. The proposed road connects by the shortest route the state capital, Dacca, with Faridpur at some 50 miles west of Dacca, and it has a crossing of the Padma river (local name of the lower Ganges) which is the largest river of the country.

The present route connecting above two cities consists of a road making a long detour north and ferry service of about 2 hours sailing time. This route has been designated as Asian Highway No. 1 and the new road is to be regarded as an improved route of the Asian Highway.

Japanese government has been making a series of technical cooperation for the road improvement projects of Asian Highway No. 1. In 1966 a survey was made upon the request of the government of Pakistan for the bridge project on the Gorai where a ferry service is being operated presently. Until 1967 the Japanese survey teams were dispatched three times to study the feasibility of the project, and a preliminary design was completed together with necessary technical investigation. And the government of Japan has started studying possibility of offering Yen credit for this project.

In 1968 a further request was made by the government of Pakistan for surveying Faridpur-Jessore Road Project in which the Gorai Bridge Project was included. Accordingly the government of Japan dispatched a survey team to make a technical and economic study as well as geographical road surveying.

The Dacca-Paridpur Road Project is closely related to the other road projects on which the government of Japan has done studies, and it holds an important position in the road system improvement plan for the whole East Pakistan. Therefore the government of Japan decided to send a surveying team for this project in responce to the above mentioned request of the government of Pakistan.

The first survey for this project was prepared as a preliminary one, as the detailed survey at the first stage is not appropriate considering that this route crosses the Padma, one of the greatest rivers in the Eurasian continent and that the river condition is not stable.

The survey team arrived in Dacca in February, 1970. In the mean time the government of East Pakistan informed the Japanese government of her idea concerning the above-mentioned road survey as follows;

1) Instead of preliminary survey, a complete Feasibility Study would be made by the team.
2) It covers a whole road project from Dacca to Khulna via Faridpur with a feeder to Gopalganj Sub-Division.
3) Feasibility of an Overhead North-South Road across the old Dacca city in the form of approach road to the proposed Buriganga Bridge would also be mde by the team.

These requests could not be fulfilled satisfactorily as the team had not been well informed in advance and their staying time was not sufficient. However, the team made their possible efforts in this aspect during their stay in East Pakistan and also worked for the requests after back to their home country.

Eventually the report on this road survey has been drafted as an outlined feasibility study report on Dacca-Faridpur Road Project, and it also mentions about the Dacca-Khulna Road Project as well as the North-south road problem in Old Dacca. As for the Padma crossing which is the most difficult problem of this project only a bit of reconnaissance survey could be done.

The final conclusion concerning the feasibility of this road project should be made according to the further study by experts including river engineers and hydrologists for the solution of technical problems of the Padma crossing.

2. Conclusions and recommendations

2-1. Significance of Dacca-Faridpur Road

The proposed road of which the team executed surveying at the request of the government of East Pakistan extends south-westwards from Dacca crossing the rivers of Padma, Ali Al Khan and others directly to near Faridpur. Present connection between Dacca and Faridpur is a 132 km long north detour with only 60 km direct distance, although it is one of the most important arterial routes in East Pakistan.

As for the Padma crossing of the present route, the 16 km ferry service takes 2 hours bringing about great losses of time and distance. Therefore, Dacca-Faridpur Road which was proposed recently holds a primal significance for the improvements of traffic condition between two economic zones of south-east region around Dacca and south-west districts around Faridpur and Khulna because of much time and distance savings. Moreover, the proposed road is an alternative which bypasses the present detouring route of Asian Highway in the future. This means the road composes one of the important parts of the Asian Highway No. 1 which starts at Saigon, South Viet-Nam ending far west at Bazargan, Iran-Turkey border. The importance and difficulties of its construction shall be highly esteemed internationally.

As for the important part of the Asian Highway No. 1 and No. 2, between Dacca and Aricha the road improvement project is now being carried on. This part of Asian Highway is inevitable for the traffic between south-east region around Dacca and north-west region surrounded by two rivers of the Jamuna and the Ganges, and its importance as an East Pakistani arterial road of East Pakistan and the Asian Highway No. 2 will be kept even after Dacca-Faridpur road is completed in the future. Therefore, the Dacca-Faridpur road project is not to make the Dacca-Aricha road improvement project meaningless and the both will contribute much to the function of the East Pakistan arterial road network in accordance with each other.

As the part between Dacca and the left bank of the Padma crossing point of the proposed route runs near the villages of comparatively dense habitation, the proposed road will produce a large development effect on the people in the

region.

After the completion of the road the traffic demand between Dacca and this region will increase and a new living zone will possibly be formed absorbing factories, business offices, etc. from the city of Dacca, which is now near the saturation. Therefore priority should be given to the Padma left side bank area near Dacca in case the stage construction has to be adopted for the proposed road.

The proposed route extends from Dacca as far as Faridpur. However, as the government of East Pakistan suggests, the route shall be a fundamental part of the connection between Dacca and Khulna which is the center of south-west district. It will improve much the traffic condition between Dacca and Khulna in accordance with the Jessore-Madhukhali road project including the Gorai Bridge project. Extension of the proposed road farther than Faridpur to Khulna will be very useful for Dacca-Khulna traffic and will attract attention as a project of high investment efficiency in the future. But at present Jessore-Madhukhali road project with the Gorai Bridge will be more advantageous for the nation's economic point of view.

2-2. Technical feasibility

This road project holds technical feasibility. However, its planning and design will be slightly changed according to the alteration of such initial condition that the proposed height of the road in the polder is decided according to the condition that two polder plans of Dacca South-West Project and Faridpur-Barisal Project will be completed in 1980.

As for the crossing point of the Padma river, Mawa site was proposed as a result of studies on river width, bank stability, total length of the road, etc. About 100 km of the banks near the point where a line connecting Dacca and Faridpur intersects the river were studied taking WAPDA (Water and Power Development Authority) Polder projects into consideration. River width at the site is about 2 km and the narrowest in the vicinity. But the more detailed survey of river sections and its conditions in rainy season should be made. The final conclusion should be made after these surveys are fulfilled.

As for the Padma crossing economic comparisons were made with respect to ferry and bridge. As a result bridge plan turned out to be more economical and therefore further technical study on ferry plan was not carried out.

For the bridge of the Padma a continuous steel truss of 300 m centerspan and 100 m sidespans were adopted as the center main spans for the navigation requirements of IWTA (Inland Waterway Transportation Authority). Approach to main spans consists of 70 m spans simple trusses. For the Daleswari and the Ali Al Khan rivers prestressed concrete boxgirder of cantilever type spans 80 m and 50 m were adopted respectively. As the difficulties are anticipated in case East Pakistan Engineering contractors execute the construction of the superstructure of these bridges, an introduction of foreign engineering in this field should be considered. This will improve much the engineering level of East Pakistani enterprises. For substructures of the main part of the Padma bridge wells of 40 m depth are proposed considering the safety of the structure. This method is prevailing widely in East Pakistan and the difficulties are presumed little. But the depth of 40 m may cause some troubles during the construction. Decision of the depth of substructures requires further investigations on foundation and river conditions, and its result may change the type of the substructures.

Further investigations and studies are required on selection of optimum methods of construction, increasing construction capacity and appropriate process control.

Except for these bridges of the Padma, the Daleswari and the Ali Al Khan there are not so difficult technical problems as to construction. Construction of road section with small bridges except above said three large bridges can be executed by East Pakistani constructors with their former experiences and engineering ability. Concerning the road in the polders such engineering problems as proposed height of the road and intersections with canals should be dealt with in close relation and coordination with related authorities.

2-3. Economic feasibility

Motor traffic in East Pakistan is in a very poor condition being interrupted by many rivers. Existences of the rivers of Padma and Jamuna as

obstacles for traffic are particularly so large that they divide the country into three regional areas. Therefore the traffic between two regions separated by the Padma is not so heavy at present.

However, the new road will generate such new traffic as that of the east region in East Pakistan where hindrances of big rivers are few.

As for the economic feasibility of the new road two cases of ferry and bridge crossing of the Padma were studied.

Estimated construction cost of the new road is about 36 million US dollars including 14 million US dollars for the Padma bridge. This means the construction cost of the case with ferry service on the Padma is 22 million US dollars excluding the cost for ferry service.

The traffic volume in 1980 is estimated as about 650 vehicle/day for the ferry case and about 1,050 vehicle/day for the bridge case. This shows the effect of traffic generation is far bigger when time and distance are shortened by the bridge.

As a result the cost benefit ratios become 0.90 for the ferry plan and 1.23 for the bridge plan. It is clear that the bridge plan can produce more benefit than the investment although the construction cost is big while the ferry plan brings about smaller benefit than the investment.

One of the reasons why the above results were obtained is that the benefit per vehicle of the bridge plan is larger than that of ferry plan.

By the time when the proposed Dacca-Faridpur road is completed the Tungi-Aricha road will also be completed shortening the Dacca-Faridpur road connection from 120 km to 90 km.

Running time is also reduced from present 4.5 to 2.3 hours of ferry plan and 1.5 hours of bridge plan. Thus, time benefit of the bridge plan becomes larger as 2.33$/vehicle than 1.68$/vehicle of ferry plan. Running benefit is also larger for the bridge plan as 4.43$/vehicle than 2.85$/vehicle of ferry plan. Another reason is that there is a big difference of traffic generation

efficiency between the ferry plan and the bridge plan. As for the traffic generation ratios the bridge plan has 2.8 and the ferry plan has only 1.3. As those factors effect one another the difference of the benefits between both plans becomes large, and the bridge plan produces a large benefit which exceeds the construction cost of the new road while the benefit of ferry plan is comparatively low. Internal rate of return for the case of bridge plan is 14%, though several assumptions were made to calculate the values. But even if the benefit is reduced by 20% considering above things, still 12% of internal rate of return is obtained. This means the project owns the sound economic appropriateness. This value of 12% for the internal rate of return which is obtained by comparative calculations of cost and benefit is considerably high taking into consideration the interest ratio of World Bank or other financial sources. And it makes the conclusion much firmer.

In addition to above benefits for running cost and time which were used in the calculation the new road will produce other benefits such as comfort increase, decrease of load's damages, decrease of accidents, etc.

As for the traffic volume only the long distance inter-regional traffic was dealt with in the calculation. But the benefit of regional users alongside the new road consisting of pedestrians and motorcyclists cannot be ignored. Particularly the effects of the new road on the development of agriculture and other industries must be enormous, as the road runs through the area where the road service is not available at present.

Those benefits which cannot be measured by monetary terms should be fully taken into consideration when the economic evaluation is done for this new road project.

2-4. Conclusions and recommendations

As the conclusion of the preliminary study it can be said that the new road project between Dacca and Faridpur is feasible not only from technical but also the economic point of view. When the road is constructed, two regions of East Pakistan which is divided by the Padma river at present shall be connected more closely in economics, and it serves greatly the economic and social development of the regions. It also means the improvement of Asian Highway No. 1

and will contribute very much to the improvement of road transport conditions in Asia.

The main characteristics and most difficult problem of this road project is the crossing of the Padma river, lower part of the Genges. There are two ways of crossing the river. One is a ferry service and another is a bridge. The result of comparing both from the technical and economic point of view showed that the bridging at the early stage of the whole project is more economic than the ferry.

In case of bridging, the total construction cost of this road with the total length of 66 Km is estimated as 36 million US dollars. Suppose the road is opened to traffic in 1980, the estimated daily traffic volume for that year will be 1,050. Moreover, such economical effects as 39 Km shortening of distance and 3 hours saving of trip time will produce cost benefit ratio of 1.23 and internal rate of return of 14%. These figures seem to be sufficiently high among road projects in East Pakistan.

On the contrary the ferry service brings such a poor saving of trip time that justification of new road project with this plan is made difficult.

The construction of access roads of both sides of the Padma river which have several smaller bridges is not particularly difficult considering the present engineering status in the East Pakistan. In the road construction is executed during the same period as the Padma embankment project which is being planned by WAPDA, the proposed height of the road and the bridge length are expected to become lower and shorter respectively. Accordingly the construction cost could be made very much lower.

The construction of the Padma bridge will require considerably long years for its survey, design as well as technical and financial preparations. The presumed opening year of the road as 1980 is not too late considering the difficulties during the construction period. However, one of the access roads to the bridge, especially the part between Dacca and the left bank of the Padma river brings much benefits to the people alongside by more convenient connection with Dacca even before the Padma bridge is constructed. In this connection the stage construction of this road becomes very economically effective.

The Dacca-Faridpur road project is very effective for the connection of Dacca, Jessore and Khulna district together with the project of the Gorai bridge and its access road of Jessore-Madhukhali road.

As the map shows, it is clear that time and distance will be much shortened, if Dacca-Faridpur road is extended from the Faridpur area to Khulna directly. However, as this proposal competes with the Gorai bridge project, its economic appropriateness will be justified only in the far future.

The most important and necessary thing for the road construction projects in the state of East Pakistan is not to study each road project separately by one but to establish the plan of arterial road system which covers the whole country and to formulate a long-term road construction programme giving priorities to road projects from the economic and social point of view.

As the success of the Dacca-Faridpur Road Project largely depends on Padma brige, surveying and planning of this bridge should be done with the close relation and coordination among not only the road administrators but also river authorities, geographical surveyors and other related administrative functions. It should be considered to set up such a particular body as coordinating committee among these administrative agencies to deal with surveying and planning effectively and suitably. This committee will act effectively not only for the bridge project but also for road projects giving them accordance with the polder plans.

Closing this chapter we sincerely appreciate the effort made by the government officials of East Pakistan in giving us various helps and advices, and would like to recommend that the planning and surveying of the road section except bridges in this project had better be executed by themselves.

3. Members and schedule of the survey team

The road survey was executed by a Team of 6 members headed by Mr. Takahiko Hayanari, chief of maintenance and facility department of Japan Highway Public Corporation.

Members and assignments of the team for the road survey are as follows,

Hayanari, Takahiko	(The team leader)	Director, Maintenance Dept. Japan Highway Public Corporation
Takebe, Kenichi	(Highway planning)	Chief, Planning Division J.H.P.C.
Hanayama, Koreaki	(Economic survey)	Chief, Economic Research Division J.H.P.C.
Fuse, Youichi	(Bridge construction)	Chief, Planning Division Kanto Construction Bureau Ministry of Construction
Matsuda, Shigenobu	(Coordination Bridge construction)	Chief, Design Division Pacific Consultants, Co.
Kurasawa, Shinya	(Highway planning)	Engineer, Planning Division J.H.P.C.

The survey is divided into such three stages:

1) preparing for the survey before leaving Japan including the survey plan
2) collecting data and informations and making reconnaissance survey along the proposed route in East Pakistan
3) making the study report with preliminary design and arranging collected informations

Preparation works in Japan were done for two months from January to February 1970, conceiving geographical, geological and climatical conditions and various survey reports produced formerly on roads, bridges and urban planning in the East Pakistan by the members with Dr. Nobutaka Katahira (Director of J.H.P.C.) and Dr. Kenichi Takebe (member of the team) who were well acquainted with the situation of East Pakistan.

The surveying works in East Pakistan were executed during the period of about one month from February 18, '69 to March 17.

For collecting data and informations, the team was divided into two groups. One was an economic surveying group which worked out the estimation of traffic volumes on the newly proposed route and valuation of the economic values of this route. And another was an engineering group for studying of geographical, geological and hydrological conditions etc. of this project. The reconaissance survey along the new proposed route was done by all members to some extent. Because of the missing of the access roads, of shallow waters, and of limited time, the team could not cover the whole section of the route, which is usually done.

As for the part where the reconnaissance survey was omitted, data were complemented by an aerial inspection survey by a plane which was provided by the government of Pakistan and by the discussions with the people concerning the route. During their stay in East Pakistan, several meeting were held with the government officials discussing about the study, survey items and the surveys, and studies by the team were executed according to the agreement between the team and the government officials. The arrangement and analysis of informations obtained and the preliminary design of the road were made by the team headed by Mr. Hayanari and OTCA personnel after returning to Japan.

According to some data and drawings collected in East Pakistan, the alignment and vertical curve of the route and the types of the structures such as bridges and viaducts were decided. After the rough estimation of the construction cost based on the above mentioned factors and the estimation of traffic volume, cost-benefit calculation was made for the economic evaluation of the new route.

Itinerary of the team in East Pakistan

1970	Feb. 18	Lv Tokyo (6 members) for Dacca
	20	Meeting with Mr. K. Ali, Mr. H. Rahman, other governmental officials, Consul H. E. NISHIKAWA and Deputy Consul FUNAKOSHI discussing the assignment of the team.
		Local press introduced the Team.
	22-27	Collecting geographical maps (1/50,000), aerial photographs, and informations of traffic etc.

25-27	Reconnaissance survey (Dacca-Faridpur-Jessore, Messrs. HAYANARI, MATSUDA and B. A. CHOUDHURY) by land rover, launch and airplane.
Feb. 28-Mar. 3	Meeting with Central Government at Islamabad, West Pakistan (HAYANARI, HANAYAMA) HAYANARI left for Japan, HANAYAMA joined the team in Dacca.
Mar. 5-10	Reconnaissance survey (Dacca-Manikganj-Faridpur-Barisal-Jessore-Khulna-Chalna)
11	Collecting diagrams showing transitions of river banks, irrigation plans, etc.
16	Presentation an interim report to and meeting and discussing with the governmental officials.
17	Lv. Dacca for Tokyo

The team appreciates deeply the sincere cooperation of the government of Pakistan.

The helps and advices made by following gentlemen are very much acknowledged.

1) Government of East Pakistan

Mr. M. Keramat Ali
Deputy Chief Secretary, CSP, ACS (P&D)

Dr. A. Hossain
Member, Planning Board

Dr. Rabbam
CSP, CE Planning

Mr. Q. J. Ahmed TQA, CSP
Secretary, Railways, Waterways and Road Transportation Department

Mr. Mohamed Ali
Secretary, R.W. & R.T.

Mr. Ahmed Abdur Rouf CSP
Deputy Chief, Roads and Highways Planning Division Development

Mr. Abu Reza
Transport Economist, R.W. & R.T.

2) Roads and Highways

Mr. Habibur Rahman
Chief Engineer (R & H)

Mr. A. R. Choudhury
Superintending Engineer (R & H)

Mr. Badruddin Ahmed Choudhury
Executive Engineer (R & H)

Mr. S. Hasan Imam
E. E. (R & H)

Mr. Ali Reza Khan
E. E. (R & H) Planning Circle

Mr. Quamruddin Haider
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A. E. (R & H)

Mr. Kamal Uddin Ahmad
A. E. (R & H)

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3) Sub-Division (R & H)

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E. E., Jessore

Mr. Badruddoza
Sub-Divisional Engineer, Jessore

Mr. Khan
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Mr. Mustafizur Rahman Monfu
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S.D.E., Manikganj

Mr. Ali Imam Khan
Sectional Officer, Manikganj

4) Survey of Pakistan

Mr. S. Q. Hasan
Deputy Surveyor General, Dacca

Mr. M. A. Monaf
I/C PPLL & MAP, Dacca

5) Water and Power Development Authority

Mr. H. Ali
Director, Surface Water (Hydrology)

Mr.
Director, Water Investigation Organization

Mr. A. Hannan
Director, Planning (General) Water

Mr. M. A. Sabur
Deputy Director, Planning (Water)

6) Inland Water Traffic Authority

Mr. M. H. Chowdhury
Senior Hydrographer, Hydrographic Sec.

Mr. Mohamed Nizamuddin
Assistant Director (Survey and Statistics)

Mr. Golan Kibria
Chief Engineer

Mr. Anwar Hossain
Senior Deputy Director, Ports and Traffic
(Traffic)

7) Other department

Mr. S. M. Shuaib
Chief Traffic Officer, East Pakistan Shipping Corporation

Mr. Daudur Rahman
Research Officer, E. P. Bureau of Statistics

Mr. K. R. Choudhury
Dacca Town Planner, Dacca Improvement Trust

Mr. S. Tayyab Ali
Deputy Director General
Geological Survey of Pakistan

PART II. DETAILS

FIG.1 EAST PAKISTAN ROAD MAP

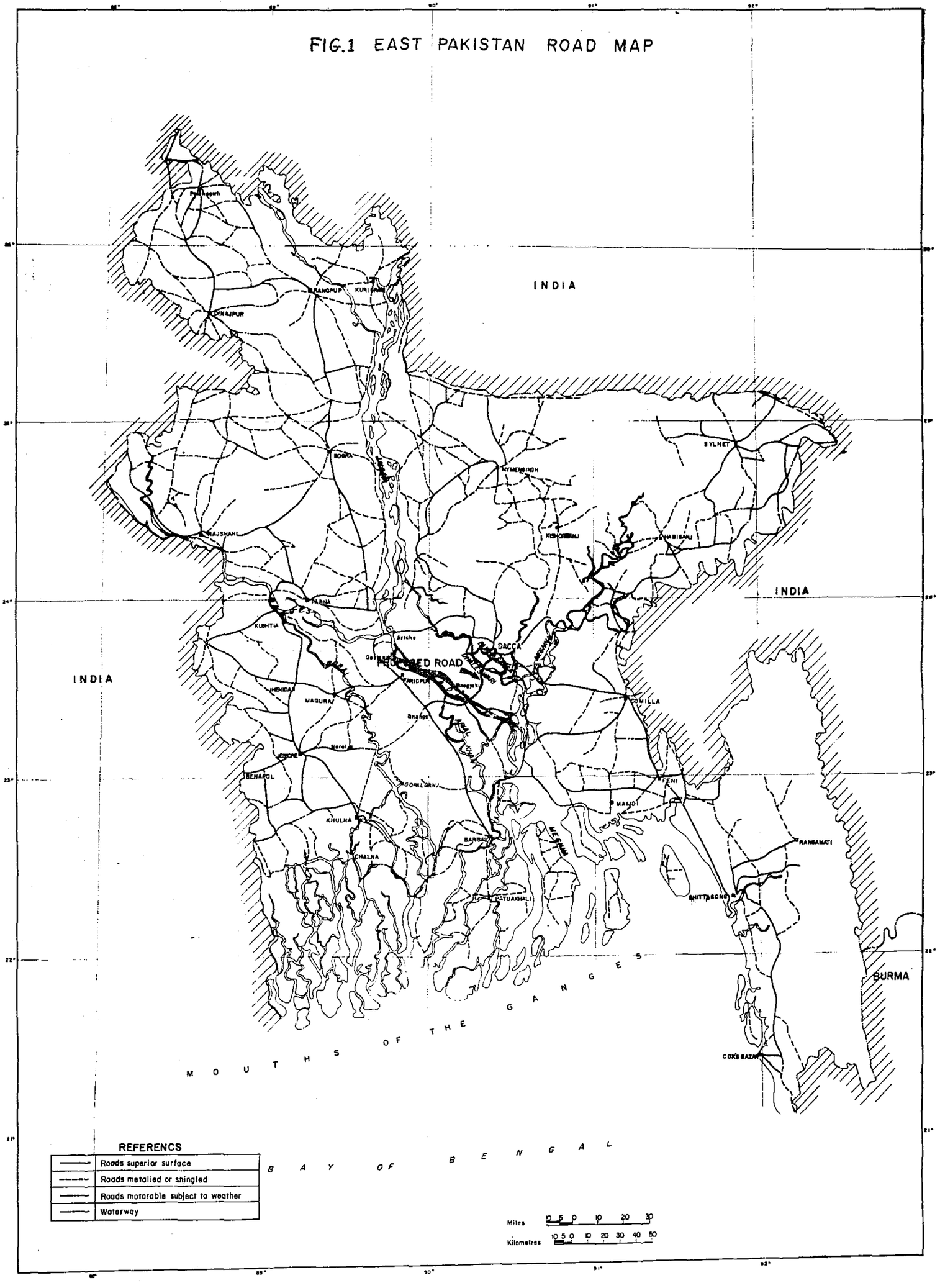
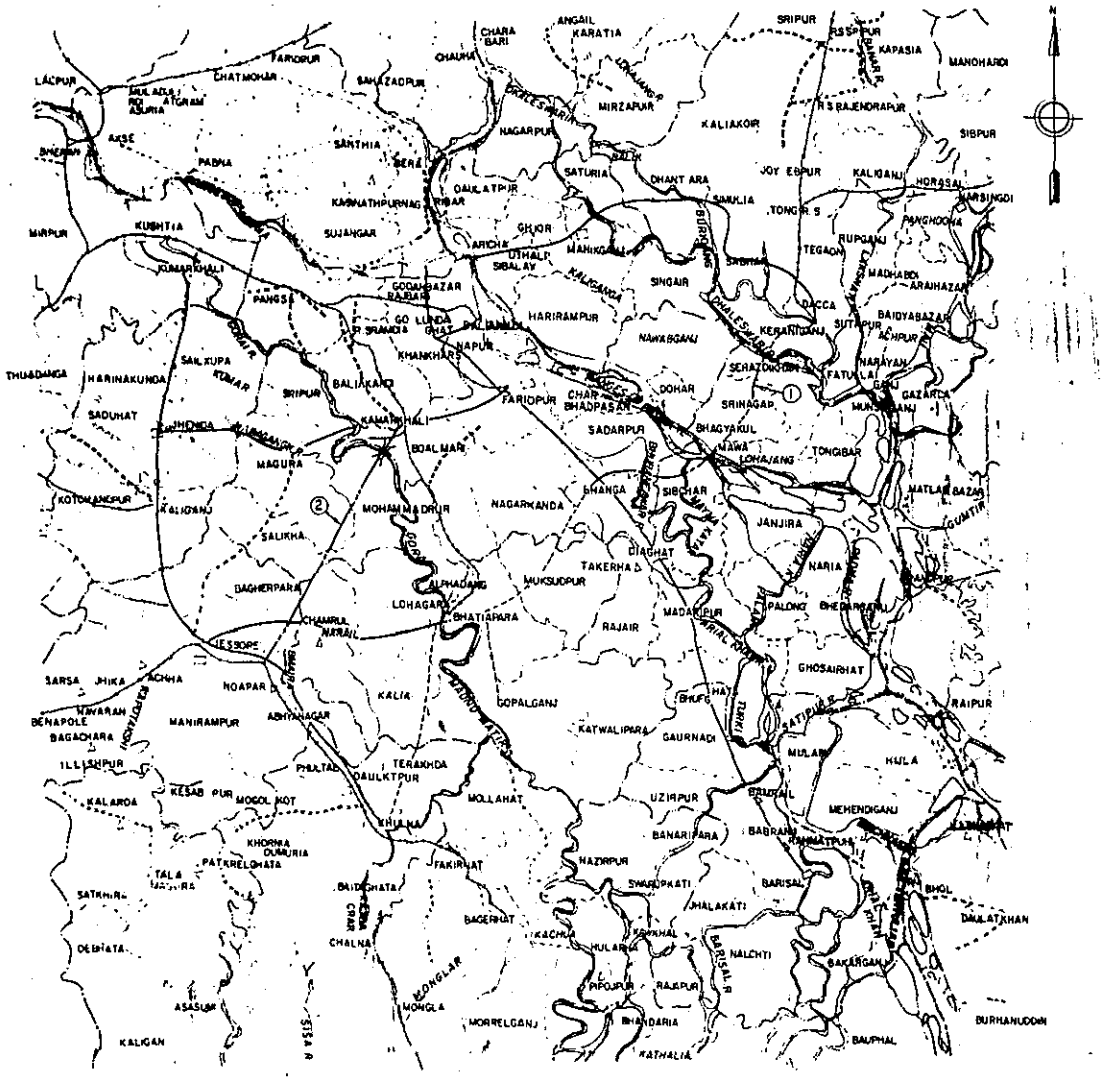


FIG.2 ROUTE LOCATION MAP FOR PROJECT AREA



Part II. Details

1. Outline of the proposed road

1-1. Topography and traffic status

The country of East Pakistan is divided into three large parts by the Bramaptra, the Ganges and the Padma river which is formed after merging of the first two rivers, and is further more divided into numerous small parts by their branches and many small rivers. (Fig.-1)

Throughout these three portions, the agriculture is the most active industry with a little difference among themselves regarding the industrial characteristics and the degree of industrial development. In the eastern part of the Bramaptra and her downstream Padma river, Dacca city, the capital, is situated at west and Chittagong, the harbor city, where the most of all overseas cargoes in this country is dealt, is situated at southeast. Therefore in this part the industrial development has been achieved comparatively earlier than in the other areas; the light industries in Dacca area and heavy industries in Chittagong area.

On the other hand, in the southwest side of the Ganges and the Padma, the main product is jute. The ports of Khulna and Chalna, both of which are close to the Indian Ocean, are the important ports for the ocean and inland waterway transport. The processing industry of jute and other light industries have been developed in these areas. In the northwest side area of the Ganges and the Bramaptra, the main product is rice and this area is the least industrialized among three areas.

As East Pakistan is called "River ridden land," there are not only numerous rivers, large and small, but also in the rainy season 70 to 80% of the area of almost all districts except in the northern part is covered with water. For this reason the economy and transport depend largely on inland waterways transport. In this country where there are about 3,000 miles of all-season inland waterways and 4,500 miles of waterways navigable during monsoon season. According to the statistics available, 3/4 of all transport is made on inland waterways, most of the rest is by railways and very little is by roads.

Total length of railways in East Pakistan is 1,700 miles in 1967 and the total length of roadway is 3,685 miles in the same year, with high type road of 2,204 miles which is paved and motorable through year and with low type road of 1,481 miles which is unpaved and motorable only during dry six months. But the paved trunk roads are mostly of one lane and two lane paved can be seen only in the suburbs of big cities like Dacca, Khulna and some others.

The transportation among three regions isolated by the Ganges, the Bramaptra and their confluent flow Padma is forced to depend on inland waterways. The only one permanent river-crossing facility now existing is the railway bridge over the Ganges near Paksey.

The routes designated as "Asian Highway" should be emphasized as the most important ones among the trunk roads. Asian Highway No. 1 runs through Calcutta in India, Benapol in East Pakistan near the Indian border, Jessore, Jenida and Faridpur and comes to Goalundo on the right bank of the Padma river. From Goalundo to Aricha on the opposite side of the Padma, the river can be crossed by ferry boats. From Aricha it runs through Dacca, Moinamati, Sylhet in the northeast part of East Pakistan, and into Assam district, India. Asian Highway No. 1 runs thus from southwest to northeast, but No. 2 runs from northwest to southeast, the middle section of which near Dacca is the same route of No. 1 and forming X figure with it. Namely it comes from Nepal through India to Rangpur, Bogra and Nagarbari on the right bank of the Bramaptra. From Nagarbari there are ferry services to cross the river to Aricha on the opposite side. Asian Highway No. 2 runs the same route of No. 1 from Aricha to Moinamati through Dacca. After that it runs through Chittagong to the Burmese border.

This huge X figure, the total length of which reaches 920 mile, forms the trunk road network of East Pakistan with many feeder roads to other main cities.

1-2. Significance of the proposed road

The survey and study for the improvement plan of a part of Asian Highway No. 1 in the southwest area of East Pakistan, which is divided by the Ganges and the Padma from other parts of the country was made by the team from

Japanese government. The studied part is the Jessore-Madhukali road including the Gorai bridge. (Fig.-2) This proposed Jessore-Madhukali road is to cover the Gorai river by bridge, which is crossed by ferry at present and also to shorten remarkably the existing long distance route. That is, the distance between Faridpur and Jessore will be reduced by 18 miles and the distance between Faridpur and Khulna, the center of transport and industry in this area, will be reduced by 36 miles as well. This road will not only play an important role in the improvement of road traffic of this area, but also consequently will contribute very much to enhancement of productivity of agriculture and industry in this area as a result.

The proposed Dacca-Faridpur road now under study means the improvement of the same Asian Highway No. 1 and means the improvement of road transport between the southeast area with Dacca as the center and the southwest area with Khulna as the center. On the contrary the Jessore-Madhukali road means the improvement of transport within the southwest area of the country. The air distance between Dacca and Faridpur is about 39 miles, and the existing road makes detour largely to the north and its total length is 83 miles, including the Padma ferry course the distance of which is 10 miles and which takes 2 hours including loading and unloading time. Therefore it takes about 5 hours to drive from Dacca to Faridpur at present.

Between Dacca and Aricha the road improvement work is now going on. The remaining three ferry sites will be taken place by bridges. This road is planned to have two paved lanes between Tungi and Aricha. So, this project will apparently contribute not so slightly to the road traffic between Dacca and Faridpur, but cannot have a sufficient effect for shortening of the total distance and for reducing the time required for ferry.

Therefore the quite new direct route should be selected for the radical improvement of road connecting Dacca and Faridpur. This new road should be the one that works effectively as one body with river-crossing facility and shortens time and distance which the existing road located in the north, if the crossing of Padma river is made either by ferry service or by bridge.

Thinking about these things, the new route would start from the south of Dacca, runs slightly southward and connects with Faridpur-Barisal road at

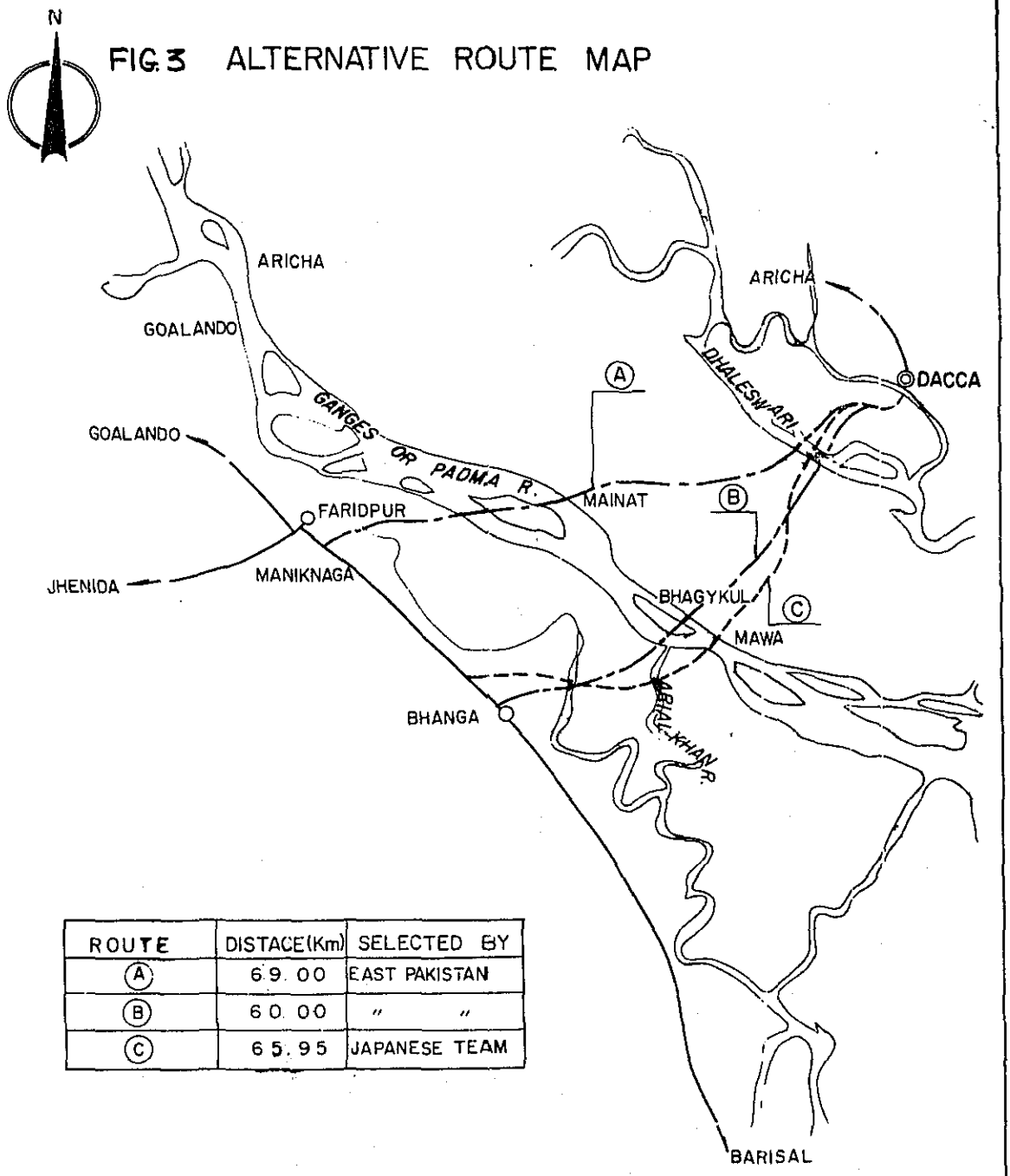
south of Faridpur because of a geographical condition on the route. When the new road constructed, it will be nominated as the Asian Highway No. 1 and then all of the traffic between the southeast and the southwest areas of the country which now uses the Dacca-Aricha road will be diverted to the new route. But the importance of the improvement work of the Dacca-Aricha road now being executed cannot be lowered, because it still should serve as the Asian Highway No. 2 and play an important role connecting the northeast to the east part.

2-3. Alternative routes shown by the government

Before the Japanese team arrived in the country, the government of East Pakistan had set up two alternative alignments on a map. (Fig.-3) Both of the routes selected by the government start from Kelaniganj side of the new bridge that will be constructed across the river Burhi Ganga flowing in the south of Dacca city. The Burhi Ganga bridge, the starting point of the routes, connects with the North-South Road or the city planning road that runs through the midst of Dacca city from north to south. This north-south road project was planned as a link of the city planning of Geater Dacca and the Burhi Ganga bridge has been studied by a Japanese survey team as an overseas technical cooperation of which report has been presented to the government with a preliminary design. The construction site of the bridge was already decided, but detail design conditions such as vertical clearance above the water level is now being adjusted among the governmental organizations concerned. The construction schedule, however, is not realized yet.

The North-South Road leading to the Burhi Ganga bridge is already completed with 100 feet width in the new Dacca, but its construction is not started yet in the old Dacca because of the opposition of the inhabitants of this area where is densely crowded of houses. The government of East Pakistan, therefore, requested the Japanese governmental survey team to study the feasibility of an elevated highway in this area. Dacca-Faridpur road, the study object of the survey team, starts at the south end of the Burhi Ganga, therefore the problem about the North-South road and the Burhi Ganga bridge is outside of the task imposed on this time survey team and should be dealt as a part of city planning of Dacca city. But as it is apparent that Dacca-Faridpur road cannot have an important meaning without completing the two above mentioned roads and bridges, the Japanese survey team decided to cooperate in the

FIG. 3 ALTERNATIVE ROUTE MAP



ROUTE	DISTACE(Km)	SELECTED BY
(A)	69.00	EAST PAKISTAN
(B)	60.00	" "
(C)	65.95	JAPANESE TEAM

technical problem of the North-South road as much as possible. Results of study on this problem will appear in Appendix 1.

Now, the route of Dacca-Faridpur road shown by the government of East Pakistan starts from the south end of Burhi Ganga bridge, runs westward along a road now existing, crosses the Dhaleswari river near Goalkhali and reaches Minat village on the left bank of the Padma river. Then it crosses the Padma by ferry to near Char Bhadyasan on the right bank, runs westward and connects with the Faridpur-Barisal road at the point of about 7 miles south of Faridpur.

In addition to this via Minat route, another route that crosses the Padma at Bhagyakul was studied. This route runs westward, like the Minat route, from the south end of Burhi Ganga bridge and reaches Bhagyakul on the left bank of Padma river after crossing the Dhaleswari river and turning the direction to the south. After crossing the Padma by ferry near Bagyakul, it runs westward and connects with Paridpur-Barisal road at the point of 17 miles south of Faridpur.

For the study of these two comparison routes, only paper-location (route setting on a map) without site inspection has been done by East Pakistan government. But the preliminary study has been very useful as a first clue to the study by the survey team.

2. Fundamental factors for planning

For study and planning of a road, the technical criteria of design standards should be decided first. The geometrical design standards for the Gorai bridge and its approaching road Jessore-Madhukhali road, of which plan and design had been conducted by Japanese government, was adopted for the proposed road referring to various projects already conducted, because the proposed road is one of the trunk roads in East Pakistan and a part of the Asian Highway as well.

The followings are the criteria and design standard.

2-1. Geometric design standards

i) Design speed 100 km/h (60 mph)

ii) Plan alignment

minimum horizontal radius

standard :	600m (2,000ft) maximum superelevation	6%
absolute :	450m (1,500ft) maximum superelevation	8%

iii) Vertical alignment

a) vertical gradient

maximum gradient

standard :	2%
absolute :	3%
special :	4% (for only long span bridge)

b) vertical curve

minimum length (in m)

	crest	sug
standard :	90i	45i
absolute :	60i	30i
special :	45i	30i (for only long span bridge)

i = angle of tangents of both side curve in degree

iv) Standard cross section

width of paved carriageway = 6.5m (22ft)

total width including shoulder = 12.2m (40ft)

lowest pavement height = 1.0m (3ft) higher than average high flood level

Standard cross section is shown Figure 12.

Some of the design criteria necessary for planning is now shown above, and for other criteria and methods of their application necessary for design the report of "Jessore-Madhukhali road construction project in East Pakistan" (Sept. 1969 Overseas Technical Cooperation Agency-Government of Japan) should be referred to. Its important part is shown in Appendix 2.

3. Route reconnaissance and works in East Pakistan

The study works done by the survey team in East Pakistan are classified into 1) Collection and arrangement of data necessary for surveying and planning of the proposed road, 2) route reconnaissance and 3) discussions with the government engineers involved in this project based on materials and results of reconnaissance survey.

Collected and arranged data, further more, are divided into a) materials necessary for route inspection such as topographical maps, aerial photographs and other topographical data, b) data related to traffic and economy and c) data of hydraurics and present status and future planning of the rivers, mainly of the Padma.

3-1. Collecting data

One of the difficulties in road planning in East Pakistan is lack of well arranged topographical maps and other data. Various data collected by WAPDA and IWTA are not prepared to give the up-to-date topographical status, for the annual changes of river courses of the Padma and other rivers are very rapid. Therefore, the endeavour of the survey team was paid especially to know the most up-to-date status of topography around the Padma river.

The materials, which the survey team could get first, were topographical maps of 1/50,000 covering the whole area, but some of them including the Padma were issued 1959-1961. Though the survey team was permitted to look at the aerial photoes of 1952 and 1968 in the office of Survey of Pakistan, the identification of ground point could not be done sufficiently accurately, because taking them out of Survey of Pakistan had been forbidden. But it became clear by them that the course of the Padma river in the area of the proposed road had been very changeable for these 10 years.

The most useful material concerning the recent status of the Padma river was Fig. 8 showing changes of the Padma river courses made by IWTA from 1951 to 1965. Though the details are not seen, for the scale is small, the transition of the river courses and the recent status are almost clarified.

It was a great pity that the survey and planning of the most important part of this project became in fact impossible, because the maps that include the proposed route on the right bank of the Padma river, which had been very unstable, could not be got, though the topographic maps of 1/16,000 (partly 1/8,000) made by Survey of Pakistan during 1963 and 1968 which include contour line and other precise data were very useful materials for planning and setting an alignment.

After the route reconnaissance the survey map of water depth of the Padma river, the polder project and other materials were given by IWTA or WAPDA.

Regarding the economic survey, collecting of the various data on the national economics and of some statistics necessary for the estimation of the future traffic volume relating to the road planning was given efforts. "Statistical Digest of East Pakistan 1968" was useful for estimating the tendency of number of registered car and "A manual for the economic appraisal of transport project, 1969" was very useful for evaluating the road construction project economically. Materials and data relating to traffic volume with origin and destination on the existing roads are, to our regret, very few. Though data in 1968 were available still, the future traffic flow should be estimated on the basis of the present status.

On the contrary the car numbers sent by ferry boats had been collected accurately enough and they were very useful in economic comparison between bridge and ferry on the Padma river.

Works of collecting technical and economic data were done at the same separately by different group of the team. Materials and data collected including maps are shown in Table 34 in Appendix 5.

3-2. Route reconnaissance survey

The most important factor for which the most time was spared during reconnaissance of the proposed route was the confirmation of the topography of the Padma river. For that 1) inspection by seaplane from air, 2) inspection by launch on the Padma river and 3) site inspection by car were done.

At first the area from Dacca to Faridpur was inspected for one hour from about 500 m above sealevel by seaplane of the government of East Pakistan. By this survey from air the present status of the Padma river was confirmed to be much different from the aerial photoes taken in 1968. But though the relative shape was clarified by the inspection from air, the confirmation of the details of ground points was still difficult. Especially as the narrowest point of the Padma river changes year by year, the very point should be confirmed on the ground survey.

For this reason, as the second step, the survey team travelled the Padma river from Aricha to the point about 40 miles down flow by IWTA launch, inspected the present status of the river course and confirmed the topography. At first, on the right bank of the river crossing point of the route passing through Minat proposed by the government of East Pakistan, the site suitable for ferry service could be found such as Narayatak near Faridpur. On the other hand, it was confirmed to be difficult to find out a site that ferry boats can approach easily on the left bank near Minat where there were many shallow tributaries.

On the contrary it was clarified that the left bank of the river crossing point of the other alternative route which passed through near Bhagyakul and was proposed by the government was fairly stable and suitable for verry service. But it was made clear by the inspection by launch that the narrowest point of the Padma river was situated near Mawa downstream of Bhagyakul. The left bank of this point is easy to access for ferry boat, too. The right bank, on the contrary, has changed its shape largely in these 10 years and the present shape is quite different from that which is shown the map the survey team could borrow from the government. The river is very shallow around this area near the right bank and the inspection by launch was impossible. So the confirmation of the topographical and geographical status was left to the inspection on foot.

An inspection by car was made on the left bank of the Padma river at first and on the right bank later. On the left bank, the survey team crossed the Burhiganga river from Dacca to Keraniganj, drove on an existing road from there, crossed the Dhaleswari river by ferry boat and drove 6 miles upto the point beyond which the road was not motorable. About 10 miles of the route from the point to the left bank of the Padma river was not inspected this time.

This area had not been inspected by the government officials, too.

On the right bank of the Padma river, the survey team drove jeeps from Jadurdia on the Faridpur - Barisal road to the Arial Khan on the right bank of the Padma river through Char Balia and Barakhas Banbarkyola and from there inspected the route area upto the divergence point of the Arial Khan river from the Padma by small boats. Though the present status of erosion and other items were roughly understood by this inspection, the detailed survey to find the suitable point for ferry service on the right side was not led.

And with regards to the inspection on land, the survey team visited Barisal, Jessore and Khulna, inspected the present conditions of roads to the said cities and got a pretty good idea about a general condition of the south-west area of the country.

3-3. Discussion with the government engineers

The survey team was given a time to discuss with engineers of WAPDA and IWTA after route reconnaissance about the changes of the river course of the Padma river and the possibilities of Mawa area for the ferry route and access facilities.

Through discussions, which were worthwhile for the study, the survey team had a chance to look at the cross-section maps of the Padma river, and the latest data of the changes of the water level. And after the discussions the team could get the prospect that the planning of the ferry boat route as well as of the bridge construction was technically feasible. But the team could not obtain the data which must have been very useful for designs, because of the problem of Farraka Barrage. So, the planning and designing of the bridges explained in this report are based on some suppositions.

Further sufficient discussions about this problem, the Padma river crossing, among the Japanese and the Pakistani technical experts of rivers, hydrologics and bridges should be held, and until the time when they have those discussions fully, and final conclusion of such an important problem of the bridge structure should be retained.

4. Route setting

4-1. Crossing point of the Padma river

The most important focus in the route setting of the newly proposed Dacca-Faridpur road is the crossing point of the Padma river. The point should, as much as possible, satisfy the following conditions.

1) It should be nearest to the straight line connecting Dacca and Faridpur.
2) Crossing distance of the Padma river by ferry or bridge should be the shortest.
3) River banks of both sides should be stable.
4) Approach roads should be used effectively when a stage construction method, first ferry and later bridge, is adopted.
5) The length of bridges should be reduced as much as possible in relation to the Polder projects of WAPDA.

The route that satisfies all these conditions does not seem to exist. One of the routes proposed by the government, Minat route, runs comparatively straight and satisfies the first condition above mentioned, but this should be abandoned, for the suitable point for river crossing facility cannot be found on the left bank near Mainat. The other alternative route, Bhagyakul route, runs more southward than Mainat route and its total distance becomes longer than the first one. The right bank is so unstable that it is very difficult to find the gangway points, though the left bank is comparatively stable.

As to the suitable site of quay for ferry boat only, the point on Bhagyakul route on the left bank and the point on Minat route on the right bank should be selected. It, however, results in that the distance between quay sites on both banks becomes about 20 miles and sailing time will be almost the same or more than that of the existing Aricha-Goalundo ferry. This will deny the propriety of the construction of the new proposed route even if the distance and the travelling time are reduced on land.

Considering the points above mentioned, there is no way but to select the narrowest point of the river as a crossing point in order that the road project can have the technical and economic feasibility.

4-2. Outline of the proposed route

Mawa and the opposite point were decided as the crossing points of the Padma river as described in the previous section and then the alignment of the approaching roads were set. Following items were considered for route setting

1) Main rivers, where a bridge is needed on the proposed route, are the Daleswari river on the left side of the Padma river and the Arial Khan river on the right. Crossing points for these rivers should be chosen where river is the narrowest and the most stable. And also much consideration should be paid on the Polder project of WAPDA.
2) Higher areas should, general ly, be chosen to be passed through. Especially the low land should be avoided.
3) On Faridpur side, the route should connect with the existing trunk, the Faridpur-Barisal road, as soon as possible.

Considering the conditions above mentioned and referring to the site inspection and topographical maps, especially that of 1/16,000 which contain contour line, the alignment was set on maps. The outline of the alignment is following:

The proposed route starts westward from the south end of the Burhi-Ganga bridge and crosses the Daleswari river southward at a right angle near Saidour where the Daleswari river becomes narrowest. It runs almost along the southern alternative route proposed by the government of East Pakistan in the direction of southwest through comparatively high lands near villages avoiding low lands and meets with the Padma river at the 0.5 mile north of Mawa and 2 miles south of Bhagyakul. As far as route reconnaissance of this time is concerned, this area was found one of the most stable area along this river, the course changes of which through years is fairly frequent, and the width of the river is narrow as much as 1.5 mile. The river-crossing facility of about 2 miles long is necessary utilizing the Polder project of WAPDA.

After crossing the Padma river it runs westward and crosses the Arial Khan river near Gazaha. This river has also many branches and tribitaries, but the river course is comparatively stable and the crossing distance would be about 0.5 mile. From there it runs westward and connects with the Faridpur-Barisal

road at the point of about 5 miles north of Banga.

Selection of the crossing point of the Padma river and the height of the embankment are based on the Polder project plan. So the Polder project is and important premise for the Dacca-Faridpur road planning. In next section 4-3 the outline of the Polder project will be explained.

4-3. Outline of the Polder project

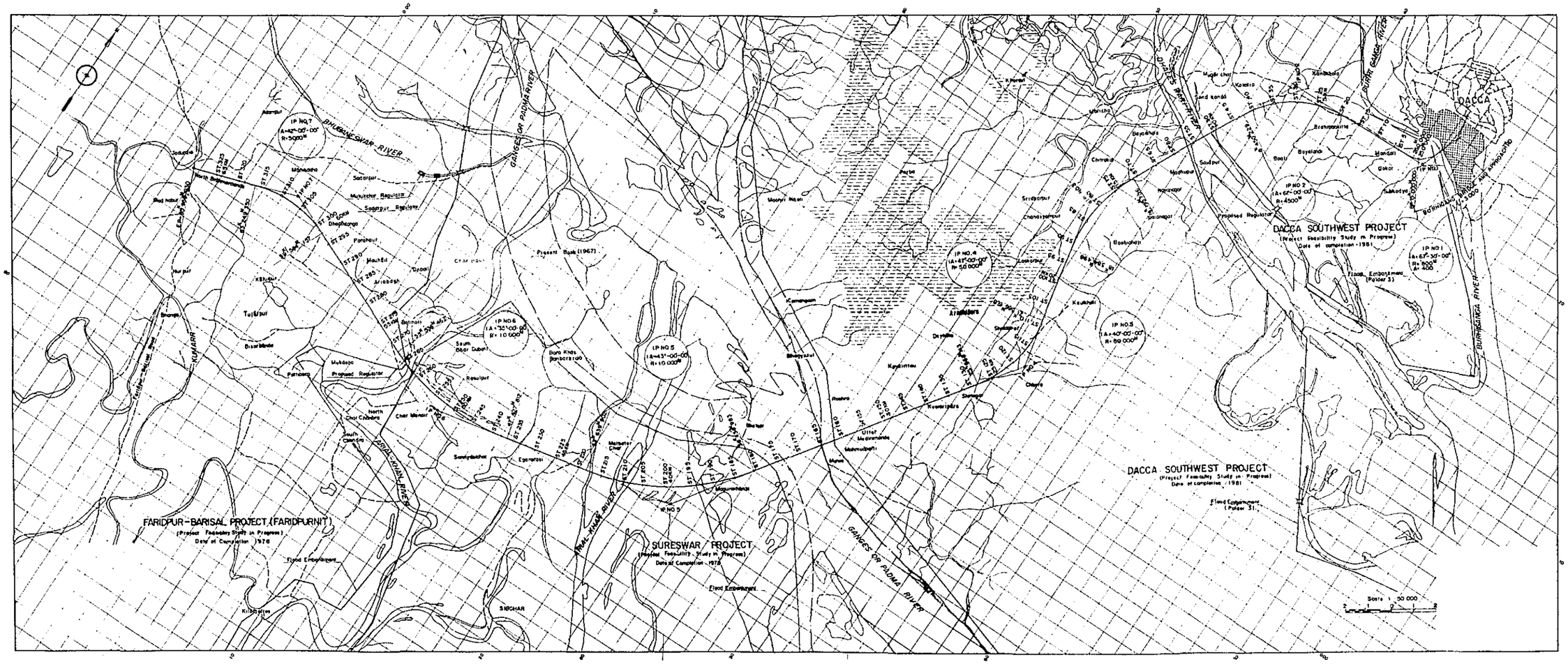
The Polder project is planned for the purpose of irrigation, drainage and flood control of whole area of the country including the road project area by E.P. WAPDA. One of the Polder projects related to the road project is called Dacca South West project and another Faridpur-Barisal project. These project aim the achievement of the purposes above mentioned with construction of an embankment surrounding the proposed area and with arrangement of rivers inside the area.

Dacca South West project will control the area of 666,000 acres. At present time there are many rivers flowing inside the area and during flood time the land is dipped 15 feet under water. Then, considering these bad conditions, whole area is divided into four polders by main and branch rivers and there are controlled by pumping facilities. The average height of embankment if planned 15 feet and after the completion of the polder project it enhances the utilization of land and enables three times crops a year. The construction of this project is scheduled to start in 1970 and to be completed in 1981.

Faridpur-Barisal project is scheduled to start in 1969 and finish in 1978 and the area of this project is about 917,000 acres. The purpose of this polder project is the same as of Dacca South West project. The Dacca-Faridpur road project should be planned in consideration with this polder project. Its influence on horizontal and vertical alignment of the proposed road and on design of structures such as bridges is very large and it enables the construction cost reduced.

Therefore, the execution of the polder project is a premise of the planning of the Dacca-Faridpur road project.

第 4 図



DACCA
DACCA SOUTHWEST PROJECT
(Project Feasibility Study in Progress)
Date of completion - 1981
DACCA SOUTHWEST PROJECT
(Project Feasibility Study in Progress)
Date of completion - 1981
FARIDPUR-BARISAL PROJECT (FARIDPURNIT)
(Project Feasibility Study in Progress)
Date of Completion 1978
SURESWAR PROJECT
(Project Feasibility Study in Progress)
Date of Completion - 1978
BHUBANESWAR RIVER
GANGES OR PADMA RIVER
DHALES WARI RIVER
BURHIGANGA RIVER
ARIAL-KHAN RIVER
KUMARR
SIBCHAR
Flood Embankment
Flood Embankment (Polder 3)
Scale 1 : 50 000

FIG. 5

	NAME OF PROJECT	ACRES	MILLIONS
A	DACCA SOUTHWEST PROJECT	193 21	382 13
B H	SURESWAR PROJECT	185 00	15 04
C	COMPREHENSIVE DRAINAGE SCHEME	366 04	38 82
D	G K PROJECT (JESSORE UNIT PHASE II)	22[illegible] 00	127 80
E F	SMALL ELECTRIC PUMP IRRIGATION PROJECT (10 UNITS)	27 90	82 47
G	FARIDPUR - BARISAL PROJECT (FARIDPUR UNIT)	59[illegible]	433 [illegible]
I	FARIDPUR - BARISAL PROJECT (BARISAL UNIT PHASE I)	450 [illegible]	328 68
J	SAFLA BOGGA PROJECT	48 63	77 00
K	COASTAL EMBANKMENT PROJECT (PHASE I)	76 [illegible]	

5. Technical features of the proposed route

5-1. Natural condition

(1) Geology

The area that the proposed project road traverse forms the recent deltaic plain is the predominant geological formation in East Pakistan. The delta consists of a number of overlapping sub-deltas that were formed by intermingling of light colored Quarternary sediments which have been deposited by the Ganges, Brahmaputra and Maghna rivers. The Himalayas were the major source of these sediments. The sub-surface strata is constantly subsiding by the weight build-up of these sediments, compacted and maintaining the surface level in a condition of geological isostasy.

The terrain is flat and has the braiding meandering pattern of the rivers. Rivers in East Pakistan show zigzag feature and stream course seems to have changed every year. Most of land sink under the water three or four months in a year. Therefore, in these circumstances land surface is rather soft, and it brings about difficult problems in road design, construction and the regional development project within this area. Furthermore there exist bugs and sedimentary transported lenses of easily compressible peats, and also throughout the area heavy textured soils are superimposed upon light soils. During the monsoon period, central part and southern part of East Pakistan are flooded to varying depths.

The Ganges river has deposited, in East Pakistan, specially this area's mantle of soil which consists chiefly of eroded particles from the plains of India. The Ganges river has slowed down in India and lost most of the larger particles before reaching East Pakistan. As the river gradient flattens about 1/12,000 - 1/20,000 within East Pakistan, a further decrease in velocity occurs and the river deposits most of fine particles. Thus in this area, the proposed project road traverses, silts and clays are deposited. The scant deposits of coarse sand, gravel and cobbles are to be found at the fringes of this province.

As seen in the map of East Pakistan, the Ganges river has shifted frequently and has a meandering and braiding stream course, with the result that particles of different sizes forming layers one on top of another. As a result of

Table 1. Characteristics of soils

Name of soil		Symbols by unified soil classification	Tint Ground water Table Above	Below	Characteristics of soils
Sandy soils		SC. SM	Greyish-Brown — Brown	Brown or Bluish Grey	When, light grey in color, soft and easily excaveted. Break-in is most conspicuous below ground water table. Sands consist of fine and very fine sand, containing 10 - 40 % fine grained soil (silt & clay). Grain size distribution curve declines sharply in each case. Contain mica in large quantity but quartz grain is generally in less quantity. Layer is less than 1.50 m in thickness except for the Gorai River and less continuous. Distribution only in small scale.
Silts (LL 50)		ML	Brown	Bluish Grey	Contain mica in large quantity and is of low viscosity. Mostly in the state of extreme fine sands, making consistency test impossible. Relatively soft (in compaction) and easily excavated. Break-in is seen in places below ground water table. Surface soil has cracks to a depth of GL-20-30 cm and is in semistiff condition. In the section of the starting point (No. 0) Nabaganga River, soil composition ratio is high and the layer is 1.0 - 2.0 m thick.
Clayey soils	Clays (LL 50)	CL	Bark Brown — Brown — Yellowish Brown	Brown — Yellowish Brown or Bluish Grey	In semi-stiff state, from hard to relatively soft (in compaction). Hardness varies greatly with each location but samples can be taken mostly in the form of clay speck. Deposits in the vicinity of ground water table are mostly of brown weathering pattern. Contain fine-grained mica in large quantity and some shells. Surface layer in the section of Nabaganga River Ending Point (No. 545) consists mostly CL. Distribution of CL is most extensive and in largest quantity.
	Silts (LL 50)	MH	Yellowish Brown	Yellowish Brown	Relatively hard in compaction and of high viscosity. Recognized only in marshes (A-4) in the vicinity of No. 32.
	Clays (LL 50)	CH	Dark Brown — Yellowish Brown or Dark Bluish Grey — Dark Grey	Dark Bluish Grey — Dark Grey	Brown weathering pattern dominant and in dry solidifled (stiff) state above ground water table. Relatively soft in compaction with high viscosity and homogenized clay below ground water table. CH is found in large quantity below ground water table and is expected to be more below boring pit (depth). Single layer is 0.5 - 1.5 m in thickness. Content of shells is on the average.

a shifting riverbed, it is leaving numerous cut-offs and oxbows have been shaped. This is a special phenomena in East Pakistan compared with other countries. These cut-offs and oxbows can vary in size from 200 - 300 square yards and to several hundred square yards. During the wet season, these low areas are filled with water and are quickly overgrown with plants, and in the dry season the water subsides and the vegetation sinks to the bottom and rots. In general, reactive colloidal clays are deposited at the low points of these areas, while coarse-grained materials collect along the fringes. In successive cycles of wetting and drying for many years, a build-up of highly organic colloidal material forms within these basins. Therefore, along the proposed route, peat and many bogs are placed, and these must be very carefully considered for road construction, embankment, and structures.

During our field study no geological survey was conducted and no trustworthy evaluation of soil condition along the proposed route can be extracted but examining the auger boring result conducted at the time of "Jessore - Madhukhali Road Construction Project" investigation in 1969, it can be summarized as in Table-1. However, it can be doubted that whether the result shown in the above project can be applied or not in this project, but seeing the geological map, it will be applicable for the proposed route because soil condition of both areas have shown similarity.

As seen in previous studies and the geological data collected this time, it will be estimated that the clayey soil which is extensively distributed along the entire length of the proposed route has a high content of silt and clay of low liquid limit for the portion under dry condition above ground water table, which serves as a boundary line, and has a high content of clay of high liquid limit for the portion under damp condition below ground water table. On the other hand, the portion under damp condition below ground water table has a high content of silt and clay. Silt and clay are usually associated with apprehension for such unfavourable factors as lack of bearing capacity, sliding and consolidation settlement. However, with the exception of marshes, apprehension for lack of bearing capacity and sliding is almost eliminated for this section because of high bearing capacity of dry portion and making of low embankment. For the portion where design height of embankment exceeds 3 meters, there should be some measures taken for the stability of foundation and against consolidation settlement. Taking into account those topography and soil conditions, following 2

types of the standard foundation of embankment may be considered.

Type 1. Removal of organic matters, stumps and roots of vegetation, for purpose of treatment of foundation.

Type 2. Necessity of sand mat of 1.0 meter thick or about 1.0 meter extra banking at the portion where compressive clayey soil is distributed for acceleration of consolidation settlement.

Most favorable soil for use as the embankment material is that with high shear strength, low compressibility, satisfactory permeability and low swelling by absorbing water. Applicable to this requirement is a mixture of gravel and sand containing clay and having a satisfactory grain distribution. According to the study at the time of "Jessore - Madhukhali Road Construction Project," it is shown that 80% of local soil and usable as the embankment material. Therefore, by this result, it will be estimated that the soil along the proposed route can also be used as the embankment material.

Soil classification based on the Unified Soil Classification Method are as following Tables 2 and 3.

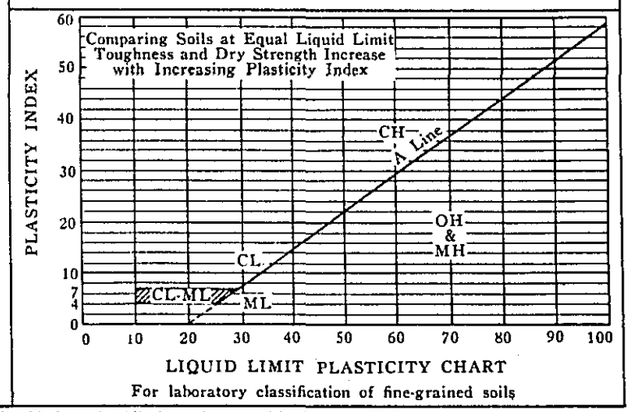
(2) Hydrology

The hydrology of East Pakistan is predominantly dependent on rainfall and snowmelt in the Himalayas. The Himalayas and the Vindha Range of India feed the Ganges-Padma river, draining almost 350,000 square miles with the flow reaching 2,100,000 cubic feet per second. The Himalayas and the hills in the Assam Province of India provide the 3,300,000 cubic feet per second flow, by maximum record, to the Brahmaputra - Jamuna area, and its drains are reported about 224,000 square miles. Also, the hills of Assam form the watershed of the Meghna river, draining about 25,000 square miles above Bhairab Bazar and having a record flow approaching 500,000 cubic feet per second, which floods the eastern plains of the province. These three systems can total more than 5,000,000 cubic feet per second. Therefore, local rainfall has only on incremental effect on the flooding. Rainfall in the province varies from 40 to 300 inches in various areas, and average is about 75 inches a year. On account of

Table 1—Unified Soil Classification (Including Identification and Description)

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

Major Divisions			Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights)			Information Required for Describing Soils	Laboratory Classification Criteria
1	2		3	4	5			6	7
Coarse-grained Soils: More than half of material is larger than No. 200 sieve size.	Gravels: More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the ¼-in. size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% — GW, GP, SW, SP, More than 12% — GM, GC, SM, SC, 5% to 12% — Borderline cases requiring use of dual symbols.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				$Cu = \frac{D_{60}}{D_{10}}$ Greater than 4 (See note, far right) $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)				Not meeting all gradation requirements for GW
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			Give typical name; indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.	Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
									Atterberg limits above "A" line with PI greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.				$Cu = \frac{D_{60}}{D_{10}}$ Greater than 6 (See note, far right) $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				Not meeting all gradation requirements for SW
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)			Example: Silty sand, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).	Atterberg limits below "A" line or PI less than 4 — Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line with PI greater than 7
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size				
					Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)		
Fine-grained Soils: More than half of material is smaller than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Silts and Clays: Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.	Use grain-size curve in identifying the fractions as given under field identification.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium		
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight		
	Silts and Clays: Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium	For undisturbed soils and information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.	
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High		
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).	
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				



LIQUID LIMIT PLASTICITY CHART

For laboratory classification of fine-grained soils

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U.S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays wihch occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Note
(Laboratory Classification)

Cu = uniformity coefficient

Cc = coefficient of curvature

D_{60} = grain diameter at 60% passing

D_{30} = grain diameter at 30% passing

D_{10} = grain diameter at 10% passing

The grain-size distributions of well-graded materials generally plot as smooth and regular concave curves with no sizes lacking or no excess of material in any size range. The uniformity coefficient (Cu) of well-graded gravels is greater than 4, and of well-graded sands is greater than 6.

The coefficient of curvature (Cc) insures that the grading curve will have a concave curvature within relatively narrow limits for a given D_{60} and D_{10} combination. All gradations not meeting the foregoing criteria are classed as poorly graded.

Table 2—Characteristics Pertinent to Roads and Airfields

Major Divisions (1)	(2)	Symbol Letter (3)		Symbol Color (5)	Name (6)	Value as Subgrade When Not Subject to Frost Action (7)	Value as Subbase When Not Subject to Frost Action (8)	Value as Base When Not Subject to Frost Action (9)	Potential Frost Action (10)	Compressibility and Expansion (11)	Drainage Characteristics (12)	Compaction Equipment (13)	Unit Dry Weight lb. per cu. ft. (14)	Typical Design Values CBR (15)	Typical Design Values Subgrade Modulus k lb. per cu. in. (16)
COARSE-GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Red	Well-graded gravels or gravel-sand mixtures, little or no fines	Excellent	Excellent	Good	None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller, steel-wheeled roller	125-140	40-80	300-500
		GP		Red	Poorly graded gravels or gravel-sand mixtures, little or no fines	Good to excellent	Good	Fair to good	None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller, steel-wheeled roller	110-140	30-60	300-500
		GM	d	Yellow	Silty gravels, gravel-sand-silt mixtures	Good to excellent	Good	Fair to good	Slight to medium	Very slight	Fair to poor	Rubber-tired roller, sheepsfoot roller; close control of moisture	125-145	40-60	300-500
			u			Good	Fair	Poor to not suitable	Slight to medium	Slight	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	115-135	20-30	200-500
		GC		Yellow	Clayey gravels, gravel-sand-clay mixtures	Good	Fair	Poor to not suitable	Slight to medium	Slight	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	130-145	20-40	200-500
	SAND AND SANDY SOILS	SW		Red	Well-graded sands or gravelly sands, little or no fines	Good	Fair to good	Poor	None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller	110-130	20-40	200-400
		SP		Red	Poorly graded sands or gravelly sands, little or no fines	Fair to good	Fair	Poor to not suitable	None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller	105-135	10-40	150-400
		SM	d	Yellow	Silty sands, sand-silt mixtures	Fair to good	Fair to good	Poor	Slight to high	Very slight	Fair to poor	Rubber-tired roller, sheepsfoot roller; close control of moisture	120-135	15-40	150-400
			u			Fair	Poor to fair	Not suitable	Slight to high	Slight to medium	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	100-130	10-20	100-300
		SC		Yellow	Clayey sands, sand-clay mixtures	Poor to fair	Poor	Not suitable	Slight to high	Slight to medium	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	100-135	5-20	100-300
FINE-GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML		Green	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Poor to fair	Not suitable	Not suitable	Medium to very high	Slight to medium	Fair to poor	Rubber-tired roller, sheepsfoot roller; close control of moisture	90-130	15 or less	100-200
		CL		Green	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Poor to fair	Not suitable	Not suitable	Medium to high	Medium	Practically impervious	Rubber-tired roller, sheepsfoot roller	90-130	15 or less	50-150
		OL		Green	Organic silts and organic silt-clays of low plasticity	Poor	Not suitable	Not suitable	Medium to high	Medium to high	Poor	Rubber-tired roller, sheepsfoot roller	90-105	5 or less	50-100
	SILTS AND CLAYS LL IS GREATER THAN 50	MH		Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor	Not suitable	Not suitable	Medium to very high	High	Fair to poor	Sheepsfoot roller, rubber-tired roller	80-105	10 or less	50-100
		CH		Blue	Inorganic clays of high plasticity, fat clays	Poor to fair	Not suitable	Not suitable	Medium	High	Practically impervious	Sheepsfoot roller, rubber-tired roller	90-115	15 or less	50-150
		OH		Blue	Organic clays of medium to high plasticity, organic silts	Poor to very poor	Not suitable	Not suitable	Medium	High	Practically impervious	Sheepsfoot roller, rubber-tired roller	80-110	5 or less	25-100
HIGHLY ORGANIC SOILS		Pt		Orange	Peat and other highly organic soils	Not suitable	Not suitable	Not suitable	Slight	Very high	Fair to poor	Compaction not practical			

Note:

1. Column 3, division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is on basis of Atterberg limits; suffix d (e.g., GMd) will be used when the liquid limit is 25 or less and the plasticity index is 5 or less; the suffix u will be used otherwise.
2. In column 13, the equipment listed will usually produce the required densities with a reasonable number of passes when moisture conditions and thickness of lift are properly controlled. In some instances, several types of equipment are listed because variable soil characteristics within a given soil group may require different equipment. In some instances, a combination of two types may be necessary.

   a. Processed base materials and other angular materials. Steel-wheeled and rubber-tired rollers are recommended for hard, angular materials with limited fines or screenings. Rubber-tired equipment is recommended for softer materials subject to degradation.

   b. Finishing. Rubber-tired equipment is recommended for rolling during final shaping operations for most soils and processed materials.

   c. Equipment size. The following sizes of equipment are necessary to assure the high densities required for airfield construction:

   Crawler-type tractor—total weight in excess of 30,000 lb.

   Rubber-tired equipment—wheel load in excess of 15,000 lb., wheel loads as high as 40,000 lb. may be necessary to obtain the required densities for some materials (based on contact pressure of approximately 65 to 150 psi).

   Sheepsfoot roller—unit pressure (on 6- to 12-sq.-in. foot) to be in excess of 250 psi and unit pressures as high as 650 psi may be necessary to obtain the required densities for some materials. The area of the feet should be at least 5 per cent of the total peripheral area of the drum, using the diameter measured to the faces of the feet.
3. Column 14, unit dry weights are for compacted soil at optimum moisture content for modified AASHO compaction effort.
4. In column 15, the maximum value that can be used in design of airfields is, in some cases, limited by gradation and plasticity requirements.

FIG. 6 GEOLOGICAL MAP OF EAST PAKISTAN

Qm — **Stream deposits**
Streambed, meander-belt, flood-plain, and low-level terrace deposits, undivided, Qm; includes some swamp deposits. Swamp deposits, Qsw

Qb **Qtf** — **Coastal deposits**
Beach-sand and sandbar deposits, Qb. Tidal mudflat deposits, Qtf

Qd **Qt** — **Deltaic and tidal deposits**
Deltaic flood-plain deposits, Qd. Tidal delta-marsh deposits and deltaic flood-plain deposits, undivided, Qt. Qd and Qt are separated primarily on the basis of differences in land use, vegetation, and drainage pattern, as distinguished on aerial photographs

Qpd — **Piedmont deposits**
Detrital material derived from the highlands of India and Burma and deposited on gentle slopes to the south and west

Qla — **Interstream deposits**
Silt, sand and gravel deposits at a slightly higher altitude than adjacent flood-plain and low-level terrace deposits

Qmc — **Older alluvial deposits**
Madhupur Clay**: mostly red and orange clay deposits at a slightly higher altitude than interstream deposits (Qla) and having an inclined dendritic drainage pattern; generally not subject to seasonal flooding. Possibly equivalent to the Dupi Tila formation*

QT — **Pleistocene and Pliocene sedimentary rocks**
Dihing formation* and Dupi Tila formation*, the latter of possible late Miocene age, undivided: ferruginous sandstone, sandy clay, and pebble beds; some lignite beds in the lower part; thickness up to 3000 feet Possibly equivalent to upper part of the Siwalik Group of West Pakistan

Tm **Tms** — **Miocene sedimentary rocks**
Tipam sandstone*, including the Girujan clay*; Tm: yellowish-brown, medium- to coarse-grained ferruginous sandstone, and mottled clay and sandy clay; thickness up to 3000 feet. Surma group*; Tms: greyish-yellow, medium-grained and cross-bedded sandstone, gray sandy shale, gray shale, and gray siltstone; thickness up to 10,000 feet

To — **Eocene sedimentary rocks**
Sylhet limestone*: gray, medium-grained, hard, massive limestone; very fossiliferous; includes the Tura sandstone*; thickness up to 3000 feet

INDIA

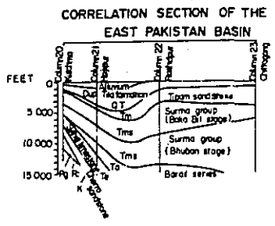
INDIA

BURMA

M O U T H S O F T H E G A N G E S

B A Y O F B E N G A L

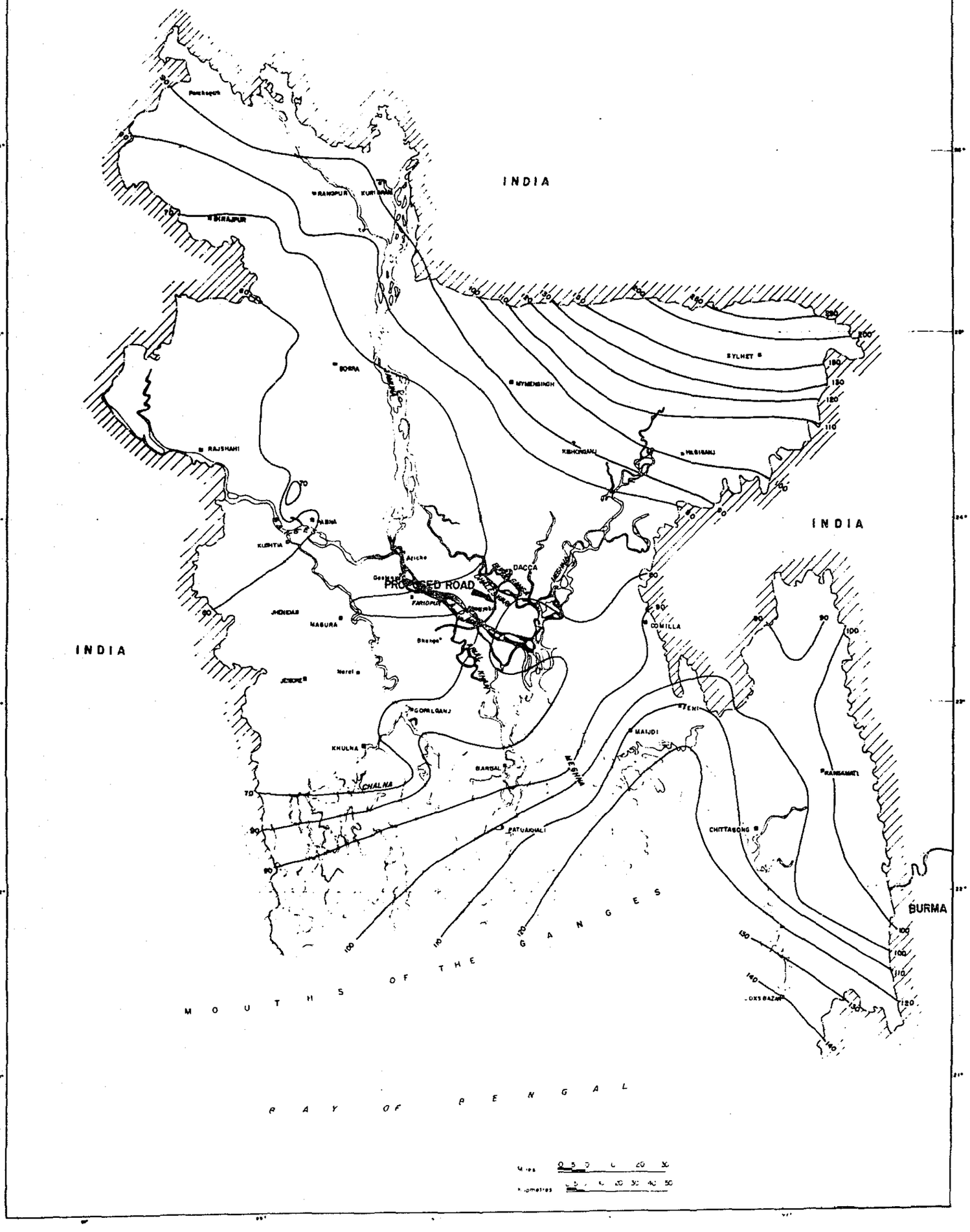
CORRELATION SECTION OF THE EAST PAKISTAN BASIN



Miles 10 5 0 10 20 30

Kilometres 10 5 0 10 20 30 40 50

FIG. 7 AVERAGE ANNUAL PRECIPITATION



the above mentioned, by the three greatest hydrological resources, extensive areas throughout East Pakistan are inundated every year, and the greatest flood occurs when the large flows from major sources coincide with tidal action from the Bay of Bengal. Also the banks of all three major rivers are overflown over considerable length every year. The Ganges-Padma and the Gorai-Madhumati river flood the entire area between them annually, as do the Dhaleswari and the Padma. The valley of the Bhugai Kangsa-Baulai, the Mogra, the Kalni and the lower Surma is flooded almost every year. The delta islands in the Bay of Bengal and Chillagong areas are often attacked by tidal waves and cyclones. The Meghna valley is regularly innundated by tides as far as 150 miles up to the Bhairab Bazar Area, and this kind of condition exists in the Ganges - Padma also.

Therefore, in order to provide all-weather road, bridges and culverts for these areas, hydrological record should fully be studied when such data is available, and if such data is not available, the estimated maximum flood must be estimated by using the records of its neighboring areas. For designing of road, we must keep in mind that the drainage design should be incorporated and will need good experience about it. In East Pakistan, the Pakistan Eastern Railway that has accumulated the many experiences of embankment work, bridges and culverts construction can give much information for this project, but during our field study, we could not spend the discussion time with them.

The most important point in our drainage design will be to prepare adequate relay openings, to know flowing direction of river, and to arrange the opening intervals.

E.P. WAPDA has the irrigation project covering all East Pakistan and already some parts are coming out. According to this project embankments are constructed by parts to form polders for the purpose to control flood and to make good irrigation system whole year round and to have the local development. Then between this irrigation project and this proposed road project a close incorporation should be kept.

5-2. Crossing facilities of the Padma river

The most important problem in planning the Dacca-Faridpur road is the

crossing facilities of the Padma river. Though the ferry system and the bridge system can be thought as a river-crossing facility, both of them should be studied elaborately from the technical and economic point of view, because, whichever may be chosen, the width of the river is as long as 3 km.

Before studying the river-crossing facilities, naturally, the present status of the hydrology of the river course and soil condition at the planned area should have been grasped as fundamental problems, but they have not been clarified by the present time. Therefore, the firm results as to the mode of river-crossing could not be got but some of the items studied by the survey team will be explained as following.

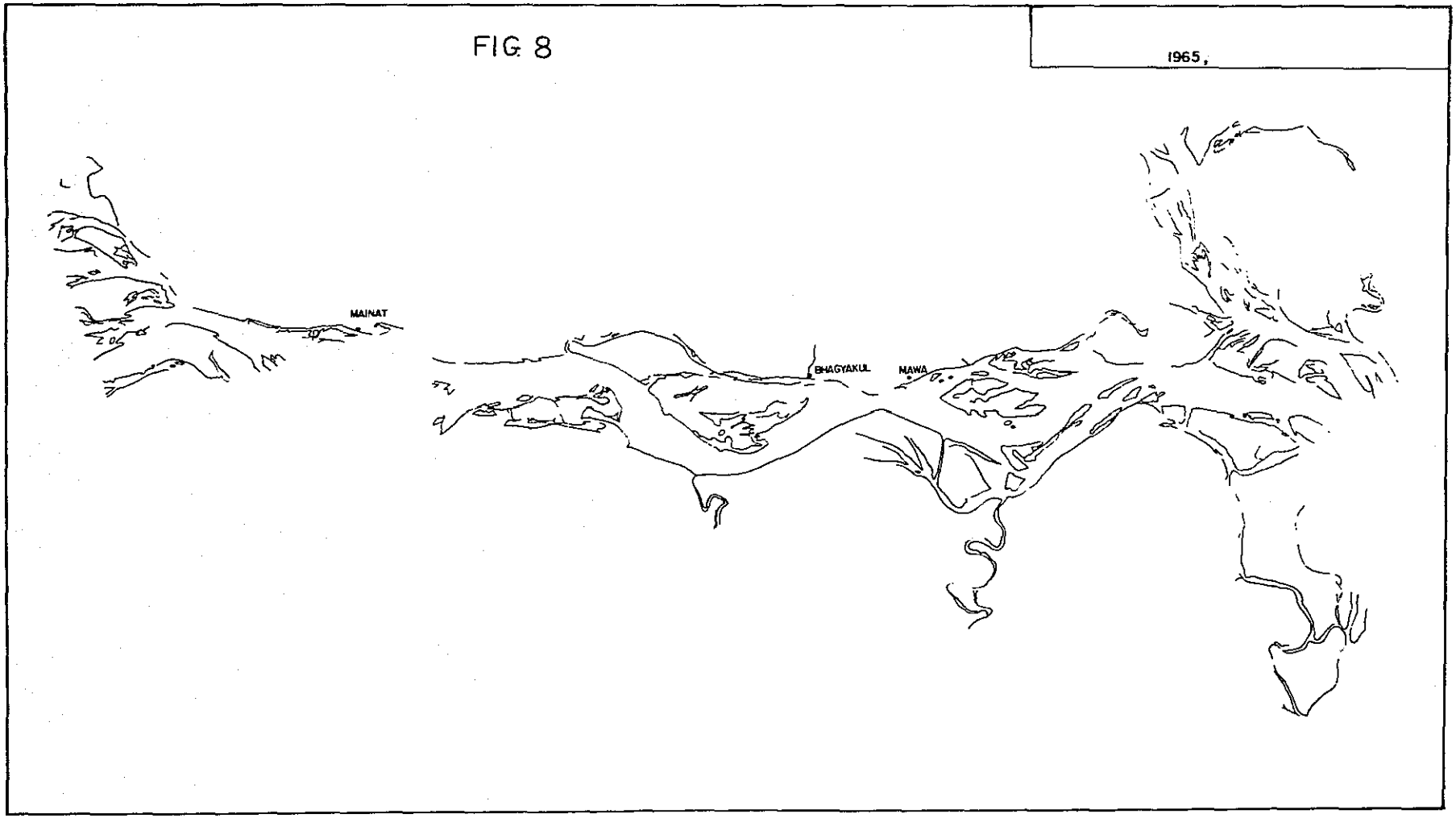
(1) Present status of the Padma river

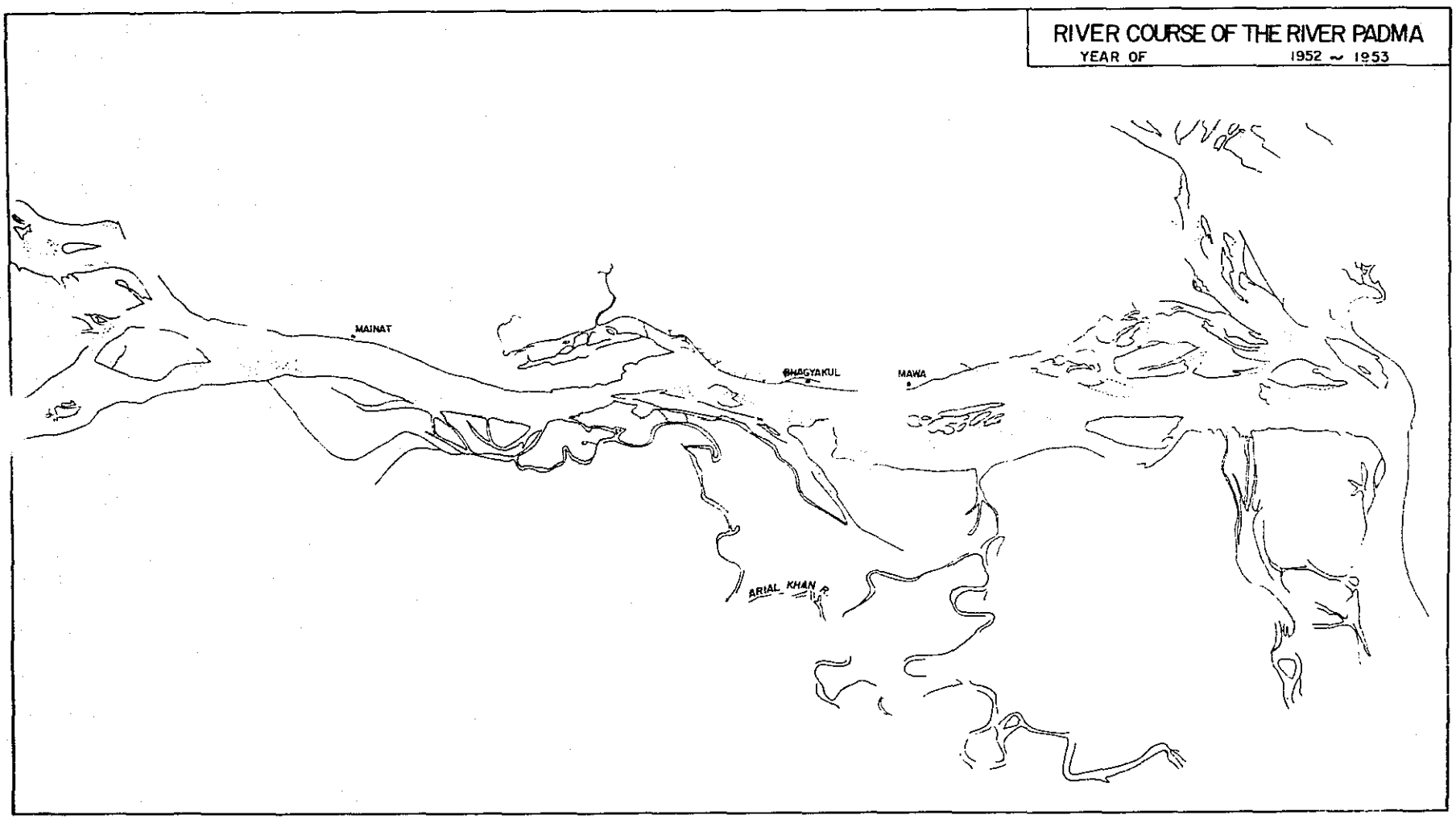
There are two huge rivers in East Pakistan, the Ganges springing from the Himalayas and flowing from west into East Pakistan through West Bengal of India and the Brahmaputra springing from Tibet and flowing from north into East Pakistan through Assam of India. The Ganges river was flowing into Bengal bay near Calcutta of India some hundred years ago, but changed the river course eastward after that and it is now flowing through East Pakistan and it is about 1,600 miles long. The Brahmaputra river called the Jamuna river in some area in East Pakistan is about 1,800 miles long and is world-wide famous because of its frequent changes of the river course.

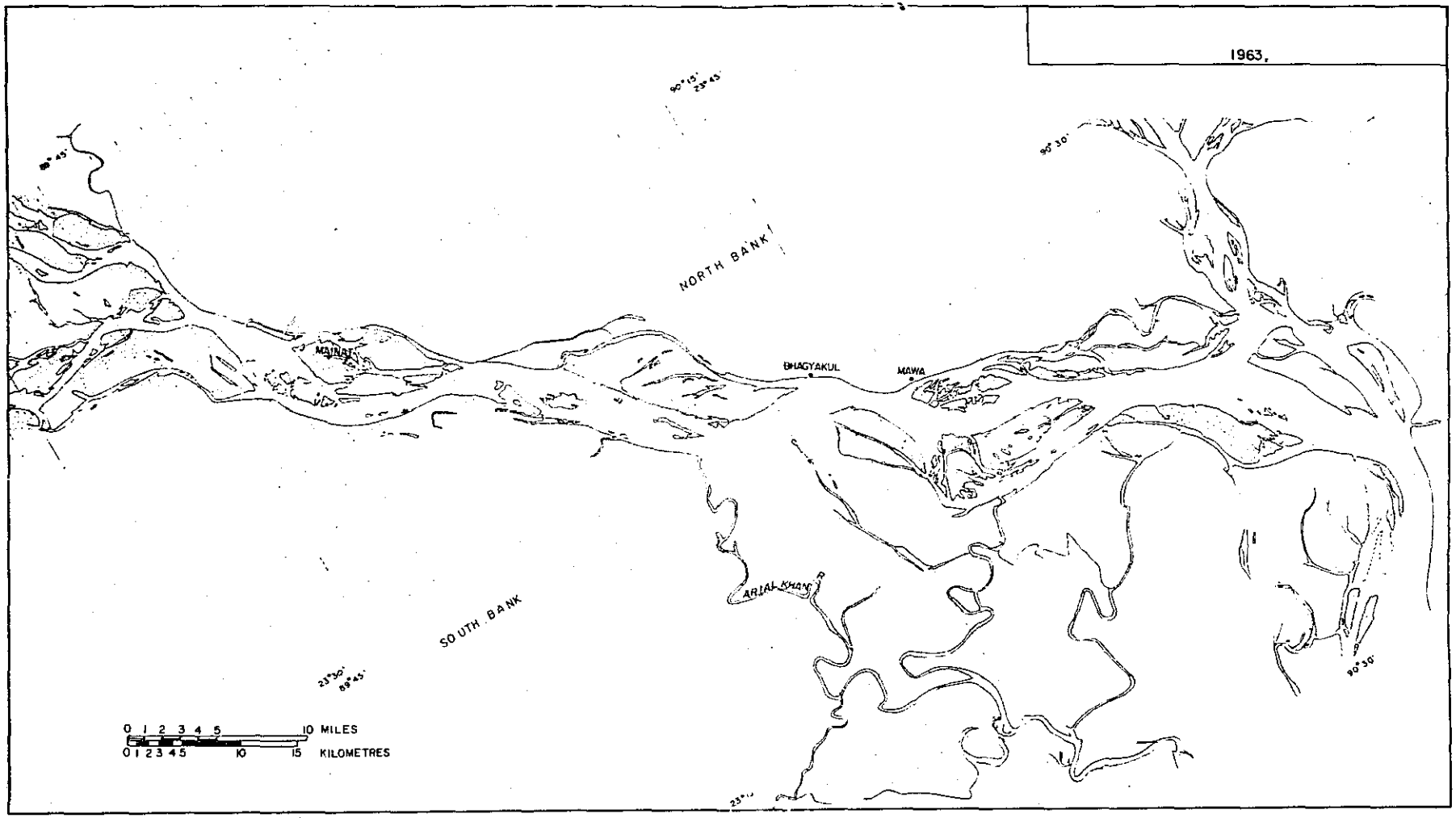
These two rivers merges near Aricha in the central part of East Pakistan, flows about 100 km southward, merges again with the Meghna river near Chandpur and flows into Bay of Bengal. A part from Aricha to Chandpur is called the Padma river.

The river related to the Dacca-Faridpur road is the very Padma river and the changes of the river course of the Padma were studied based on various topographical maps, aerial photos and, maps showing the changes of the river course made by IWTA, etc. Then the most useful materials among those were the maps showing the changes of the river course of the Padma river made by IWTA through long year surveys. The maps record the river course in five eras; 1918-25, 1952-53, 1960, 1963 and 1965 as shown in Fig. 8.

FIG. 8




RIVER COURSE OF THE RIVER PADMA
YEAR OF 1952 ~ 1953
MAINAT
BHAGYAKUL
MAWA
ARIAL KHAN


1963.
NORTH BANK
SOUTH BANK
MAINAT
BHAGYAKUL
MAWA
ARIAL KHAN R.
90° 15'
23° 45'
90° 30'
89° 45'
23° 30'
0 1 2 3 4 5 10 MILES
0 1 2 3 4 5 10 15 KILOMETRES

According to the maps, the changes of the river course has occurred generally very frequent and the maximum amplitude of the river course reaches about 7 km. But, by the precise studies, the point, where the change of the river course is not so frequent, could be found and such a point should be noted as a very valuable point in planning the river-crossing facilities.

The changes of the river course of the Padma river about 100 km divided into four parts can be described as follows from the upper stream to the lower stream.

1) The first part: It consists of 10-15 km down from the merging points of the Ganges and the Brahmaputra and includes Aricha on the left bank and Goalundo on the right bank in an inlet. It is apparent that the left bank is relatively stable, because Aricha is an existing ferry port, but on the contrary the right bank changed its position during 1952-53 and 1960 and it shows that this bank is unstable.

2) The second part: It consists of 35-40 km down from the first part and includes Mainat on the left bank and Narartak on the right bank. The left bank near Mainat fairly progressed in 1952-53, but it went back largely to the present position. Generally it can be said unstable. On the contrary the changes of the right bank, though the slight changes can be seen now and then, have been small comparing to the left bank, and especially the bank near Narartak can be seen fairly stable.

3) The third part: It consists of about 20 km down from the middle point of the Padma river and includes Bethua, Bhagyakul and Mawa on the left bank. The change of the left bank has been very slight and it seems very stable, but the change of the right bank is fairly large. Namely the narrowest point of the Padma river was situated near Bethua in 1952-53, near Bhagyakul in 1960 and near Mawa in 1965, with the right bank near Bethua and Bhagyakul going backward largely. And the amplitude of the change of the river course has been the minimum in the part between Bhagyakul and Mawa through the Padma river. It was confirmed by the survey of this time that the present status of the river bank is almost the same as that of 1965 and the

width is the narrowest near Mawa as a result of reconnaissance by air and launch.

4) The fourth part: It consists of about 30 km of the lower stream of the Padma river. The river has been wide comparing with the other parts and very unstable and has changed both banks very largely.

About the location of the crossing facilities of the Padma river, as described already in the chapter of route setting, the survey team has decided that the point near Mawa is the most suitable at the present time, taking consideration of the polder project planned by WAPDA based on the river conditions of the Padma above mentioned. But, as described as followings, there are some problems not fully understood such as hydrological and geological conditions of the crossing point of the river and it is necessary to decide the crossing point concretely through the further technical surveys by experts and the structural study of the river-crossing facilities.

(2) Ferry

The ferry service crossing the Padma river exists now between Aricha and Goalundo. The distance is about 16 km and it takes about 2 hours, but the distance between the two points is not shortest. It is the result of influence of the selection of the approaching point on the right bank of the Padma river and at present Goalundo has various difficulties for the operation of ferry boats. In case to plan a ferry service across the Padma river, the most important focus is whether the points suitable for ferry service can be found or not.

The river-crossing point near Mawa chosen this time, has almost no problem in planning approaching facilities on the left bank, but has difficult problems on the right bank, for the bank has shifted in the past and water depth is too shallow for ferry boats to approach. But after review of available materials and discussions with engineers of WAPDA and IWTA, it was concluded that the ferry facilities could be planned on this point when it would be based on the polder project planned by WAPDA.

Ferry boats and approaching facilities are the two main facilities necessary for the ferry service. And as these two facilities have certain relations

each other and control fundamentally the traffic capacity of the ferry system, these should be studied and planned elaborately considering the traffic volume.

At first, as to ferry boat, its size and structure, performance and the number of boats needed, etc. very according to the traffic volume, conditions of waterways, travelling distance, travelling schedule, etc. In the plan of this time a ferry boat of large draught will probably be uneconomical, for the cost of maintaining the waterways is estimated very much considering the river conditions and ferry boat of high performance is not necessary, because the travelling distance is thought to be only 3 km if it is based on WAPDA polder project. And in case for the use for the existing Aricha-Goalundo ferry service, it will be a recommendable policy to adopt the same type of ferry boat as Aricha-Goalundo ferry, which is of twin type and has a capacity of 6 cars. Though the number of ferry boats to be equipped is to be changed according to the increase of the traffic volume, it should be decided after careful study of the operation schedule, for it has some relation with the enlarging tendency of the ferry boats.

Secondly, as to the approaching facilities as the water depth of the Padma river changes largely by season, the facilities should be able to respond with the river changes. The gangway, or approaching facility, of steel box caisson hinged with a simple beam bridge is used commonly in East Pakistan and in the plan of this time such a structure will be adopted fundamentally. The size of gangways is decided by the number of ferry boats which approach at the same time. The important keys to this decision are the traffic volume and operation schedule of ferry boats. In relation with the approaching facilities much consideration should be taken also in access road and parking area.

In case of ferry, keeping of the sufficient depth in waterways is inevitable and in some cases the expenditure for the maintenance and dredging is tremendous. Therefore the sufficient study and research on changes of river course and accumulation of sand and soil should be undertaken. And as the hydrological condition influences much on safety of ferry boat operation and approaching of boats to gangways hydrological studies and surveys are also necessary.

As the traffic capacity of ferry system which is controled by the cycle-time including loading and unloading time, capacity and number of ferry boats,

capacity of approaching facilities, etc. has naturally a limit from the economical point of view, the construction of bridge will be necessary if the traffic volume becomes more than the limit.

The survey team thought at the first stage of this survey that it might be advisable to have ferry system as a crossing facility for some years when the traffic volume is not so much and began to study concretely about ferry system from the stand point above mentioned. But as it was clarified that the construction of the bridge from the first stage is profitable and that the stage construction of ferry system at the first stage is not economical from the results of the economic study described in the later chapter, it was decided not to continue the studies in the middle of works. Therefore any concrete planning about ferry system such as the structure of the facilities, operating schedule and costs of construction maintenance and management is not described in this report.

(3) Construction of the bridge

Comparing the bridge with the ferry as a crossing facility of the Padma river, it is apparent that the bridge is superior to the ferry in the sense of traffic engineering such as the traffic capacity, running time, easiness of use and every other points and especially the significance of the connecting every parts of the country by the permanent link road, which is not disturbed by the natural condition like weather, is immeasurably great. In case of the bridge the most important factor controlling its adoption or rejection is the cost of construction and its economy. But as to the economical feasibility, it was clarified that the construction of the bridge from the first stage was more profitable than the ferry as the results of study as laready described. Therefore the survey team decided to make study putting emphasis on bridge as a crossing facility of the Padma river, studied the premise conditions necessary for the planning at first, and next made some studies and made a preliminary bridge design on the basis of these premises.

First, as to the water depth near the proposed bridge site, the cross survey of the river bed has been executed by WAPDA every year and its results are shown on cross-section maps which shows the annual change. However, unfortunately, the maps were not available to the survey team. But according to the information obtained from discussions with the concerned engineers of

WAPDA, the maximum water depth at the proposed site is about 150 feet, and the depth and its position changes only a little. And there seems only one deep valley with the maximum depth in the cross profile of the river bed and other parts seem to form a gently-sloping river bed.

Secondly, as to the stream of the river, materials and data about the direction and velocity distribution of the stream were not available, but sufficient consideration should be paid on the structural design and the construction plan, because the maximum velocity of the stream near the proposed site seems to be about one to two knots.

Scouring of the bridge foundation is the phenomenon which can be seen more or less in the existing bridges in East Pakistan and it is a very serious problem in planning a bridge. There is no data concerning the scouring at the proposed site, but about five meters of the scouring was measured at the foundation of the Daleswari bridge on the Dacca-Aricha road which was completed five years ago. Considering that 10 m of the scouring depth were assumed in the project of the Burhi-Ganga bridge and the Gorai bridge, the appropriate depth —that may be 10-15 m— of the scouring by stream is necessary to be presumed in the project of the Padma river bridge. And for such an expected deep scouring the caisson may be most suitable for a structural form of the bridge foundation.

Next, as to the geology at the proposed bridge site, as there is no data of the geological survey like a boring survey and others, the direct information could not be obtained. Therefore the survey team assumed from the general geological condition of the whole East Pakistan and from the data of the boring survey already done at other similar points that the surface of the ground or the river bed consists of alluvial layer of 10-30 m depth brought by the Ganges and the Brahmaputra and its main components are sand, silt, clay and no gravel. There lies a very thick diluvial layer under the alluvial layer and its main comnent is sand.

The Tertiary is thought to lie below 300 m deep from the ground level.

Technical characteristics of ground soil cannot be explained concretely, but it can be said qualitatively that the alluvial layer is not appropriate to be a

supporting base and the diluvial layer can be. And it is not necessary to think over the scouring of the foundation of the bridge in the diluvial layer.

Concerning the navigation of the ships, IWTA has the regulations and the minimum conditions to keep for rivers, according to which 250 ft for horizontal clearance, 60 ft for vertical clearance should be maintained at the proposed site. Though only to satisfy this condition is not difficult problem in the technical sense, it becomes a serious problem in planning a bridge when the route of navigation moves according to the changes of the river course. But this point was not cleared this time.

Though there are many unknown factors in the premise conditions in planning the Padma river bridge as explained above, such a consideration should be paid as follows in planning a bridge based on materials and informations obtained by this time.

It would be appropriate at the present time to plan a bridge all through 3 km between polders of both sides, for there would be many difficulties in planning an embankment in the flood field outside the polders.

Though the horizontal clearance to be secured is about 75 m as explained above, it would be appropriate to secure a span of about 300 m at the navigation at the present time, considering that the deepest part may shift to some extent giving no influence to the foundations in accompany with the changes of the river course, that the depth of the bridge foundation should be as shallow as possible and that the total length of the bridge is about 3 km. Though the position of the route of navigation is not clear, the span of the bridge will include the route of the ships according to the map showing the changes of the river course when the span of 300 m is set at the present route of the ships.

Though various types of the super structure can be designed for the bridge with span of 300 m, cantilever truss and continuous truss can be said to be the most suitable. And also various types can be designed for the other spans than the central span for the route of ships and to adopt the simple truss with span of 60-100 m is a leading idea when the geological condition is not so clear. And there is no difficult problem in choosing the types of the bridge for the parts near banks.

As final, some comments will appear about the technical problems of the Padma river bridge and the scope of studies and researches that should be undertaken in order to solve them as follows.

As the Padma bridge that will be constructed across the great river, the Padma, is of world-wide scale, there are many technical problems that should be solved before its construction. These would be divided into three stages, the problems of planning, designing and construction.

In the problems concerning planning, the selection of the bridge site, the decision of the location of the piers and the selection of the most suitable type of structure are the important problems. Though the changes of the river conditions of the Padma in the past years as well as the present conditions were considered in selection Mawa as the bridge site, the scope of the river conditions in the future and geological conditions were paid little consideration in this survey. Therefore the final decision of the bridge site should be done after sufficient studies of these points and after adjusting the various relating projects like polder project. As the natural conditions and the navigation conditions of ships could not be clear this time, only a practical sample of the bridge plan could be shown as a result of the general studies, which should have a close relation to the span division and the type of the bridge structure. From now on, therefore, it is necessary to make some alternative plans of sub-span bridge as well as main-span bridge and compare them each other precisely.

There is not so serious problem in the design itself seeing from the world technical level, though the outer force action on the structure and various constants to be used in the design are not cleared yet, which will be naturally solved by the study in the future. But in order to conduct a more reasonable design, it is hoped to make efforts to make clear of the premise conditions and to make study and development of new type of structure and new design method.

Though there is not a serious problem in the construction judging from the cases of long-span bridges in the world, the construction of the sub-structure, which is thought to be a big scale under water structure, will induce various difficult problems. At the present time, however, conducting a feasibility study, it is difficult to describe these problems precisely. Generally speaking, the most important things are to develop a synthetic technic of the construction

including materials, machines and methods of construction as well as to aim at establishment of the powerful construction system.

As the most fundamental and common item in solving the technical problems of the Padma bridge described above is the natural condition, the greatest endeavour should be paid on grasping it, especially hydrologic condition of the river and geological condition.

Concretely it is necessary for the expert engineers to grasp the past and present status of the hydrographic conditions of the river after the study and analysis of the available data, and reconnaissance survey and site observation and to estimate the water depth, changes of the river bed, the stream flow, changes of the water level, scouring depth, etc. In that case, as it is expected that the hydrologic conditions of the river will change after the realization of the polder project of WAPDA, it is very important to pay attention to this fact.

As the lack of the direct information of the geological conditions of the proposed bridge site is a very weak point, it is necessary to execute the boring tests on land near the proposed site as early as possible and further it is desirable to grasp the geological condition of the sub-ground under the water through a method of Sonic Prospecting in the river part as much as possible. The execution of the boring survey and other special survey concerning the characteristics of the sub-ground for the river part are recommended to be executed later when the prospect of the realization of construction of the bridge becomes firm.

5-3. Preliminary design

(1) Road design

1) Horizontal alignment

Because our reconnaissance could not cover all the area of the proposed route, the horizontal alignment was decided by using the maps of 1/50,000, 1/16,000 and 1/8,000 scale obtained this time and the partial field reconnaissance. It should be noted; therefore, that this proposed route is to be a base alignment for the fundamental design in future, and the horizontal alignment in this stage has been

designed with rough touch. By the flatten topography, mainly straight line with a few large circular curves are applied to form the horizontal alignment of the route.

The transition curve formed by Clothoid curve is used only at the point of No. 1. I.P. which is located at the junction with the unpaved local existing road where the proposed route comes from the direction.

The Burhiganga river and passing through the Central road in the Great Dacca city, and all other I.P. points are designed with large circular curve.

Generally speaking, application of Clothoid curve is as follows. Clothoid curve is connected to the circular curve of less than 3,000 m in radius but its parameter is determined within the range of A = 1/3R - 1/2R in proportion to the value adopted for circular curve. Thus in our alignment, a fundamental Clothoid curve with a parameter of A = 1/2R which is same size of Clothoid curves are used at both and of circular curve, was adopted.

For the bridge sites, specially Burhiganga, Dhaleswari, Padma and Arial Khan bridge, the design calls for a straight line over the bridge as a principle for the easiness of design and construction.

As mentioned already, this horizontal alignment is designed with rough touch, and therefore it should be adjusted in the next stage of the primary design with consideration of the local condition and the topography. However, in this time (except the bridge site) for the horizontal alignment of the embankment portions low lands are as much as avoided to get the low construction cost, but to keep safety driving the minimum radius curvature is made not less than 800 m.

2) Gradient

In the ideal case, the standard gradient of a highway should be so determined that the running speed within a vertical curve may be

brought close to the design speed. Yet in actual cases this is not attainable since it is subject to restriction by economical reason, and usually the value of running speed declines some from the design speed.

Selection of the gradient of roads in East Pakistan needs careful consideration of an influence of low speed traffics to higher speed traffics and also an uniformity of whole traffic flow.

The traffics in East Pakistan are mainly composed of pedestrians with head loads, cycles, bullock carts, rickshaws and automobiles, and among these traffics bullock carts are influenced by gradient and its bullock carts give much influences to other speedy traffics. Consequently, a maximum gradient of 3.0 per cent has been adopted for all bridge sites, and the gradient of embankment part is not more than 0.5 per cent. As for determination of the gradient of embankment portion flood level should be considered. However, this proposed route was designed based on an assumption that the flood can be controlled by the polder project. By this assumption the height of the embankment was reduced by 1.0 - 1.5 meter than when the polder project is not considered, and it was said to be good saving of the construction cost.

3) Cross-section of road

Generally utility of roads in East Pakistan, as already mentioned, differs largely from that in Japan; it is characterized by a good number of pedestrians, bicycles and bullock carts, and they do not try to avoid faster moving traffics as if such faster moving traffics should avoid them. Under these circumstances, the following items should be taken into consideration in designing of a cross-section of the road.

i) Cross-section should be economical and insure enough capacity of smooth flow of all types of traffic.

ii) Cross-section should have enough space for automobiles

without being impeded by other slow moving traffic. To satisfy these conditions, the road must be provided with a sufficient paved width, flat and smooth shoulders for traffic other than motorcars, as well as suitable drainage facilities to protect the road during the flood season.

The government of East Pakistan has been adopted the typical cross-section more or less considering the above reason and also it is almost the same of the cross-section previously designed in "Jessore - Madhukhali Road" adopted. Thus the same cross-section was adopted in this proposed road. The typical cross-section adopted in this road design is shown in *Fig. 11*.

4) Width of right of way

In general the materials for road embankment in East Pakistan will be collected from both sides of the road. It is said that 80 per cent of those materials are usable for embankment materials. This method is the cheapest practice in East Pakistan and after completion of road the borrow pit is effective for road drainage. Therefore, the width of right of way depends on the embankment height, quality of soil and size of the borrow pit. It also varies substantially by whether the pit is provided on one side alone or both sides of the road. For the future growth of traffic volume if widening of road is necessary the borrow pit should be provided at one side of the road. In damp areas, however, this is not justified since the embankment height would become excessively large and the excavation work would be made difficult by the underground water level. Thus, it will be understood that the borrow pit should not necessarily be provided at one side alone nor should it location be determined simply by the existence of villages, rivers, woods, etc. along the route.

The borrow pit has been designed to be excavated not deeper than the underground water level since the excavation will be the hard work. In this case, the depth of the borrow pit was decided as 1.70 m by the local geological data which we collected during the

field survey, and since the depth of the borrow pit was fixed the variation of the borrow pit size according to the embankment size was adjusted by the width. The average of the width came to near around 10.0 m in this design.

(2) Bridge design

1) Type of super structure

Within this proposed route besides the great Padma bridge. Daleswari bridge, Arial Khan bridge and some short span bridges are necessary. Under the present insufficient information no final decision can be made for the site of the short span bridges. Therefore in the estimation of the construction cost five numbers of the short span, P.C. simple girder of 2 @ 25.0 m = 50.0 m, are included. Except the great Padma bridge, consideration in designing the bridges were given to the full utilization of locally available materials, experience of local contractors, easy maintenance, beauty, cost and future technical development of East Pakistan, and the decision came to employ P.C. bridges.

Through comparison between bridge and ferry facilities for the Padma river the conclusion was extracted that the bridge construction is favourable from the economical viewpoint, which is described in later chapter. However, as for the type of this bridge due to the lack of sufficient technical information about the Padma river, no final decision of type of the super structure nor the substructure was possible. Therefore, this time we designed the Padma bridge as follows that the type of main span is three-span continuous steel truss bridge with spaning of 100 m + 300 m + 100 m, the type of the connection bridges to main bridge are simple steel truss bridge of 70 m span and simple P.C. bridges of 30 m span is adopted for the approach bridge over the land portion. The total length of the Padma bridge came to 3,040 m (main span = 500 m, total connection span = 1,400 m, total approach span = 1,140 m).

As for the profile of the Padma bridge the position of the crest

could not be decided clearly since the cross-section of this river was not obtained. Therefore for convenience sake, the crest point of this bridge was planned at the 1/4 point of the river width from Mawa side assuming that this point was the deepest river bed according to our observation of the river. The basic figures of the superstructures are as tabulated below.

Table 4. Basic Data for Bridge

Name of Bridge	Type of Bridge	Bridge Length (m)	Span (m)	Navigable Clearance	
				Vertical (feet)	Horizontal (feet)
Padma Bridge	Metal Truss (P.C. Br. for approach)	3,040	(20@30=600) + (4@70=280) + (100+300+100) + (16@70=1,120) + (18@30=540) = 3,040	60	250
Dhaleswari Bridge	P.C. Cantilever	1,200	(10@26.5=26.5) + 57.5 + 7@80=560) + 57.5 + (10@26.5=26.5) + 1,200	40	250
Arial Khan Bridge	- " -	500	(3@30=90) + 35 + (5@50=250) + 35 + (3@30=90) = 500	25	100
Short Span Bridge	P.C. Simple Beam	50	2@25 = 50		

Vigorous efforts are being made at present by the government of East Pakistan in the construction of new roads as well as in the repair and widening of existing roads. The progress of road construction and repair is accompanied by the construction of bridges having a cross-section which is based on AASHO's standard for 2-lane road bridge. Therefore considering the balance with existing roads, designing road at present and future traffic volume, the effective width of these bridges have been set at 24 feet.

2) Live load for bridge

At present, the live load of AASHO standard H 20 - S 16 - 44 is applied for all types of bridge design in East Pakistan. By examining this live load, it is said to be favourable one since live load at

present is growing much bigger and contains the possibility of using road for military purpose some time in future. Therefore, for designing of the bridges AASHO's standard H 20 - S 16 - 44 was used as the design live load.

3) Substructure and foundation

The type of substructure and foundation is largely effected by the ground condition as well as by the superstructure, reaction force, magnitude, intended function and other factors, and therefore the superstructure will have an influence on selection of the type of substructure and foundation. Specially for determination of a foundation type, we must study very carefully the local scouring depth of the river bed, the depth of the supporting layer and its allowable supporting power.

For the determination of the substructure that is the type of pier we considered the following matters. When a bridge is constructed across a river, the flow is impeded by piers on their upstream side, resulting in the creation of the so-called "pier backwater." Further, the river bed around the upstream side of piers is subjected to heavy scouring action, which is liable to endanger the pier stability. Also the scouring action varies by the shape and arrangement of piers.

Piers are generally provided with circular, single circular arc, double circular arc, or rectangular shape. Experiments conducted on pier models with these different shapes to clarify the relationship between the angle of the upstream tip of pier foot against flow direction α , and the scouring depth and width, revealed that as the angle 2α is made narrower than 180°, the scouring depth and width decrease sharply. However, no substantial decrease can be achieved after the angle has been reduced to a certain extent. But if the angle is made excessively sharp, the pier foot of upstream tip is liable to be damaged by the collision of various hard materials flowing from the upper reaches. The best recommendable pier foot would therefore be either the double circular arc whose tip angle is $2\alpha =$

$70^{\circ} - 80^{\circ}$, or the rectangular shaped foot with the tip angle, $2\alpha = 40^{\circ} - 60^{\circ}$.

The shape of pier considered from the standpoint of pier arrangement with respect to scouring action needs serious attention. In general, river does not flow steadily in long straight direction and flow direction will more or less have a some angle with pier by the discharge and level of water. Rivers in East Pakistan are particularly apt to change their flow direction because of geological conditions. The river flows more or less diagonally against the piers. Experiments revealed that no substantial increase was noticed in the scouring action if the angle of the major axis of pier against the flow direction is held within a small value. If, however, the angle exceeds a certain value, it inevitably leads to the increased scouring action on the upstream as well as downstream side of the pier foot, and endanger the pier.

The scouring effect caused by increase of the value of the angle differs by the shape of pier. Generally, in the case of wall-type piers, the scouring action decreases as the pier food of upstream side is made sharper. Provided that the value of the angle is constant, the degree of piers becomes larger as the pier foot tip is made sharper. However, it is advisable to make the round tip in case of rivers whose flow direction is not stabilized.

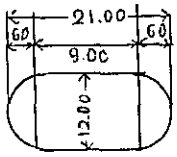
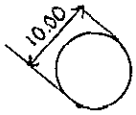
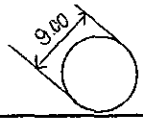
Above explanation leads to a conclusion that both the upstream and downstream side of pier foot of the proposed bridges should preferably be semi-circular in shape and the cross-section of the pier should be elliptic in view of the anticipated fluctuation of flow direction.

An estimation of scouring depth is one of the most important factors for the determination of effective length of foundation. Many formulae were devised in the past for obtaining the local scouring depth, but it is very doubtful that whether those formulae can be applied or not for the river in East Pakistan.

However, local scouring records of rivers in East Pakistan show more than 10 m, and yet it is still doubtful whether it can be applied in the proposed rivers.

Finally a conclusion came to that the scouring depth was determined as 10 m for the proposed rivers but they require further studies. The type of foundation of the proposed bridges are shown in the following table.

Table 5. Basic Data for Foundation of Bridge

Name of Bridge	Size (m)	Type of Cross Section		
		Foundation	Pier	Pile
Padma Bridge	12.00 × 21.00 × 40.00 8.00 × 30.00 0.45 × 20.00			0.45
Dhaleswari Bridge	10.00 × 30.00 6.00 × 25.00 0.45 × 20.00			0.45
Arial Khan Bridge	9.00 × 30.00 6.00 × 30.00 0.45 × 20.00			0.45

4) Navigable clearance

Rivers in East Pakistan are grouped into a number of classes for which specific navigable clearances are required.

In designing the bridges, division of spans and vertical clearance have been so determined that an ample navigable clearance may be secured at least one span at any time of a year, flood season or dry season. The navigable clearance of the designed bridge are as shown in the following table.

Table 6. Navigation

Name of River	Class	Horizontal (feet)	Vertical (feet)
Padma River	I	250	60
Dhaleswari River	II	250	40
Arial Khan River	III	100	25

5) Short span bridge, culvert and drain pipe

It can not be avoided that the proposed road traverses a number of marshy lands and channels along village roads. Because of lacking of enough reconnaissance survey along the proposed route, we could not clarify marshy lands and channels and thus the site of the short span bridge could not be determined but the sites for culverts and drain pipes were determined on the 1/16,000 map by considering flood areas. However, these sites are not confirmed and needs more study in next stage and those sites are revisible.

(3) Construction materials

Natural coarse aggregates used for structures, asphaltic pavement, soil cement or base course of road in East Pakistan are transported mostly from the Chhatak area of Sylhet. It covers approximately 75 percent of all natural coarse aggregates used in East Pakistan. They consist of derivatives of slate, sandstone, limestone, quartzite and marble. These fields are annually replenished by material that is washed down from the hills of Assam in India. Aggregates from the stone fields are transported during the wet season abroad "barki" boats of approximately 2-ton capacity for other districts. Along the northern border of the Mymensingh district, alluvial deposits of aggregate are available in the Garo Hills, but this area is too far to be of significance to this project. Also, the Chittagong Hill tracts are relatively inaccessible areas except where the large new Karnaphuli Reservoir could be used as a waterway for the transportation of stone from the rock areas. Much of the stone from the area is soft shale or sandstone, and not suitable for road or concrete aggregate.

From the above reason, it is very difficult to collect natural coarse aggregate in East Pakistan. Therefore, in present situation in East Pakistan most of coarse aggregate used for road and structure construction is the manufactured aggregate.

Material of manufactured coarse aggregate is brick which is properly crushed. For the base course of road, bricks are used uncrushed or crushed and it is said to be strong enough for the purpose. Thus, except special places, bricks are used extensively as base coarse of road. Also, the over baked bricks are used for concrete aggregate. Considering the similarity in the nature of brick and the light weight aggregate which is composed of clay, use of crushed bricks as aggregate for concrete is considered possible. Field survey revealed that the use of hard bricks as aggregate for concrete in building structures is general practice in East Pakistan.

Since soil of East Pakistan is mostly composed of alluvial clay, brick baked with alluvial clay as the raw material is seen in every parts of the country. Therefore, bricks are available almost at any places and at a considerable low cost. By taking into account the above peculiar local situation a decision was made on the use of hard bricks as aggregate for base course and for the concrete structure specially bridge foundation.

5-4. Estimation of construction cost

It is envisaged that constructional materials and equipments which are imported will be landed at the port of Chittagong and Khulna, and the port of Dacca, Dhaleswari bridge site and the Padma bridge site will be taken up as the landing places, so that, the construction may be started at the same time at the four embankment work sections. The project was divided as Table 7.

Local roads along the proposed route shall not be used for carrying heavy construction materials and equipments because of imperfect road. If the new construction road was constructed the total construction cost will be brought higher; therefore an embankment work and construction of structures are intended to be executed simultaneously in all the work sections, after the right of way has been cleaned.

It is recommended that the construction work of all sections will be

started at the same time and focused within short period because in East Pakistan wet season is very long and working days are very short in year.

Through the construction of this proposed road, the construction of the Padma bridge will be the most hardest part specially construction of its foundation, and it requires further reconnaissance and analysis in future.

Table 7. Section of Construction

Section of Construction	Station No.		Length (m)
Section 1 Burhiganga R. — Dhaleswari R.	No. 0	No. 50 + 150,000	10,150
Dhaleswari Bridge	No. 50 + 150,000	No. 56 + 150,000	1,200
Section 2 Dhaleswari R. Padma R.	No. 56 + 150,000	No. 162 + 0.000	21,050
Padma Bridge	No. 162 + 0.000	No. 177 + 0.000	3,000
Section 3 Padma R. — Arial Khan R.	No. 177 + 0.000	No. 261 + 100,000	16,900
Arial Khan Bridge	No. 261 + 100.00	No. 264 + 0.000	500
Section 4 Arial Khan R. — Foridpur Dd.	No. 264 + 0.000	No. 329 + 150,030	13,150.3
Road Length (5 bridges, 2@25.0^{m} = 50.0^{m} are included			61,250.3
Total Bridge Length			4,700

On the other hand, the pavement work is designed to be started at least one year after the completion of compaction of the embankment.

As for the estimation of the construction cost the following items are assumed.

1) Unit construction cost

The unit construction cost given below has been based on the investigation conducted during the previous and this time survey on the prevailing cost in East Pakistan and on the assumption that special materials and equipments required for the construction would be imported from Japan.

2) Contingency

Two percent of the local currency portion of actual construction cost will be allocated to contingency required to provide against accidents, revision of design due to unavoidable reasons unusual escalation of construction cost during construction period, etc.

3) *Construction supervision fee*

The consultant firm which prepares the detailed design of the road will be entursted with supervision of the construction work. 5 percent of the actual construction cost will be allocated for this purpose and this is divided into that 40 percent of the fee will be covered by foreign currency and 60 percent by local currency.

4) Detail design fee

The detailed design of the road is assumed to be undertaken by a consultant firm, which will be paid 3 percent of the total construction cost not including the right-of-way appraisal and taxes.

60 percent of the design fee will be paid in foreign currency and the remaining 40 percent in local currency. The consultant firm will

be bound to prepare the contract specification, detailed cost, detailed drawings and all other documents required for the execution of the work. The detailed design including tender period is set at 3 years.

Table 8. Unit Construction Cost

(1) Unit Cost for Road Construction

Item	Unit	Unit Cost ($)
Embankment	m^3	0.86
Mechanical Compaction (Cost of machines are included)	"	0.35
Pavement of Roadway	m^2	7.56
Pavement of Shoulder	"	4.81
Right of way and land for Temporary work	"	0.51
Clearance of Right of way	"	0.12

(2) Unit Cost of Structure

Item	Unit	Unit Cost ($)
Excavation (for well foundation)	m^3	28.40
Concrete		
1) P.C. for Superstructure	m^3	134.00
2) R.C. for Superstructure	"	123.00
3) R.C. for Substructure	"	123.00
4) R.C. for Substructure (Use of brick aggregate	"	103.00
5) Culvert	"	123.00
6) Other concrete	"	58.50
Reinforcement Bor.	t	270.00
P.C. Steel Bor.	"	342.00
Structure Steel	"	297.00
R.C. Pile		135.00
Corrugated Pipe	m	30.00
General Excavation	m^3	0.30

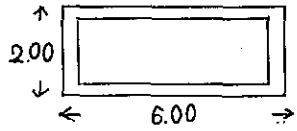
Table 9. Quantities of Construction Work

(1) Earthwork and Right of Way

Work Section / Kind of Work	No.0+0.0 — No.50+ 15.0	No.56+ 150.0 — No.162+ 0.0	No.177+0.0 — No.162+ 100.0	No.264+0.0 — No.329+ 150.03	Total
Earth for embarkment (m^3)	241.925	596.220	432.116	419.354	1,689.615 m^3
Earth Excavaded for Culverts and Drain Pipes (m^3)					11.600 "
Total					1,678.015 "
Pavement Area (Roadway) (m^3)	68.005	141.035	113.230	88.105	410.375 m^2
Pavement Area (Shoulder) (m^3)	49.532	102.724	82.472	64.172	298.900 "
Area of Right of Way	536.570	1,192.356	916.622	780.481	3,426.029 "
Area for Temporary Work	30.000	30.000	30.000	30.000	120.000 "
Compensation of Articles and Clearance (m^2)	20.000	30.000	25.000	25.000	100.000 "

(2) Culvert

Proposed height



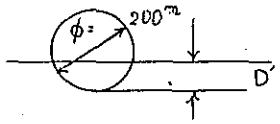
Station No.	Size (m)	D (m)	L (m)	Station No.	Size (m)	D (m)	L (m)
No. 6+ 0.00	2@6.00x2.00	1.0	15.0	No.195+ 0.00	6.00x2.00	0.5	13.5
No. 11+ 0.00	6.00x2.00	1.0	13.5	No.200+ 0.00	"	0.5	13.5
No. 15+ 0.00	2@6.00x2.00	1.0	15.0	No.205+ 0.00	"	0.5	13.5
No. 20+ 0.00	"	1.0	15.0	No.212+ 0.00	2@6.00x2.00	0.5	13.5
No. 33+ 0.00	6.00x2.00	1.0	13.5	No.217+ 50.00	"	0.5	13.5
No. 38+ 0.00	"	0.5	14.5	No.225+ 50.00	"	0.5	13.5
No. 40+ 0.00	2@6.00x2.00	1.0	15.0	No.231+ 0.00	6.00x2.00	0.5	16.5
No. 44+ 0.00	6.00x2.00	0.5	13.5	No.233+100.00	2@6.00x2.00	0.5	14.0
No. 48+ 0.00	"	0.5	16.0	No.242 0.00	"	1.0	13.5
No. 60+ 0.00	"	0.5	15.0	No.252+ 0.00	6.00x2.00	0.5	13.5
No. 65+100.00	2@6.00x2.00	0.5	15.0	No.256+ 0.00	"	0.5	13.5
No. 71+ 0.00	"	1.0	15.0	No.275+ 0.00	2@6.00x2.00	0.5	14.0
No. 76+ 0.00	"	1.0	13.5	No.283+ 0.00	6.00x2.00	1.0	13.5
No. 86+ 0.00	6.00x2.00	0.5	13.5	No.285+100.00	2@6.00x2.00	1.5	13.5
No. 91+ 0.00	"	1.0	13.5	No.293+ 0.00	6.00x2.00	0.5	14.0
No. 99+ 0.00	2@6.00x2.00	1.5	13.5	No.298+ 0.00	"	0.5	13.5
No.103+ 0.00	6.00x2.00	0.5	13.5	No.303+ 0.00	"	0.5	13.5
No.107+100.00	2@6.00x2.00	1.0	14.5	No.308+ 0.00	"	0.5	15.0
No.111+ 0.00	6.00x2.00	0.5	15.5	No.314+ 0.00	6.00x2.00	0.5	16.5
No.118+ 0.00	2@6.00x2.00	1.0	13.5	No.320+ 0.00	"	0.5	17.5
No.125+100.00	"	1.0	13.5	No.325+ 0.00	"	0.5	19.0
No.128+ 0.00	"	1.0	13.5				
No.132+ 0.00	6.00x2.00	0.5	14.5				
No.147+ 0.00	"	0.5	14.5				
No.135+ 0.00	"	0.5	16.5				
No.159+ 0.00	2@6.00x2.00	0.5	21.0				
No.185+ 0.00	6.00x2.00	0.5	13.5				
No.190+ 0.00	"	0.5	13.5				

Total length

6.00x2.00	420.5 m
2@6.00x2.00	288.5 m

(3) Drain Pipe

Proposed height



Station	Size (m)	D' (m)	L' (m)
No. 27 + 0.00	ø 2.00	1.0	19.0
No. 30 + 0.00	"	1.0	21.0
No. 80 + 0.00	"	0.5	23.0
No. 95 + 0.00	"	1.0	18.5
No. 135 + 0.00	"	0.5	22.5
No. 138 + 0.00	"	0.5	24.0
No. 142 + 0.00	"	0.5	21.5
No. 228 + 0.00	"	0.5	25.0
No. 236 + 0.00	"	1.0	20.0
No. 267 + 100.00	"	0.5	22.0
No. 271 + 0.00	"	1.0	19.5
No. 288 + 0.00	"	1.5	12.5
No. 328 + 0.00	"	0.5	30.0
Total Length			278.5

(4) Quantities of Materials

Superstructure

Item	Remarks	Unit	Padma Br.	Dhaleswari Br.	Arial Khan Br.	Short Span Br.	Total
Concrete	σ_{ck}=350 kg/cm²	m^3	4,952.7	5,990.7	2,335.5	1,118.0	14,396.9
	σ_{ck}=240 kg/cm²	"	3,340.0	-	-	-	3,340.1
Steel Bar	SR 24	t	1,113.7	211.2	211.2	105.1	1,993.0
P.C. Bar	-	"	296.7	130.0	130.0	50.4	800.0
Steel	-	"	8,217.1	-	-	-	8,217.1

Substructure

Item	Remarks	Unit	Padma Br.	Dhaleswari Br.	Arial Khan Br.	Short Span Br.	Total
Concrete	σ_{ck}=240 kg/cm²	m^3	19,095.7	12,196.6	6,729.4	3,357.9	41,379.6
	σ_{ck}=180 kg/cm²	"	26,605.0	7,400.6	5,139.8	-	38,745.4
Steel Bar	-	t	3,815.0	1,689.7	1,016.8	302.1	7,125.8
General Excavation	-	m^3	2,841.8	2,315.7	797.7	262.6	6,217.8
Excavation (well foundation)	-	"	72,595.0	21,622.0	13,734.3	-	107,951.3
Pile	-		672	410	168	545	1,795.0

(5) Number of structures by Section of Construction

Section	Station	Length	Culvert		Drain Pipe	Short Span Br.
			A Type (No)	B Type (No)		
Section 1 Burhiganga R. - Dhaleswari R.	No.0 No.50+150.00	10,150	5	4	2	1
Dhaleswari Br.	No.50+150.00 No.56+150.00	1,200	-	-	-	-
Section 2 Dhaleswari R. - Padma R.	No.56+150.00 No.162+0.00	21,050	8	9	5	2
Padma Br.	No.162+0.00 No.177+0.00	3,000	-	-	-	-
Section 3 Padma R. - Arial Khan R.	No.177+0.00 No.261+100.00	16,900	8	5	2	1
Arial Khan R.	No.261+100.00 No.264+0.00	500	-	-	-	-
Section 4 Arial Khan R. - Faridpur Rd.	No.264+0.00 No.329+150.00	13,150.3	8	2	4	1

Note: A Type ... single box

B Type ... double box

(6) Construction Cost for Road

	Item	Unit	Unit Cost($)	Quantities	Local Currency	Foreign Currency	Total Cost
Section 1	Excavation and Embankment Work	m^3	0.86	276,873	190,489	47,622	238,111
	Pavement Work — Road way	m^2	7.46	67,711	409,516	102,379	511,895
	Pavement Work — Shoulder	m^2	4.81	49,318	189,776	47,444	237,220
	Right of way and land reserved for construction work	m^2	0.15	585,095	87,764	—	87,764
	Mechanical compaction	m^3	0.35	276,873	48,453	48,453	96,906
	Readjustment of right of way	m^2	0.12	292,500	28,080	7,020	35,100
	Indemnification for crops and houses	m^2	0.30	19,800	5,940	—	5,940
	Culvert — Concrete	m^3	123.0	1,253.74	123,368	30,842	154,210
	Culvert — Steel Bar	t	270.0	144.19	35,038	3,893	38,931
	Corrugated pipe ¢2.0 m	m	30.0	41.78	1,128	125	1,253
	Temporary facilities	Set			41,067	5,133	46,200
	Contingency (5%)	Set			60,564	12,113	72,677
	Sub Total				1,221,183	305,024	1,526,207
	Short Span Bridge			1	130,307	32,488	162,795
	Total				1,351,490	337,512	1,689,002
Section 2	Excavation and Embankment Work	m^3	0.86	577,237	397,139	99,285	496,424
	Pavement Work — Road way	m^2	7.56	141,169	853,790	213,448	1,067,238
	Pavement Work — Shoulder	m^2	4.81	102,822	395,659	98,915	494,574
	Right of way and land reserved for construction work	m^2	0.15	1,219,834	182,975	—	182,975
	Mechanical compaction	m^3	0.35	577,237	101,016	101,017	202,033
	Readjustment of right of way	m^2	0.12	609,400	58,507	14,626	73,128
	Indemnification for crops and houses	m^2	0.30	41,280	12,384	—	12,384
	Culvert — Concrete	m^3	123.0	2,572.01	253,086	63,271	316,357
	Culvert — Steel Bar	t	270.0	295.75	71,868	7,985	79,853
	Corrugated pipe ¢2.0 m	m	30.0	105.82	318	2,857	3,175
	Temporary facilities	Set			85,618	10,702	96,320
	Contingency (5%)	Set			126,019	25,004	151,223
	Sub Total				2,533,374	637,310	3,175,684
	Short Span Bridge				260,614	64,976	325,590
	Total				2,798,988	702,286	3,501,274
Section 3	Excavation and Embankment Work	m^3	0.86	463,132	318,635	79,659	398,294
	Pavement Work — Road way	m^2	7.56	113,264	685,021	171,255	856,276
	Pavement Work — Shoulder	m^2	4.81	82,496	317,444	79,361	396,805
	Right of way and land reserved for construction work	m^2	0.15	978,704	146,806	—	146,806
	Mechanical compaction	m^3	0.35	463,132	81,048	81,048	162,096
	Readjustment of right of way	m^2	0.12	488,750	46,920	11,730	58,650
	Indemnification for crops and houses	m^2	0.30	33,120	9,936	—	9,936
	Culvert — Concrete	m^3	123.0	1,816.13	178,707	44,677	223,384
	Culvert — Steel Bar	t	270.0	208.83	50,746	5,638	56,384
	Corrugated pipe ¢2.0 m	m	30.0	44.56	134	1,203	1,337
	Temporary facilities	Set			68,693	8,587	77,280
	Contingency (5%)	Set			99,468	19,894	119,362
	Sub Total				2,003,558	503,052	2,506,610
	Short Span Bridge			1	130,307	32,488	162,795
	Total				2,133,865	535,540	2,669,405
Section 4	Excavation and Embankment Work	m^3	0.86	360,773	248,212	62,053	310,265
	Pavement Work — Road way	m^2	7.56	88,231	533,620	133,406	667,026
	Pavement Work — Shoulder	m^2	4.81	64,264	247,288	61,822	309,110
	Right of way and land reserved for construction work	m^2	0.15	762,396	114,359	—	7,740
	Mechanical compaction	m^3	0.35	360,773	63,135	63,136	126,271
	Readjustment of right of way	m^2	0.12	381,005	36,576	9,145	45,721
	Indemification for crops and houses	m^2	0.30	25,800	7,740	—	7,740
	Culvert — Concrete	m^3	123.0	1,249.22	122,923	30,731	153,654
	Culvert — Steel Bar	t	270.0	143.64	34,905	3,878	38,783
	Corrugated pipe ¢2.0 m	m	30.0	86.34	259	2,331	2,590
	Temporary facilities	Set			53,511	6,689	60,200
	Contingency (5%)	Set			76,488	15,298	91,786
	Sub Total				1,539,016	388,489	1,927,505
	Short Span Bridge			1	130,307	32,488	162,795
	Total				1,669,323	420,977	2,090,300
Grand Total (without Short Span Br.)					7,302,131	8,863,470	9,136,006
Grand Total (with Short Span Br.)					7,953,666	1,996,315	9,949,981

(7) Construction Cost for Bridge

Item	Unit	Unit Cost($)	Quantities	Local Currency	Foreign Currency	Total Cost
1. Padma Bridge						
Excavation (welt foundation)	m^3	28.4	72,595.0	1,649,358	412,340	2,061,698
General Excavation	m^3	0.3	2,841.8	853	—	853
Concrete: P.C. for Superstructure	m^3	134.0	5,312.7	569,522	142,380	711,902
Concrete: R.C. for Suparstructure	m^3	123.0	3,340.1	328,666	82,166	410,832
Concrete: R.C. for Substructure	m^3	123.0	19,095.7	1,879,017	469,754	2,348,771
Concrete: R.C. for Substructure (use of brick aggregate)	m^3	103.0	26,605.0	2,192,252	548,063	2,740,315
Concrete: Other Concrete	m^3	58.5	6,383.0	298,725	74,681	373,406
Steel Bar	t	270.0	4,928.7	1,197,674	133,075	1,330,749
P.C. Bar	t	342.0	296.7	10,147	91,324	101,471
Steel	t	297.0	8,217.1	244,048	2,196,431	2,440,479
R.C. Pile		135.0	672	81,648	9,072	90,720
Temporary facilities				43,333	21,667	65,000
Contingency				950,715	190,143	1,140,858
Total				9,445,958	4,371,096	13,817,054
2. Dhaleswar. Bridge						
Excavation (welt foundation)	m^3	28.4	21,622.0	491,252	122,813	614,065
General Excavation	m^3	0.3	2,315.7	695	—	695
Concrete: P.C. for Superstructure	m^3	134.0	6,130.7	657,211	164,303	821,514
Concrete: R.C. for Suparstructure	m^3	123.0	—	—	—	—
Concrete: R.C. for Substructure	m^3	123.0	12,196.6	1,200,146	300,036	1,500,182
Concrete: R.C. for Substructure (use of brick aggregate)	m^3	103.0	7,400.6	609,810	152,452	762,262
Concrete: Other Concrete	m^3	58.5	100.0	4,680	1,170	5,850
Steel Bar	t	270.0	2,252.7	547,406	60,823	608,229
P.C. Bar	t	342.0	323.2	11,053	99,481	110,534
Steel	t	297.0	10.0	297	2,673	2,970
R.C. Pile		135.0	410.0	49,815	5,535	55,350
Temporary facilities				13,333	6,667	20,000
Contingency				75,027	15,006	90,033
Total				3,660,725	930,959	4,591,684
3. Arial Khan Bridge						
Excavation (welt foundation)	m^3	28.4	13,734.3	312,043	78,011	390,054
General Excavation	m^3	0.3	797.7	239	—	239
Concrete: P.C. for Superstructure	m^3	134.0	2,395.5	256,798	64,199	320,997
Concrete: R.C. for Suparstructure	m^3	123.0	—	—	—	—
Concrete: R.C. for Substructure	m^3	123.0	6,729.4	662,173	165,543	826,716
Concrete: R.C. for Substructure (use of brick aggregate)	m^3	103.0	5,139.8	423,519	105,880	529,399
Concrete: Other Concrete	m^3	58.5	50.0	2,340	585	2,925
Steel Bar	t	270.0	1,228.0	298,404	33,156	331,560
P.C. Bar	t	342.0	130.0	4,446	40,014	44,460
Steel	t	297.0	8.0	238	2,138	2,376
R.C. Pile		135.0	168	20,412	2,268	22,680
Temporary facilities				6,667	3,333	10,000
Contingency				41,373	8,275	49,648
Total				2,028,652	503,402	2,532,054
Grand Total		Length 3,000 + 1,200 + 500 = 4,700 m			Cost	20,940,792
4. Short Span Bridge						
Excavation (welt foundation)	m^3	28.4	—	—	—	—
General Excavation	m^3	0.3	52.2	16	—	16
Concrete: P.C. for Superstructure	m^3	134.0	229.6	24,163	6,153	30,766
Concrete: R.C. for Suparstructure	m^3	123.0	—	—	—	—
Concrete: R.C. for Substructure	m^3	123.0	671.6	66,086	16,521	82,607
Concrete: R.C. for Substructure (use of brick aggregate)	m^3	103.0	—	—	—	—
Concrete: Other Concret	m^3	58.5	3.0	141	35	176
Steel Bar	t	270.0	81.4	19,780	2,198	21,978
P.C. Bar	t	342.0	10.1	345	3,109	3,454
Steel	t	297.0	3.0	89	802	891
R.C. Pile		135.0	10.9	13,244	1,471	14,715
Temporary facilities				3,333	1,667	5,000
Contingency				2,660	532	3,192
Total				130,307	32,488	162,795

(8) Summarized Table of Construction Cost

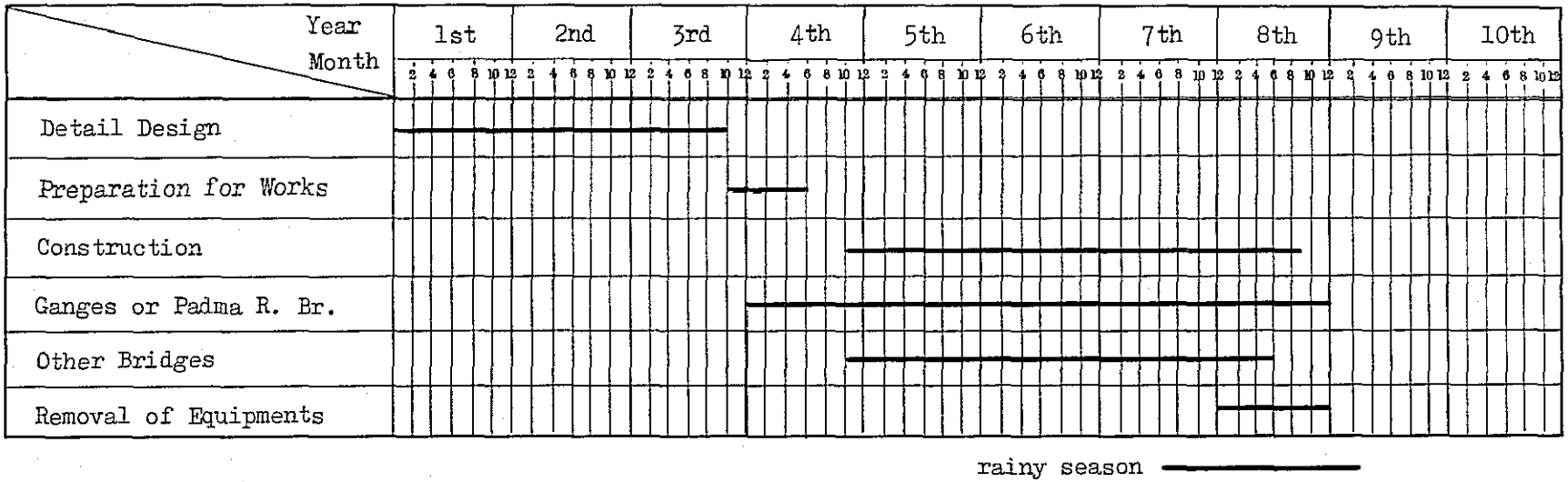
Item	Local Currency	Unit: US$ Foreign Currency	Total Cost
Section 1 (Burhiganga R. - Dhaleswari R.)	1,351.490	337.512	1,689.002
Dhaleswari Bridge	3,660.725	930.959	4,591.684
Section 2 (Dhaleswari R. - Padma R.)	2,798.988	702.286	3,501.274
Padma Bridge	9,445.958	4,371.096	13,817.054
Section 3 (Padma R. - Arial Khan R.)	2,133.865	535.540	2,669.405
Arial Khan Bridge	2,028.652	503.402	2,532.054
Section 4 (Arial Khan R. - Faridpur Rd.)	1,669.323	420.977	2,090.300
Temporary Facilities	120.000	30.000	150.000
Contingency (2%)	464.180	-	464.180
Supervision Fee for Consultant Firm (5%)	931.223	620.816	1,552.039
Net Construction Cost	24,604.404	8,452.588	33,056.992
Design Fee for Consultant Firm (3%)	396.684	595.026	99.710
Taxes (7% for Local Currency)	1,722.308	-	1,722.308
Grand Construction Cost	26,723.396	9,047.614	35,771.010

(9) Yearly Construction Cost

Unit: US$

Design Period			Construction Period					Total (Taxes are included)
1972	1973	1974	1975	1976	1977	1978	1979	
300.000	300.000	391.710	1,652.850	3,305.699	6,611.398	11,569.947	9,917.098	35,771.010

(10) *Construction Schedule*



6. Economic characteristics of the route

6-1. Traffic condition of the existing route

The present traffic volume of the existing Dacca-Aricha road is approximately 800 vehicles/day on the Dacca-Sabhal section, 500 vehicles/day on Sabhal-Manikganj and 360 veniches/day on the Manikganj-Aricha section (according to a survey in 1968 conducted by Roads and Highways Directorate), and is not so heavy. This statistic involves short-distance traffic in a zone, and the volumes of long-distance traffic between the cities occupies only a small part of the statistic.

Also according to an O.D. (Origin and Destination) survey in 1968 by the said Roads and Highways Directorate, the volume of the traffic between Dacca and Faridpur on the area beyond Faridpur on this route is only 74 vehicles/day (passenger car equivalent) as follows. (Fig. 9)

Dacca-Faridpur	22 vehicles/day
Dacca-Barisal	2 "
Dacca-Jessore	16 "
Dacca-Kushtia	14 "
Dacca-Khulna	20 "
Total	74 vehicles/day

This statistic shows that the Padma river is a big obstacle to overland transportation between both side regions of the river. Factually, a bus service with seating capacity of 9 passengers is available only once a day between Dacca and Khulna, and there is no bus service between Barisal and Dacca in spite of some cities along the route.

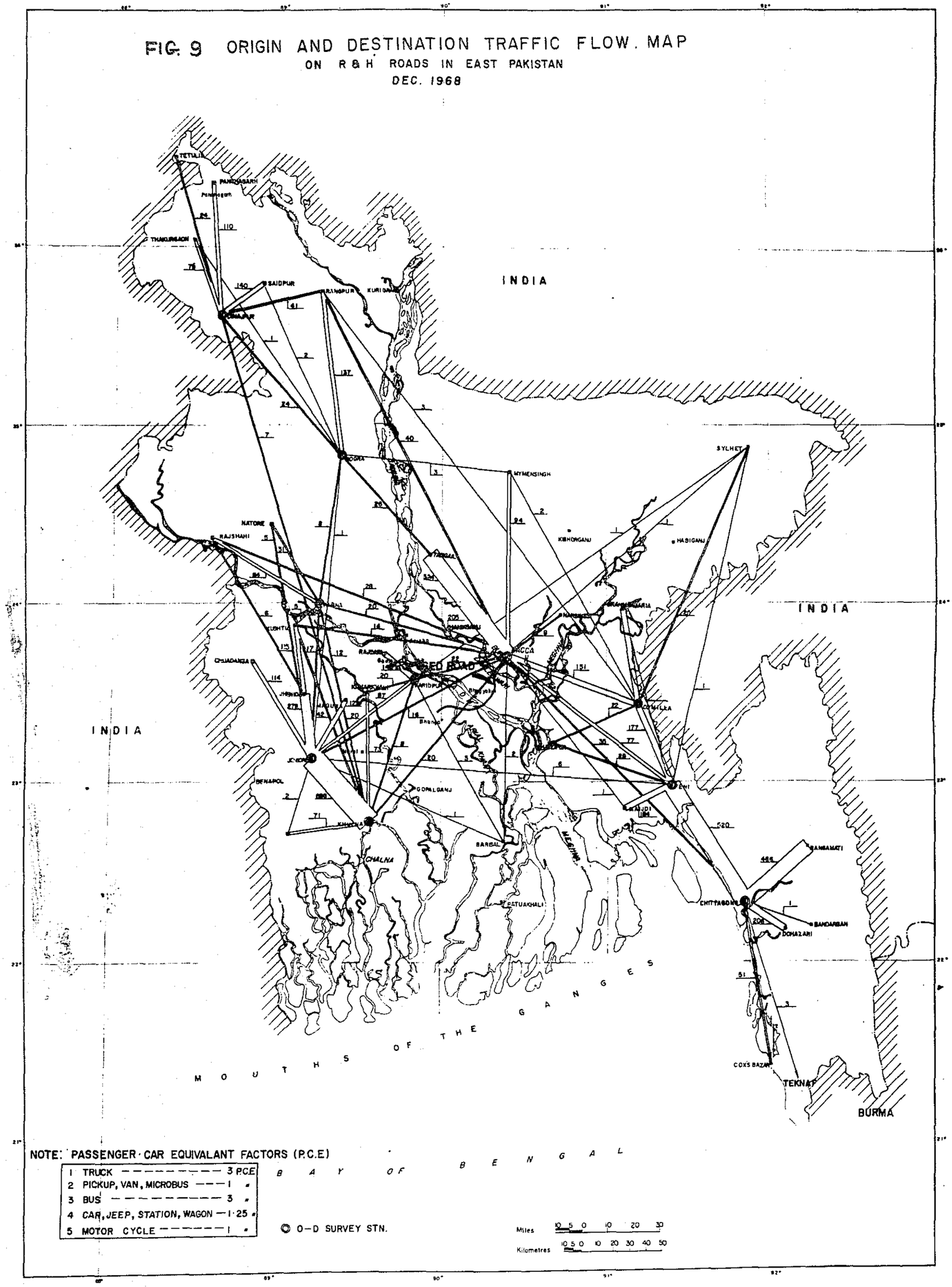
Figure-9 clearly shows that road traffic system in the whole East Pakistan is divided into three regions by the Bramaputra river, the Ganges river and the Padma river which is the confluent stream of the said two rivers.

The proposed route would cause many and new traffic streams by getting rid of this obstacle and shortening a trip time from Dacca to Faridpur into 1/2 or 1/3 of the present trip time when completed. Consequently a traffic pattern

FIG. 9 ORIGIN AND DESTINATION TRAFFIC FLOW. MAP

ON R & H ROADS IN EAST PAKISTAN

DEC. 1968



NOTE: PASSENGER CAR EQUIVALANT FACTORS (P.C.E)

1	TRUCK	3 PCE
2	PICKUP, VAN, MICROBUS	1 "
3	BUS	3 "
4	CAR, JEEP, STATION, WAGON	1·25 "
5	MOTOR CYCLE	1 "

◎ O–D SURVEY STN.

Miles 10 5 0 10 20 30

Kilometres 10 5 0 10 20 30 40 50

which is similar to that of the east part in East Pakistan not influenced by the big rivers would be found also between those regions divided by the Padma river.

As for the water transportation, the cargo of 1,000 ton/day (in 1966) and 400 or 500 passengers (in 1968) were carried between Dacca and Khulna and between Dacca and Barisal, and so potentiality of transportation is not low in those regions. Although water transportation is a suitable means for mass and long-distance transportation, it is slow in speed and even by a passenger steamer it takes more than 20 hours from Dacca to Khulna. Therefore it is easily imagined that as for the cargos and passengers which need high speed to be transported in accordance with modernization of industrial structure, the means of transportation would change from water transportation to overland transportation gradually in the future.

Although the number of motorvehicles in East Pakistan is still not so many, the increase of passenger cars during the recent years is remarkable. The annual rate of its increase reached to 15% in last 10 years. During the survey a group of youths who were traveling with cars were seen on the ferry boat between Aricha and Goalundo. This fact seemed to indicate coming motorization in this country.

6-2. Traffic volume of the new road

(1) Method of computation

Fig. 10 shows the newly proposed route (Dacca-Faridpur). It is assumed that the other two proposed roads (Tungi-Aricha and Jessore-Madhukali) shall be opened by the time of the completion of the proposed road. Distance and time required for a trip between origin and destination are shown in Appendix 4.

All of the O.D. traffic whose trip time is shortened by the new route will be diverted to this route and moreover, it is expected that this new route generate the new traffic. These traffic volumes were calculated according to a gravity model method, and the result of O.D. survey in 1968 was used as the materials to decide parameters of the gravity model. The gravity model itself and the detail of calculation are explained in Appendix-3.

In computation in this chapter, the two cases for crossing the Padma river were assumed: case 1, ferry and case 2, bridge.

(2) Type of vehicles

The statistic of O.D. survey is shown as the passenger car equivalent, so in order to get the true number of vehicles by type, the multiplier rate was fixed according to the component ratio by type of the registered number of vehichels in 1968 and passenger car equivalence. It is assumed that no motorcycle is included in this statistic, considering that trip length of this O.D. traffic is considerably long (more than about 100 km).

(type of vehicle)	(component ratio)		(equivalence)	(multiplier rate)
passenger car	5	×	1 = 5	5 ÷ 14 = 0.357
bus	1	×	3 = 3	1 ÷ 14 = 0.073
truck	2	×	3 = 6	2 ÷ 14 = 0.145
Total			14	

(3) Growth rate

Annual growth rate of traffic volume was calculated according to the records of the number of vehicles from 1960 to 1969. Thus the annual growth rate by type was assumed as follows.

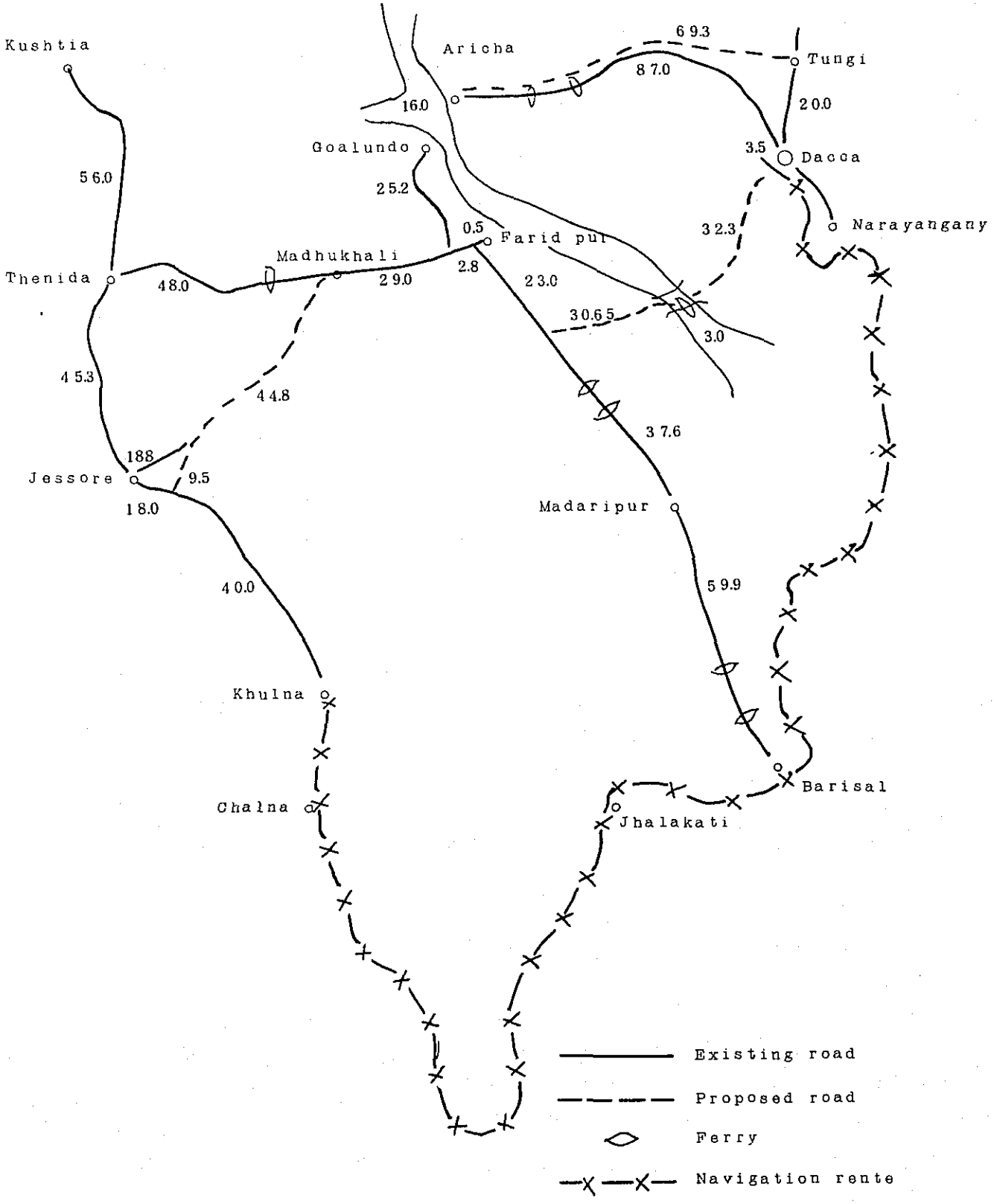
	passenger car	bus	truck
1968 - 1970	15%	9%	9%
1971 - 1980	13%	7%	7%
1981 - 1990	10%	5%	5%
1990 - 2000	8%	4%	4%
2001 - 2010	6%	3%	3%

(4) Diverted traffic volume from water transportation

When the new road completed, some part of traffic volume seems to divert from water transportation, as Figure 10 shows.

Fig 10 Route Map

unit : Km



According to the materials from Traffic Department in E.P. IWTA (East Pakistan Inland Water Transport Authority), number of passengers a part of which will divert to the proposed road, and its O.D. are as follows.

Dacca - Khulna	100,700 persons/year (1968 - 1969)
Dacca - Barisal	65,900 "

Converting into persons per day.

100,700 ÷ 365 = 274 persons/day
65,900 ÷ 365 = 182 "

The bus service is available only once a day between Dacca and Khulna which has nine seats and takes nine hours of trip time for which the fare is 25 Rs. There is no bus service between Dacca and Barisal. This status came from inferiority of road condition, and with improvement of the roads, growth of income, increase of time value, modernization of bus service and so forth, the passengers will divert from water transport to the new road transportation. Supposing that diverting rate and annual growth rate of water transportation keep 10% and 15% respectively till 1980 (ref. "Annual Traffic Report 1966 - 1967", E.P. IWTA, p. 39), diverted traffic volume in 1980 is estimated as follows.

Dacca - Khulna	274 person x 10% = 27.4	27.4 x 5.4 = 148	persons/day
Dacca - Barisal	181 " x 10% = 18.1	18.1 x 5.4 = 98	"

Supposing that all of diverted passengers from water transportation use bus service and that seating capacity of a bus has 40 seats, the number of buses needed in 1980 is;

Dacca - Khulna	4 vehicles/day
Dacca - Barisal	3 "

This value is for case 2 (bridge), and as for case 1 (ferry), number of buses are their 80% basing on triptime ratio between these two cases, i.e.,

Dacca - Khulna	3 vehicles/day
Dacca - Barisal	2 "

According to the said Annual Traffic Report, volume of the freight transportation a part of which will divert to the proposed road and its O.D. are as follows.

Dacca - Khulna	1,023 tons/year (1966 - 1967)
Dacca - Chalna	7,477 "
Narayanganj - Khulna	4,259 "
Narayanganj - Chalna	296,889 "
Khulna - Dacca	9,565 "
Khulna - Narayanganj	7,210 "
Chalna - Dacca	30,030 "
Chalna - Narayanganj	22,174 "
Total	378,627 "
Dacca - Barisal	369 "
Barisal - Dacca	1,691 "
Narayanganj - Barisal	2,509 "
Barisal - Narayanganj	243 "
Total	4,812 "
Grand Total	383,439 "

Supposing that annual growth rate of freight transportation by water is 7.1% based on the records (Ref. the said Report, p. 37) from 1961 to 1966, volume of the freight in 1980 is estimated as follows.

	volume of freights having possibility of divertion (tons/year)
Dacca - Khulna	378,627 x 2.6 = 984,430
Dacca - Barisal	4,812 x 2.6 = 12,511

Supposing that 5% of this volume (Ref. the said Report, p. 42) will divert to the proposed road and the average loading capacity of trucks is 3 tons (Ref. "A Manual for the Economic Appraisal of Transport Projects 1969," Government of Pakistan Planning Commission, p. 47), number of trucks needed to accomodate

the diverted freight in 1980 is estimated as follows.

Dacca - Khulna	984,430 x 5% ÷ 365 ÷ 3 = 45 vehicles/day
Dacca - Barisal	12,511 x 5% ÷ 365 ÷ 3 = 1 "

This value is for case 2 (bridge) and as for case 1 (ferry), number of trucks is its 80% basing on trip time ratio between these two cases.

Dacca - Khulna	36 vehicles/day
Dacca - Barisal	1 "

(5) Growth rate of diverted traffic volume from water transportation

Growth rate of diverted traffic volume from water transportation is estimated as follows.

	passenger	freight
1980 - 1990	10%	5%
1991 - 2000	8%	4%
2001 - 2010	6%	3%

Traffic volume computed with the said conditions is shown in Table-11, Table-12, Table-13 and Table-14. Traffic volume on the proposed road (including diverted traffic volume from water transportation) in case 2 is 1,057 vehicles/day and comparing with case 1 of 654 vehicles/day, it indicates that spanning the Padma river with a bridge has an advantage in the effects of shortening a trip time and of generating new traffic.

6-3. Benefit of the proposed road

It is well known that a new road brings great indirect effects such as extension of market, development of industry and so forth besides direct benefits which are brought to the road users, such as reduction in vehicle operating cost, time saving, increase of comfort and so forth. It is usually impossible, however, to measure these effects with monetary terms. Only reduction in vehicle operating cost and time saving are taken up as benefit of the new road in this report.

Vehicle operating cost on the new and existing roads per vehicle mile are as follows (Ref. the said "Manual" p. 34).

Table 10. Vehicle Operating Cost

Unit: Paisas

	Passenger Car		Bus or Trucks	
	New road	Existing road	New road	Existing road
Fuel & Oil	6	7	17	20
Tire wear	2	3	8	12
Depreciation	10	12	22	27
Interest	6	8	11	18
Maintenance	2	3	17	25
Wages	-	-	5	7
Total	26	33	80	104

Converting this value into dollar per vehicle kilometer:

	passenger car (US$/vehicle kilometer)	bus or truck (US$/vehicle kilometer)
Operating cost on the existing road	0.0433	0.1365
Cost on the new road	0.0341	0.1050
Benefit of the new road against the existing	0.0092	0.0315

As to the cost and benefit of a ferry across the Padma river on the proposed route the increase of working efficiency of boats coming from shortening a length of navigation in case 1 and the saving of ferry boat or cost in case 2 should be considered as the benefit of the proposed road.

Supposing that the fare of a ferry is fixed appropriately, this benefit may be computed by adding this fare to transportation cost of each route in each case.

The fare of a ferry across the Padma river on the existing route is fixed on the basis of the present fare as follows.

passenger car	3.36 US dollar
bus	8.40 "
truck	10.61 "

The fare of a ferry on the new road must be one third of the present fare if only based on the said working efficiency.

As there are necessities, however, of building an access road from the proposed bridge site which is to be constructed in the future to the gangways and of dredging, the fare is fixed at the half of the said fare instead of the one third as follows:

passenger car	1.68 US dollar
bus	4.20 "
truck	5.31 "

* Supposing that the operating hours of ferries is ten hours, the loading and unloading time 30 minutes, and the navigation time is two hours, one boat can serve twice a day for return trip. On a new route, one boat can serve six times return trip a day, because this working efficiency with only 20 minutes of navigation is three times as that of the ferry on the existing route.

The benefit from shortening trip time on a new road is composed of decreasing a number of vehicles, saving the wages of the truck drivers and shortening time of passengers and freights transportation. These values per vehicle hour are as follows. (Ref. "Manual" p. 46)

Converting these values into dollar per vehicle minute:

	US$/vehicle minute
passenger car	0.01323
bus	0.04347
truck	0.02982

The running speed with which a trip time is computed is the same one, that the Jessore-Madhukhali Road Survey Mission has adopted, which are as follows:

(unit: mile/hour)

	passenger car	bus	truck
existing road	35	20	30
new road	40	25	35

Converting these values into kilometer per hour:

	psssenger car	bus	truck
existing road	56	32	48
new road	64	40	56

On computing a trip time using the existing road, the two proposed road shown in Fig. 10 (Tungi-Aricha, Jessore-Madhukhali) is supposed to be completed before this new proposed road. The running speed on these two roads are assumed as on a new road shown in the above table.

The time of a ferry across the Padma river is 150 minutes (including 30 minutes for waiting) between Aricha and Goalundo and 52.5 minutes (120 x $\frac{3 \text{ km}}{16 \text{ km}}$ = 22.5 minutes 22.5 + 30 = 52.5 minutes) between two points on this proposed route.

As for the other ferries, 15 minutes is added to these values. The value of benefits per vehicle computed under conditions described above is shown on Table-15 and Table-16 with by type of vehicle and O.D. Details of computation

of benefits is shown in Appendix 4.

There are various methods to evaluate the benefits which need many data such as regarding insurance, damage of commodities and value of trip time. But many data are not available. Therefore, only the time saving of traffic diverted from existing road is considered here for computation for convenience sake.

6-4. Economic evaluation

The construction cost of the proposed road is 36 million US$ as shown in Table 9-(8). Excluding tax and adopting a shadow rate, the part of foreign currency of the cost is multiplied by 1.75, then the cost of construction becomes 41 million US dollar (See Table 17, 18).

The annual maintenance expense is supposed to be 1 percent of the construction cost referring to the records in Japan Highway Public Corporation. As for the maintenance of the Padma river bridge, its expense is assumed as 0.4 percent of its construction cost also referring to the said results.

The comparison of costs and benefits was made with the present worth at the beginning of 1980, and interest and discount rate were fixed to be 12 percent referring to examples in East Pakistan. It is assumed that the expense is paid in the middle of year and benefit occurs in the end of year.

The results of those evaluation are shown on Table-19 and Table-20. The cost benefit ratios are 0.90 in case 1 and 1.24 in case 2. These ratios indicate that adequate benefit comparing with investment can not be expected on crossing the Padma river with a ferry and building a bridge across this river brings about the said adequate benefit.

As the reasons for this conclusion, it is pointed out as the first reason that at first the benefit per vehicle using a bridge is much more than that for a ferry. For example, though the reduction of distance between Dacca and Faridpur for both case 1 and case 2 is about 30 km, the reduction in the vehicle operating cost for a passenger car is 2.85 US$/vehicle for case 1 and is 4.43 US$/vehicle for case 2 considering the expense of building and operating ferry.

The saved time is about 2 hours for case 1 and about 3 hours for case 2, and the value of time saving is counted as 1.68 US$/vehicle and 2.33 US$/vehicle respectively.

The second reason is that there is a big difference in effect of generating traffic between bridge and ferry. According to Table-11 the rate of generation is 1.3 for case 1, (Traffic volume of 1.3 times of that diverted from existing road is assumed to be generated.) and 2.8 for case 2.

These effects are multiplied each other and result in a big difference between two cases, and is case 2 the benefit exceeding sufficiently the construction cost of lnew road including bridges can be derived.

Even if 20% of benefit is deducted, still there remains 12% of internal rate of return, because this calculation was made on safe side and it shows this project economically justified.

And the value of discount rate of 12% used in calculation of the cost benefit comparison is fairly high considering the rate of interest of World Bank loan, which makes the conclusion more confirmed.

Though only the reduction in the vehicle operating cost and the time saving are considered in calculation of benefit, the new road brings, in addition to the said two, enhancement of comfortability, reduction in number of accidents and damages of good.

Though the traffic dealt with in this report is limited to region to region long trip traffic, the inside-region traffic by the inhabitants along the new road who ride on motor cycles or wolk on foot must not be so low and also the benefit for these people can not be ignored.

Especially, the effect on development of agriculture, industry and so on in the area along the proposed road may be uncountably large, for the new road will be constructed in the area that has no roads at all at present.

These benefits that can not be calculated in monetary terms should be fully considered in the economic evaluation of the proposed road project.

Table 11 Traffic volume diverted from existing road and generated (1)

(1968)

Zone-Pair \ Case	Kinds of vehicle	Existing road *	Case 1 (ferry)	Case 2 (bridge)
Dacca - Faridpur	PCE	(23)	(63)	(133)
	P	8	22	48
	B	2	4	9
	T	3	9	19
	Total	13	35	76
Dacca - Jessore	PCE	(14)	(31)	(44)
	P	5	11	16
	B	1	2	3
	T	2	4	6
	Total	8	17	25
Dacca - Khulna	PCE	(23)	(53)	(77)
	P	8	19	27
	B	2	4	6
	T	3	8	11
	Total	13	31	44
Dacca - Jherida	PCE	(13)	(24)	(39)
	P	5	9	13
	B	1	2	3
	T	2	3	6
	Total	8	14	22
Dacca - Barisal	PCE	(15)	(32)	(44)
	P	5	11	16
	B	1	2	3
	T	2	5	6
	Total	8	18	25

Zone-Pair \ Case	Kinds of vehicle	Existing road *	Case 1 (ferry)	Case 2 (bridge)
Dacca Madaripur	PCE	(25)	(65)	(112)
	P	9	23	40
	B	2	5	8
	T	4	9	16
	Total	15	37	64
Dacca - Kushtia	PCE	(13)	(22)	(28)
	P	5	8	10
	B	1	2	2
	T	2	3	4
	Total	8	13	16
Total	PCE	(126)	(190)	(477)
	P	45	103	170
	B	10	21	34
	T	18	41	68
	Grand Total	73	165	272

Unit: vehicle/day

PCE: passenger car equivalent

P: passenger car

B: bus

T: truck

* estimated using parameter for Case 1

note: At first PCE was estimated and them it was broken down into P, B and T.

Table 12 Traffic volume diverted from existing road and generated (2)

(1980)

Zone-Pair \ Case	Kinds of vehicle	Existing road	Case 1 (ferry)	Case 2 (bridge)
Dacca - Faridpur	PCE	(73)	(197)	(415)
	P	37	101	214
	B	4	11	22
	T	8	21	45
	Total	49	133	281
Dacca - Jessore	PCE	(43)	(98)	(142)
	P	22	50	73
	B	2	5	8
	T	5	11	15
	Total	29	66	96
Dacca - Khulna	PCE	(73)	(166)	(238)
	P	37	85	121
	B	4	9	13
	T	8	18	26
	Total	49	112	160
Dacca - Jenida	PCE	(39)	(75)	(116)
	P	21	39	59
	B	2	4	6
	T	4	8	13
	Total	27	51	78
Dacca - Barisal	PCE	(45)	(99)	(136)
	P	24	51	70
	B	2	5	7
	T	5	11	15
	Total	31	67	92
Dacca - Madaripur	PCE	(76)	(203)	(349)
	P	40	104	178
	B	4	11	19
	T	8	22	38
	Total	52	137	235
Dacca - Kushtia	PCE	(39)	(68)	(92)
	P	21	135	47
	B	2	4	5
	T	4	7	10
	Total	27	46	62
Total	PCE	(388)	(906)	(1,488)
	P	202	465	762
	B	20	49	80
	T	42	98	162
	Grand Total	264	612	1,004

Unit: *vehicle/day*

PCE: passenger car equivalent

P: passenger car

B: bus

T: truck

note: At first B. P and T were eatimated and then they were totaled to PCE.

Tabel 13 Traffic volume diverted from waterways

(1980)

Zone-Pair \ Case	Kinds of vehicle	Case 1 (ferry)	Case 2 (bridge)
Dacca - Khulna	PCE	(117)	(147)
	bus	3	4
	truck	36	45
	Total	39	49
Dacca - Barisal	PCE	(9)	(12)
	bus	2	3
	truck	1	1
	Total	3	4
Total	PCE	(126)	(159)
	bus	5	7
	truck	37	46
	Grand Total	42	53

unit: vehicle/day

Table 15 Benefit calculation (case 1: ferry)

unit: $/vehicle

O. D.	Kinds of vehicle	Reduction in operating cost	Time saving	Total
Dacca - Faridpur	P	2.85	1.68	4.53
	B	7.91	6.49	14.35
	T	9.01	3.92	12.93
Dacca - Kushtia	P	2.61	1.60	4.21
	B	7.15	6.00	13.15
	T	8.25	3.72	11.97
Dacca - Jhenida	P	2.61	1.60	4.21
	B	7.15	6.00	13.15
	T	8.25	3.72	11.97
Dacca - Jessore	P	2.61	1.60	4.21
	B	7.15	6.00	13.15
	T	8.25	3.72	11.97
Dacca - Khulna	P	2.61	1.60	4.21
	B	7.15	6.00	13.15
	T	8.25	3.72	11.97
Dacca - Madaripur	P	4.84	2.33	7.17
	B	14.19	10.17	24.36
	T	15.29	5.63	20.92
Dacca - Barisal	P	4.84	2.33	7.17
	B	14.19	10.17	24.36
	T	15.29	5.63	20.92

P: passenger car
B: bus
T: truck

Table 14 *Traffic volume of proposed road*

unit: vehicle/day

Year	Case 1 (ferry)			Case 2 (bridge)		
	Traffic volume diverted from existing road and generated	Traffic volume diverted from waterways	Total	Traffic volume diverted from existing road and generated	Traffic volume diverted from waterways	Total
1980	612	42	654	1,004	53	1,057
81	695	45	740	1,141	57	1,198
82	778	49	827	1,277	61	1,338
83	862	51	913	1,414	65	1,479
84	945	54	999	1,551	69	1,620
85	1,029	58	1,087	1,688	74	1,762
86	1,111	61	1,172	1,824	77	1,901
87	1,194	64	1,258	1,961	81	2,042
88	1,278	66	1,343	2,098	85	2,183
89	1,361	70	1,431	2,243	89	2,332
1990	1,444	73	1,517	2,371	93	2,464
91	1,596	78	1,674	2,619	99	2,718
92	1,747	82	1,829	2,867	104	2,971
93	1,899	87	1,986	3,115	110	3,225
94	2,050	91	2,141	3,363	115	3,478
95	2,202	96	2,298	3,611	122	3,733
96	2,352	99	2,451	3,859	128	3,987
97	2,503	104	2,607	4,107	133	4,240
98	2,655	108	2,763	4,355	139	4,490
99	2,806	113	2,919	4,603	144	4,747
2000	2,958	117	3,075	4,851	150	5,001
01	3,176	122	3,298	5,208	157	5,365
02	3,394	127	3,521	5,566	164	5,
03	3,613	133	3,746	5,923	170	6,093
04	3,831	138	3,969	6,281	177	6,458
05	4,051	144	4,195	6,638	185	6,823
06	4,268	149	4,417	6,995	192	7,187
07	4,486	154	4,640	7,353	199	7,552
08	4,704	160	4,864	7,710	205	7,915
09	4,932	165	5,097	8,068	212	8,280

Table 16 Benefit calculation (case 2: bridge)

unit: $/vehicle

O. D.	Kinds of vehicle	Reduction in operating cost	Time saving	Total
Dacca - Faridpur	P	4.43	2.33	6.76
	B	11.80	8.53	20.33
	T	14.01	5.39	19.40
Dacca - Kushtia	P	4.19	2.26	6.45
	B	11.04	8.09	19.13
	T	13.25	5.19	18.44
Dacca - Jhenida	P	4.19	2.26	6.45
	B	11.04	8.09	19.13
	T	13.25	5.19	18.44
Dacca - Jessore	P	4.19	2.26	6.45
	B	11.04	8.09	19.13
	T	13.25	5.19	18.44
Dacca - Khulna	P	4.19	2.26	6.45
	B	11.04	8.09	19.13
	T	13.25	5.19	18.44
Dacca - Madaripur	P	6.42	2.98	9.40
	B	18.08	12.26	30.34
	T	20.29	7.10	27.39
Dacca - Barisal	P	6.42	2.98	9.40
	B	18.08	12.26	30.34
	T	20.29	7.10	27.39

P: passenger car
B: bus
T: truck

Table 17 Breakdown of Construction Cost

Unit: US$

Item	Pakistan Currency	Foreign Currency	Total	Foreign Currency multiplied by Shadow Rate 1.75		
				Pakistan Currency	Foreign Currency	Total
1st section (BURHIGANGA R. - DHALESWARI R.)	1,351,490	337,512	1,689,002	1,351,490	590,646	1,942,136
DHALESWARI RIVER BRIDGE	3,660,725	930,959	4,591,684	3,660,725	1,629,178	5,289,903
2nd section (DHALESWARI R. - GANGES OR PADMA R.)	2,798,988	702,286	3,501,274	2,798,988	1,229,001	4,027,989
GANGES OR PADMA RIVER BRIDGE	9,445,958	4,371,096	73,817,054	9,445,958	7,649,418	17,095,376
3rd section (GANGES OR PADMA R. - ARIALKHAN R.)	2,133,865	535,540	2,669,405	2,133,865	937,195	3,071,060
ARIALKHAN RIVER BRIDGE	2,028,652	503,402	2,532,054	2,028,652	880,954	2,909,606
4th section (ARIALKHAN R. - FARIDPUR ROAD)	1,669,323	420,977	2,090,300	1,669,323	736,710	2,406,033
Preparing	120,000	30,000	150,000	120,000	52,500	172,500
Contingency 2%	464,180	-	464,180	464,180	-	464,180
Supervising	931,223	620,816	1,552,039	931,223	1,086,428	2,017,651
Construction	24,604,404	8,452,588	33,056,992	24,604,404	14,792,030	39,396,434
Design	396,684	595,026	991,710	396,684	1,041,296	1,437,980
Taxes	1,722,309	-	1,722,308	1,722,308	-	1,722,308
Total	26,723,396	9,047,614	35,771,010	26,723,396	15,833,326	42,556,722

Table 18 Annual Expenditure

Unit: 1,000US$

Case \ Expenditure / Year	for Design			for Construction					Total
	1972	1973	1974	1975	1976	1977	1978	1979	
Case 1	470	470	498	1,115	2,230	4,460	7,805	6,691	23,739
Case 2	470	470	498	1,970	3,940	7,879	13,789	11,818	40,834

Note: Taxes excluded

Table 19 Cost Benefit Calculation (case 1: ferry)

Unit: 1,000 US$

Year	Costs			Benefits			Net Worth		Internal Rate of Return (14%)	
	Construction	Maintenance	Total	Traffic diverted from existing road and generated	Diverted from waterways	Total	Cost	Benefit	Cost	Benefit
1972	470		470				1,102		1,029	
1973	470		470				983		927	
1974	498		498				930		885	
1975	1,115		1,115				1,860		1,785	
1976	2,230		2,230				3,320		3,218	
1977	4,460		4,460				5,927		5,798	
1978	7,805		7,805				9,265		9,140	
1979	6,691		6,691				7,092		7,059	
1980		174	174	1,743	65	1,808	164	1,615	165	1,629
1981		174	174	1,939	70	2,009	147	1,601	149	1,631
1982		174	174	2,135	76	2,211	131	1,574	134	1,616
1983		174	174	2,330	81	2,411	117	1,533	121	1,589
1984		174	174	2,526	87	2,613	104	1,481	109	1,550
1985		174	174	2,722	92	2,814	93	1,427	98	1,505
1986		174	174	2,918	97	3,015	83	1,363	88	1,453
1987		174	174	3,114	103	3,217	74	1,300	80	1,396
1988		174	174	3,309	109	3,417	66	1,234	72	1,336
1989		174	174	3,505	114	3,619	59	1,165	65	1,274
1990		174	174	3,701	119	3,820	53	1,096	58	1,211
1991		174	174	4,044	127	4,171	47	1,072	52	1,193
1992		174	174	4,388	135	4,523	42	1,036	47	1,167
1993		174	174	4,731	144	4,875	38	999	43	1,131
1994		174	174	5,074	152	5,226	34	956	38	1,092
1995		174	174	5,418	160	5,578	30	909	34	1,049
1996		174	174	5,761	168	5,929	27	866	31	1,008
1997		174	174	6,104	176	6,280	24	816	28	961
1998		174	174	6,447	185	6,632	21	769	25	915
1999		174	174	6,791	193	6,984	19	726	23	866

Table 19 (continued)

Year	Costs			Benefits			Net Worth		Internal Rate of Return (14%)	
	Construction	Maintenance	Total	Traffic diverted from existing road and generate	Diverted from waterways	Total	Cost	Benefit	Cost	Benefit
2000		174	174	7,134	201	7,335	17	682	21	822
2001		174	174	7,607	211	7,818	15	649	18	790
2002		174	174	8,079	222	8,301	14	614	17	755
2003		174	174	8,552	232	8,784	12	580	15	720
2004		174	174	9,024	243	9,267	11	547	14	686
2005		174	174	9,497	253	9,750	10	517	12	644
2006		174	174	9,970	263	10,233	9	481	12	614
2007		174	174	10,442	274	10,716	8	450	10	579
2008		174	174	10,915	284	11,199	7	414	9	538
2009		174	174	11,387	295	11,682	6	386	8	514
Total							31,961	28,858	31,437	72,234

Net Present Worth = -3,103,000 US$ (1980)

Cost Benefit Ratio = 0.90

Table 20 Cost Benefit calculation (case 2: bridge)

Unit: 1,000 US$

Year	Costs			Benefits			Net Worth		Internal Rate of Return (14%)	
	Construction	Maintenance	Total	Traffic diverted from existing road and generated	Diverted from waterways	Total	Cost	Benefit	Cost	Benefit
1972	470		470				1,102		1,258	
1973	470		470				983		1,104	
1974	498		498				930		1,026	
1975	1,970		1,970				3,286		3,560	
1976	3,940		3,940				5,867		6,249	
1977	7,879		7,879				10,471		10,960	
1978	13,789		13,789				16,368		16,823	
1979	11,818		11,818				12,527		12,645	
1980		242	242	4,039	113	4,152	228	3,796	226	3,641
1981		242	242	4,494	123	4,617	204	3,680	198	3,550
1982		242	242	4,950	132	5,082	182	3,618	174	3,430
1983		242	242	5,405	142	5,547	162	3,528	153	3,284
1984		242	242	5,860	151	6,011	145	3,408	134	3,120
1985		242	242	6,316	161	6,477	129	3,284	117	2,954
1986		242	242	6,771	171	6,942	116	3,138	103	2,777
1987		242	242	7,226	180	7,406	103	2,992	91	2,600
1988		242	242	7,681	190	8,871	92	2,841	79	2,424
1989		242	242	8,137	199	8,336	82	2,684	70	2,251
1990		242	242	8,592	209	8,301	74	2,526	61	2,086
1991		242	242	9,372	223	9,595	66	2,466	54	1,996
1992		242	242	10,151	238	10,389	59	2,379	47	1,891
1993		242	242	10,931	252	11,183	52	2,293	41	1,789
1994		242	242	11,710	267	11,977	47	2,192	36	1,677
1995		242	242	12,490	281	12,771	42	2,082	32	1,571
1996		242	242	13,270	295	13,565	37	1,980	28	1,465
1997		242	242	14,049	310	14,359	33	1,867	24	1,364
1998		242	242	14,829	324	15,153	30	1,758	22	1,258

Table 20 (continued)

Year	Costs			Benefits			Net Worth		Internal Rate of Return (14%)	
	Construction	Maintenance	Total	Traffic diverted from existing road and generated	Diverted from waterways	Total	Cost	Benefit	Cost	Benefit
1999		242	242	15,608	339	15,947	26	1,658	19	1,164
2000		242	242	16,388	353	16,741	24	1,557	16	1,071
2001		242	242	17,473	372	17,845	21	1,481	15	999
2002		242	242	18,559	390	18,949	19	1,402	13	929
2003		242	242	19,644	409	20,053	17	1,324	11	862
2004		242	242	20,729	427	21,156	15	1,248	10	804
2005		242	242	21,815	446	22,261	14	1,180	9	735
2006		242	242	22,900	464	23,364	12	1,098	8	678
2007		242	242	23,985	483	24,468	11	1,028	7	636
2008		242	242	25,070	501	25,571	10	946	6	563
2009		242	242	26,156	520	26,676	9	880	5	534
Total							53,595	66,314	55,434	54,103

Net Present Worth = 12,719,000 US$ (1980)

Cost Benefit Ratio = 1.24

7. General Assessment

7-1. Technical problems of crossing the Padma river.

The most difficult and characteristic problem of this new road planning for linking Dacca and Faridpur is how to cross the Padma river. So, as for the works on the site (collecting the materials, field reconnaissance, discussion with the engineers concerned), emphasis was laid on this problem. As the result it was found that establishing ferry system would be technically feasible, though the spot for crossing this river by ferry was not settled. With regards to technical feasibility of bridging, although there exist the waterways whose depth reach to 150 ft at the deepest spot, location of those waterways changes little and is pretty stable annually, as far as according to the materials of IWTA and WAPDA concerned. Therefore, it can be judged that bridging to cross the Padma river with a long span is technically feasible. The continuous truss with a maximum length of 300 m span, as shown in the outline plan, is one of the feasible types of bridge, but it is necessary to make more detailed study.

As it has come to the conclusion after economic comparison that building the bridge from the first stage of construction is more profitable rather than stage construction with ferry system, the further study should be made only for bridging hereafter.

7-2. Road construction plan

Considering the accomplishments of road construction in the past in East Pakistan and the construction plan of the Gorai bridge, the construction of the access road to the both sides of the Padma river including constructions of the Ali Al Khan river and the Daleswari river bridges, does not seem very difficult.

As construction plan of the embankment (Polder) is now also under consideration by WAPDA in the same area where the said road construction is planned, it is expected to lower the proposed height of the road and shorten the length of the bridge, and after all to lower the construction cost by adjusting the construction time to carry out the road construction in accordance with the time of the embankment construction.

As for the construction of the Padma river bridge, it will take some years for surveying, designing and technical or financial preparation. It is estimated that this road will be opened in 1980 as described in the chapter of economic evaluation and this target of opening is not too late considering various difficulties in construction.

Completion of the access road, however, especially between Dacca and the left bank of the Padma river would bring a benefit to the dwellers along the route in spite of completion of only a part of the whole road project. From this standpoint, it can be said that stage construction is advantageous, and in this case construction should be started from the nearest section to Dacca.

Completion of the North-South road in Old Dacca, or access road to the Buriganga bridge, and of the Buriganga bridge are the preconditions of this road construction plan. And the improvement of Faridpur-Barisal Road is also one of the said preconditions.

7-3. Construction plan of the road directly connecting to Khulna.

The government of East Pakistan is interested in possibility of extending this road from Faridpur direct to Khulna beyond the Faridpur-Barisal road junction. It is under consideration that this road has a branch route to Gopalganj. (Fig. 1 and 2)

If this plan is carried out the distance shall be shortened by about 60 km between Faridpur and Khulna, and by about 20 km between Dacca and Khulna comparing with the route through the Gorai river bridge and the Jessore-Madhukhali road. Therefore, there is no doubt in that this plan is effective for improvement of traffic conditions between Khulna and Faridpur or Dacca.

Considering the construction plans of the Gorai river bridge and the Jessore-Madhukhali road, however, it may still take many years before the justification of economic feasibility of this plan will be made.

Various problems of this road construction are pointed out as follows.

(1) According to the plan of the new route, it is necessary to span the Madhumati

river, the lower reach of the Gorai river, with a bridge. When two brdiges are proposed to be built close to each other over one river, the order of priority of the construction should be decided at first between the two.

(2) As for the construction plan of the Gorai river bridge, completion of this bridge with only a part of the access road will have an economic effect without completion of the Jessore-Madhukali road as the whole access road. But as for the construction plan of the road directly connecting to Khulna, completion of the Madhumati river bridge only will not have such an effect but just only an effect of improving local traffic condition.

(3) Therefore it is made clear that construction of the Gorai bridge should be started at first.

(4) Even in this case, it is imagined that opening of the Madhumati river bridge probably decrease the traffic volume on the Gorai bridge and threaten an economic adequacy of the Gorai bridge construction. So construction of the Madhumati bridge should be postponed until the effect of investing in the Gorai bridge construction comes to prospective.

(5) The content described above, however, never means to obstruct the construction of the Madhumati river bridge in a long term prospect. If this bridge is necessary for composing the traffic network, it should be built in the future.

(6) In planning the road directly connecting to Khulna, the construction schedule should be made so that opening section by section of this road may be effective. For example, if the Madhumati bridge is built between Bhatiapara and Naral, it would improve local traffic condition between the said two spots and also between Bhatiapara and Jessore.

(7) And by connecting the Dacca-Faridpur road further with this bridge, the new route between Dacca and Jessore will be opened. If necessary, a road from the Madhumati river bridge to Khulna might be planned at the next stage. Considering the various problems mentioned above, the follows may be concluded.

When two routes are proposed competing with each other like the case mentioned above, in some case only one of those routes would be necessary and

in other case both of them may be necessary in future. It may sometimes lead to wrong judgements to make the road construction plans whenever an idea comes up without a long range plan.

The matter necessary for road construction plan in East Pakistan is to make a plan of the arterial road network covering the whole country and decide the order of carrying out each construction plan with an investigation from economic and social point of view, and after all to make the whole road construction plan with a long range prospect.

8. Plan of further study

By the study of this time, the fundamental data necessary for judging the feasibility of this road construction were collected and as the result of study, the project was found feasible.

As for the crossing the Padma river, now the focus of this plan, however, there remain some technical problems about which further study is needed.

The course of investigation should be directed to building a bridge, not to building a ferry, and further discussions among the Japanese and East Pakistani experts of hydraulics, river, and bridge construction should be done further about the matter concerned. The result of the discussions will be reported as the volume 2 of the feasibility study following after this report. If neccesity of further study or design for this road construction plan is pointed out as the result of such discussions, boring or other surveying methods which are necessary for designing should be taken. Also the new-planned data concerning the rivers will be needed. As the construction of the Padma river bridge is a key to the success of this road construction, investigation for it should be made not only by the authorities of the road, but also under intimate communication and cooperation with the other administrative organizations which have any concern with, such as river, survey and others.

In order to make these study effective and correct, it is recommended to establish the certain organization like a committee among the said authorities concerned. This organization would be helpful not only for carrying out the bridge construction plan, but also for adjustment between the polder plan and the road construction plan.

As for the part of the road except the bridges, there may be no special difficult problem and the government of East Pakistan can design and construct well enough without help from outside referring to the experiences in East Pakistan and the design of the Jessore-Madhukali road.

Appendix 1. Technical study on the viaduct plan of North-South road in Dacca

1-1. Forewords

The capital of East Pakistan, Dacca, consists of an old city which has developed along the Buriganga river since ancient times and a new city which has recently expanded on the north of the old city. Most of the population is concentrated in the old city. And the increase of the population of Dacca is so rapidly that more slums are being produced in the old city. To solve above problems Dacca Improvement Trust is executing or planning various projects on the basis of the Greater Dacca Plan which was established in 1959.

North-South road is one of the arterial roads proposed in the Greater Dacca Plan, and it extends to the Keraniganj district through the new bridge on the Buriganga. The road is inevitable for the development of the greater Dacca which includes modernization of the old city and the development of the Keraniganj district.

At present the North-South Road is completed only in the new city with the width of 100 ft. But on the old city the construction of the road has not yet been started as it passes through the dense habitation area with the objections of the residents.

Original plan of the Dacca Improvement Trust for the North-South road in the old city defined the road as of 300 ft total width with 100 ft level roadway in the center, 75 ft commercial zones on its both sides and 25 ft side roads further outside of each commercial zone.

The government of East Pakistan proposed a viaduct plan in order to decrease land acquisition for the construction of the road, and requested the Japanese survey team to study the feasibility of the plan. Generally speaking to make balance between the land acquisition and other problems is the greatest key point for a viaduct plan. However, we could not obtain the sufficient and reliable data and information during this survey as for the cost required for land acquisition and its difficulties. So that the following study we made refers mainly with respect to the technical aspects of the North-South road viaduct plan.

1-2. Premise conditions of the study

Before the technical study on the North-South road viaduct plan in the old city is started, the following initial conditions were presumed.

1) Section From the left bank of the Buriganga river to the railway
2) Length 1,900 m
3) Lane 6 lanes
   (Note) The Buriganga bridge has 4 lanes and pedestrian side walks. (v. "Report on investigations for construction of the Buriganga river bridge" Nov. 1964 OTCA, The government of Japan)
4) Width
   Width of the following table is presumed considering the width of the Buriganga bridge and the importance of the road's function as a street.
   (Note that it differs from that of Dacca-Faridpur road.)

Table 21. Width of Road and Viaduct

			Level road case	Viaduct case
Width of roadway			11' (3.3m)	10' (3.0m)
Shoulder	case for over two lanes	right	1' (0.3m)	1' (0.3m)
		left	1' (0.3m)	1' (0.3m)
	case for simple lane	right	1' (0.3m)	1' (0.3m)
		left	5' (1.5m)	5' (1.5m)
Median Strip (multi-lane case)			6' (1.8m)	-
Side walk width			12' (3.6m)	-

Provided always the width of right shoulder is 2' in order to maintain side clearance, when the roadway connects to the bridge of viaduct.

5) Maximum grade 2.5%
6) Minimum clearance under the viaduct 4.8 m
7) Proposed height of the road surface of the Buriganga bridge 20.856 m above D.L. (on the left bank)
8) Miscellaneous

i) Preliminary assumption is made for the alignment (road center)

ii) As sidewalks of the Buriganga bridge are proposed to be lowered to the level apart from the viaduct at the bridge end, they are not dealt with in the viaduct plan.

iii) Utilization of the viaduct shades for commercial purpose, etc. is not considered.

1-3. Content of study

The following three cases were studied for preliminary design of viaduct, rough cost estimation, estimation of required land, and so forth.

Case A Four lanes of the Buriganga bridge are immediately lowered down to the street level producing no viaduct. Additional one-lane lavel roads are proposed on both sides of the above four lanes access to the Buriganga bridge and the level part from the end of the access to the north becomes six lanes road.

Case B Four lanes of the Buriganga bridge are extended for the total section as a viaduct with one-lane level roads on the both sides.

Case C Outside two lanes of the Buriganga bridge are immediately lowered at the end of the bridge. Remaining central two lanes are extended for the total section as a viaduct. Level road is two lanes for access length, four lanes from the access to the north end respectively.

Schematic models of the above three cases are seen in Fig. 11.

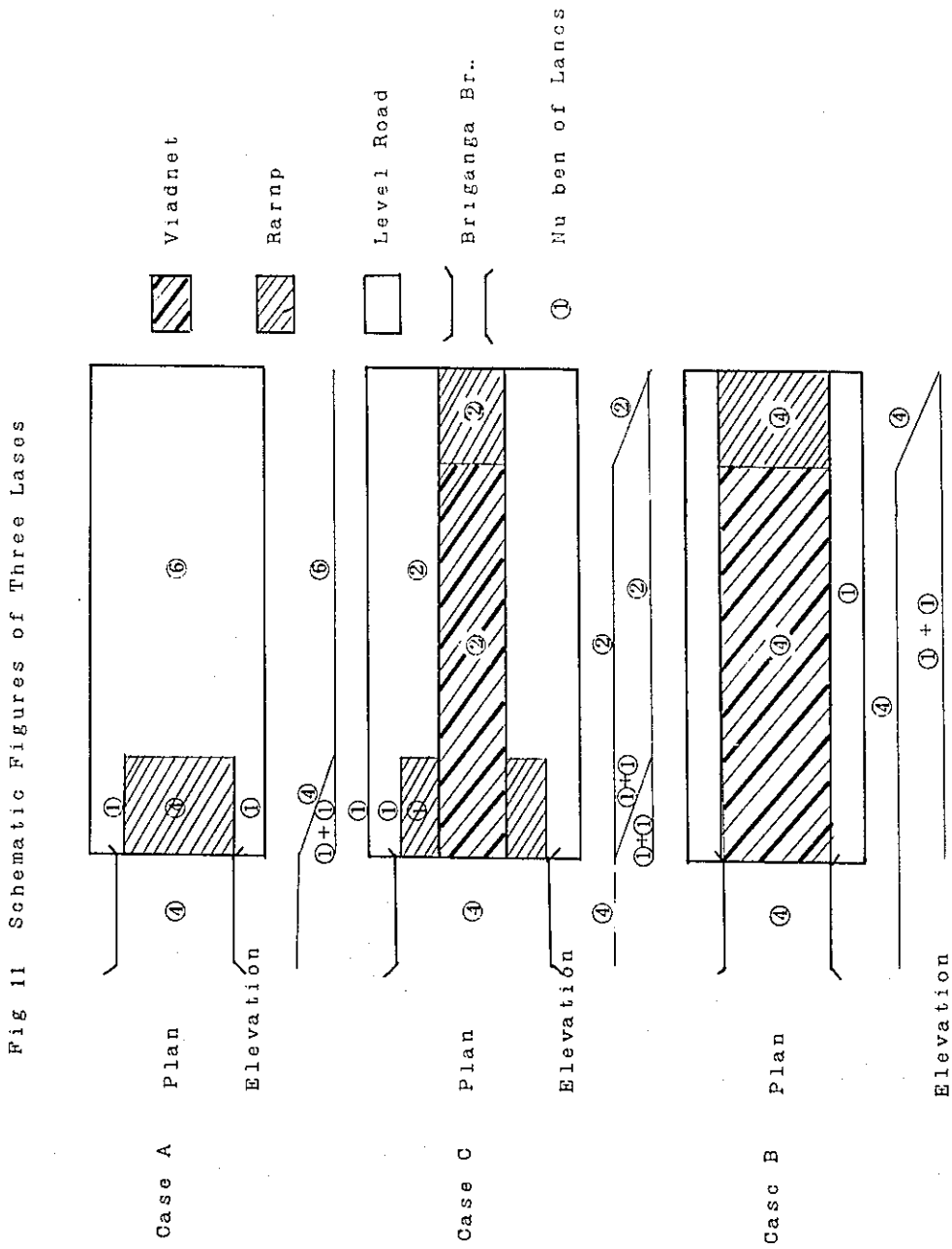


Fig 11 Schematic Figures of Three Lases

1-4. Results of the study

(1) Typical cross section and vertical curve

Typical sections and vertical curve for each three cases are presumed taking initial conditioned in the 2nd section and the results of the preliminary design of the viaduct into consideration.

The results are shown in Table 22.

Table 22. Length Comparison of Three Cases

(unit: m)

	Level road				Viaduct			Access		
	2 lanes	4 lanes	6 lanes	total	2 lanes	4 lanes	total	2 lanes	4 lanes	total
Case A	541	-	1,359	1,900	-	-	-	-	541	541
Case B	1,900	-	-	1,900	-	1,490	1,490	-	410	410
Case C	541	1,359	-	1,900	1,490	-	1,490	541 410	-	951

Note: Numbers of lanes in case of median separation are total numbers.

(2) Construction cost and materials (Fig. 23, 24, 26)

i) As for the viaduct, the cost estimation and design were made assuming that the viaduct was composed of reinforced concrete T-shape 15 m span girder's superstructure and substructures with reinforced concrete piles (ϕ60 cm, L = 15 m)

ii) As for the access such assumption was made that the parts with the proposed height of about 18 m above D. L. and over are made of similar structures as the viaduct and that the parts of the proposed height under about 15 m about D.L. are banks with retaining walls.

iii) For the cost estimation, the same unit construction cost used in the Dacca-Faridpur road project, which is shown in Table 8, is used here.

Table 23. Amount of Construction Materials

	Viaduct and Access Road					Level Road Pavement (m^2)
	Concrete	Reinforcement Bar (t)	Concrete Pile 0.6m x 15m (pce)	Excavation (m^3)	Embankment (m^3)	
Case - A	6,086.6 (56.0)	622.8	336.0	2,290.7	3,121.9	53,600
Case - B	30,251.6 (150.0)	3,458.4	2,054.0	13,900.7	27,636.0	36,600
Case - C	23,134.4 (130.0)	2,590.7	1,136.0	7,427.8	39,600.0	48,800

Table 24. Cost of Construction

	Viaduct & Access Road	Level Road	Total	Other Costs	Grand Total
Case - A	968.819	375.200	1,344.019	131.320	1,609.739
Case - B	4,968.717	256.200	5,224.917	461.900	6,229.317
Case - C	3,744.429	341.600	4,086.029	367.900	4,882.529

Note: Other Costs = Supervision Fee + Detail Design Fee
+ Temporary Facilities + Contingency

(3) *Area of land required*

Table 25 shows areas of land required for each of three cases studied. As for the problems of housing compensation which occurs in land acquisition, number of houses to be compensated in each case can be regarded as comparable to the area of land required considering the results of site survey and aerial photographs.

Table 25. Required Area

	Area of land required
Case - A	58.000 m^2
Case - B	44.600 m^2
Case - C	56.200 m^2

1-5. Conclusions

Followings are the conclusions of the study on the North-South Road Viaduct plan derived from the results in the last chapter from the technical points of view.

(1) Area of the land required is the minimum of about 44,600 m^2 in case B followed by case C of 56,200 m^2. These figures are smaller by about 25% in case

B and by 3% in case C comparing with the case A which corresponds to the original plan of the Dacca Improvement Trust. But these decreases are not so large as expected in the beginning.

(2) On the contrary construction cost is the maximum in case B of about 6.2 million US dollars followed by case C of 4.9 million US dollars. Construction cost of 1.6 million US dollars in case A is the minimum of the three. It is quite natural that the construction cost becomes the lowest in case A where the viaduct is short. The reason why the construction cost of case C is considerably high comparing with that of case B is that the cost of 2 lane access from the Buriganga bridge is unexpectedly high.

(3) The traffic which utilizes the North-South Road can be divided into "Inter-city traffic" and "Inside-city traffic." The former is the traffic between Dacca and Southwest part of East Pakistan through Dacca-Faridpur Road which we deal with in this report and the latter is the traffic inside the city of Dacca. The characteristics of traffic function of the road in each case can be generally summarized as follows:

Case A; As for "Inter-city traffic," the road will serve both the old city and the new city. However, the connection to the new city is poorer than in other two cases, as the traffic utilizer the level road where "inter-city traffic" and "inside-city traffic" are mixed. As for "Inside-city traffic," 6 lanes of the level road are available. The level road with no viaduct will serve much more the road side people for shopping or other purposes than in other two cases.

Case B; As for "Inter-city" the full connection to the new city is expected, but on the contrary no direct service to the old city will be obtained. In order to acquire the connection to the old city new accesses are needed requiring additional land on both sides.
As the level road has only one lane on each side, the service level for "Inside-city traffic" is considerably low comparing with other two cases.

Case C; This case is an intermediate case of other two in all aspects. Satisfactory service can be expected for the Inter-city traffic both to the old city and the new city, and this case is better than other two in this aspect. For "Inside-city traffic" the level road has two lanes on both sides and its serv-

ice to the road side will be slight poorer than in case A but considerably high comparing with case B.

(4) As mentioned in the beginning, the North-South road is to hold various function as an important element of the Greater Dacca Plan, therefore comprehensive outsides and comparisons are necessary for planning its viaduct. Therefore, the final conclusion for the viaduct plan should be derived only from the results of the study which we carried out recently.

(5) However, one of the most important factors to decide one of the three as the best will be the balance between the construction cost of the viaduct and the cost needed of land acquisition, housing compensation, etc.

(6) Above technical feasibility study on the viaduct plan of the North-South road contains several presumed conditions, because the basic information was not enough. Therefore, the further survey and stury on land acquisition and technical fields should be undertaken to reach final conclusion which is most rational from the comprehensive points of view.

Table 26 (1) Comparison of Construction Cost

Item	Case A			Case B			Case C		
	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total
Viaduct Construction Cost	851,753	117,066	968,819	4,096,914	871,803	4,968,717	3,081,490	662,939	3,744,429
Level Road	300,160	75,040	375,200	204,960	51,240	256,200	273,280	68,320	341,600
Subtotal	1,151,913	192,106	1,344,019	4,301,874	923,043	5,224,917	3,354,770	731,259	4,086,029
Temporary Facilities	6,667	3,333	10,000	13,333	6,667	20,000	13,335	6,667	20,000
Contingency	112,000	24,400	134,400	435,417	87,083	522,500	340,500	68,100	406,600
Total	1,270,580	211,839	1,488,419	4,750,624	1,016,793	5,767,417	3,108,603	806,026	4,514,629
Supervision Fee	44,652	29,768	74,420	170,040	113,360	283,400	135,420	90,180	225,700
Net Construction Cost	1,315,232	247,607	1,562,839	4,920,664	1,130,153	6,050,817	3,844,023	896,306	4,740,329
Detail Design Fee	18,760	28,140	46,900	71,400	107,100	178,500	56,880	85,320	142,200
Total Construction Cost	1,333,992	275,747	1,609,739	4,991,064	1,237,243	6,229,317	3,900,903	981,626	4,882,529

Table 26 (2) Construction Cost

			Unit	Unit Cost	Quantities	Local Currency	Foreign Currency	Total Cost
Case - A	Super-structure	Concrete	m^3	123.0	1,598.1	157,253	39,313	196,566
		Steel Bar	t	270.0	263.7	64,079	7,120	71,199
		Sub Total				221,332	46,433	267,765
	Sub-structure	Concrete	m^3	123.0	4,488.5	496,880	55,209	552,089
		Steel Bar	t	270.0	359.1	87,261	9,696	96,951
		Other Concrete	m^3	58.5	56.0	2,621	655	3,276
		Excavation	m^3	0.3	2,290.7	687	—	687
		Embankment	m^3	0.86	3,121.9	2,148	537	2,685
		Pile	pce	135.0	336.0	40,824	4,536	45,360
		Sub Total				630,421	70,633	701,054
	Level Road	Pavement	m^2	7.0	53,600	300,160	75,040	375,200
		Sub Total				300,160	75,040	375,200
	Total					1,151,913	192,106	1,344,019
	Temporary Facilities					6,667	3,333	10,000
	Contingency					112,000	22,400	134,400
	Grand Total					1,270,580	217,839	1,488,419
Case - B	Super-structure	Concrete	m^3	123.0	12,214.4	1,201,897	300,474	1,502,371
		Steel Bar	t	270.0	2,015.4	489,742	54,416	544,158
		Sub Total				1,691,639	354,890	2,046,529
	Sub-structure	Concrete	m^3	123.0	18,037.2	1,774,861	443,715	2,218,576
		Steel Bar	t	270.0	1,443.0	350,649	38,961	389,610
		Other Concrete	m^3	58.5	150.0	7,020	1,755	8,775
		Excavation	m^3	0.3	13,900.7	4,170	—	4,170
		Embankment	m^3	0.86	27,636.0	19,014	4,753	23,767
		Pile	pce	135.0	2,054.0	249,561	27,729	277,290
		Sub Total				2,405,275	516,913	2,922,188
	Level Road	Pavement	m^2	7.0	36,600	204,960	51,240	256,200
		Sub Total				204,960	51,240	256,200
		Total				4,301,874	923,043	5,224,917
	Temporary Facilities					13,333	6,667	20,000
	Contingency					435,417	87,083	522,500
	Grand Total					4,750,624	1,016,793	5,767,417
Case - C	Super-structure	Concrete	m^3	123.0	8,799.4	865,861	216,465	1,082,326
		Steel Bar	t	270.0	1,451.9	352,812	39,201	392,013
		Sub Total				1,218,673	255,666	1,474,339
	Sub-structure	Concrete	m^3	123.0	14,335.0	1,410,564	352,641	1,763,205
		Steel Bar	t	270.0	1,146.8	278,672	30,964	309,636
		Other Concrete	m^3	58.5	130.0	6,084	1,521	7,605
		Excavation	m^3	0.3	7,427.8	2,228	—	2,228
		Embankment	m^3	0.86	39,600.0	27,245	6,811	34,056
		Pile	pce	135.0	1,136.0	138,024	15,336	153,360
		Sub Total				1,862,817	407,273	2,270,090
	Level Road	Pavement	m^2	7.0	48,800	273,280	68,320	341,600
		Sub Total				273,280	68,320	341,600
		Total				3,354,770	731,259	4,086,029
	Temporary Facilities					13,333	6,667	20,000
	Contingency					340,500	68,100	408,600
	Grand Total					3,708,603	806,026	4,514,629

Appendix 2. Design criteria

2-1. Geometric design standard

For the design standard of this road, design speed of 100 km/hr (60 mph), which is being adopted by the East Pakistan Government for all new roads and existing roads which are to be improved in the future, has been applied.

Typical cross-section to be used for this road was suggested by the East Pakistan Government. The typical cross-section consists of pavement of 26 feet wide for two lanes and crest width of 40 feet. The total width of right of way including borrow pits is shown in Figure 2.

In general, design speed of more than 80 km/hr (50 mph) is not appropriate for two lanes highway without median in view of the potential hazard when vehicle passes each other. However, in view of the fact that the proposed route is an integral part of the Asian Highway and that the proposed route may possibly be turned to a high speed expressway by adding another road in parallel to this one in the future, design speed for the proposed road was set at 100 km/hr. In East Pakistan where flat terrain prevails throughout the country, large horizontal curve may be obtained without too much difficulty and such design will not result in an increase in the construction cost.

With the above design speed as the basis, the following standard values were established for each factor of geometric design:

(1) Horizontal Alignment

	Minimum radius of curve	Maximum superelevation
(Desirable)	600 m (2,000 feet)	6%
(Absolute)	450 m (1,500 feet)	8%

This road, on the one hand, must meet the requirement for the safe traffic of automobiles at a prescribed speed and on the other, must provide easy access to other slow moving traffic such as animal drawn carts, etc. Minimum radius was determined with reference to the standard value (700 m) in Japan. In this case, the value of superelevation should be 6%. This value is considered

to be the allowable limit for unobstructed traffic of slow moving vehicles such as animal drawn carts, etc. Relationship between the radius of curve and superelevation is expressed in the following formula:

$$R = \frac{V^2}{g\,(i + f)} \qquad (1)$$

Where: R: Radius of curve (m), v: Running speed (m/sec),
g: Acceleration of gravity (m/sec^2),
i: Superelevation (m/m), f: Coefficient of skid resistance (m/m)

If the speed in the above formula is shown in the unit of km/hr:

$$R = \frac{V^2}{3.6^2 \quad 9.18\,(i + f)} = \frac{V^2}{127\,(i + f)} \qquad (2)$$

Where: V: Running speed (km/h)

With a 600 m standard minimum radius of curve and 6% superelevation coefficient of skid resistance will be:

$$f = \frac{V^2}{127\ R} - i = \frac{100^2}{127 \quad 600} - 0.06 = 0.131 - 0.06 = 0.071$$

If the design with the standard minimum value is not practical because of topography, it is possible to use lower values not smaller than the absolute minimum value. In this case, value of superelevation should be 8%. This value is not desirable for slow moving traffic. However, use of such a small radius should be limited only for special conditions.

(2) Superelevation

Under the condition of 8% superelevation for 450 m minimum radius, the value of superelevation corresponding to the radius will be as follows:

Superelevation (%)		8	7	6	5	4	3	2
Radius of curve (m)	More than	450	520	600	750	1,000	1,400	2,000
		≀	≀	≀	≀	≀	≀	≀
	Less than	520	600	750	1,000	1,400	2,000	5,000

Radius of more than 5,000 m will not require superelevation.

(3) Safety sight distance

160 m (480 feet)

(4) Transition curve

In principle transition curve will be provided on both sides of curved portion of the road and used as the runoff section of curvature and superelevation.

Minimum length of transition curve is 85 m.

Radius of more than 1,500 m may omit the transition curve.

Minimum length of transition curve must be so determined that the variation of centrifugal acceleration will not exceed a certain limit (0.5 m/sec^3) in the case of high speed traffic and is obtained by taking into account the minimum allowable limit of running time on transition curve (3 seconds).

For transition curve, use of clothoide curve is most desirable.

Clothoide curve shows the following simple relationship:

$$RL = A^2 \text{ (constant)}$$

Where: R: Radius of curve (m), L: Length of Clothoide curve,
A: Parameter of Clothoide.

By providing parameter A, its size can be determined just as the radius of circular curve is determined by R. Generally Clothoide curve serves for smooth connection between curved section and straight line.

Therefore, as the circular curve becomes larger, Clothoide curve should be made larger proportionately.

Their relationship is usually shown in the following formula:

$$R > A \geqq 1/3 \ R$$

From the standpoint of gradial change of curvature, radius of 1,500 m or more does not require transition curve but from the standpoint of visibility, it is desirable to provide a Clothoide curve even for the radius larger than this. However, no Clothoide curve is required for R = 3,000 or more.

(5) Superelevation on runoff

Length of superelevation runoff should be determined so that the ratio of superelevation along the edge of roadway will not exceed 1/175. However, if transition curve is provided, a runoff should be made along its entire length.

(6) Widening of the lane width of curved portion.

Because of its large minimum radius, no widening is required for this road with the exception of ramp at the intersection of the road.

(7) Gradient

Desirable maximum gradient is 2%. Absolute maximum gradient is 3% (4% in special case). Because of generally flat topography and straight horizontal alignment available in the area, gentle gradient for bridge should be provided. However, gradient up to 4% may be allowed as an exception to save construction cost for long bridge.

(8) Vertical curve

Vertical curve should be provided at the changing point of gradient. Minimum value provided should be as follows:

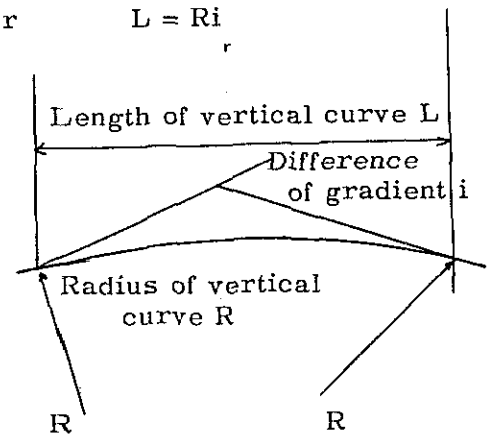
	Convex type	Concave type
Standard minimum length (m)	90i	45i
Absolute minimum length (m)	60i	30i
Exceptional minimum length (m)	45i	30i

i: In the above table represents absolute value (%) of gradient variation.

In any event, however, minimum length of approximately 85 m (running distance in 3 seconds) must be secured. This requires particular attention when gradient variation is small. When the gradient variation is less than 0.01%, vertical curve is not required, however.

Vertical curve is generally designed with the use of parabolic curve. By assuming the parabolic curve as the approximate circular curve, its radius may easily be determined. Approximate relationship between the radius of vertical curve and curve length is as follows:

$$R = \frac{L}{i} \qquad \text{or} \qquad L = Ri$$



Where: R: Radius of vertical curve (m)
L: Length of vertical curve (m)
i: Difference of gradient (m/m)

In the foregoing table, desirable minimum length of convex type vertical curve was shown as 90i (i in this case is expressed in per cent) and this is synonymous with 9,000 m minimum radius of vertical curve. Radius of vertical curve must increase in proportion to the increase in running speed. What is

actually needed for design purpose is the length of vertical curve. This is obtained from the product of required radius of vertical curve and the variance of gradient. In designing the road, therefore, care should be exercised not to es tablish a fixed length of vertical curve by neglecting variance of gradient.

2-2. Structural design standard

The East Pakistan Government applies the provisions of "Highway Bridge Code for East Pakistan" to the design of highway structures. This code, however, does not specify in detail and does not include provisions for P.C. bridge and is not considered adequate for this project. As a result, provisions of AASHO are being used to supplement inadequate data and the application of AASHO provisions to the design of this project may be considered. However, if the design on the basis of Japanese materials is to be taken into account, it is considered most appropriate to apply Japanese code as the standard for allowable stress of materials. As a result, code to be used for the design of this project will be as follows:

i) AASHO
ii) Highway Bridge Code for East Pakistan
iii) Standard Specifications for Concrete Works (Japan Society of Civil Engineers, 1961)
iv) Design Code for Reinforced Concrete Road Bridge (Japan Road Association, 1964)
v) Guide to Design and Construct Pre-stressed Concrete (Japan Society of Civil Engineers, 1961)
vi) Guide to Design of Substructure of Road Bridge (Japan Road Association, 1966)

However, in view of geographical characteristics and other conditions peculiar to East Pakistan, following conditions were specially incorporated in the design of the project:

i) Live Load: H20 - S16 - 44
ii) Wind Load: 100 miles / hr = 45^{m} / sec.
iii) Temperature Fluctuation: 0° $40^{\circ}C$
iv) Seismic load

Considered only for dead load - (Horizontal Earthquake 5%
(Vertical Earthquake ± 0

v) Allowable stress for concrete when hard brick is used for aggregate.

Coarse aggregate for concrete naturally produced in East Pakistan may be obtained mainly from rivers in Sylhet district in the northeastern part of East Pakistan and are transported to the destination by sea and land transportation. Fine aggregate, on the other hand, is not to be obtained from Sylhet, instead, the river sand of the Gorai river, may be used after removing silt by washing. However, their grain size is too small to make concrete of good quality.

Sylhet is approximately 180 miles from the proposed road site by air distance and it will be approximately 250 miles or more if inland water route and land route are utilized. Besides, transportation may be possible only in certain period of the year and the transportation cost of aggregate will greatly affect the overall construction cost.

Surface soil of East Pakistan is mostly composed of alluvial clay, and brick baking with alluvial clay as its raw material is seen in every part of the country. Therefore, bricks are available at a considerable low cost compared to natural aggregate. Use of crushed bricks having sufficient hardness for aggregate for concrete will contribute to the savings of construction cost. However, because of lack of record on the use of bricks as concrete aggregate, no accurate data on their strength is available at present. Considering the similarity in the nature of brick and light weight aggregate which is composed of clay, use of crushed brick as aggregate for concrete is considerable possible. Field survey revealed the use of hard brick as aggregate for concrete in building structures. By taking into account the above peculiar local situation a decision was made on the use of hard brick as aggregate for concrete in the design of substructures of the bridge.

Mixing of concrete and allowable stress in this case will be as follows:

Table 27. Concrete Mixture for Substructures

Aggregate	Maximum grain size of coarse aggregate (mm)	C (kg)	w/c (%)	S/A (%)	Admixture	Slump (cm)	Amount of Air(%)	Compressive Strength (kg/cm^2)
Coarse aggregate hard brick Fire aggregate, river sand	20	360	50	50	Pozzolith	More than 10	5 ± 1	less than 165

Table 28. Allowable Stress for Substructures

Allowable Stress (Kg/cm^2)		Design strength of concrete 0 28 (Kg/cm^2)			165
	Concrete	Compressive Stress bending moment (Kg/cm^2)			55
		Axial Compressive Stress (Kg/cm^2)			41
		Shearing Stress	In case where diagonal tensile stress is sustained by concrete only	Slab Beam	5.0 3.7
			In case where diagonal tensile stress is sustained only by shear reinforcement		11
		Bond Stress			4.5
		Bearing Stress			41
	Reinforcement	Tensile Stress S R 24			1,200
		Yield Point Stress S R 24			2,400

Note: Unit weight of reinforce concrete = 2.1 t/m^3

Table 29. Allowable Stress for R. C. Superstructure

Allowable Stress (Kg/cm^2)					
Design strength of concrete σ 28 (Kg/cm^2)					240
	Concrete	Compressive stress by bending moment			80
		Axial compressive stress			72
		Shearing Stress	In case where diagonal tensile stress is sustained only by concrete	Slab	9
				Beam	7
			In case where diagonal tensile stress is sustained only by shear reinforcement		20
		Bond Stress			8
		Bearing Stress			72
	Reinforcement	Tensile Stress S D 30			1,800
		Yield Point Stress S D 30			3,000

Table 30. Allowable Stress for P. C. Superstructure

Concrete	Allowable Stress
Standard design strength σ 28	350 Kg/cm^2
At design load (compressive)	115 "
" (tensile)	13.5 "
When prestress is employed	300
Aggregate grain size	25 mm

PC Steel Wire	Strength ϕ = 7 mm
Tensile strength	155 Kg/mm^2
Yield point stress	135 "
Allowable tensile stress (Design)	93
" (Strained)	121.5 "

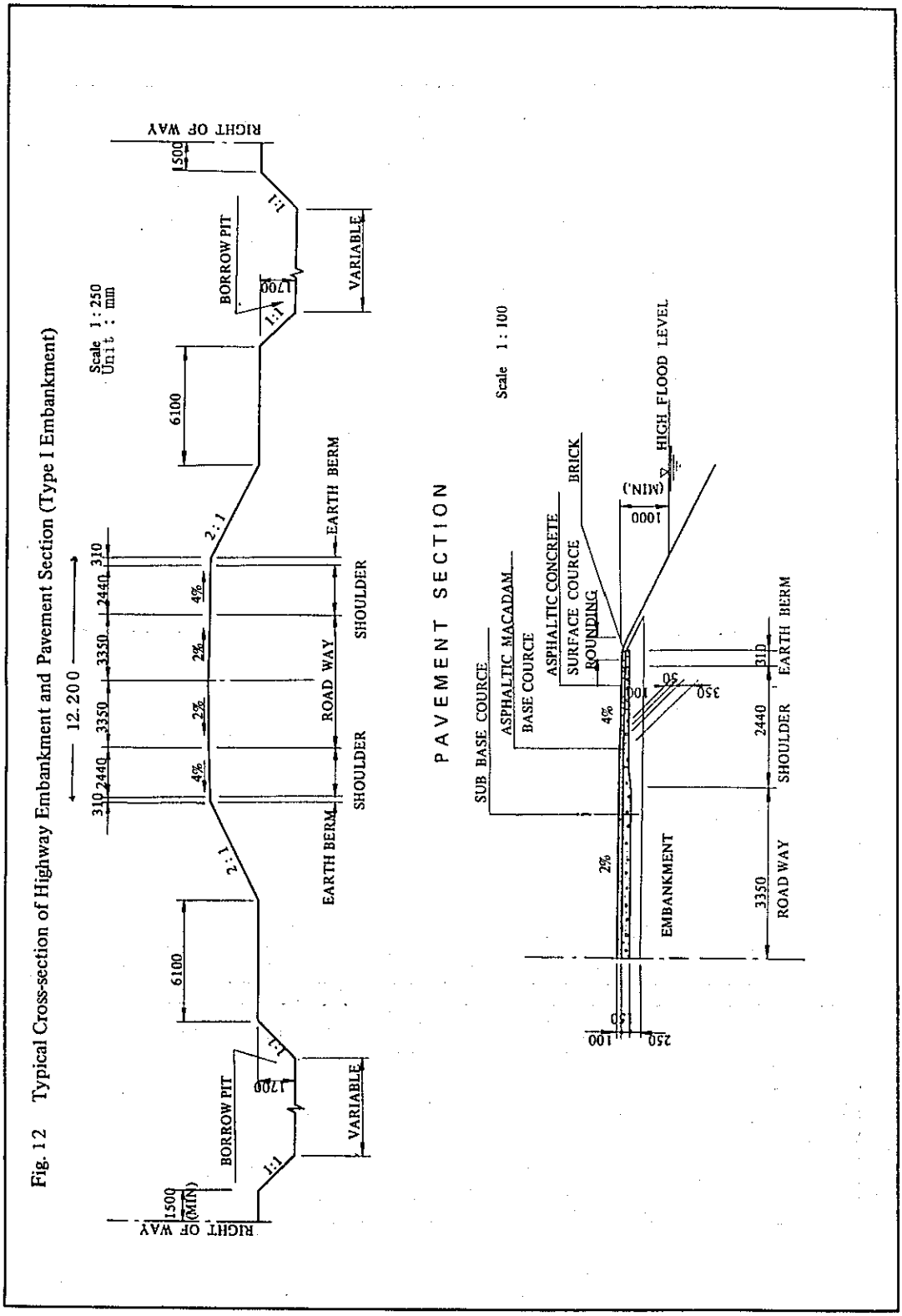


Fig. 12 Typical Cross-section of Highway Embankment and Pavement Section (Type I Embankment)

Appendix 3. Gravity model

3-1. Fundamental idea

Gravity model is one of the models which explain the inner-zone movement of goods by economical power such as population, products, quantity of shipment and arrival of goods and so on-of origin and destination of transportation and by the distance between the two zones such as air distance, time distance, cost of transportation etc.

This idea is derived from Newton's universal gravitation law that explains gravitation acting between two objects as follows:

$$F = f \cdot \frac{m_1 \cdot m_2}{r^2}$$

m_1, m_2 = mass of two objects
r = distance between two objects
f = constance coefficient

In this report, population and time-distance were taken as economic power and distance respectively. At first, the parameter of the model formula was deduced from existing road conditions (time distance) and the traffic volume at present and then the future traffic volume was calculated for the new road (shortened time distance) considering the proposed road. This traffic volume includes the generated traffic as well as the diverted traffic from the existing road.

3-2. Model formula

Model formula is as follows:

$$Tij = k_1 \frac{(aPi)\quad(bPi)}{Dij^{n1}} \qquad = a.b.k_1 \frac{Pi\ Pj}{Dij^{n1}}$$

$$= Ke \frac{Pi.\ Pj}{Dij^{n1}} \qquad (a.b.k1 = Ke\ )$$

Tij = traffic volume between zone i and j
(vehicles / day, 1968)

a, b = coefficient modifying time lag between satistics of population and that of traffic

Pi, Pj = Population of zone i and j (1,000 people, 1961)

Dij = traveling time between the center of zone i and that of zone j (hours) represented by passenger car.

k, n = parameter

l = case number

3-3. Case and parameter

It is named as Case 1 that the proposed route crosses the Padma river by ferry system and Case 2 bridge and parameters for each case are calculated separately.

Case 1 Taking some zones such as Dacca, Faridpur, Jessore, and Khulna area connected with Dacca through Aricha-Goalundo ferry, parameter k_1 and n_1 are calculated by population, traffic volume and time distance using the method of least squares.

Case 2 Taking some zones connected directly by land with Dacca such as Comilla, Noakhali and Mymensingh, parameters k_2 and n_2 are calculated by population, traffic volume and time distance using the method of least squares.

Input data and parameters are shown on the Table 31.

3-4. Verification

The results of reappearance of Origin and Destination (OD) traffic volume by using the parameters thus calculated through the model formula are as follows, and the parameters seem very appropriate. The number of vehicles is shown as the passenger car equivalent in 1968.

(O-D)	(surveyed)	(calculated)	(difference)
Case 1			
Dacca-Faridpur	22	23	-1
Dacca-Jessore	16	14	+2
Dacca-Khulna	20	23	-3
Case 2			
Dacca-Comilla	151	145	+6
Dacca-Noakhali	79	81	-2
Dacca-Mymensingh	94	94	0

Table 31. Input Data for Determining Parameters and Results of Calculation

	Case 1	Case 2
Tij Traffic volume from and to Dacca (vehicles/day,1968)	Dacca - Faridpur 22 " - Jessore 16 " - Khulna 20	Dacca - Comilla 151 " - Noakhali 79 " - Mymensingh 94
Pi, Pj Population (1,000 people, 1961)	Dacca 2,117 Faridpur 1,264 Jessore 1,213 Khulna 2,449	Dacca 2,117 Comilla 2,079 Noakhali 2,483 Mymensingh 2,853
Dij Driving time (hours)	Dacca - Faridpur 5.66 " - Jessore 7.44 " - Khulna 8.47	Dacca - Comilla 2.00 " - Noakhali 3.44 " - Mymensingh 3.42
Parameters	$K_1 = 7.01 \times 10^{-5}$ $N_1 = 1.29$	$K_2 = 8.72 \times 10^{-5}$ $N_2 = 1.40$

3-5. Calculation of traffic volume

The results of calculation are shown in Table 11. Though the traffic volume of existing road is estimated as 73 (vehicles/day), the traffic volume of Case 1 and Case 2 are estimated 165 (vehicles/day) and 272 (vehicles/day) respectively after the road condition is improved. This shows that the effect of the bridge construction on traffic generation is very high.

Appendix 4. Estimation of benefits

The benefits are divided into driving benefits and time benefits, each of which are estimated by O-D and by Type of vehicle. Details are shown on Tab. 32 - Tab. 35.

(1) on these tables are for the existing road and (2) for the proposed road such as Dacca-Faridpur road, Jessore-Madhukhali road and Tungi-Aricha road. The driving cost and speed per a unit of distance applied for these two roads are different.

As it is explained in Section 6-3, two proposed roads shown in Fig. 10 - Tungi-Aricha road and Jessore-Madhukhali road - are supposed to have been opened already to traffic when the very proposed road — Dacca-Faridpur road — is completed. For the case it is profittable in calculating the cost and time for using the existing road, these two above said roads are supposed to exist at present.

Table 32 Reduction in vehicle operating costs (Case 1)

P: Passenger car
B: Bus
T: Truck

Distance in Km
Price in US$

O.D	kinds of vehicle	Existing road					Proposed road					reduction in vehicle operating cost A-B $/vehicle
		a: distance	b: operating unit cost	a x b	c: ferry charge	A=axb+c	d: distance	b: operating unit cost	d x b	e: ferry charge	B=dxb+e	
Dacca	P	(1) 48.5 (2) 69.3	0.0433 0.0341	2.10 2.36	3.36	7.82	(1) 23.5 (2) 66.45	0.0433 0.0341	1.02 2.27	1.68	4.97	2.85
}	B	(1) 48.5 (2) 69.3	0.1365 0.1050	6.62 7.28	8.40	23.30	(1) 23.5 (2) 66.45	0.1365 0.1050	3.21 6.98	4.20	14.39	7.91
Faridpur	T	(1) 48.5 (2) 69.3	0.1365 0.1050	6.62 7.28	10.61	24.51	(1) 23.5 (2) 66.45	0.1365 0.1050	3.21 6.98	5.31	15.5	9.01
Dacca	P	(1) 172.2 (2) 69.3	0.0433 0.0341	7.46 2.36	3.36	13.18	(1) 152.8 (2) 66.45	0.0433 0.0341	6.22 2.27	1.68	10.57	2.61
}	B	(1) 172.2 (2) 69.3	0.1365 0.1050	23.51 7.28	8.40	39.19	(1) 152.8 (2) 66.45	0.1365 0.1050	20.86 6.98	4.20	32.04	7.15
Kushtia	T	(1) 172.2 (2) 69.3	0.1365 0.1050	23.51 7.28	10.61	41.40	(1) 152.8 (2) 66.45	0.1365 0.1050	20.86 6.98	5.31	33.15	8.25
Dacca	P	(1) 122.2 (2) 69.3	0.0433 0.0341	5.29 2.36	3.36	11.01	(1) 102.8 (2) 66.45	0.0433 0.0341	4.45 2.27	1.68	8.4	2.61
}	B	(1) 122.2 (2) 69.3	0.1365 0.1050	16.68 7.28	8.40	32.36	(1) 102.8 (2) 66.45	0.1365 0.1050	14.03 6.98	4.20	25.21	7.15
Jhenida	T	(1) 122.2 (2) 69.3	0.1365 0.1050	16.68 7.28	10.61	34.57	(1) 102.8 (2) 66.45	0.1365 0.1050	14.03 6.98	5.31	26.32	8.25
Dacca	P	(1) 93.0 (2) 114.1	0.0433 0.0341	4.02 3.89	3.36	11.27	(1) 73.6 (2) 111.25	0.0433 0.0341	3.19 3.79	1.68	8.66	2.61
}	B	(1) 93.0 (2) 114.1	0.1365 0.1050	12.69 11.98	8.40	33.07	(1) 73.6 (2) 111.25	0.1365 0.1050	10.04 11.68	4.20	25.92	7.15
Jessore	T	(1) 9310 (2) 114.1	0.1365 0.1050	12.69 11.98	10.61	35.28	(1) 73.6 (2) 111.25	0.1365 0.1050	10.04 11.68	5.31	27.03	8.25
Dacca	P	(1) 114.2 (2) 123.6	0.0433 0.0341	4.94 4.21	3.36	12.51	(1) 94.8 (2) 120.75	0.0433 0.0341	4.10 4.12	1.68	9.9	2.61
}	B	(1) 114.2 (2) 123.6	0.1365 0.1050	15.59 12.98	8.40	36.97	(1) 94.8 (2) 120.75	0.1365 0.1050	12.94 12.68	4.20	29.82	7.15
Khulna	T	(1) 114.2 (2) 123.6	0.1365 0.1050	15.59 12.98	10.61	39.18	(1) 94.8 (2) 120.75	0.1365 0.1050	12.94 12.68	5.31	30.93	8.25

(to be continued)

Table 32 (Continued)

O.D	kinds of vehicle	Existing road					Proposed road					reduction in vehicle operating cost A-B $/vehicle
		a: distance	b: operating unit cost	a x b	c: ferry charge	A=axb+c	d: distance	b: operating unit cost	d x b	e: ferry charge	B=dxb+e	
Dacca	P	(1) 109.5 (2) 691.3	0.0433 0.0341	4.74 2.36	3.36	10.46	(1) 38.5 (2) 66.45	0.0433 0.0341	1.67 2.27	1.68	5.62	4.84
↓	B	(1) 109.5 (2) 69.3	0.1365 0.1050	14.95 7.28	8.40	30.63	(1) 38.5 (2) 66.45	0.1365 0.1050	5.26 6.98	4.20	16.44	14.19
Madaripur	T	(1) 109.5 (2) 69.3	0.1365 0.1050	14.95 7.28	10.61	32.84	(1) 38.5 (2) 66.45	0.1365 0.1050	5.26 6.98	5.31	17.55	15.29
Dacca	P	(1) 168.5 (2) 69.3	0.0433 0.1050	7.29 2.36	3.36 -	13.01	(1) 97.5 (2) 66.45	0.0433 0.0341	4.22 2.27	1.68	8.17	4.84
↓	B	(1) 168.5 (2) 69.3	0.1365 0.1050	23.00 7.28	8.40 -	38.68	(1) 97.5 (2) 66.45	0.1365 0.1050	13.31 6.98	4.20	34.49	14.19
Barisal	T	(1) 168.5 (2) 69.3	0.1365 0.1050	23.00 7.28	10.61 -	40.89	(1) 97.5 (2) 66.45	0.1365 0.1050	13.31 6.98	5.31	25.6	15.29

Table 33 Reduction in vehicle operating costs (Case 2)

P: Passenger car
B: Bus
T: Truck

Distance in Km
Price in US$

O.D	kinds of vehicle	Existing road					Proposed road			Reduction in vehicle operation cost A-B $/vehicle
		a: distance	b: operating unit cost	a × b	c: ferry charge	A=axb+c	d: distance	b: operating unit cost	B=dxb	
Dacca	P	(1) 48.5 (2) 69.3	0.0433 0.0341	2.10 2.36	3.36	7.82	(1) 23.5 (2) 69.45	0.0433 0.0341	1.02 2.37	4.43
〃	B	(1) 48.5 (2) 69.3	0.1365 0.1050	6.62 7.28	8.40	22.30	(1) 23.5 (2) 69.34	0.1365 0.1050	3.21 7.29	11.80
Faridpur	T	(1) 48.5 (2) 69.3	0.1365 0.1050	6.62 7.28	10.61	24.51	(1) 23.5 (2) 69.45	0.1365 0.1050	3.21 7.29	14.01
Dacca	P	(1) 172.2 (2) 69.3	0.0433 0.0341	7.46 2.36	3.36	13.18	(1) 152.8 (2) 69.45	0.0433 0.0341	6.62 2.37	4.17
〃	B	(1) 172.2 (2) 69.3	0.1365 0.1050	23.51 7.28	8.40	39.19	(1) 152.8 (2) 69.45	0.1365 0.1050	20.86 7.29	11.04
Kushtia	T	(1) 172.2 (2) 69.3	0.1365 0.1050	23.51 7.28	10.61	41.40	(1) 152.8 (2) 69.45	0.1365 0.1050	20.86 7.29	13.25
Dacca	P	(1) 122.2 (2) 69.3	0.0433 0.0341	5.29 2.36	3.36	11.01	(1) 102.8 (2) 69.45	0.0433 0.0341	4.45 2.37	4.19
〃	B	(1) 122.2 (2) 69.3	0.1365 0.1050	16.68 7.28	8.40	32.36	(1) 102.8 (2) 69.45	0.1365 0.1050	14.03 7.29	11.04
Jhenida	T	(1) 122.2 (2) 69.3	0.1365 0.1050	16.68 7.28	10.61	34.57	(1) 102.8 (2) 69.45	0.1365 0.1050	14.03 7.29	13.25
Dacca	P	(1) 93.0 (2) 114.1	0.0433 0.0341	4.03 3.89	3.36	11.28	(1) 73.6 (2) 114.25	0.0433 0.0341	3.19 3.90	4.19
〃	B	(1) 93.0 (2) 114.1	0.1365 0.1050	12.69 11.98	8.40	33.07	(1) 73.6 (2) 114.25	0.1365 0.1050	10.04 11.99	11.04
Jessore	T	(1) 93.0 (2) 114.1	0.1365 0.1050	12.69 11.98	10.61	35.28	(1) 73.6 (2) 114.25	0.1365 0.1050	10.04 11.99	13.25
Dacca	P	(1) 114.2 (2) 123.6	0.0433 0.0341	4.94 4.21	3.36	12.51	(1) 94.8 (2) 123.75	0.0433 0.0341	4.10 4.22	4.19
〃	B	(1) 114.2 (2) 123.6	0.1365 0.1050	15.59 12.98	8.40	36.97	(1) 94.8 (2) 123.75	0.1365 0.1050	12.94 12.99	11.04
Khulna	T	(1) 114.2 (2) 123.6	0.1365 0.1050	15.59 12.98	10.61	39.18	(1) 94.8 (2) 123.75	0.1365 0.1050	12.94 12.99	13.25

(to be continued)

Table 33 (Continued)

O.D	kinds of vehicle	Existing road					Proposed road			Reduction in vehicle operation cost A-B $/vehicle
		a: distance	b: operating unit cost	a × b	c: ferry charge	A=axb+c	d: distance	b: operating unit cost	B=dxb	
Dacca	P	(1) 109.5 (2) 69.3	0.0433 0.0341	4.74 2.36	3.36	10.46	(1) 38.5 (2) 69.45	0.0433 0.0341	1.67 2.37	6.42
↓	B	(1) 109.5 (2) 69.3	0.1365 0.1050	14.95 7.28	8.40	30.63	(1) 38.5 (2) 69.45	0.1365 0.1050	5.26 7.29	18.08
Madaripur	T	(1) 109.5 (2) 69.3	0.1365 0.1050	14.95 7.28	10.61	32.84	(1) 38.5 (2) 69.45	0.1365 0.1050	5.26 7.29	20.29
Dacca	P	(1) 168.5 (2) 69.3	0.0433 0.0341	7.30 2.36	3.36	13.01	(1) 97.5 (2) 69.45	0.0433 0.0341	4.22 2.37	6.42
↓	B	(1) 168.5 (2) 69.3	0.1365 0.1050	23.00 7.28	8.40	38.68	(1) 97.5 (2) 69.45	0.1365 0.1050	13.31 7.29	18.08
Barisal	T	(1) 168.5 (2) 69.3	0.1365 0.1050	23.00 7.28	10.61	40.89	(1) 97.5 (2) 69.45	0.1365 0.1050	13.31 7.29	20.29

Table 34 Time saving (Case 1)

P: Passenger car — Distance in km
B: Bus — Time in minite
T: Truck — Price in US$

O.D	kind of vehicle	Existing road							Proposed road							time saving A-B $/vehicle
		a: distance	b: speed (km/h)	c: ariving time on road	d: ferry time (min)	c + d	e: time value per minite	A=(c+d)xe	f: distance	g: speed (km/h)	h: driving time on road	i: ferry time (min)	h + i	e: time value per minite	B=(h+i)xe	
Dacca	P	(1) 48.5 (2) 69.3	56.3 64.4	51.7 64.6	150	266.3	0.01323	3.52	(1) 23.5 (2) 66.45	56.3 64.4	25.04 61.91	52.5	139.45	0.01323	1.84	1.68
⌇	B	(1) 48.5 (2) 69.3	32.2 40.2	90.4 103.4	150	343.8	0.04347	14.94	(1) 23.5 (2) 66.45	32.2 40.2	43.79 99.18	52.5	195.47	0.04347	8.50	6.44
Faridpur	T	(1) 48.5 (2) 69.3	48.3 56.3	60.2 73.9	150	284.1	0.02982	8.47	(1) 23.5 (2) 66.45	48.3 56.3	29.19 70.82	52.5	152.51	0.02982	4.55	3.92
Dacca	P	(1) 172.2 (2) 69.3	56.3 64.4	183.5 64.6	165	413.1	0.01323	5.47	(1) 152.8 (2) 66.45	56.3 64.4	162.84 61.91	67.5	292.25	0.01323	3.87	1.60
⌇	B	(1) 172.2 (2) 69.3	32.2 40.2	320.9 103.4	165	589.1	0.04347	25.62	(1) 152.8 (2) 66.45	32.2 40.2	284.72 99.18	67.5	451.40	0.04347	19.62	6.00
Kushtia	T	(1) 172.2 (2) 69.3	48.3 56.3	213.9 73.9	165	452.8	0.02982	13.50	(1) 152.8 (2) 66.45	48.3 56.3	189.81 70.82	67.5	328.13	0.02982	9.78	3.72
Dacca	P	(1) 122.2 (2) 69.3	56.3 64.4	130.2 64.6	165	359.8	0.01323	4.76	(1) 102.8 (2) 66.45	56.3 64.4	109.55 61.91	67.5	238.96	0.01323	3.16	1.60
⌇	B	(1) 122.2 (2) 69.3	32.2 40.2	227.7 103.4	165	496.1	0.04347	21.57	(1) 102.8 (2) 66.45	32.2 40.2	191.55 99.18	67.5	358.23	0.04347	15.57	6.00
Jhenida	T	(1) 122.2 (2) 69.3	48.3 56.3	151.8 73.9	165	390.7	0.02982	11.65	(1) 102.8 (2) 66.45	48.3 56.3	127.70 70.82	67.5	266.02	0.02982	7.93	3.72
Dacca	P	(1) 93.0 (2) 114.1	56.3 64.4	99.11 106.30	150	355.41	0.01323	4.70	(1) 73.6 (2) 111.25	56.3 64.4	78.44 103.65	52.5	234.59	0.01323	3.10	1.60
⌇	B	(1) 93.0 (2) 114.1	32.2 40.2	173.29 170.30	150	493.59	0.04347	21.46	(1) 73.6 (2) 111.25	32.2 56.3	137.14 118.56	52.5	355.68	0.04347	15.46	6.00
Jessore	T	(1) 93.0 (2) 114.1	48.3 56.3	115.53 121.60	150	387.13	0.02982	11.54	(1) 73.6 (2) 111.25	48.3 56.3	91.43 118.56	52.5	262.49	0.02782	7.82	3.72
Dacca	P	(1) 114.2 (2) 123.6	56.3 64.4	121.71 115.16	150	386.87	0.1323	5.12	(1) 94.8 (2) 120.75	56.3 64.4	101.03 112.50	52.5	266.03	0.01323	3.52	1.60
⌇	B	(1) 114.2 (2) 123.6	32.2 40.2	212.79 184.48	150	547.27	0.04347	23.79	(1) 94.8 (2) 120.75	32.2 40.2	176.65 180.22	52.5	409.37	0.04347	17.79	6.00
Khulna	T	(1) 114.2 (2) 123.6	48.3 56.3	141.86 131.72	150	423.58	0.02982	12.63	(1) 94.8 (2) 120.75	48.3 56.3	117.76 128.69	52.5	298.95	0.02982	8.91	3.72

(to be continued)

Table 34 (continued)

O.D	kind of vehicle	Existing road							Proposed road							time saving A-B $/vehicle
		a: distance	b: speed (km/h)	c: ariving time on road	d: ferry time (min)	c + d	e: time value per minite	A=(c+d)xe	f: distance	g: speed (km/h)	h: driving time on road	i: ferry time (min)	h + i	e: time value per minite	B=(h+i)xe	
Dacca	P	(1) 109.5 (2) 69.3	56.3 64.4	116.70 64.6	180	361.3	0.01323	4.78	(1) 38.5 (2) 66.45	56.3 64.4	41.03 61.91	82.5	185.44	0.01323	2.45	2.33
〃	B	(1) 109.5 (2) 69.3	32.2 40.2	204.04 103 5	180	487.54	0.04347	21.19	(1) 38.5 (2) 66.45	32.2 40.2	71.74 99.18	82.5	253.42	0.04347	11.02	10.17
Madaripur	T	(1) 109.5 (2) 69.3	48.3 56.3	136.02 73.9	180	389.92	0.02982	11.63	(1) 38.5 (2) 66.45	48.3 56.3	47.83 70.82	82.5	201.15	0.02982	6.00	5.63
Dacca	P	(1) 168.5 (2) 69.3	56.3 64.4	179.57 64.6	210	454.17	0.01323	6.01	(1) 97.5 (2) 66.45	56.3 64.4	103.91 61.91	112.5	278.32	0.01323	3.68	2.33
〃	B	(1) 168.5 (2) 69.3	32.2 40.2	313.97 103.5	210	627.47	0.04347	27.27	(1) 97.5 (2) 66.45	32.2 40.2	181.68 99.18	112.5	393.36	0.04347	17.10	10.17
Barisal	T	(1) 168.5 (2) 69.3	48.3 56.3	209.32 73.9	210	493.22	0.02982	14.71	(1) 97.5 (2) 66.45	48.3 56.3	121.12 70.82	112.5	304.44	0.02982	9.08	5.63

Table 35 Time saving

P: Passenger car
B: Bus
T: Truck

Distance in km
Time in hour and minute
Price in US$

O.D	kind of vehicle	Existing road							Proposed road					B=(h+i)xe	time saving A-B $/vehicle
		a: distance	b: speed (km/h)	c: ariving time on road	d: ferry time (min)	c + d	e: time value per minite	A=(c+d)xe	f: distance	g: speed (km/h)	h: driving time on road	i: ferry time (min)	e: time value per minite		
Dacca	P	(1) 48.5 (2) 69.3	56.3 64.4	51.7 64.6	150	266.3	0.01323	3.52	(1) 23.5 (2) 69.45	56.3 64.4	25.04 64.70	-	0.01323	1.19	2.33
↓	B	(1) 48.5 (2) 69.3	32.2 40.2	90.4 103.4	150	343.8	0.04347	14.74	(1) 23.5 (2) 69.45	32.2 40.2	43.79 103.66	-	0.04347	6.41	8.53
Faridpur	T	(1) 48.5 (2) 69.3	48.3 56.3	60.2 73.9	150	284.1	0.02982	8.47	(1) 23.5 (2) 69.45	48.3 56.3	29.19 74.01	-	0.02982	3.08	5.39
Dacca	P	(1) 172.2 (2) 69.3	56.3 64.4	183.5 64.6	165	413.1	0.01323	5.47	(1) 152.8 (2) 69.45	56.3 64.4	162.84 64.70	15.0	0.01323	3.21	2.26
↓	B	(1) 172.2 (2) 69.3	32.2 40.2	320.9 103.4	165	589.3	0.04347	25.62	(1) 152.8 (2) 69.45	32.2 40.2	284.72 103.66	15.0	0.04347	17.53	8.09
Kushtia	T	(1) 172.2 (2) 69.3	48.3 56.3	213.9 103.4	165	452.8	0.02982	13.50	(1) 152.8 (2) 69.45	48.3 56.3	189.81 74.01	15.0	0.02982	8.31	5.19
Dacca	P	(1) 122.2 (2) 69.3	56.3 64.4	130.2 64.6	165	359.8	0.01323	4.76	(1) 102.8 (2) 69.45	56.3 64.4	109.55 64.70	15.0	0.01323	2.50	2.26
↓	B	(1) 122.2 (2) 69.3	32.2 40.2	227.7 103.4	165	496.1	0.04347	21.57	(1) 102.8 (2) 69.45	32.2 40.2	191.55 103.66	15.0	0.04347	13.48	8.09
Jhenida	T	(1) 122.2 (2) 69.3	48.3 56.3	151.8 73.9	165	390.7	0.02982	11.65	(1) 102.8 (2) 69.45	48.3 56.3	127.70 74.01	15.0	0.02982	6.46	5.19
Dacca	P	(1) 93.0 (2) 114.1	56.3 64.4	99.11 106.30	150	355.4	0.01323	4.70	(1) 118.4 (2) 69.45	56.3 64.4	78.44 106.44	-	0.01323	2.44	2.26
↓	B	(1) 93.0 (2) 114.1	32.2 40.2	173.29 170.30	150	493.59	0.04347	21.46	(1) 118.4 (2) 69.45	32.2 40.2	137.14 170.52	-	0.04347	13.37	8.09
Jessore	T	(1) 93.0 (2) 114.1	48.3 56.3	115.53 121.60	150	387.13	0.02982	11.54	(1) 118.4 (2) 69.45	48.3 56.3	91.43 121.76	-	0.02982	6.35	5.19
Dacca	P	(1) 114.2 (2) 123.6	56.3 64.4	121.71 115.15	150	386.87	0.01323	5.12	(1) 149.1 (2) 69.45	56.3 64.4	101.03 115.30	-	0.01323	2.86	2.26
↓	B	(1) 114.2 (2) 123.6	32.2 40.2	212.79 184.48	150	547.27	0.04347	23.80	(1) 149.1 (2) 69.45	32.2 40.2	176.65 184.70	-	0.04347	15.71	8.09
Khulna	T	(1) 114.2 (2) 123.6	48.3 56.3	141.86 13.172	150	423.58	0.02982	12.63	(1) 149.1 (2) 69.45	48.3 56.3	117.76 131.88	-	0.02982	7.44	5.19

(to be continued)

Table 35 (continued)

O.D	kind of vehicle	Existing road							Proposed road						time saving A-B $/vehicle
		a: distance	b: speed (km/h)	c: ariving time on road	d: ferry time (min)	c + d	e: time value per minite	A=(c+d)xe	f: distance	g: speed (km/h)	h: driving time on road	i: ferry time (min)	e: time value per minite	B=(h+i)	
Dacca	P	(1) 109.5 (2) 69.3	56.3 64.4	116.70 64.6	180	361.3	0.03123	4.78	(1) 38.5 (2) 69.45	56.3 64.4	41.03 64.70	30.0	0.01323	1.80	2.98
|	B	(1) 109.5 (2) 69.3	32.2 40.2	204.04 103.5	180	487.54	0.04347	21.19	(1) 38.5 (2) 69.45	32.2 40.2	71.74 103.66	30.0	0.04347	8.93	12.26
Madaripur	T	(1) 109.5 (2) 69.3	48.3 56.3	136.02 73.9	180	389.92	0.02982	1.63	(1) 38.5 (2) 69.45	48.3 56.3	47.83 74.01	30.0	0.02982	4.53	7.10
Dacca	P	(1) 168.3 (2) 69.3	56.3 64.4	179.57 64.6	210	454.17	0.03123	6.01	(1) 97.5 (2) 69.45	56.3 64.4	103.91 64.	60.0	0.01323	3.03	2.98
|	B	(1) 168.3 (2) 69.3	32.2 40.2	313.97 103.5	210	627.47	0.04347	27.27	(1) 97.5 (2) 69.45	32.2 40.2	181.69 103.66	60.0	0.04347	5.01	12.26
Barisal	T	(1) 168.3 (2) 69.3	48.3 56.3	209.32 73.9	210	493.22	0.02982	14.71	(1) 97.5 (2) 69.45	48.3 56.3	121.11 74.01	60.00	0.02982	7.61	7.10

Appendix 5. Data list

Table 36. *Materials and data collected*

1. - Dacca southwest project report; p.c.; Nov. 1969

2. - Flood protection phase of Faridpur unit report: p.c.: Nov. 1969

3. - Feasibility studies of Buriganga bridge, Dacca-Faridpur road and Faridpur-Khulna road (Phase - I); p.c.; Oct. 1969

4. - North south road from the existing railway track upto river Buriganga; p.c.

5. - Preliminary report on limestone, coal, and glass sand, Lamakata-Bhangarghat area, Sylhet district, East Pakistan; F. H. Khan; Apr. 1963

6. - Peat deposit of Kola Mouza, Khulna; M. A. Zaher; Oct. 1962

7. - *Investigation of peat in the Faridpur district; F. H. Khan; June 1957*

8. - Geological map of Pakistan; 1964

9. - Origin and destination traffic flow map; Dec. 1968

10. - Statistical Digest of East Pakistan No. 5: 1968
East Pakistan Bureau of Statistics

11. - Economic Survey of East Pakistan 1968 - 69
Government of East Pakistan, Planning Department

12. - *Annual Plan for East Pakistan for 1969 - 70*
Government of East Pakistan, Planning Department

13. - A Manual for the Economic Appraisal of Transport Projects, Jun. 1969
Government of East Pakistan, Planning Commission

14. - Annual Traffic Report 1966 - 67
EPIWTA Director of Ports & Traffic

15. - Time Table and Guide - 16
EPIWTA

16. - Time Table and Guide - 19 E.P. IWTA

17. - Pakistan Year Book 1969
National Publishing House Limited

18. - Average Daily Passenger Car Equivalents Dec. 1968
Roads & Highways Directorate

19. - Origin & Destination

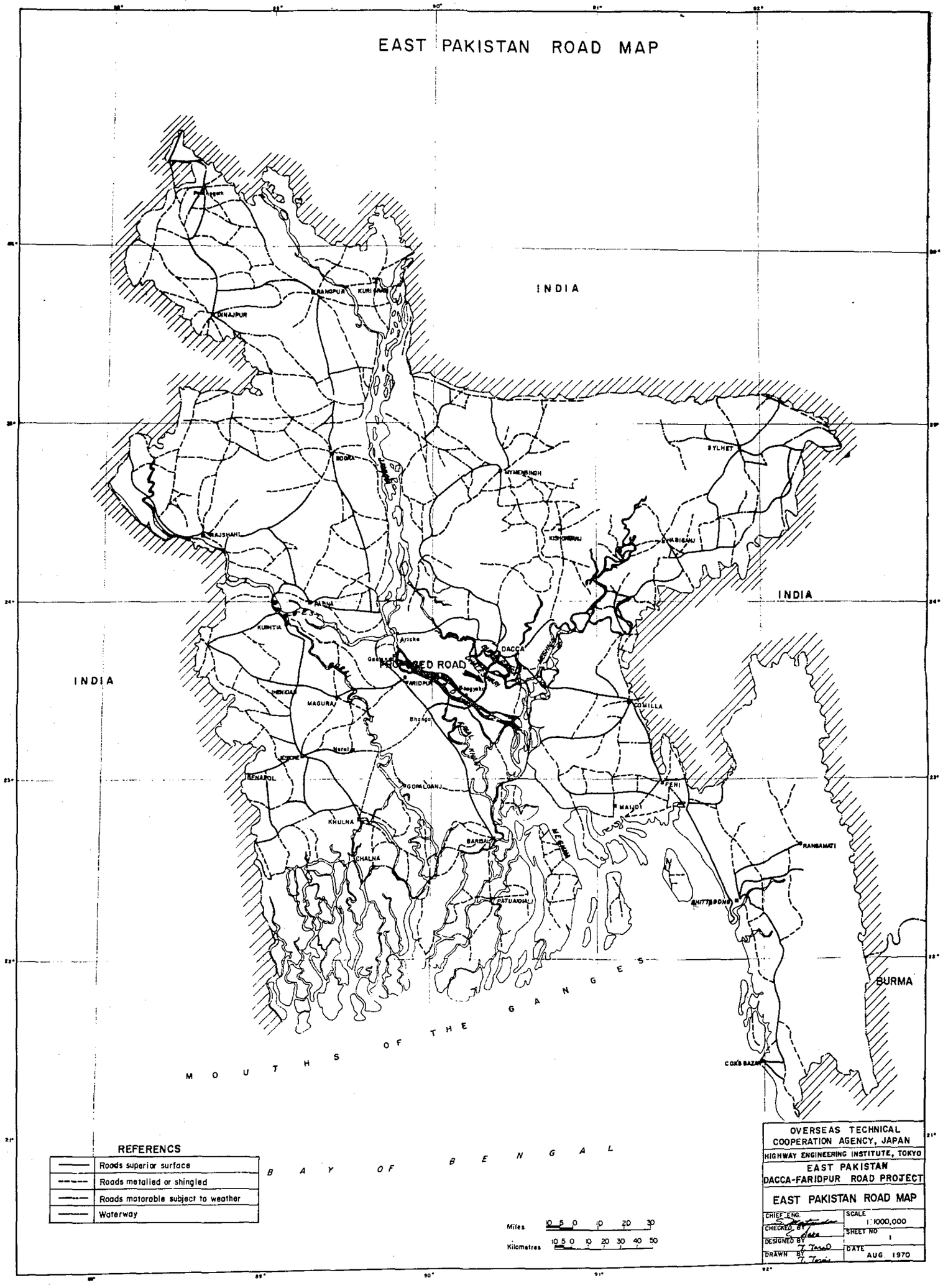
20. - Classification of Waterways in East Pakistan
EPIWTA

21. - Map showing Minimum Vertical and Horizontal Clearances Across Different Waterways
EPIWTA

22. - Statement of Passengers and Vehicular Traffic carried over the Aricha-Goalundo Ferry Service
East Pakistan Shipping Corporation

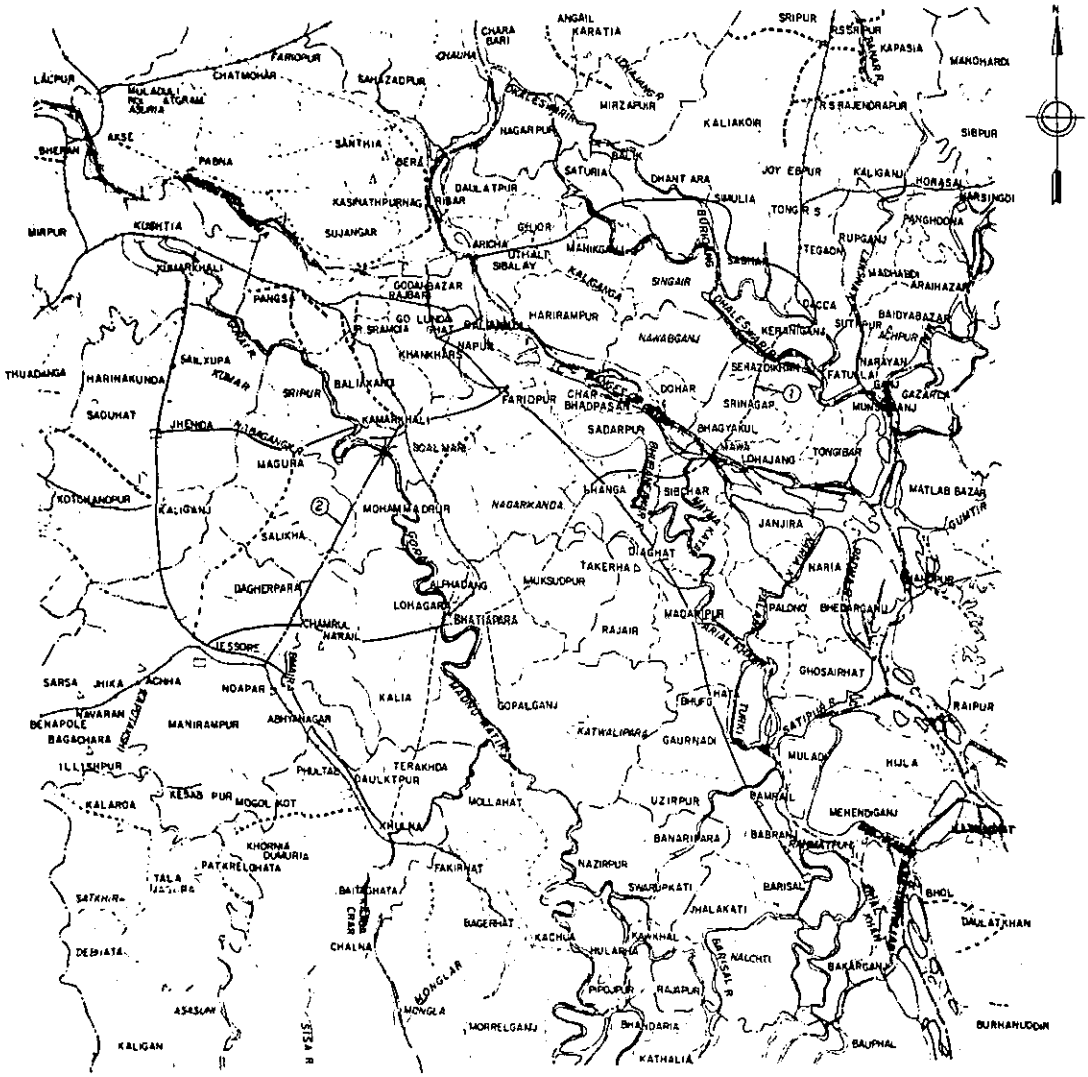
PART III. DRAWINGS

EAST PAKISTAN ROAD MAP



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
EAST PAKISTAN ROAD MAP	
CHIEF ENG.	SCALE 1:1000,000
CHECKED BY	SHEET NO 1
DESIGNED BY T. Terao	DATE AUG 1970
DRAWN BY T. Terao	

ROUTE LOCATION MAP FOR PROJECT AREA



REFERENCES

- Existing road
- Proposed road
- Future road
- ① Dacca - Faridpur road
- ② Jessore - Madhumati road

Miles: 10 5 0 10 20
Kilometres: 0 10 20 30 40

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT
ROUTE LOCATION MAP FOR PROJECT AREA
CHIEF ENG. — SCALE 1 : 500,000
CHECKED BY — SHEET NO 2
DESIGNED BY — DATE AUG 1970
DRAWN BY

GEOLOGICAL MAP OF EAST PAKISTAN

Stream deposits
Streambed, meander-belt, *flood-plain, and low-level terrace deposits*, undivided, Qm; includes some swamp deposits Swamp deposits, Qsw

Coastal deposits
Beach-sand and sandbar deposits, Qb. Tidal mudflat deposits, Qtf

Deltaic and tidal deposits
Deltaic flood-plain deposits, Qd. Tidal delta-marsh deposits and deltaic flood-plain deposits, undivided, Qt. Qd and Qt are separated primarily on the basis of differences in land use, vegetation, and drainage pattern, as distinguished on aerial photographs

Piedmont deposits
Detrital material derived from the highlands of India and Burma and deposited on gentle slopes to the south and west

Interstream deposits
Silt, sand and gravel deposits at a slightly higher altitude than adjacent *flood-plain and low-level terrace deposits*

Older alluvial deposits
Madhupur Clay**: mostly red and orange clay deposits at a slightly higher altitude than *interstream deposits (Qia) and having an incised dendritic* drainage pattern; generally not subject to seasonal flooding. Possibly equivalent to the Dupi Tila formation*

Pleistocene and Pliocene sedimentary rocks
Dihing formation* and Dupi Tila formation*, the latter of possible late Miocene age; undivided: ferruginous sandstone, sandy clay, and pebble beds; some lignite beds in the lower part; thickness up to 2000 feet Possibly equivalent to upper part of the Siwalik Group of West Pakistan

Miocene sedimentary rocks
Tipam sandstone*, *including the Girujan clay*†; Tm: yellowish-brown, medium- to coarse-grained ferruginous sandstone, and mottled clay and sandy clay; thickness up to 3000 feet. Surma group¶, Tms: greyish-yellow, medium-grained and cross-bedded sandstone, grey sandy shale, grey shale, and grey siltstone; thickness up to 10,000 feet

Eocene sedimentary rocks
Sylhet limestone*: grey, medium-grained, hard, massive limestone; very fossiliferous; includes the Tura sandstone*; thickness up to 3000 feet

INDIA

REPROPOSED ROAD

INDIA

BURMA

B A Y O F B E N G A L

M O U T H S O F T H E G A N G E S

CORRELATION SECTION OF THE EAST PAKISTAN BASIN

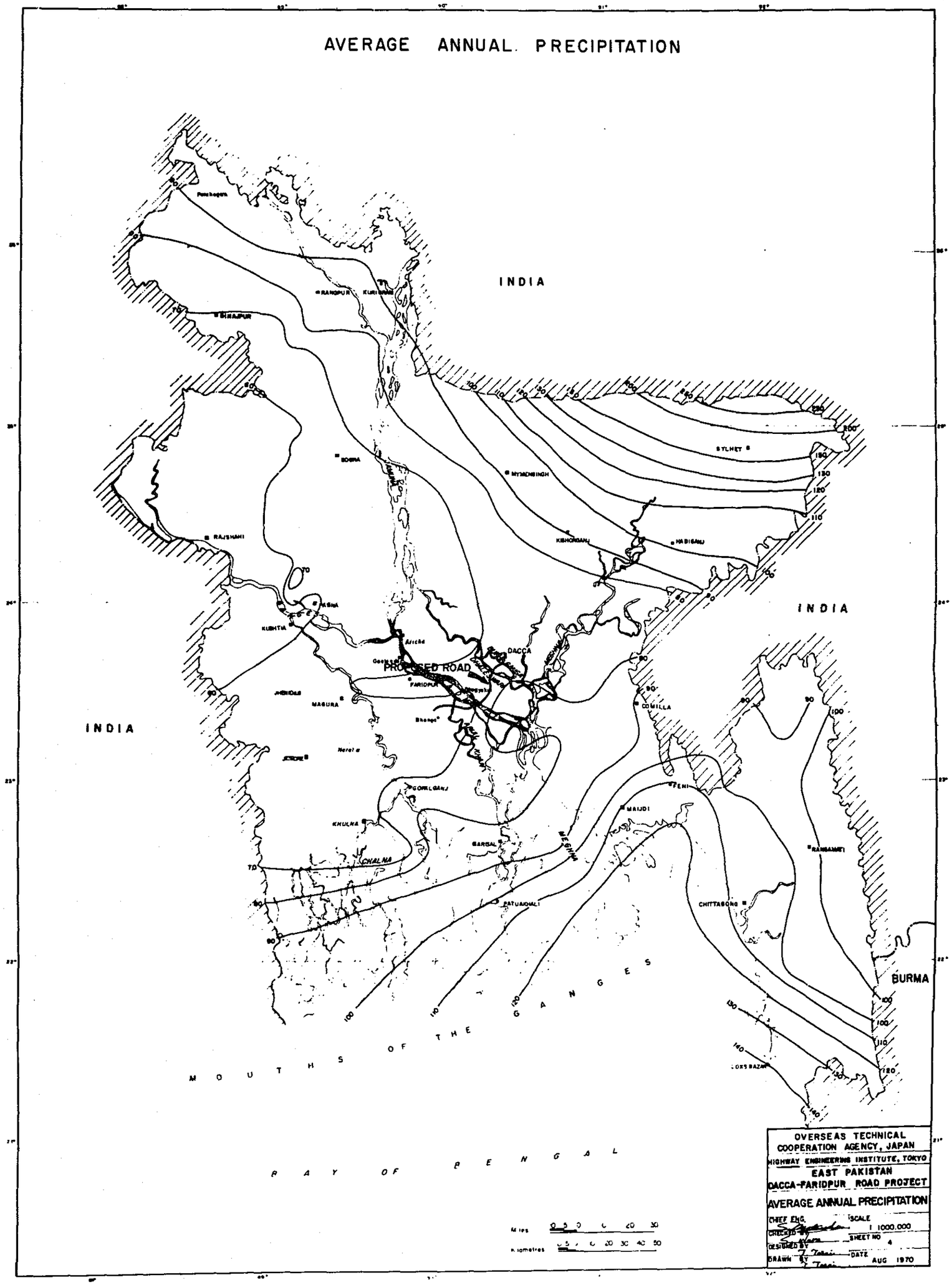
FEET 0 5 000 10 000 15 000

Miles 10 5 0 10 20 30

Kilometres 10 5 0 10 20 30 40 50

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT
GEOLOGICAL MAP OF EAST PAKISTAN

CHIEF ENG.	SCALE 1 1000,000
CHECKED BY	SHEET NO 3
DESIGNED BY	
DRAWN	DATE AUG. 1970

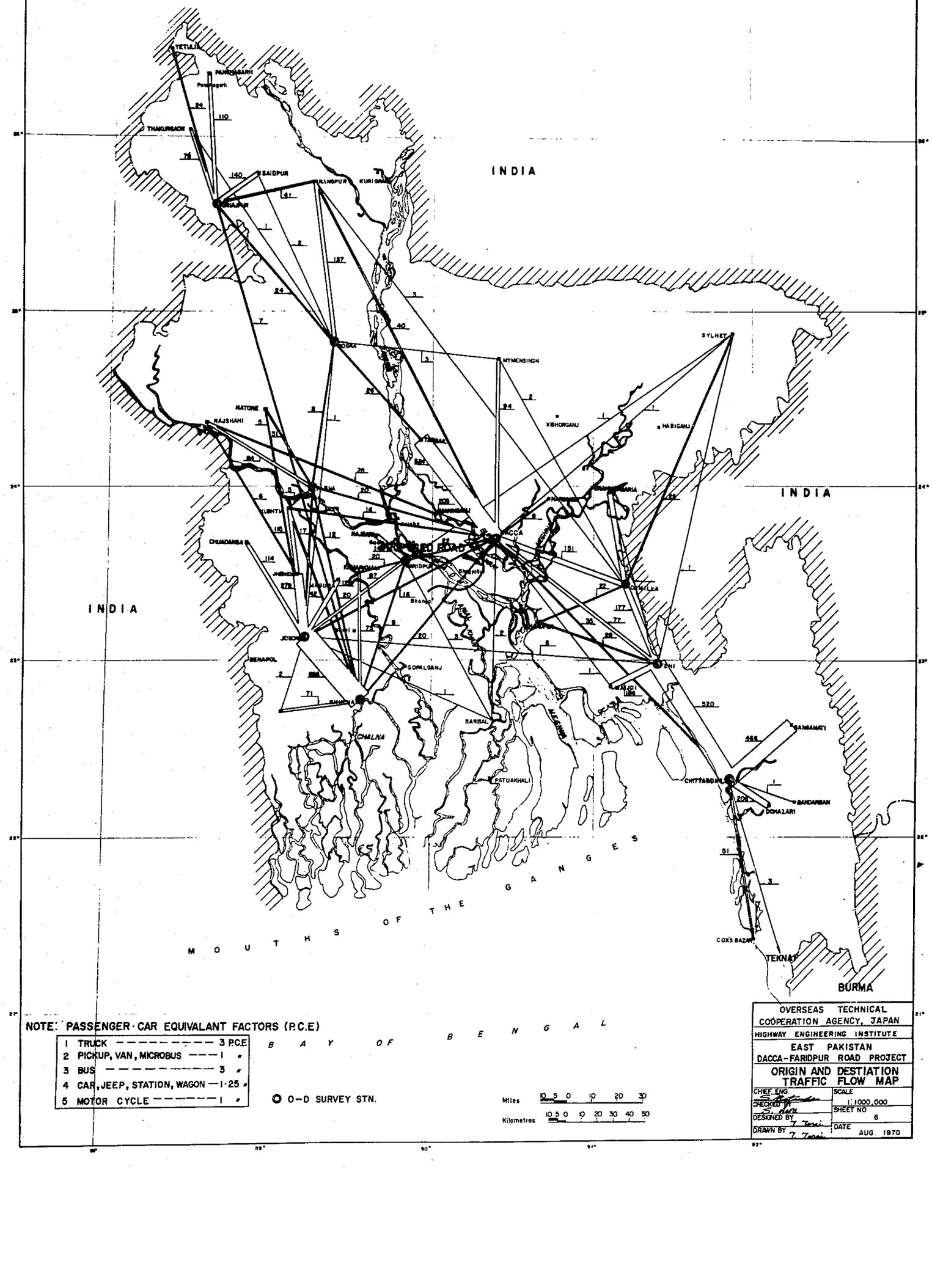

AVERAGE ANNUAL PRECIPITATION
INDIA
INDIA
INDIA
BURMA
RANGPUR
KURIGRAM
BINAJPUR
BOGRA
RAJSHAHI
KUSHTIA
PABNA
MAGURA
JHENIDAH
JESSORE
KHULNA
CHALNA
GOPALGANJ
BARISAL
PATUAKHALI
MEGHNA
DACCA
FARIDPUR
PROPOSED ROAD
MYMENSINGH
KISHORGANJ
HABIGANJ
SYLHET
COMILLA
FENI
MAIJDI
RANGAMATI
CHITTAGONG
COXS BAZAR
MOUTHS OF THE GANGES
BAY OF BENGAL
Miles
Kilometres
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT
AVERAGE ANNUAL PRECIPITATION
CHIEF ENG.
CHECKED BY
DESIGNED BY
DRAWN BY
SCALE 1:1000,000
SHEET NO 4
DATE AUG 1970

FARIDPUR
PROPOSED ROAD
KHULNA
BARISAL
Ganges Barrage
LEGEND
PROJECTS COMPLETED
PROJECTS FEASIBILITY STUDY COMPLETED
PROJECT FEASIBILITY STUDY IN PROGRESS
PROJECTS FEASIBILITY STUDY PROPOSED
PROJECTS UNDER CONSTRUCTION
NAME OF PROJECT
ACRES MILLIONS
A DACCA SOUTHWEST PROJECT 593 21 582 13
B H SURESWAR PROJECT 180 00 15 04
C COMPREHENSIVE DRAINAGE SCHEME 366 04 38 82
D G K PROJECT (JESSORE UNIT PHASE II)
E F SMALL ELECTRIC PUMP IRRIGATION PROJECT (14 UNITS) 21 90 82 47
G FARIDPUR-BARISAL PROJECT (FARIDPUR UNIT)
I FARIDPUR-BARISAL PROJECT (BARISAL UNIT PHASE I)
J SAFLA BOGDA PROJECT 48 63 77 00
K COASTAL EMBANKMENT PROJECT PHASE II
Miles
Kilometers
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT
POLDER PROJECT FOR ROAD PROJECT AREA
CHIEF ENG
CHECKED BY
DESIGNED BY
DRAWN BY
SCALE 1 : 500,000
SHEET NO 5
DATE AUG 1970

ORIGIN AND DESTINATION TRAFFIC FLOW. MAP

ON R & H ROADS IN EAST PAKISTAN

DEC. 1968



NOTE: PASSENGER CAR EQUIVALANT FACTORS (P.C.E)

1	TRUCK	3 P.C.E
2	PICKUP, VAN, MICROBUS	1 "
3	BUS	3 "
4	CAR, JEEP, STATION, WAGON	1·25 "
5	MOTOR CYCLE	1 "

O O-D SURVEY STN.

Miles 10 5 0 10 20 30

Kilometres 10 5 0 10 20 30 40 50

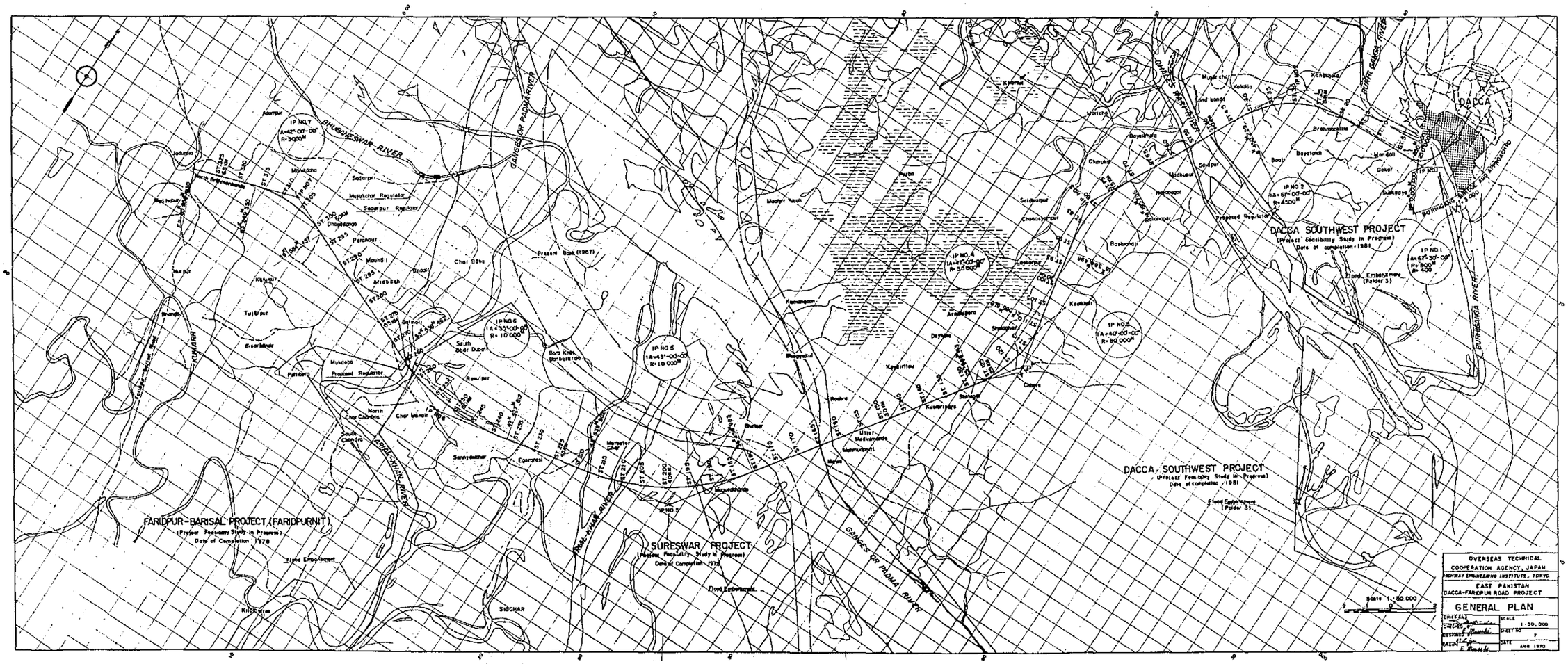
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

HIGHWAY ENGINEERING INSTITUTE

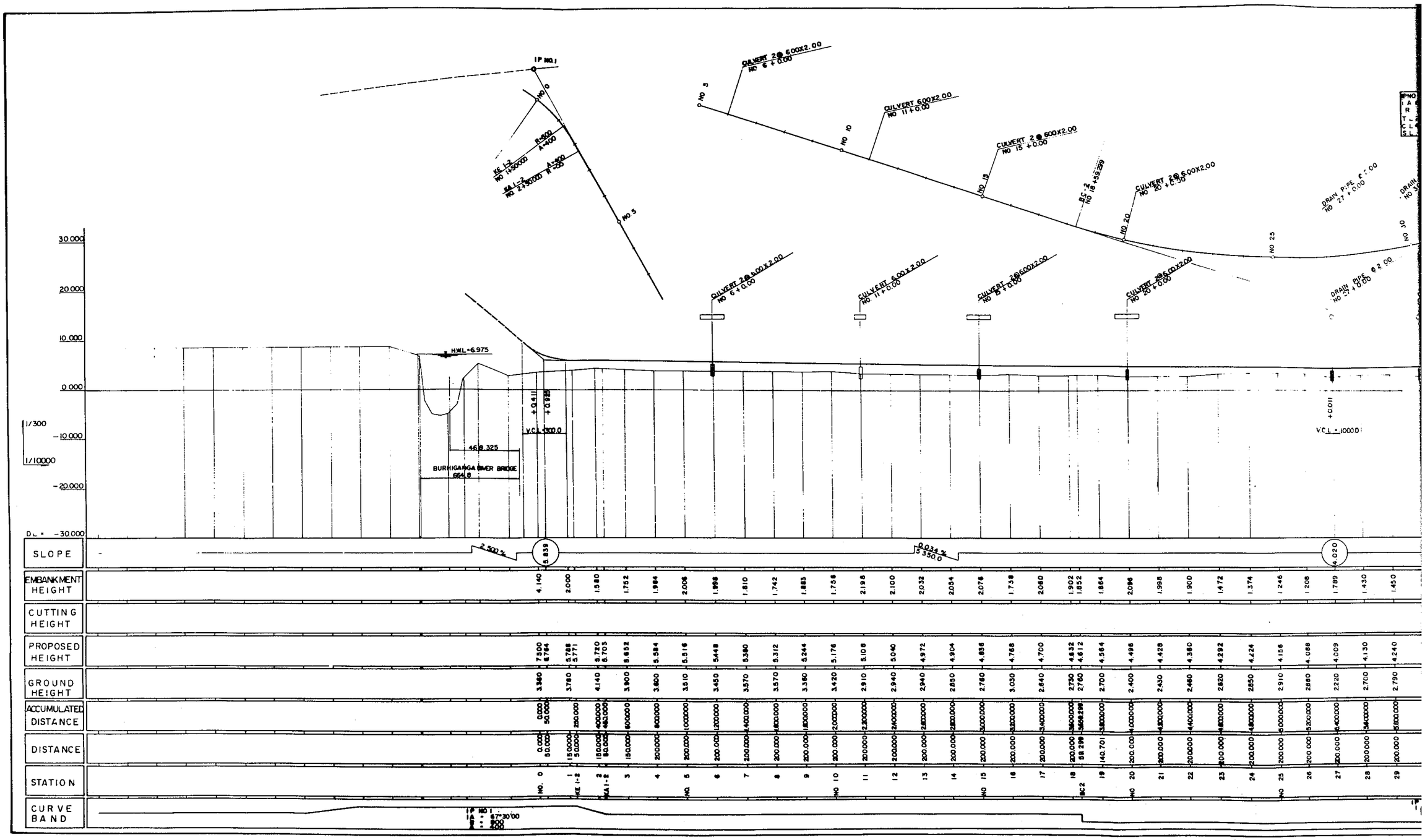
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT

ORIGIN AND DESTIATION TRAFFIC FLOW MAP

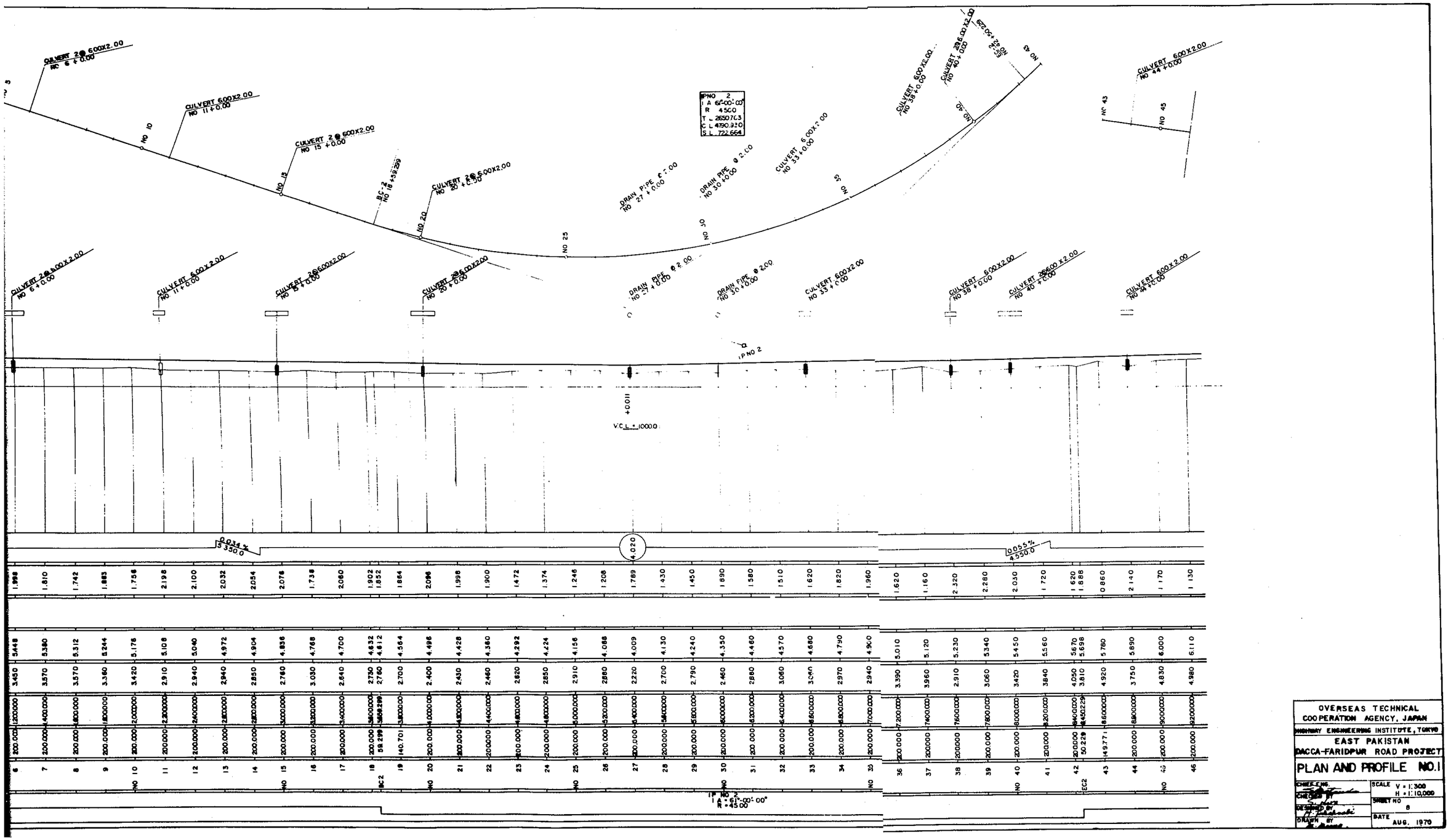
CHIEF ENG.	SCALE 1:1000,000
CHECKED BY	SHEET NO 6
DESIGNED BY T. Terai	DATE AUG. 1970
DRAWN BY T. Terai	



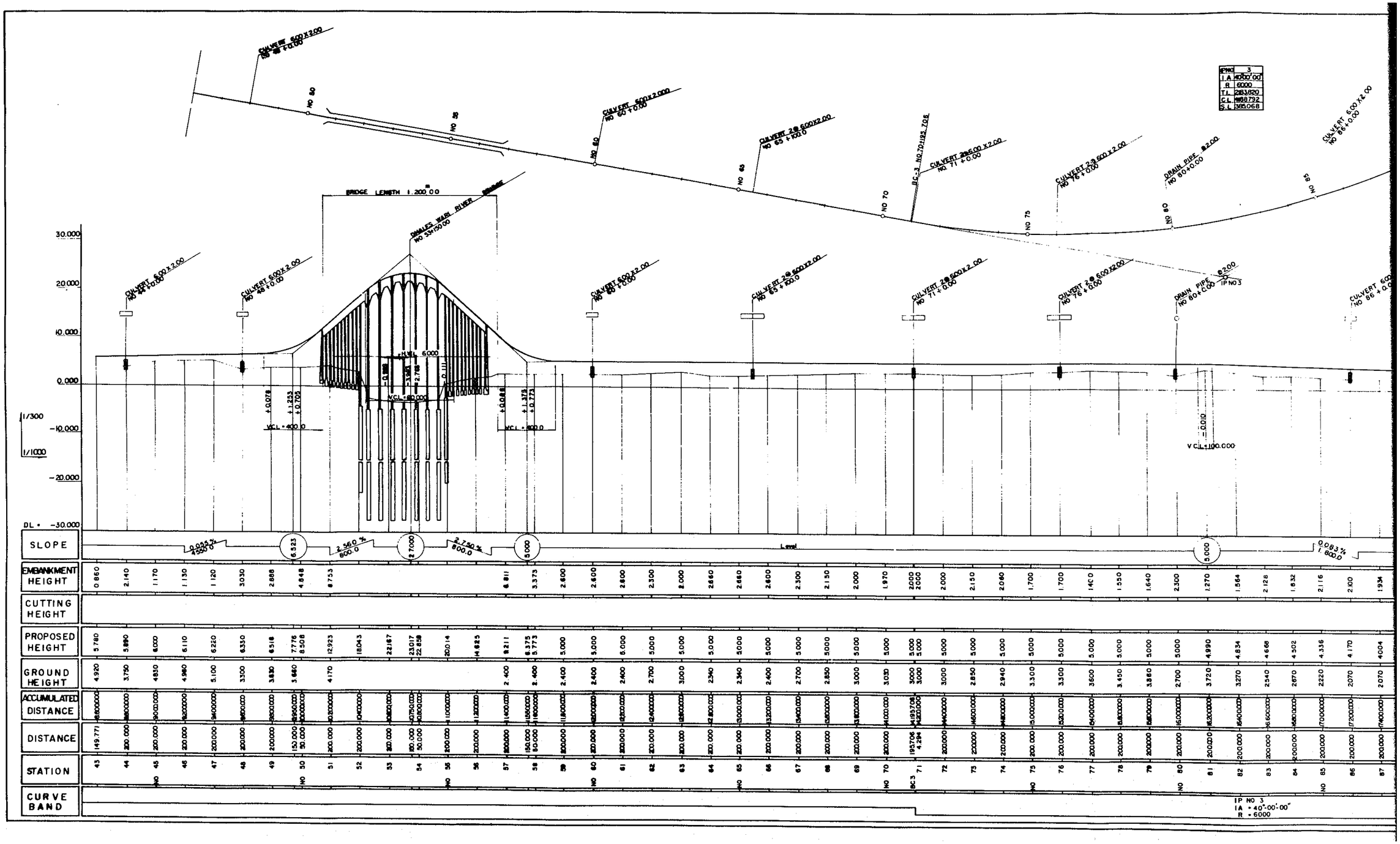
DACCA
DACCA SOUTHWEST PROJECT
(Project Feasibility Study in Progress)
Date of completion 1981
DACCA SOUTHWEST PROJECT
(Project Feasibility Study in Progress)
Date of completion 1981
FARIDPUR-BARISAL PROJECT (FARIDPURNIT)
(Project Feasibility Study in Progress)
Date of Completion 1978
SURESWAR PROJECT
(Project Feasibility Study in Progress)
Date of Completion 1978
BHUBANESWAR RIVER
GANGES OR PADMA RIVER
BURHIGANGA RIVER
KUMARR
ARIAL-KHAN RIVER
IP NO.1
IP NO.2
IP NO.3
IP NO.4
IP NO.5
IP NO.6
IP NO.7
Scale 1:50 000
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT
GENERAL PLAN
SCALE 1:50,000
SHEET NO 7
DATE AUG 1970



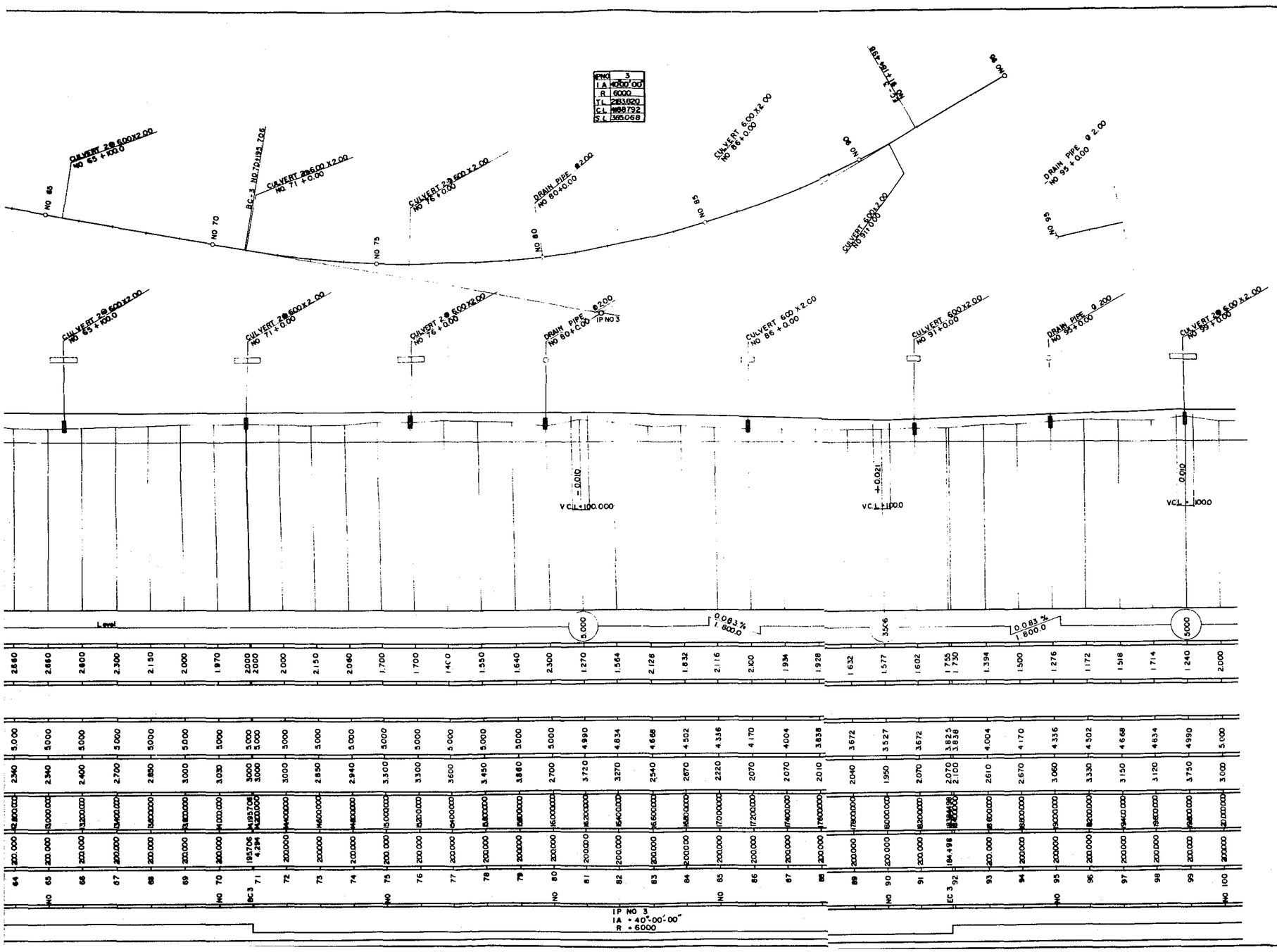
IP NO.1
CULVERT 2@ 6.00X2.00
NO 6 + 0.00
CULVERT 6.00X2.00
NO 11 + 0.00
CULVERT 2@ 6.00X2.00
NO 15 + 0.00
CULVERT 2@ 6.00X2.00
NO 20 + 0.00
DRAIN PIPE
NO 27 + 0.00
H.W.L.=6.975
V.C.L.=300.0
V.C.L.=1000.0
BURHIGANGA RIVER BRIDGE
664.8
1/300
1/10000
30.000
20.000
10.000
0.000
-10.000
-20.000
DL = -30.000
SLOPE
2.500 %
5.839
0.034 %
5350.0
4.020
EMBANKMENT HEIGHT
CUTTING HEIGHT
PROPOSED HEIGHT
GROUND HEIGHT
ACCUMULATED DISTANCE
DISTANCE
STATION
CURVE BAND
IP NO 1
IA = 67°30'00



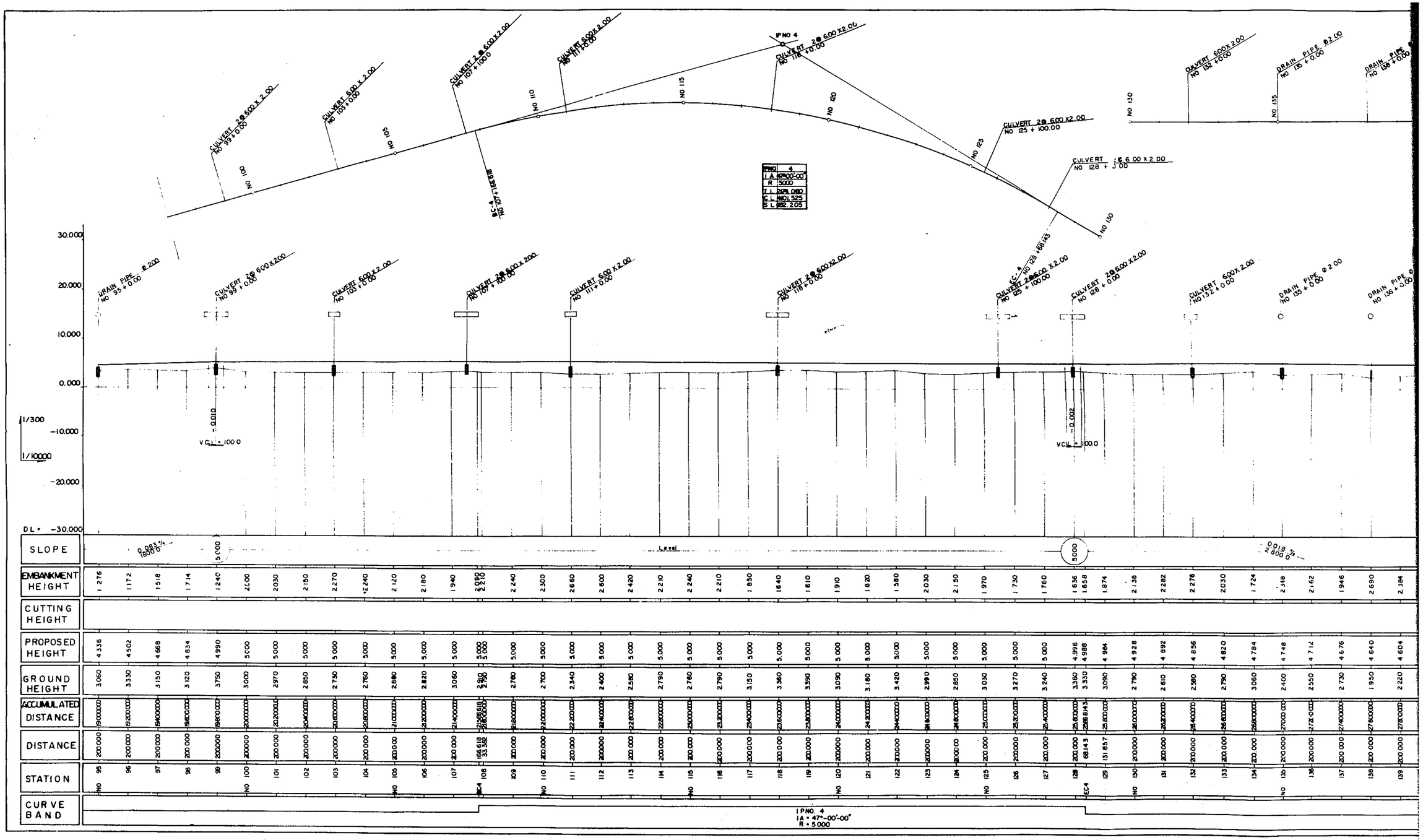
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
PLAN AND PROFILE NO.1	
CHIEF ENG.	SCALE V = 1:300 H = 1:10,000
CHECKED BY	SHEET NO 8
DESIGNED BY	DATE AUG. 1970
DRAWN BY	



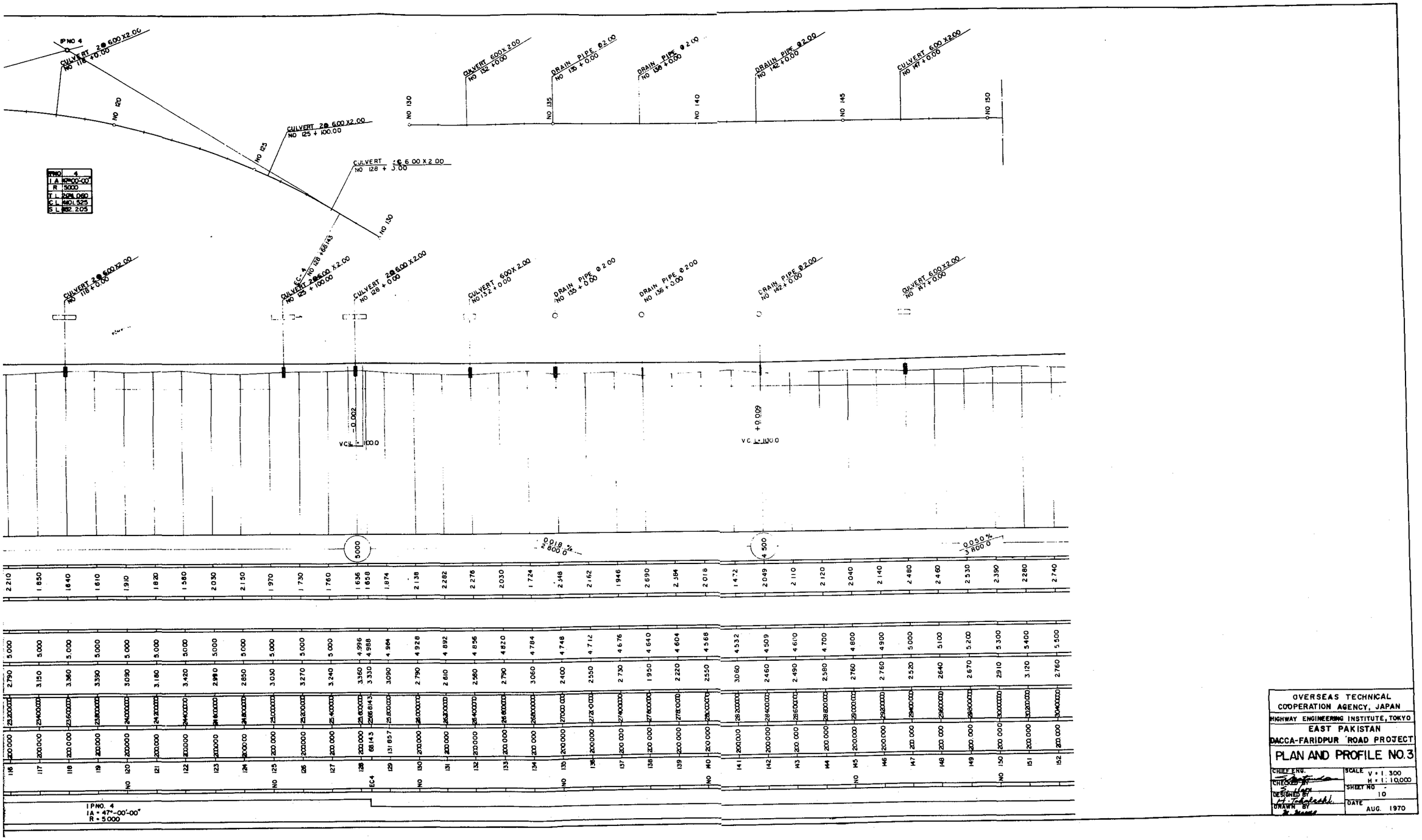
IP NO 3
I.A 40°00'00"
R 6000
T.L 283820
C.L 488792
S.L 385068
BRIDGE LENGTH 1.200 00 m
DHALES WARI RIVER
NO 53+150.00
CULVERT 6.00 X 2.00
NO 44 + 0.00
CULVERT 6.00 X 2.00
NO 48 + 0.00
CULVERT 6.00 X 2.00
NO 60 + 0.00
CULVERT 2@ 6.00 X 2.00
NO 65 + 100.0
CULVERT 2@ 6.00 X 2.00
NO 71 + 0.00
CULVERT 2@ 6.00 X 2.00
NO 76 + 0.00
DRAIN PIPE @ 2.00
NO 80 + 0.00
CULVERT 6.00 X 2.00
NO 86 + 0.00
DRAIN PIPE @ 2.00
NO 80 + 0.00
IP NO 3
H.W.L 6.000
V.C.L = 60.000
V.C.L = 400.0
V.C.L = 100.000
1/300
1/1000
DL = -30.000
SLOPE
0.055 % 4550.0
6.523
2.560 % 800.0
27.000
2.750 % 800.0
5.000
Level
5.000
0.083 % 1.800.0
EMBANKMENT HEIGHT
CUTTING HEIGHT
PROPOSED HEIGHT
GROUND HEIGHT
ACCUMULATED DISTANCE
DISTANCE
STATION
CURVE BAND
IP NO 3
IA = 40°-00'-00"
R = 6000



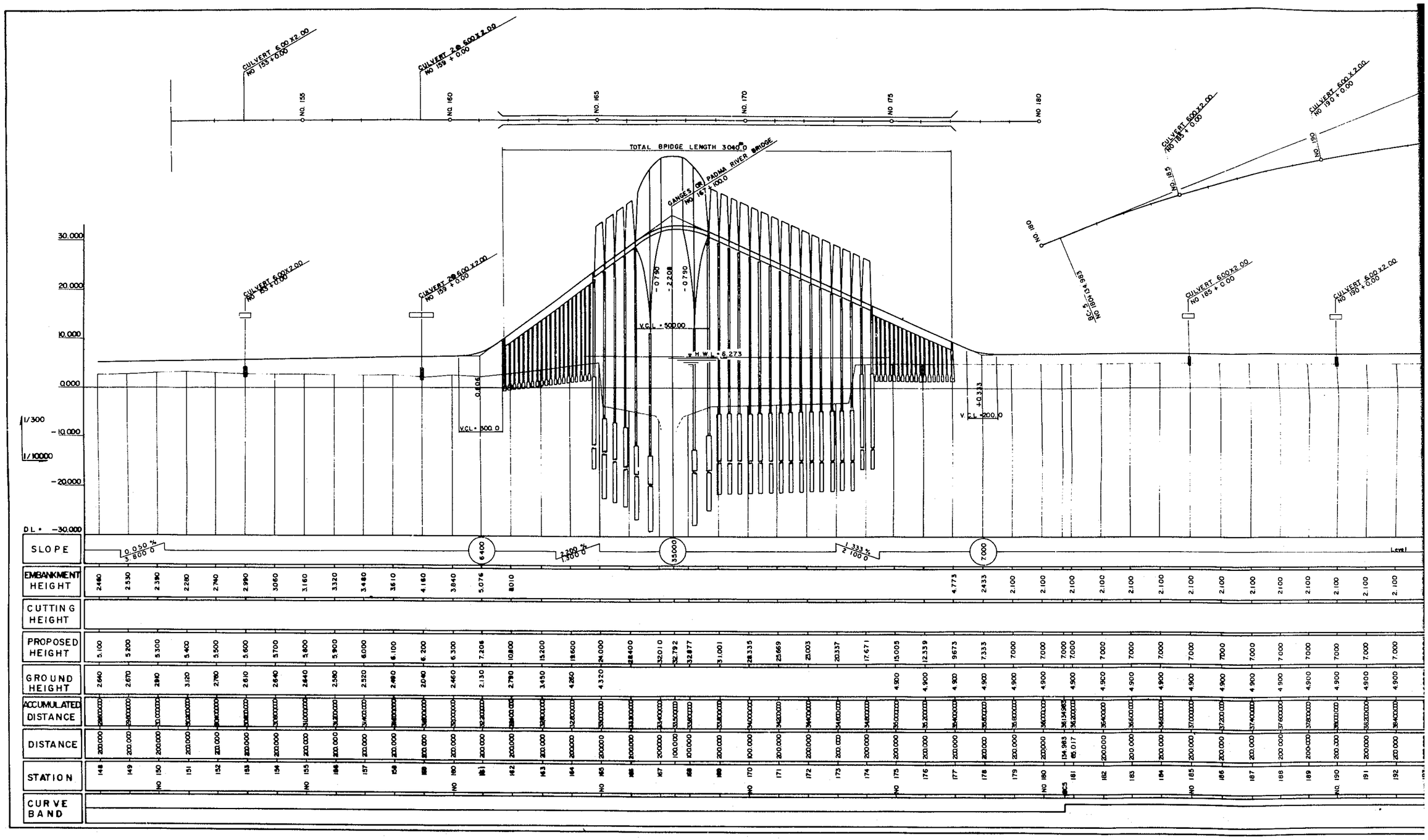
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
PLAN AND PLOFILE NO.2	
CHIEF ENG.	SCALE V = 1: 300 H = 1: 10,000
CHECKED BY	SHEET NO 9
DESIGNED BY	DATE AUG 1970
DRAWN BY	



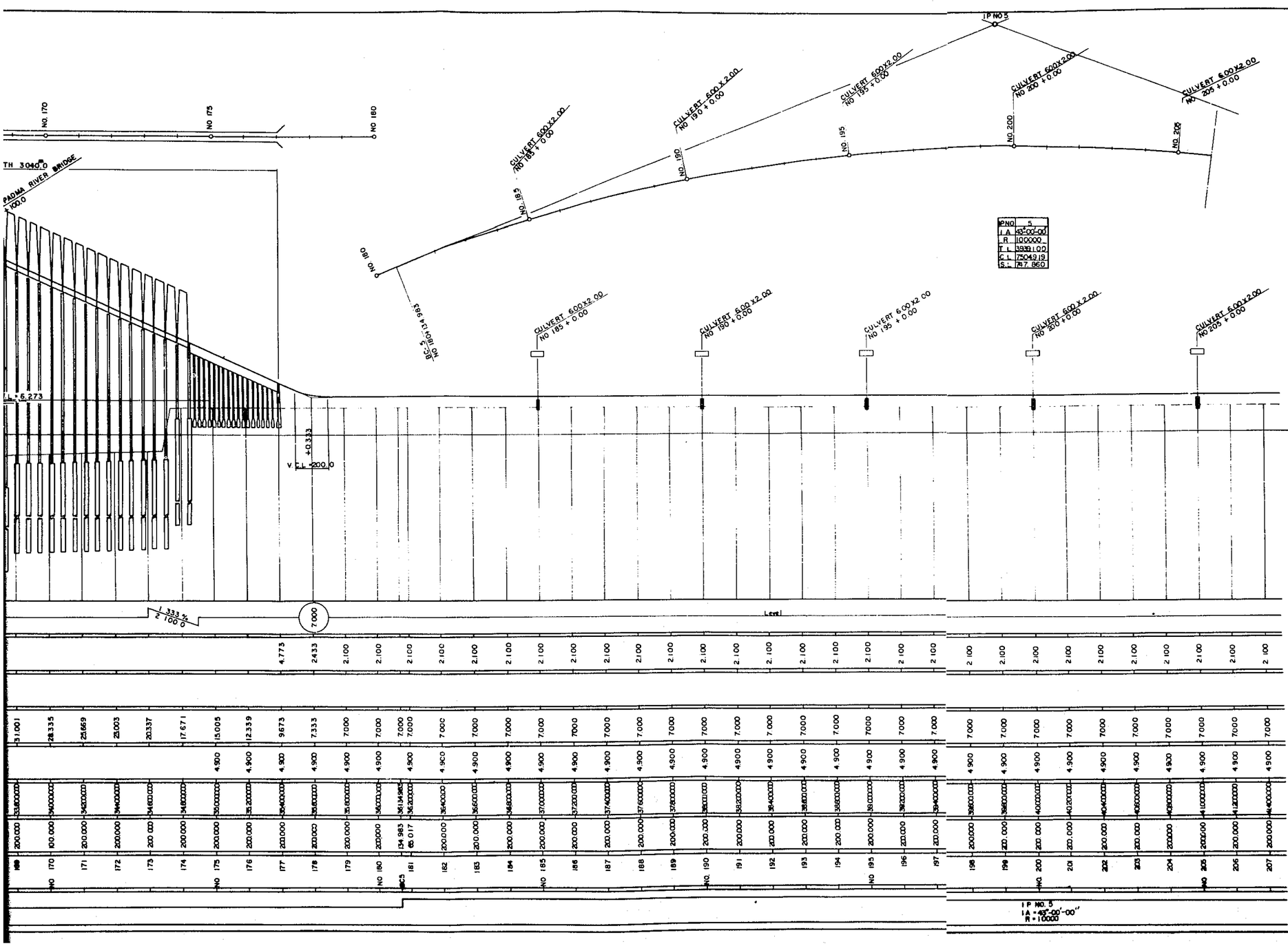
IP NO 4
IA 47°00'00"
R 5000
T L 2291.080
C L 4401.525
S L 882.205
CULVERT 2@ 6.00 X 2.00 NO 99 + 0.00
CULVERT 6.00 X 2.00 NO 103 + 0.00
CULVERT 2@ 6.00 X 2.00 NO 107 + 100.0
CULVERT 6.00 X 2.00 NO 111 + 0.00
CULVERT 2@ 6.00 X 2.00 NO 118 + 0.00
CULVERT 2@ 6.00 X 2.00 NO 125 + 100.00
CULVERT 2@ 6.00 X 2.00 NO 128 + 0.00
CULVERT 6.00 X 2.00 NO 132 + 0.00
DRAIN PIPE @ 2.00 NO 135 + 0.00
DRAIN PIPE @ 2.00 NO 136 + 0.00
NO 100
NO 105
NO 110
NO 115
NO 120
NO 125
NO 130
NO 135
30.000
20.000
10.000
0.000
-10.000
-20.000
DL = -30.000
1/300
1/10000
-0.010
VCL = 100.0
-0.002
VCL = 100.0
SLOPE
0.083 % 1800.0
5000
Level
5000
0.018 % 2800.0
EMBANKMENT HEIGHT
CUTTING HEIGHT
PROPOSED HEIGHT
GROUND HEIGHT
ACCUMULATED DISTANCE
DISTANCE
STATION
CURVE BAND
IP NO. 4
IA = 47°-00'-00"
R = 5000



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN	
DACCA-FARIDPUR ROAD PROJECT	
PLAN AND PROFILE NO.3	
CHIEF ENG.	SCALE V = 1:300 H = 1:10,000
CHECKED BY	SHEET NO 10
DESIGNED BY	DATE AUG. 1970
DRAWN BY	



CULVERT 6.00 X 2.00 NO 153 + 0.00
CULVERT 2 @ 6.00 X 2.00 NO 159 + 0.00
NO. 155
NO. 160
NO. 165
NO. 170
NO. 175
NO. 180
TOTAL BRIDGE LENGTH 3040.0
GANGES OR PADMA RIVER BRIDGE NO 167 + 100.0
CULVERT 6.00 X 2.00 NO 183 + 0.00
CULVERT 6.00 X 2.00 NO 190 + 0.00
NO. 185
NO. 190
BC-5 NO 180+134.983
V.C.L. = 500.00
H.W.L. = 6.273
V.C.L. = 300.0
V.C.L. = 200.0
30.000
20.000
10.000
0.000
-10.000
-20.000
DL = -30.000
1/300
1/10000
SLOPE
0.050 % 3.800 0
6400
2.200 % 1.300 0
35000
1.333 % 2.100 0
7000
Level
EMBANKMENT HEIGHT
CUTTING HEIGHT
PROPOSED HEIGHT
GROUND HEIGHT
ACCUMULATED DISTANCE
DISTANCE
STATION
CURVE BAND



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

HIGHWAY ENGINEERING INSTITUTE, TOKYO

EAST PAKISTAN

DACCA-FARIDPUR ROAD PROJECT

PLAN AND PROFILE NO.4

CHIEF ENG.

CHECKED BY

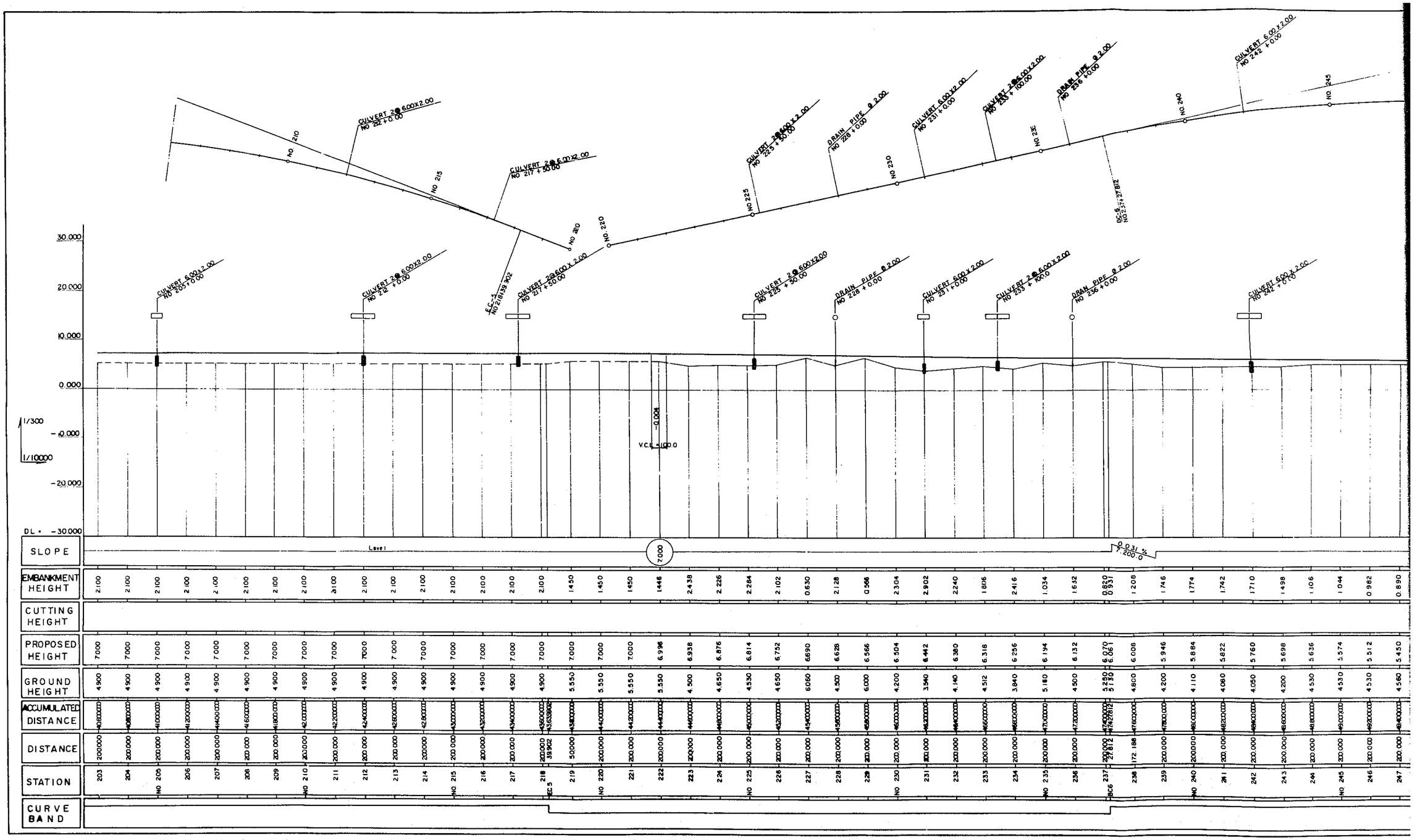
DESIGNED BY

DRAWN BY

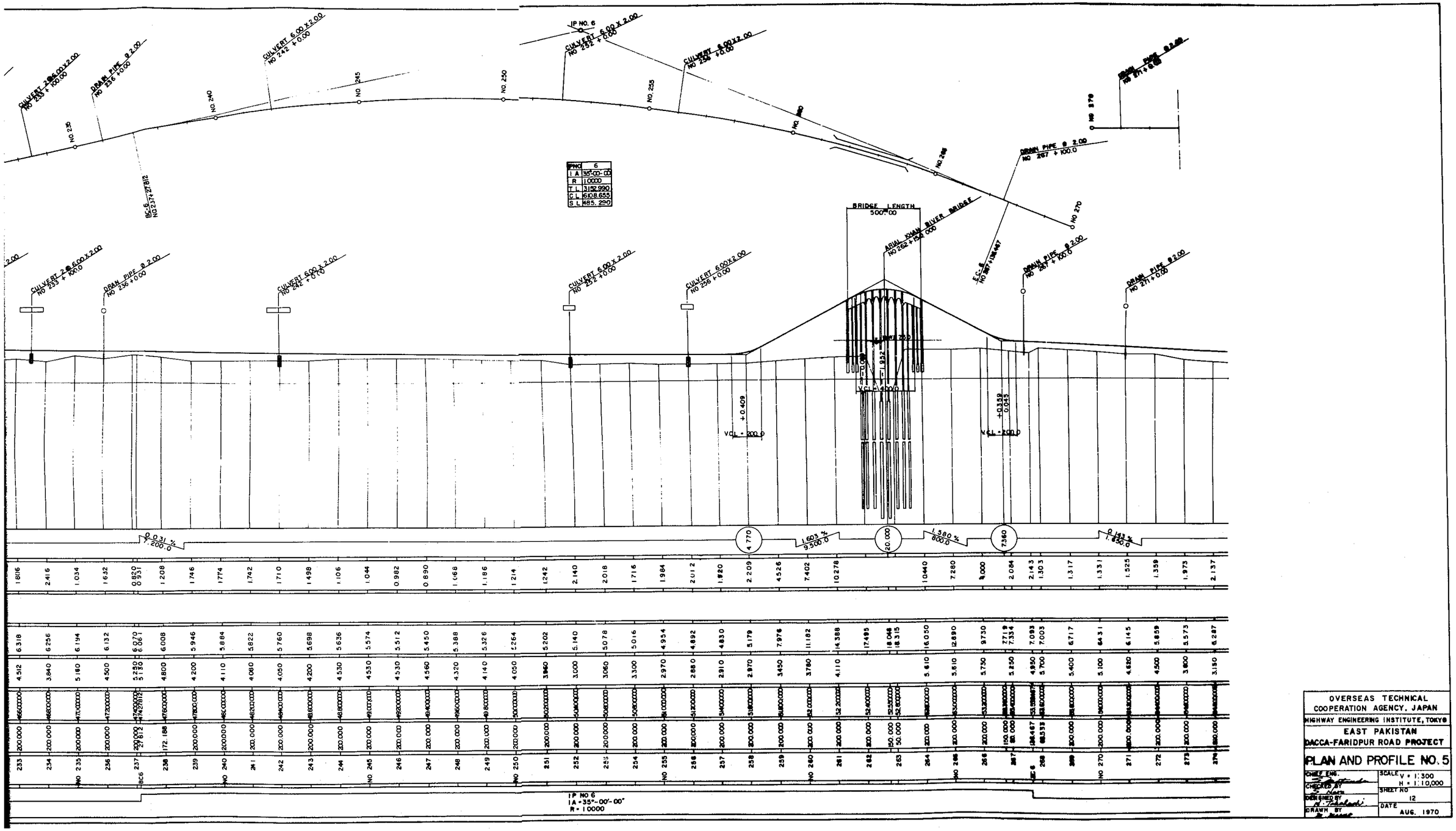
SCALE V = 1:300
H = 1:10,000

SHEET NO 11

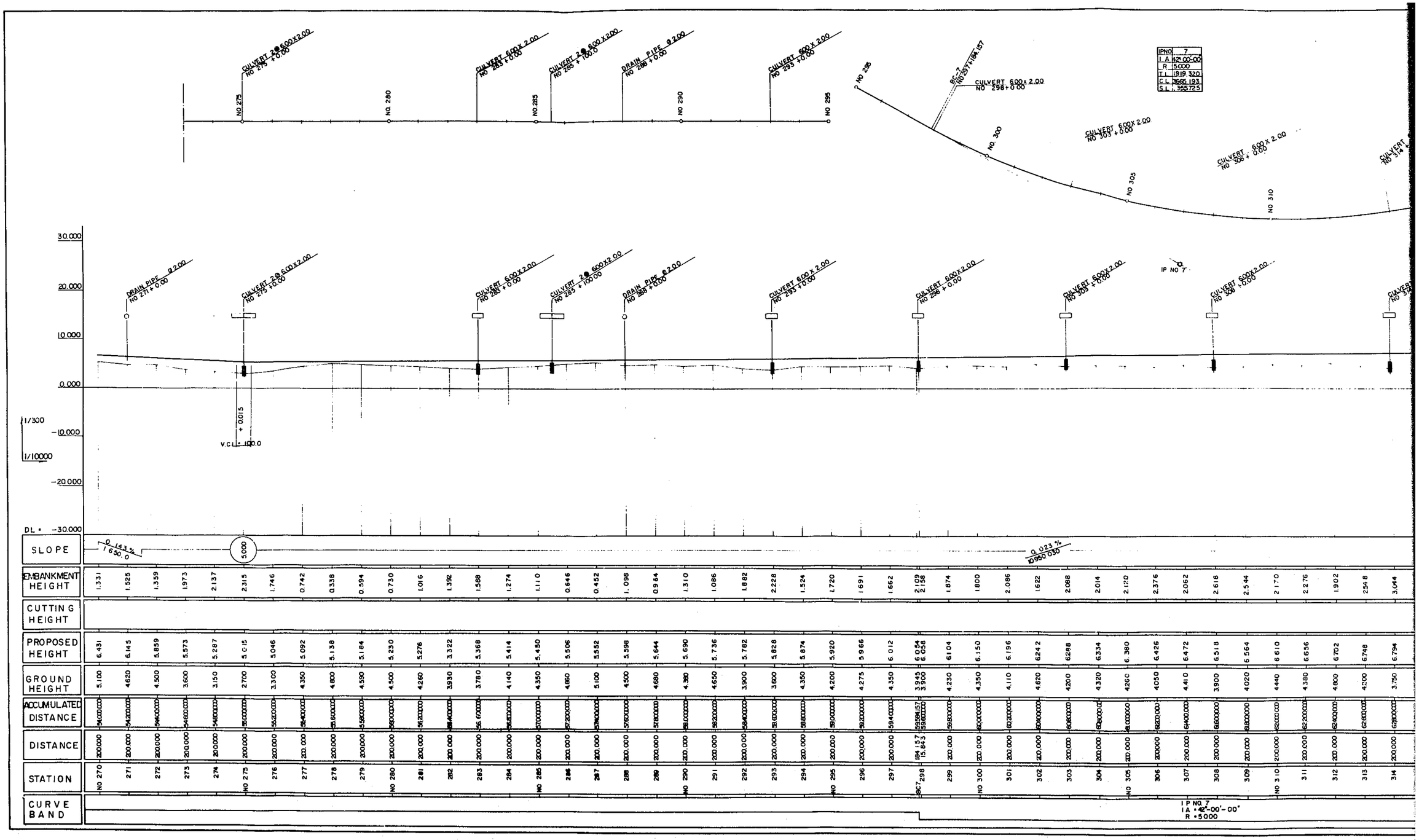
DATE AUG. 1970



CULVERT 2@6.00X2.00 NO 212+0.00
CULVERT 2@6.00X2.00 NO 217+50.00
CULVERT 2@6.00X2.00 NO 225+50.00
DRAIN PIPE @ 2.00 NO 228+0.00
CULVERT 6.00X2.00 NO 231+0.00
CULVERT 2@6.00X2.00 NO 233+100.00
DRAIN PIPE @ 2.00 NO 236+0.00
CULVERT 6.00X2.00 NO 242+0.00
NO 210
NO 215
NO 220
NO 225
NO 230
NO 235
NO 240
NO 245
E.C.-5 NO 218+39.902
BC-6 NO 237+27.812
30.000
20.000
10.000
0.000
-10.000
-20.000
DL = -30.000
1/300
1/10000
-0.004
V.C.L. = 100.0
SLOPE
Level
7.000
0.031 %
7.200.0
EMBANKMENT HEIGHT
CUTTING HEIGHT
PROPOSED HEIGHT
GROUND HEIGHT
ACCUMULATED DISTANCE
DISTANCE
STATION
CURVE BAND



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN	
DACCA-FARIDPUR ROAD PROJECT	
PLAN AND PROFILE NO. 5	
CHIEF ENG.	SCALE V = 1:300 H = 1:10,000
CHECKED BY	SHEET NO 12
DESIGNED BY	DATE AUG. 1970
DRAWN BY	


CULVERT 2 Ø 600 X 2.00 NO 275 + 0.00
CULVERT 600 X 2.00 NO 283 + 0.00
CULVERT 2 Ø 600 X 2.00 NO 285 + 100.00
DRAIN PIPE Ø 2.00 NO 288 + 0.00
CULVERT 600 X 2.00 NO 293 + 0.00
NO 275
NO 280
NO 285
NO 290
NO 295
NO 298
BC-7 NO 297 + 184.157
CULVERT 600 X 2.00 NO 298 + 0.00
NO 300
CULVERT 600 X 2.00 NO 303 + 0.00
CULVERT 600 X 2.00 NO 306 + 0.00
NO 305
NO 310
IP NO 7
I A 42°00'-00"
R 5.000
T L 1919.320
C L 3665.193
S L 355725
DRAIN PIPE Ø 2.00 NO 271 + 0.00
CULVERT 2 Ø 600 X 2.00 NO 275 + 0.00
CULVERT 600 X 2.00 NO 283 + 0.00
CULVERT 2 Ø 600 X 2.00 NO 285 + 100.00
DRAIN PIPE Ø 2.00 NO 288 + 0.00
CULVERT 600 X 2.00 NO 293 + 0.00
CULVERT 600 X 2.00 NO 298 + 0.00
CULVERT 600 X 2.00 NO 303 + 0.00
CULVERT 600 X 2.00 NO 308 + 0.00
IP NO 7
30.000
20.000
10.000
0.000
-10.000
-20.000
DL = -30.000
1/300
1/10000
+ 0.015
V.C.L = 100.0
SLOPE
0.143 % 1/650.0
5.000
0.023 % 1/4350.0
EMBANKMENT HEIGHT
CUTTING HEIGHT
PROPOSED HEIGHT
GROUND HEIGHT
ACCUMULATED DISTANCE
DISTANCE
STATION
CURVE BAND
IP NO 7
I A = 42°-00'-00"
R = 5000

292	200.000	58400.000	3.900	5.782	1.882
293	200.000	58600.000	3.600	5.828	2.228
294	200.000	58800.000	4.350	5.874	1.524
NO 295	200.000	59000.000	4.200	5.920	1.720
296	200.000	59200.000	4.275	5.966	1.691
297	200.000	59400.000	4.350	6.012	1.662
BC7 298	184.157 15.843	59584.157 59600.000	3.945 3.900	6.054 6.058	2.109 2.158
299	200.000	59800.000	4.230	6.104	1.874
NO 300	200.000	60000.000	4.350	6.150	1.800
301	200.000	60200.000	4.110	6.196	2.086
302	200.000	60400.000	4.620	6.242	1.622
303	200.000	60600.000	4.200	6.288	2.088
304	200.000	60800.000	4.320	6.334	2.014
NO 305	200.000	61000.000	4.260	6.380	2.120
306	200.000	61200.000	4.050	6.426	2.376
307	200.000	61400.000	4.410	6.472	2.062
308	200.000	61600.000	3.900	6.518	2.618
309	200.000	61800.000	4.020	6.564	2.544
NO 310	200.000	62000.000	4.440	6.610	2.170
311	200.000	62200.000	4.380	6.656	2.276
312	200.000	62400.000	4.800	6.702	1.902
313	200.000	62600.000	4.200	6.748	2.548
314	200.000	62800.000	3.750	6.794	3.044
NO 315	200.000	63000.000	4.320	6.840	2.520
316 ECT	200.000 49.350	63200.000 63249.350	4.560 4.350	6.886 6.897	2.326 2.547
317	150.650	63400.000	4.410	6.932	2.522
318	200.000	63600.000	4.560	6.978	2.418
319	200.000	63800.000	4.650	7.024	2.374
NO 320	200.000	64000.000	3.870	7.070	3.200
321	200.000	64200.000	4.200	7.116	2.916
322	200.000	64400.000	4.230	7.162	2.932
323	200.000	64600.000	4.230	7.208	2.978
324	200.000	64800.000	3.975	7.254	3.279
NO 325	200.000	65000.000	3.660	7.300	3.640
326	200.000	65200.000	3.660	7.346	3.686
327	200.000	65400.000	3.900	7.392	3.492
328	200.000	65600.000	3.300	7.438	4.138
329	200.000	65800.000	3.900	7.484	3.584
	150.030	65950.030	4.050	7.519	3.469

I P NO 7
I A = 42°-00'-00"
R = 5000

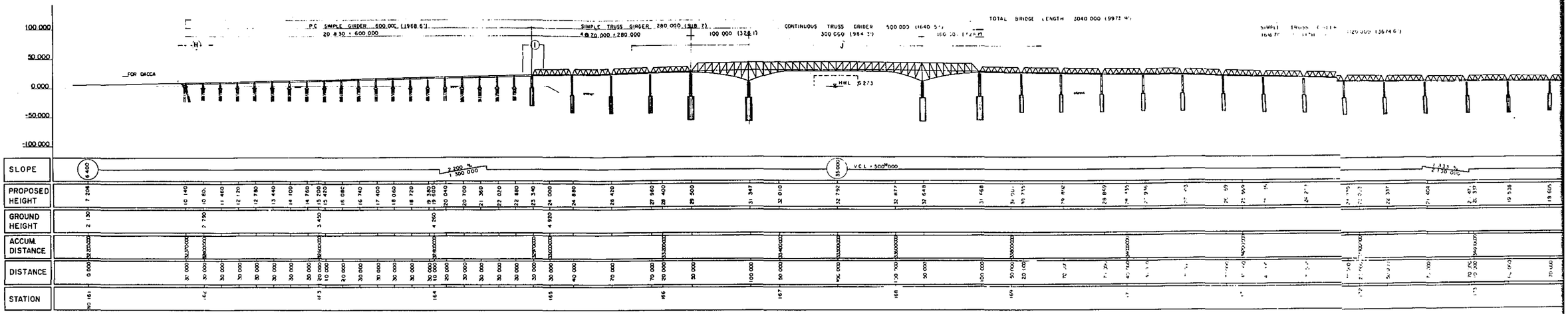
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

PLAN AND PROFILE NO.6

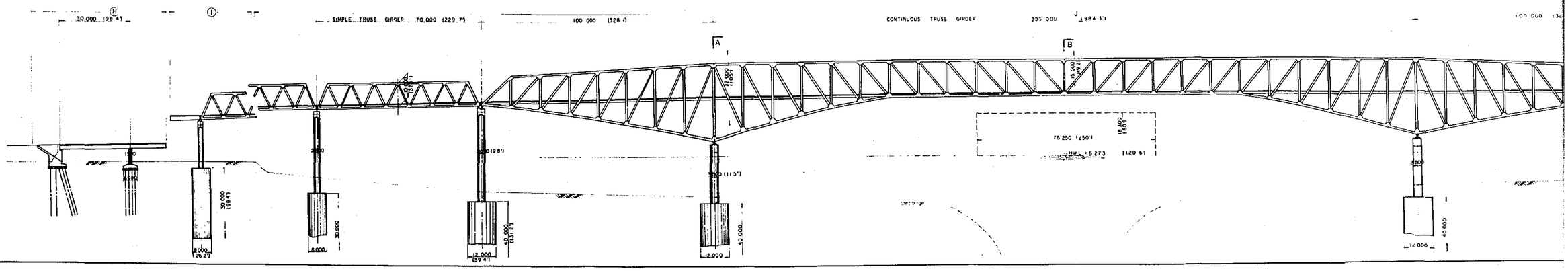
CHIEF ENG.	SCALE V = 1:500 H = 1:10,000
CHECKED BY	SHEET NO 13
DESIGNED BY H. Takahashi	
DRAWN BY	DATE AUG. 1970

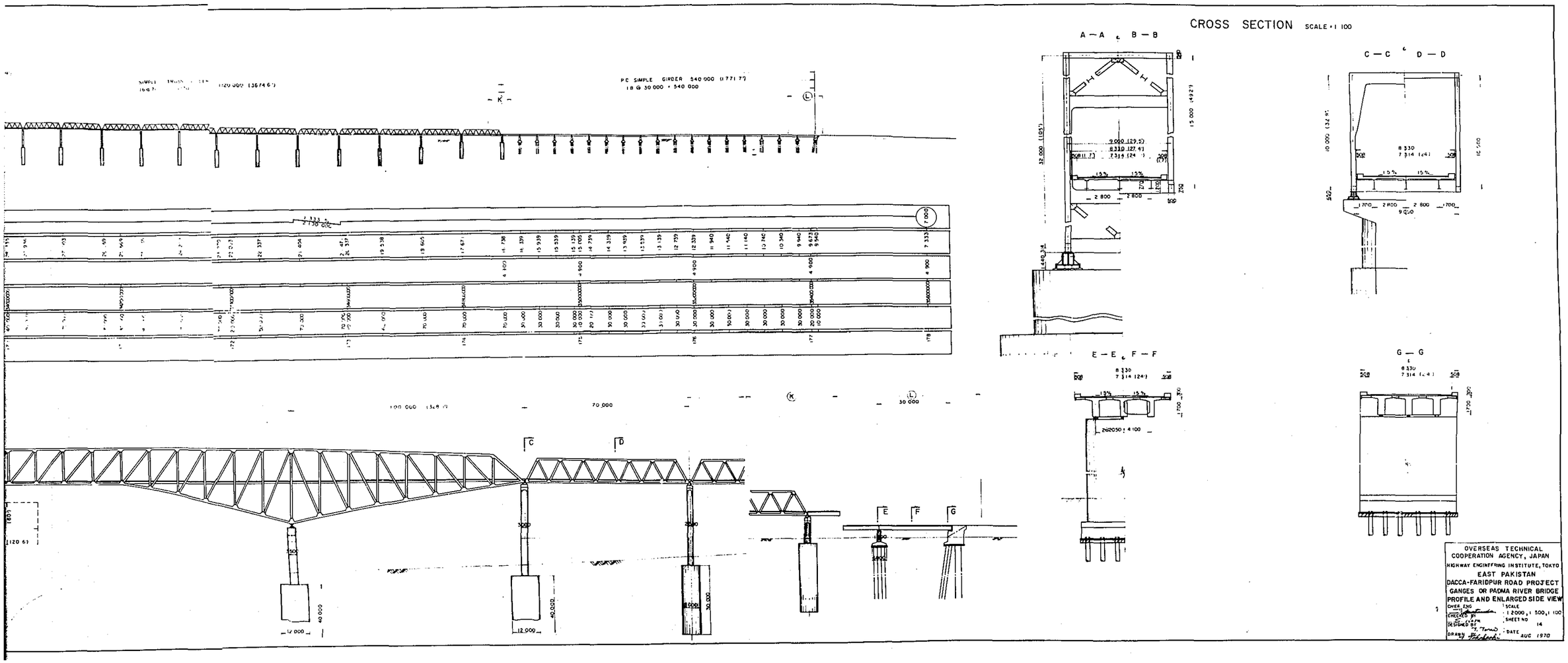
GANGES OR PADMA RIVER BRIGE SCALE : 1 2000

PROFILE



ENLARGED SIDE VIEW SCALE 1 500




CROSS SECTION SCALE 1:100
A — A & B — B
C — C & D — D
E — E & F — F
G — G
PC SIMPLE GIRDER 540 000 (1771.7')
18 @ 30 000 = 540 000
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT
GANGES OR PADMA RIVER BRIDGE
PROFILE AND ENLARGED SIDE VIEW
CHIEF ENG
CHECKED BY
DESIGNED BY
DRAWN BY
SCALE 1:2000, 1:500, 1:100
SHEET NO 14
DATE AUG 1970

DHALES WARI RIVER BRIDGE

SCALE=1:1000

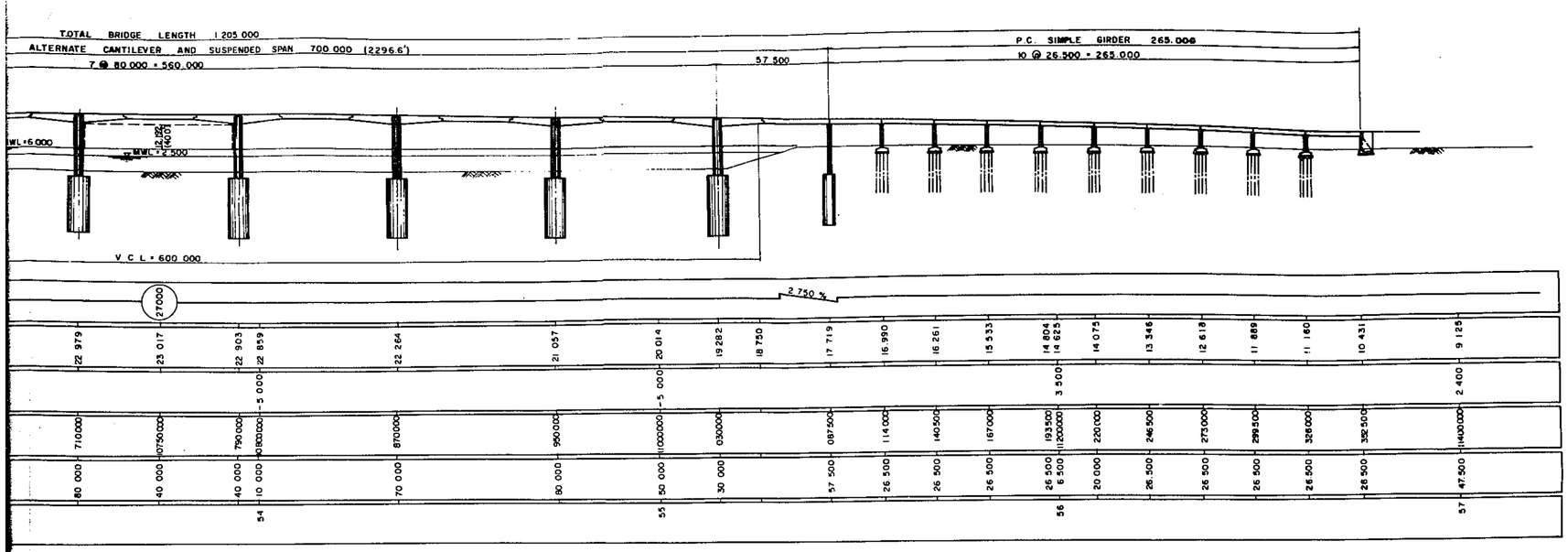
PROFILE

ENLARGED SIDE VIEW

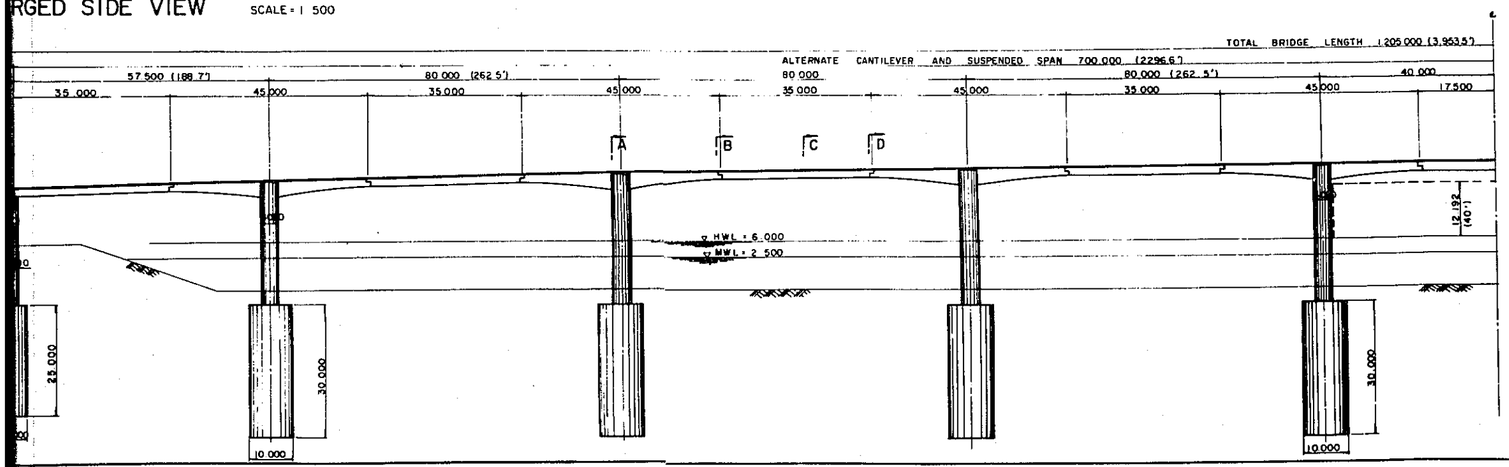
SCALE = 1:500

WARI RIVER BRIDGE SCALE = 1:1000

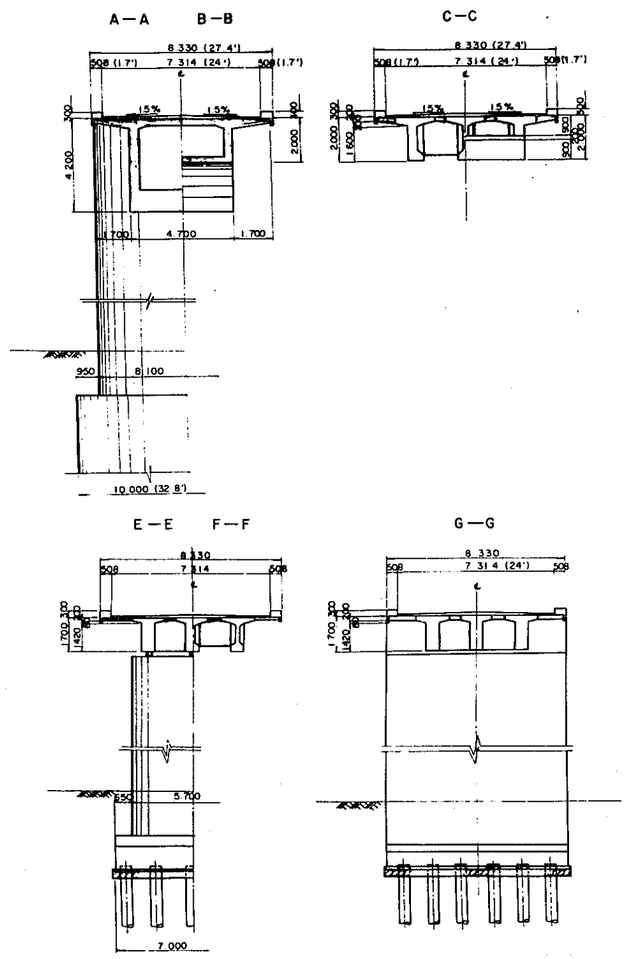
PROFILE



ENLARGED SIDE VIEW SCALE = 1 500



CROSS SECTION SCALE = 1:100



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
DHALES WARI RIVER BRIDGE PROFILE AND ENLARGED SIDE VIEW	
CHIEF ENG.	SCALE 1:1000, 1:500, 1:100
CHECKED BY	SHEET NO 15
DESIGNED BY	DATE AUG. 1970
DRAWN BY	

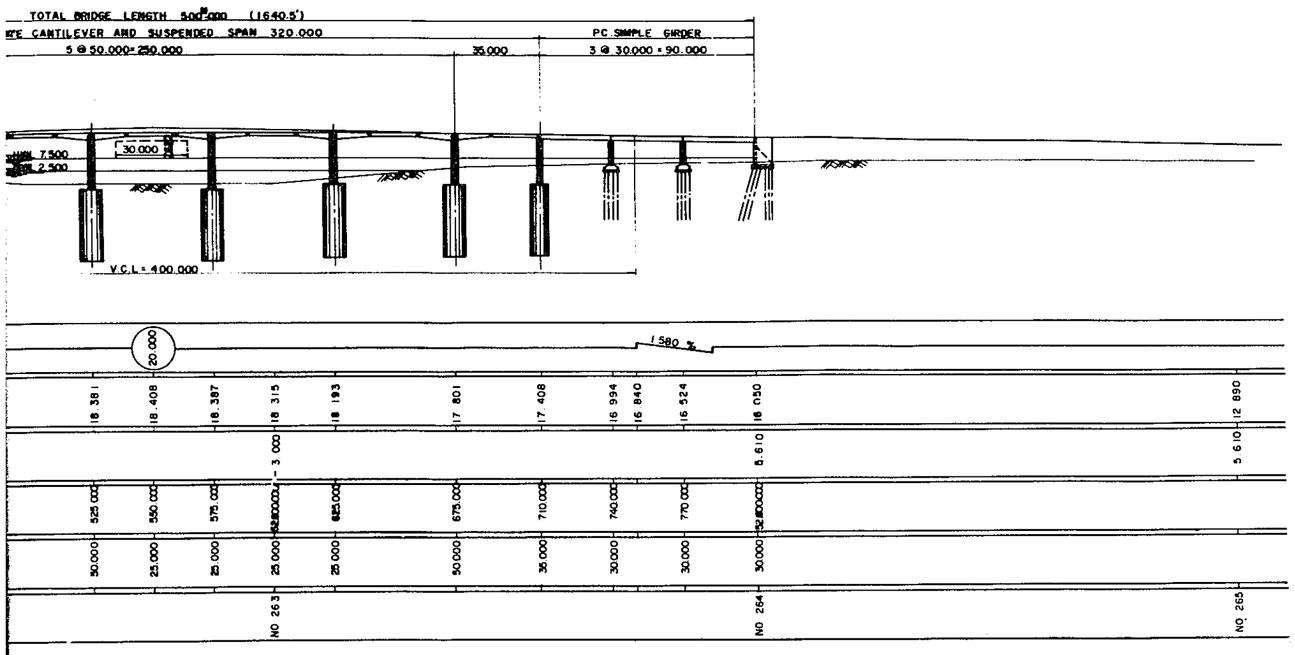
ARIAL KHAN RIVER BRIDGE SCALE = 1:1000

PROFILE

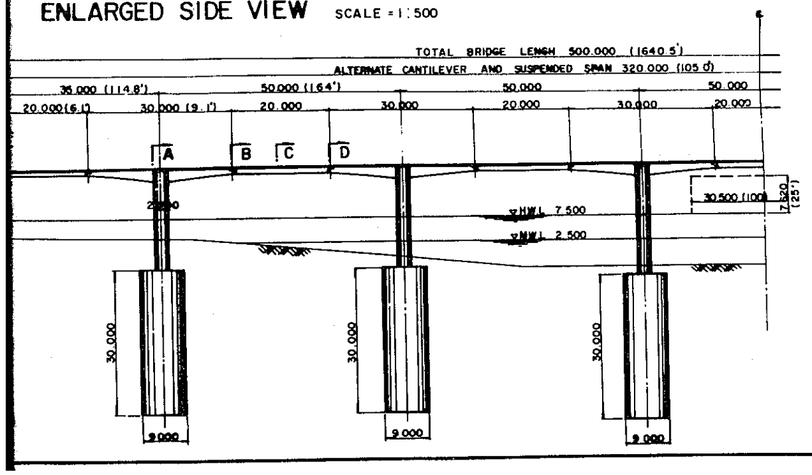
ENLARGED SIDE VIEW SCALE = 1:500

ARIAL KHAN RIVER BRIDGE SCALE = 1 : 1000

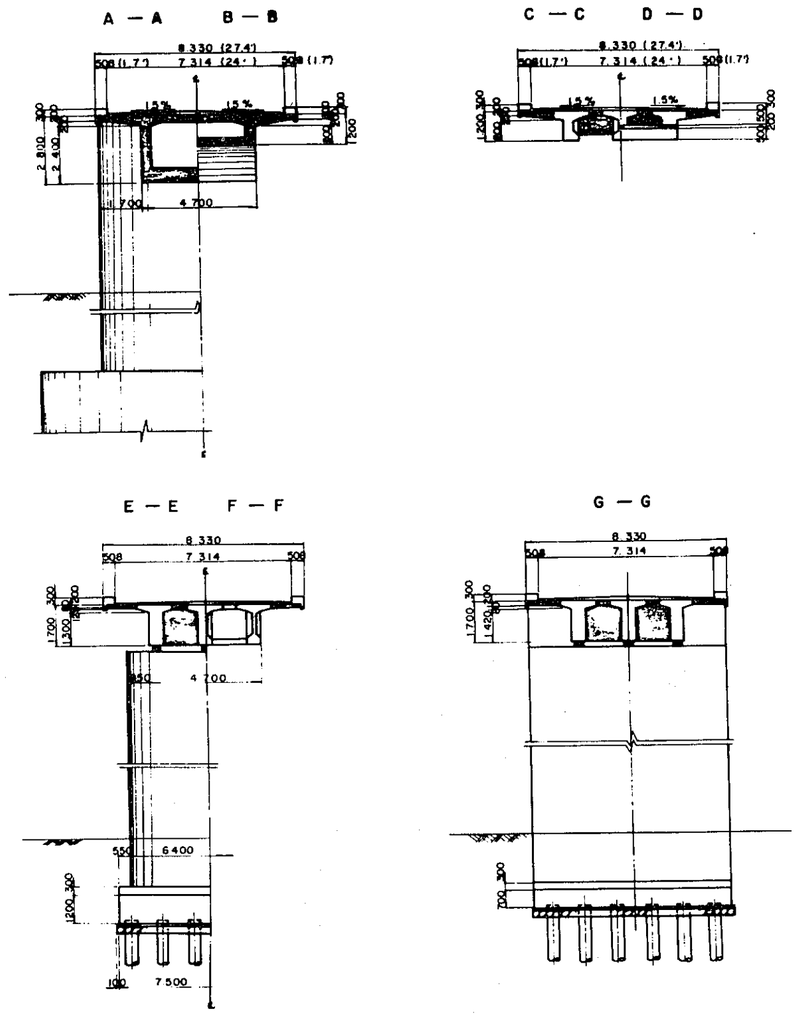
PROFILE



ENLARGED SIDE VIEW SCALE = 1 : 500



CROSS SECTION

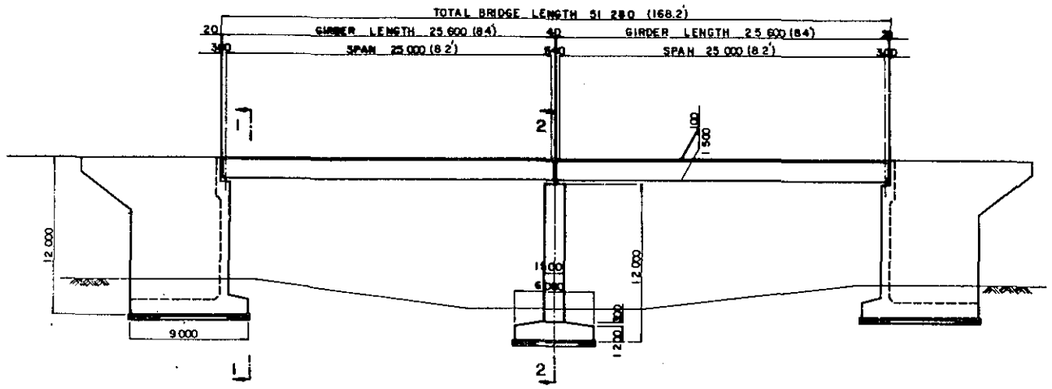


OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN	
DACCA-FARIDPUR ROAD PROJECT	
ARIAL KHAN RIVER BRIDGE PROFILE AND ENLARGED SIDE VIEW	
CHIEF ENG.	SCALE 1:1000, 1:500, 1:100
CHECKED BY S. Khan	SHEET NO 16
DESIGNED BY E. Mundi	DATE AUG. 1970
DRAWN BY E. Mundi	

GENERAL VIEW

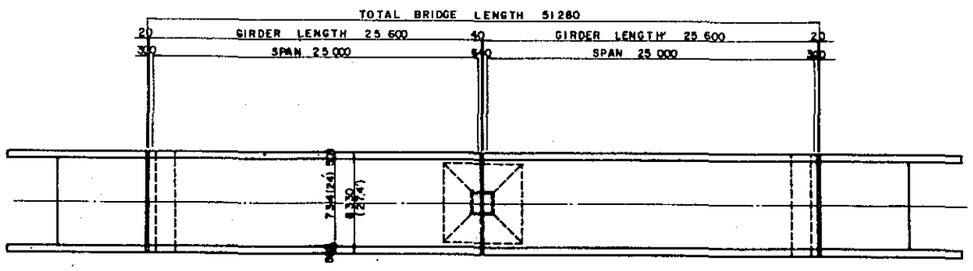
SCALE 1:200

PROFILE



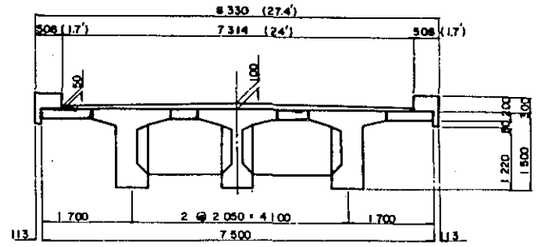
PLAN

SCALE 1 : 200



TYPICAL CROSS SECTION

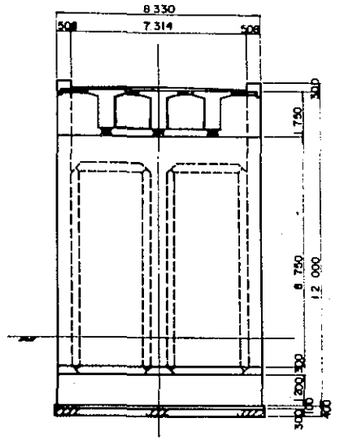
SCALE 1 : 50



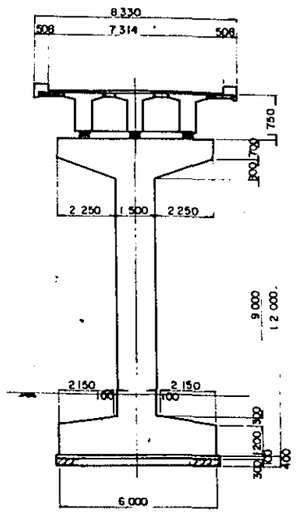
CROSS SECTION

SCALE 1 : 100

1 – 1



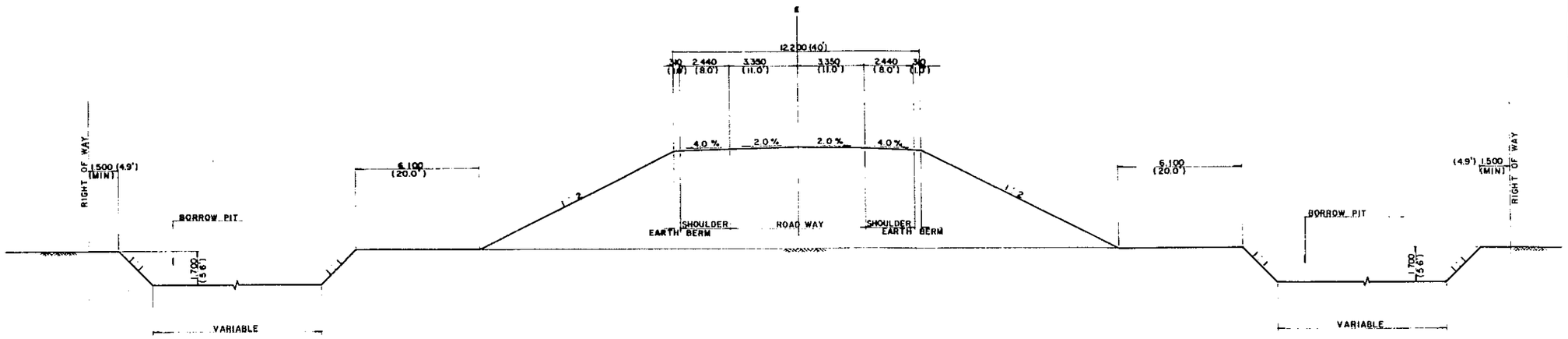
2 – 2



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
P.C. GIRDER BRIDGE	
CHIEF ENG.	SCALE 1:100, 1:50
CHECKED BY	SHEET NO 17
DESIGNED BY	
DRAWN BY	DATE AUG. 1970

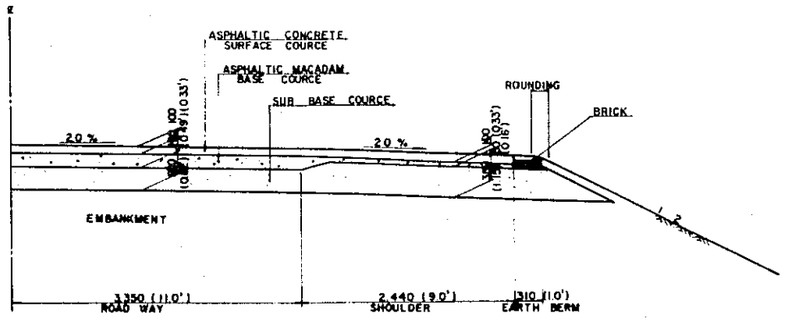
TYPICAL CROSS SECTION

SCALE 1:100



PAVEMENT SECTION

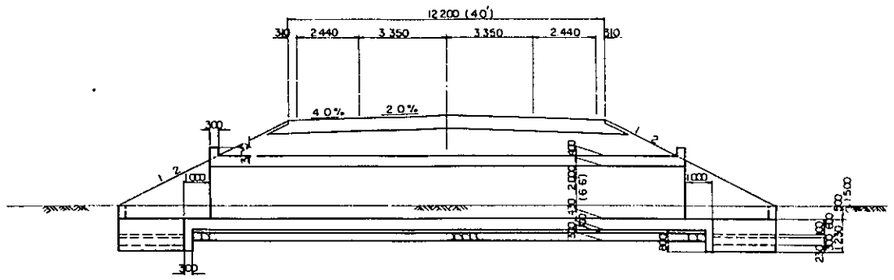
SCALE 1:30



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
TYPICAL CROSS SECTION AND PAVEMENT	
CHIEF ENG.	SCALE 1:100, 1:30
CHECKED BY	SHEET NO 18
DESIGNED BY H. Takahashi	DATE AUG. 1970
DRAWN BY H. Takahashi	

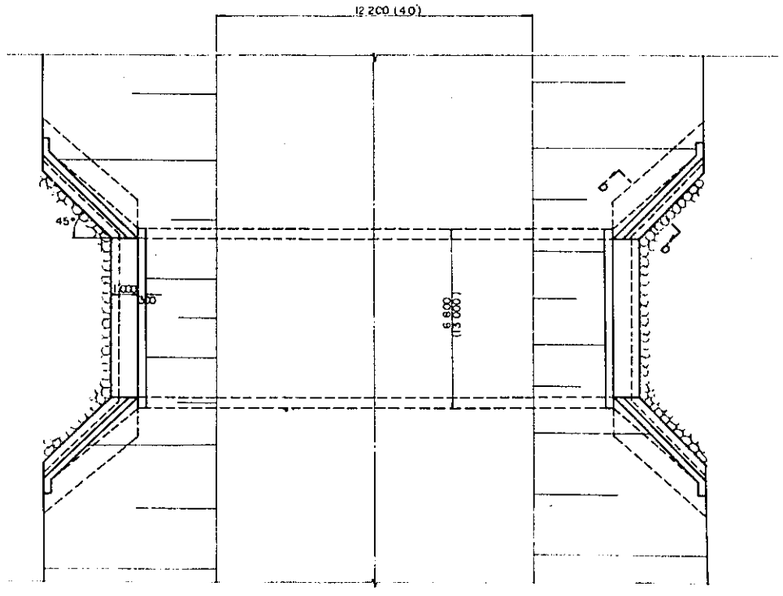
PROFILE

SCALE 1 : 100



PLAN

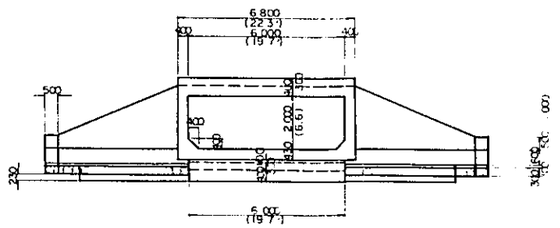
SCALE 1 100



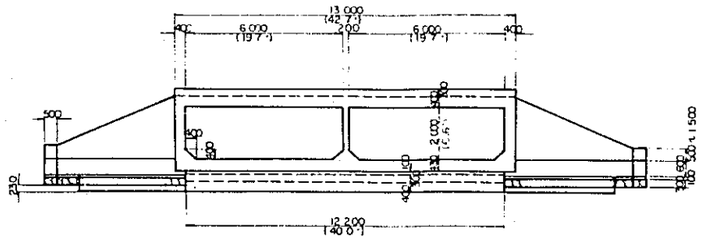
CROSS SECTION

SCALE 1 : 100

6.00 x 2.00

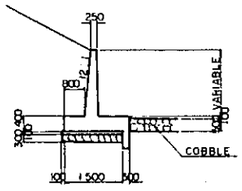


2 @ 6.00 x 2.00



SECTION b-b

SCALE 1 : 100



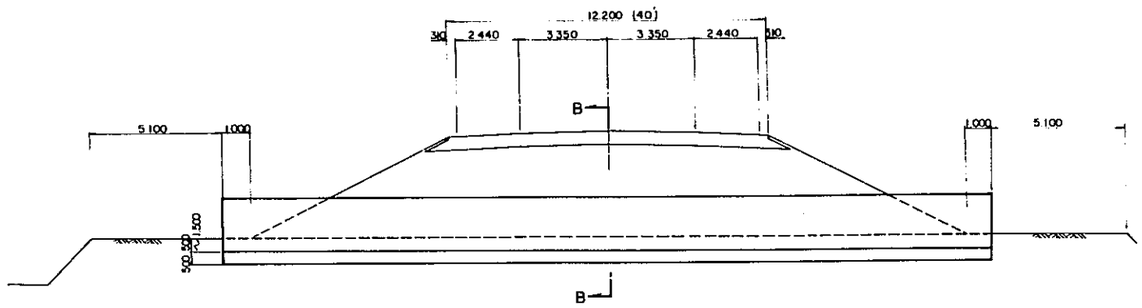
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

CULVERT DETAILS

CHIEF ENG	SCALE 1 100
CHECKED BY	SHEET NO 19
DESIGNED BY T. Takahashi	DATE AUG 1970
DRAWN BY T. Takahashi	

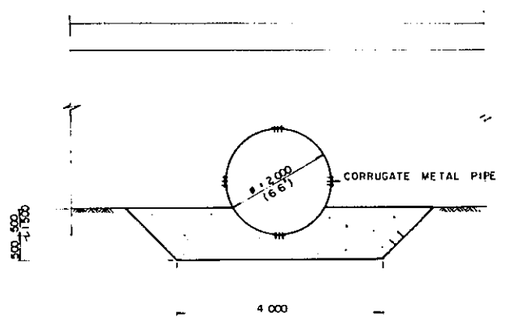
SECTION A-A

SCALE 1 : 100



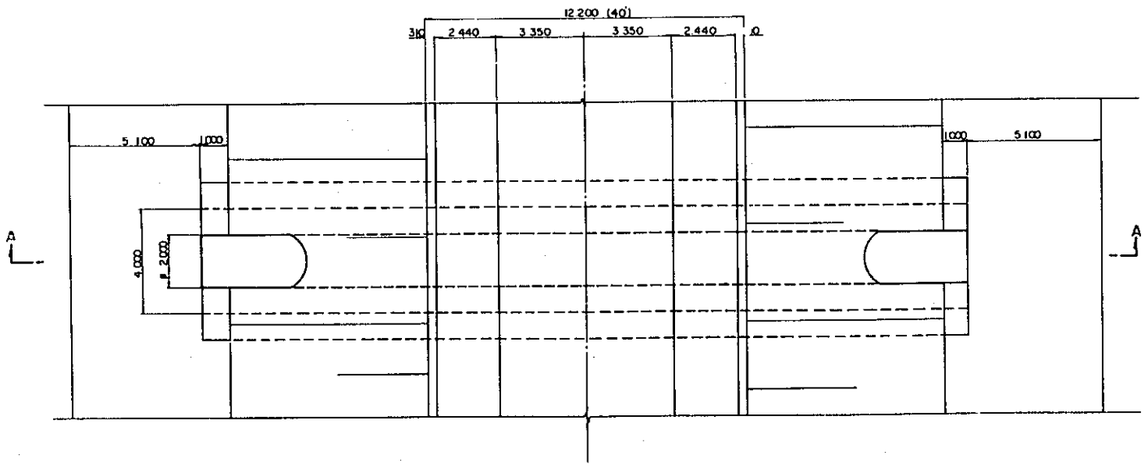
SECTION B-B

SCALE 1:50



PLAN

SCALE 1 : 100



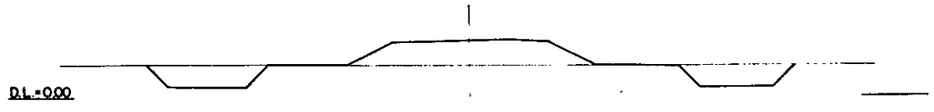
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN	
DACCA-FARIDPUR ROAD PROJECT	
DRAIN PIPE DETAILS	
CHIEF ENG.	SCALE 1 : 100
CHECKED BY	SHEET NO
DESIGNED BY	20
DRAWN BY	DATE AUG 1970

NO. 15

GH = 2.760
PH = 4.836

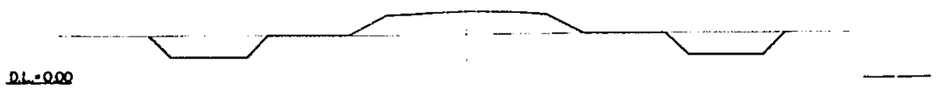
NO. 30

GH = 2.460
PH = 4.350



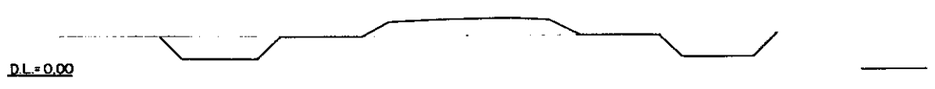
NO. 10

GH = 3.420
PH = 5.176



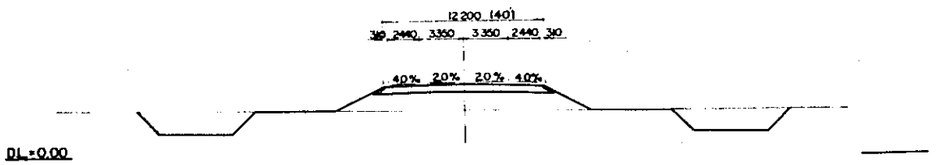
NO. 25

GH = 2.910
PH = 4.156



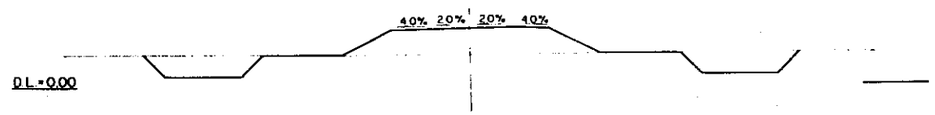
NO. 5

GH = 3.510
PH = 5.516



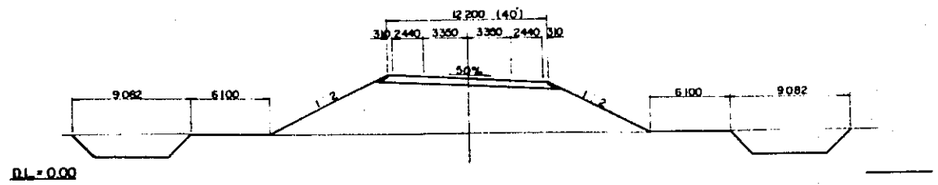
NO. 20

GH = 2.400
PH = 4.496



NO. 0

GH = 3.360
PH = 7.500



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

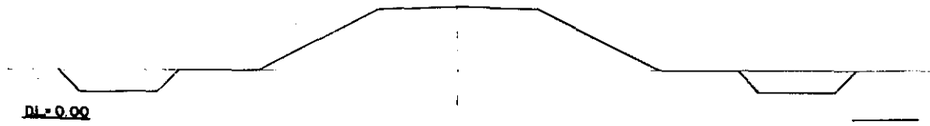
ROAD CROSS SECTION NO. 1

CHIEF ENG.
CHECKED BY
DESIGNED BY
DRAWN BY

SCALE 1:200
SHEET NO 21
DATE AUG 1970

NO. 50

G.H. = 3.660
P.H. = 8.508



NO. 56 + 150.0

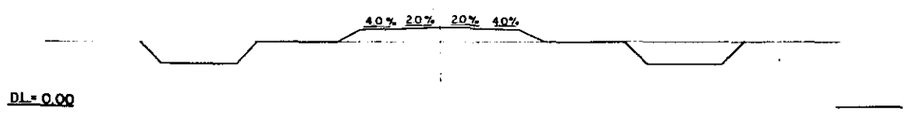
G.H. = 2.400
P.H. = 10.500

NO. 55

G.H. =
P.H. =

NO. 45

G.H. = 4.830
P.H. = 6.000



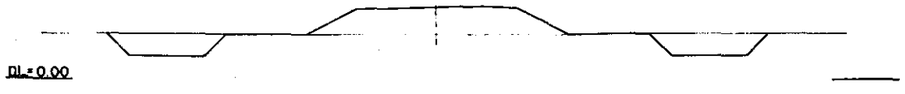
DL = 0.00

NO. 50 + 150.0

G.H. = 4.170
P.H. = 11.643

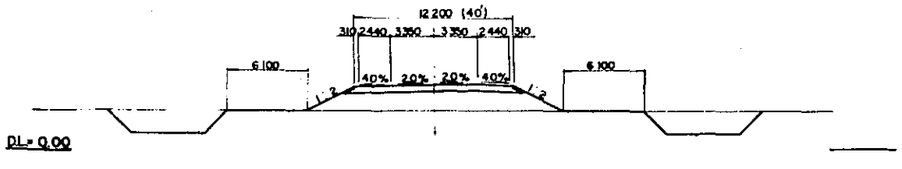
NO. 40

G.H. = 3.420
P.H. = 5.450



NO. 35

G.H. = 2.940
P.H. = 4.900



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

HIGHWAY ENGINEERING INSTITUTE, TOKYO

EAST PAKISTAN

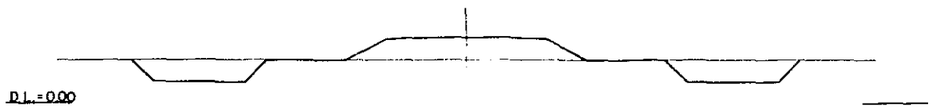
DACCA-FARIDPUR ROAD PROJECT

ROAD CROSS SECTION NO.2

CHIEF ENG.	SCALE 1 : 200
CHECKED BY	SHEET NO 22
DESIGNED BY N. Takasaki	DATE AUG. 1970
DRAWN BY	

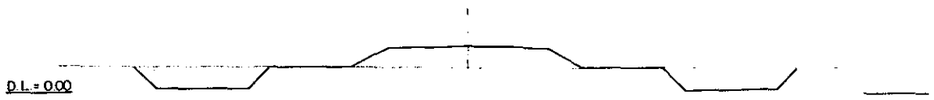
NO. 75

G.H. = 3.300
P.H. = 5.000



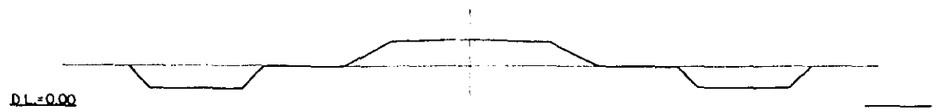
NO. 90

G.H. = 1.950
P.H. = 3.527



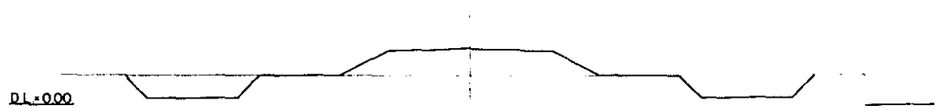
NO. 70

G.H. = 3.030
P.H. = 5.000



NO. 85

G.H. = 2.220
P.H. = 4.336

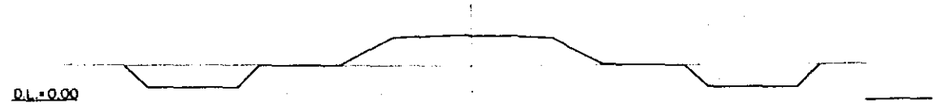


NO. 65

G.H. = 2.340
P.H. = 5.000

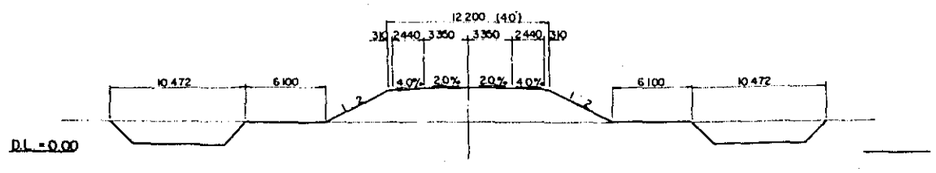
NO. 80

G.H. = 2.700
P.H. = 5.000



NO. 60

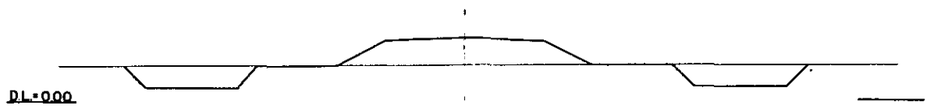
G.H. = 2.400
P.H. = 5.000



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
ROAD CROSS SECTION NO. 3	
CHIEF ENG.	SCALE 1 : 200
CHECKED BY	SHEET NO 23
DESIGNED BY M. Takahashi	DATE AUG. 1970
DRAWN BY	

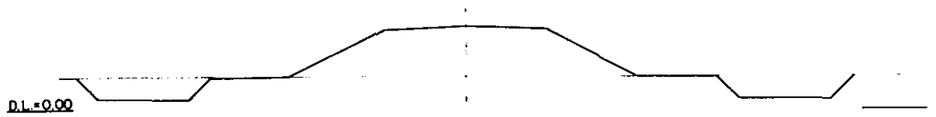
NO. 145

G.H. = 2.760
P.H. = 4.900



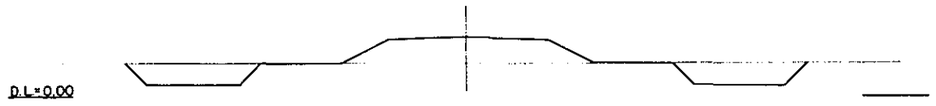
NO. 160

G.H. = 2.460
P.H. = 6.300



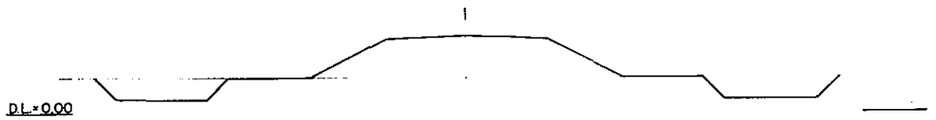
NO. 140

G.H. = 2.550
P.H. = 4.568



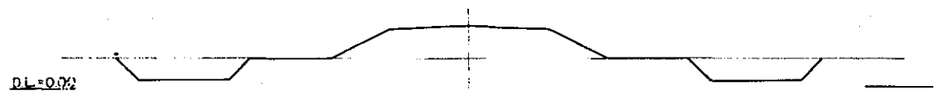
NO. 155

G.H. = 2.640
P.H. = 5.800



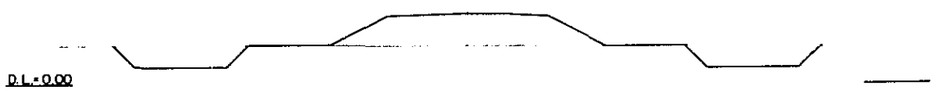
NO. 135

G.H. = 2.400
P.H. = 4.748



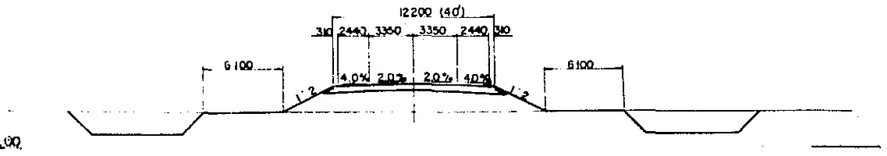
NO. 150

G.H. = 2.910
P.H. = 5.300



NO. 130

G.H. = 2.790
P.H. = 4.928



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

ROAD CROSS SECTION NO4

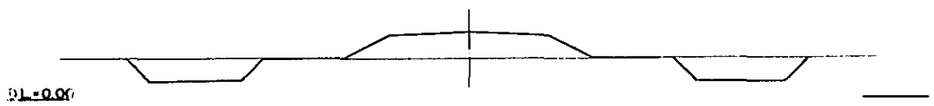
CHIEF ENG
CHECKED BY
DESIGNED BY
DRAWN BY
SCALE
SHEET NO
DATE AUG 1970

NO. 110

G.H. = 2.700
P.H. = 5.000

NO. 125

G.H. = 3.000
P.H. = 5.000



NO. 105

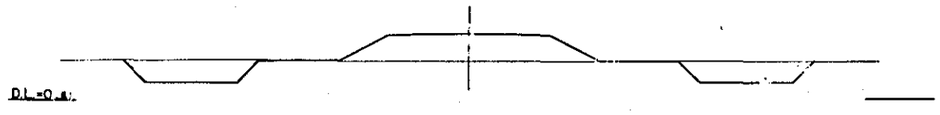
G.H. = 2.850
P.H. = 5.000

NO. 120

G.H. = 3.000
P.H. = 5.000

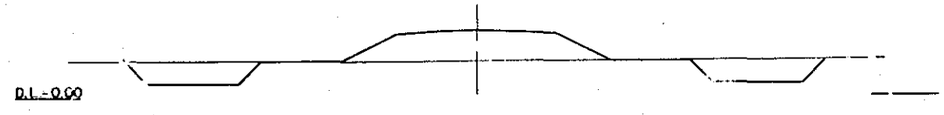
NO. 100

G.H. = 3.000
P.H. = 5.000



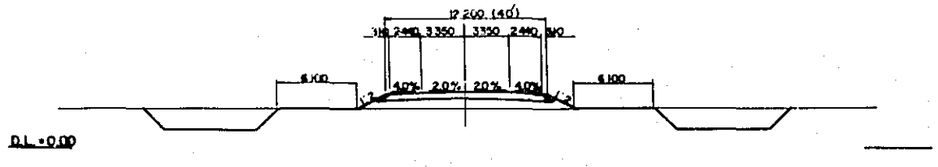
NO. 115

G.H. = 2.760
P.H. = 5.000



NO. 95

G.H. = 3.060
P.H. = 4.336



OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
ROAD CROSS SECTION NO. 5	
CHIEF ENG.	SCALE 1:200
CHECKED BY	SHEET NO 25
DESIGNED BY M. Takahashi	DATE AUG. 1970
DRAWN BY	

NO. 175

D.L.=0.00

NO. 170

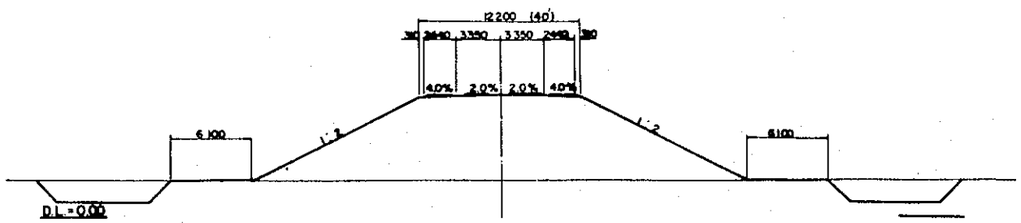
D.L.=0.00

NO. 165

D.L.=0.00

NO. 162+0.0

G.H.= 2.790
P.H.= 9.412



NO. 185

G.H.= 4.900
P.H.= 7.000

D.L.=0.00

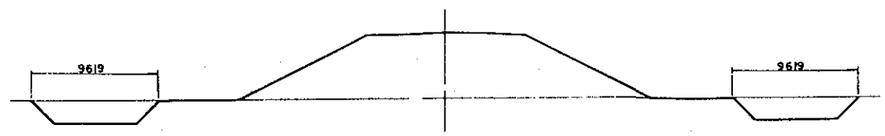
NO. 180

G.H.= 4.900
P.H.= 7.000

D.L.=0.00

NO. 177+0.0

G.H.= 4.900
P.H.= 9.935



D.L.=0.00

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

HIGHWAY ENGINEERING INSTITUTE, TOKYO

EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

ROAD CROSS SECTION NO.6

CHIEF ENG.	SCALE 1: 200
CHECKED BY	SHEET NO 26
DESIGNED BY	DATE AUG. 1970
DRAWN BY	

NO. 205

G.H.=4.900
P.H.=7.000

D.L.=0.00

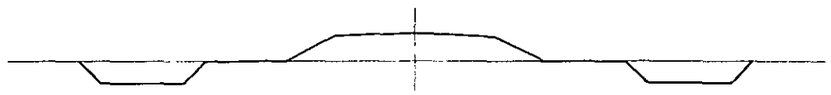
NO. 220

G.H.=5.550
P.H.=7.000

D.L.=0.00

NO. 200

G.H.=4.900
P.H.=7.000



D.L.=0.00

NO. 215

G.H.=4.900
P.H.=7.000

D.L.=0.00

NO. 195

G.H.=4.900
P.H.=7.000

D.L.=0.00

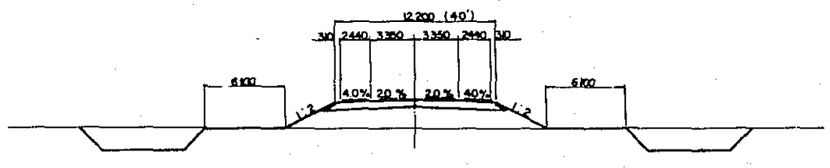
NO. 210

G.H.=4.900
P.H.=7.000

D.L.=0.00

NO. 190

G.H.=4.900
P.H.=7.000



D.L.=0.00

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
ROAD CROSS SECTION NO. 7	
CHIEF ENG.	SCALE 1:200
CHECKED	SHEET NO 27
DESIGNED BY M. Takahashi	DATE AUG. 1970
DRAWN BY	

NO. 240

G.H.=4.110
P.H.=5.884

D.L.=0.00

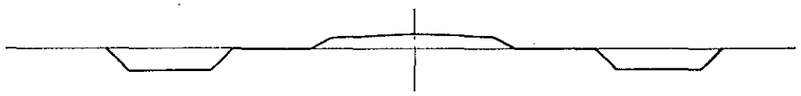
NO. 255

G.H.= 2.970
P.H.= 4.984

D.L.=0.00

NO. 235

G.H.= 5.160
P.H.= 6.194



D.L.=0.00

NO. 250

G.H.=4.050
P.H.=5.264

D.L.=0.00

NO. 230

G.H.=4.200
P.H.=6.504

D.L.=0.00

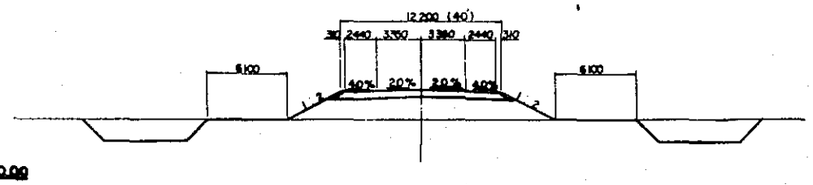
NO. 245

G.H.= 4.530
P.H.= 5.574

D.L.=0.00

NO. 225

G.H.= 4.530
P.H.= 6.814



D.L.=0.00

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

HIGHWAY ENGINEERING INSTITUTE, TOKYO

EAST PAKISTAN

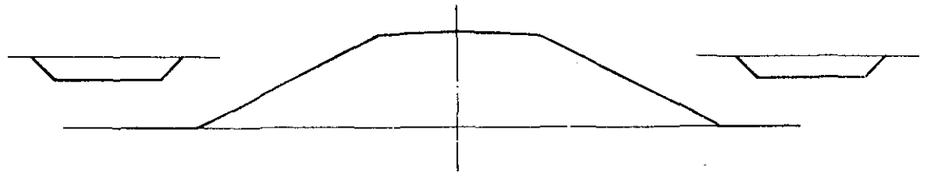
DACCA-FARIDPUR ROAD PROJECT

ROAD CROSS SECTION NO. 8

CHIEF ENG.	SCALE 1:200
CHECKED BY	SHEET NO 28
DESIGNED BY	DATE AUG. 1970
DRAWN BY	

NO. 285

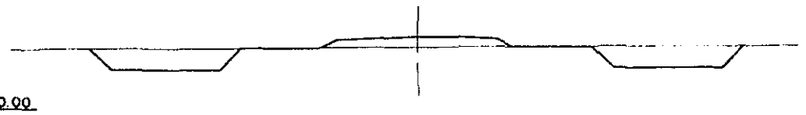
G.H. = 5.610
P.H. = 12.880



D.L. = 0.00

NO. 280

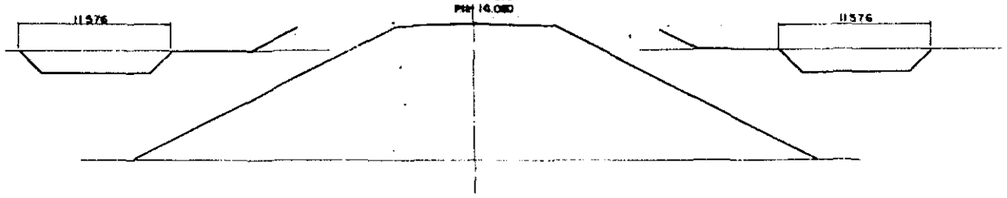
G.H. = 4.500
P.H. = 5.230



D.L. = 0.00

NO. 284 + 0.0

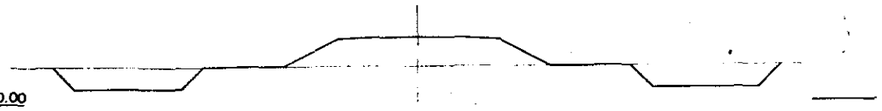
G.H. = 5.610
P.H. = 14.080



D.L. = 0.00

NO. 275

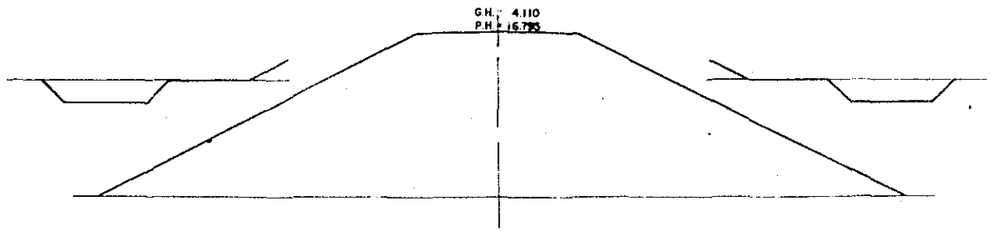
G.H. = 2.700
P.H. = 5.015



D.L. = 0.00

NO. 261 + 100.0

G.H. = 4.110
P.H. = 16.785



D.L. = 0.00

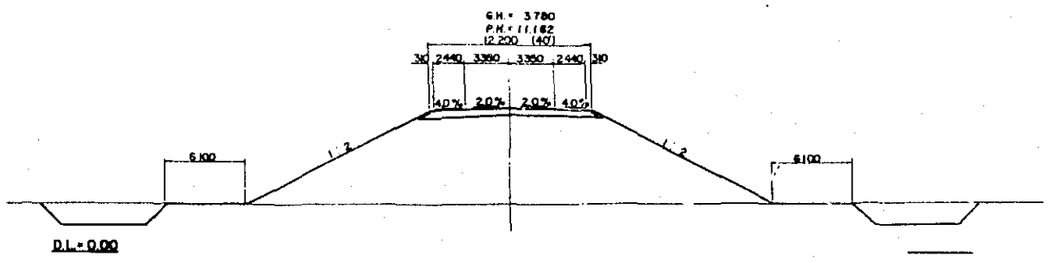
NO. 270

G.H. = 5.100
P.H. = 6.431

D.L. = 0.00

NO. 260

G.H. = 3.780
P.H. = 11.182
12.200 (40')



D.L. = 0.00

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

HIGHWAY ENGINEERING INSTITUTE, TOKYO

EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

ROAD CROSS SECTION NO. 9

CHIEF ENG.	SCALE 1:200
CHECKED	SHEET NO 29
DESIGNED BY M. Takeuchi	DATE AUG. 1970
DRAWN BY	

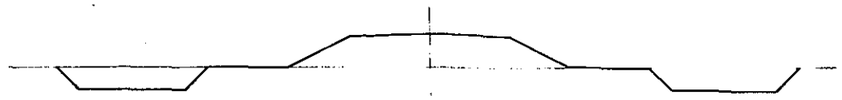
NO. 300

G.H. = 4.350
P.H. = 6.150

D.L. = 0.00

NO. 315

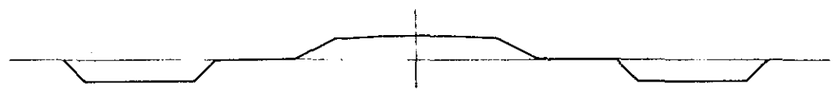
G.H. = 4.320
P.H. = 6.840



D.L. = 0.00

NO. 295

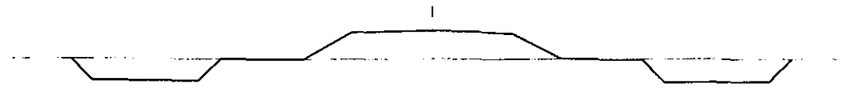
G.H. = 4.200
P.H. = 5.920



D.L. = 0.00

NO. 310

G.H. = 4.440
P.H. = 6.610



D.L. = 0.00

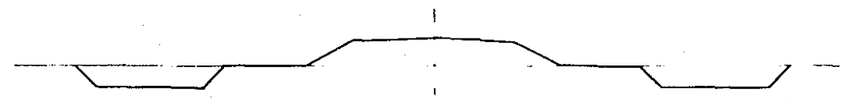
NO. 290

G.H. = 4.380
P.H. = 5.690

D.L. = 0.00

NO. 305

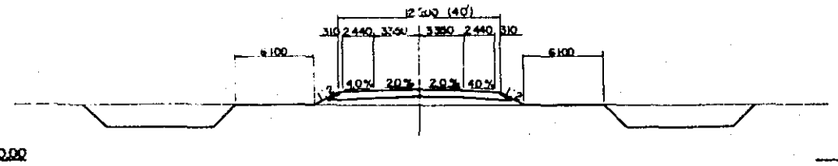
G.H. = 4.260
P.H. = 6.380



D.L. = 0.00

NO. 285

G.H. = 4.350
P.H. = 5.460



D.L. = 0.00

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

HIGHWAY ENGINEERING INSTITUTE, TOKYO

EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

ROAD CROSS SECTION NO.10

CHIEF ENG.	SCALE 1:200
CHECKED BY	SHEET NO 30
DESIGNED BY	DATE AUG. 1970
DRAWN BY	

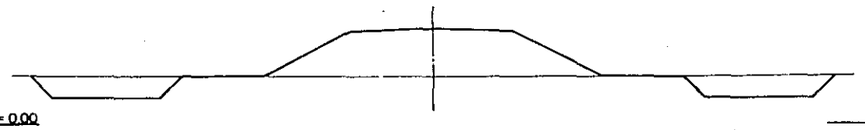
NO. 329+150.030

G.H. = 4.050
P.H. = 7.519

D.L. = 0.00

NO. 325

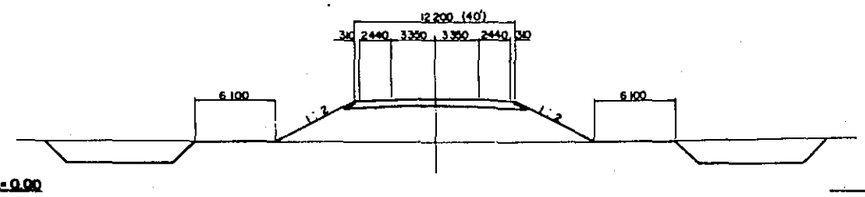
G.H. = 3.660
P.H. = 7.300



D.L. = 0.00

NO. 320

G.H. = 3.870
P.H. = 7.070



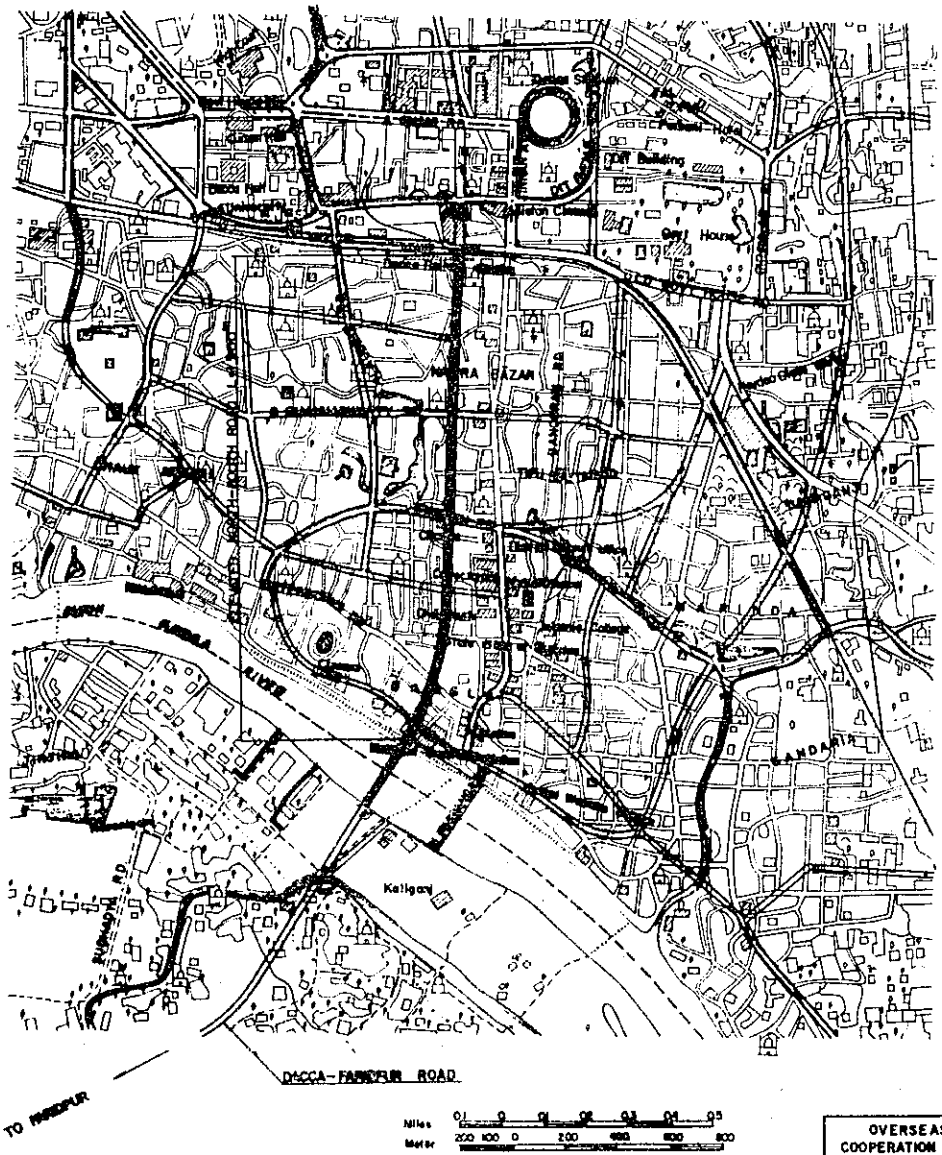
D.L. = 0.00

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT

ROAD CROSS SECTION NO.11

CHIEF ENG.	SCALE 1 : 200
CHECKED BY	SHEET NO 31
DESIGNED BY M. Takeuchi	DATE AUG 1970
DRAWN BY	

DACCA NORTH-SOUTH ROAD PLAN

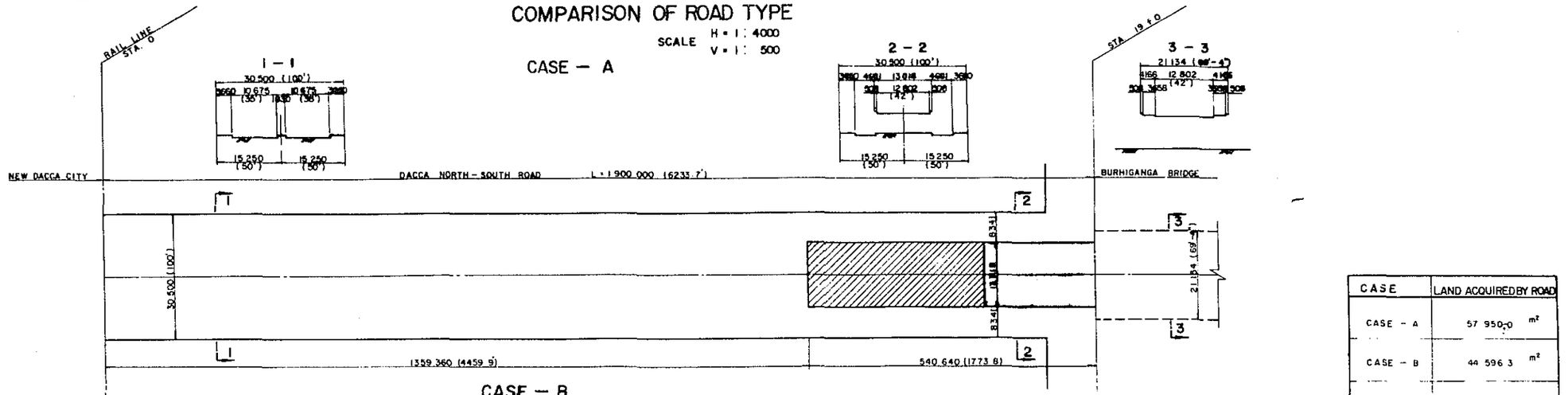


OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN DACCA-FARIDPUR ROAD PROJECT	
DACCA NORTH-SOUTH ROAD PLAN	
CHIEF [redacted]	SCALE 1 : 10,000
CHECKED [redacted]	SHEET NO 32
DESIGNED [redacted]	DATE AUG 1970
DRAWN [redacted]	

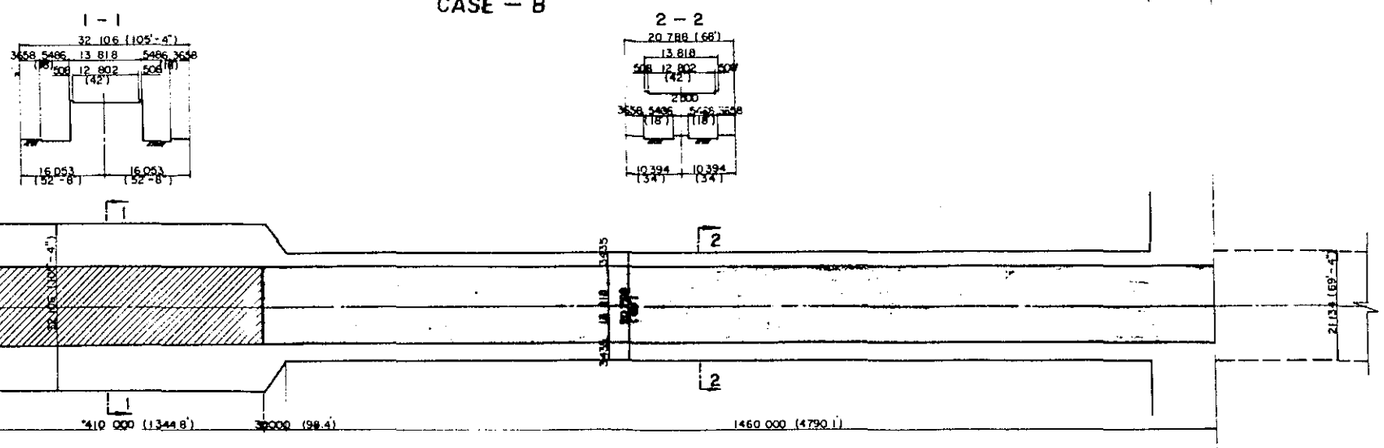
COMPARISON OF ROAD TYPE

SCALE H = 1 : 4000
V = 1 : 500

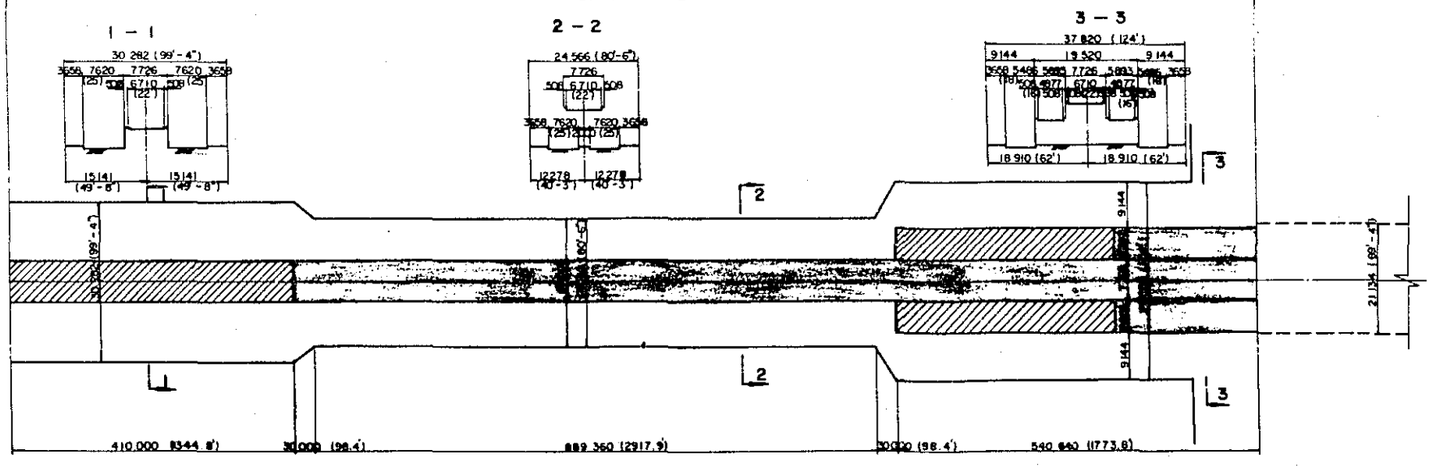
CASE — A



CASE — B



CASE — C



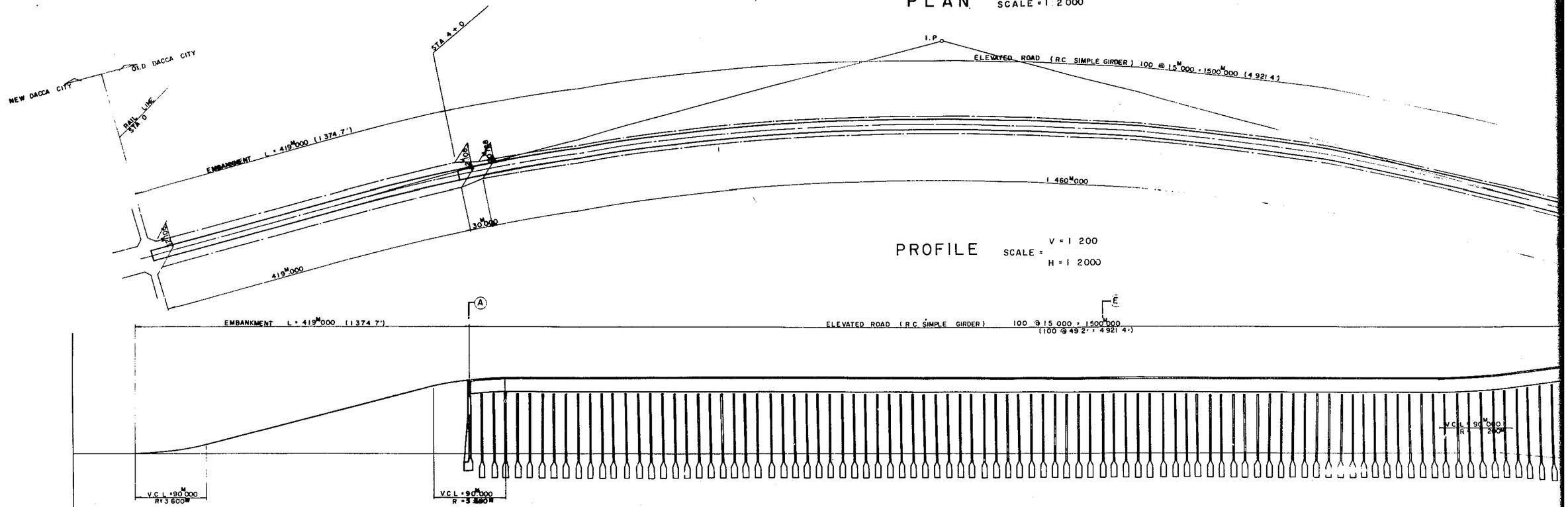
CASE	LAND ACQUIRED BY ROAD
CASE – A	57 950.0 m²
CASE – B	44 596.3 m²
CASE – C	56 157.1 m²

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO

EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT
DACCA NORTH-SOUTH ROAD PROJECT
COMPARISON OF ROAD CASE

CHIEF ENG.	SCALE 1:4000, 1:500
CHECKED BY	SHEET NO 33
DESIGNED BY E. Murasaki	DATE AUG. 1970
DRAWN BY	

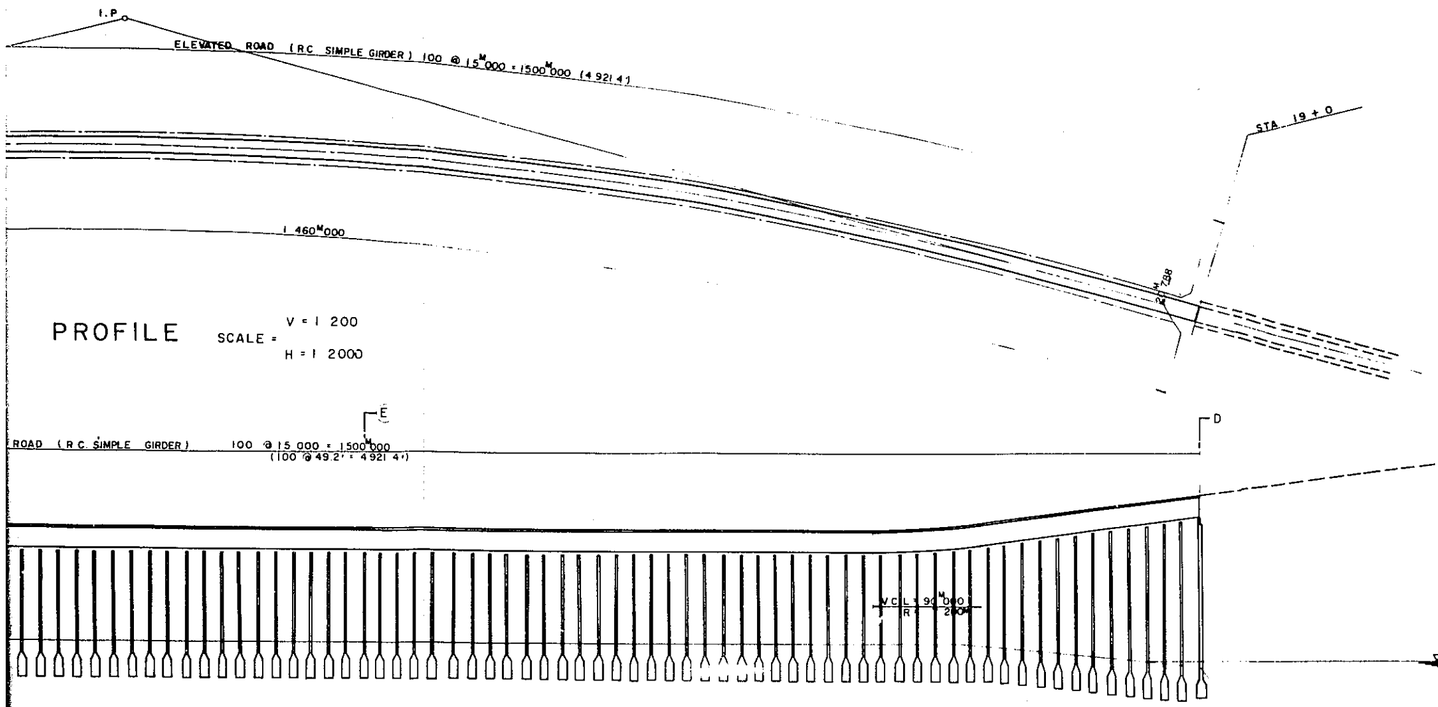
PLAN SCALE = 1:2000



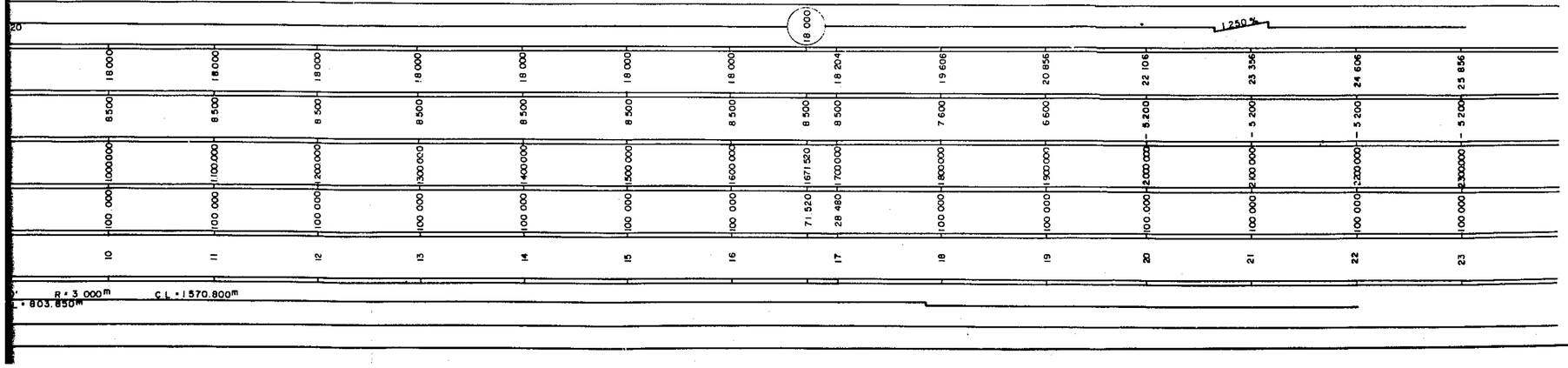
PROFILE SCALE = V = 1:200, H = 1:2000

SLOPE	(8.551)		2.500% 377.960			(18.000)					Level 1271.520							(18.000)
PROPOSED HEIGHT	8.628	8.811	10.500	13.000	15.500	17.719	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.204
GROUND HEIGHT	8.551	8.530	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500	8.500
ACCUMULATIVE DISTANCE	0.000	22.040	100.000	200.000	300.000	400.000	500.000	600.000	700.000	800.000	900.000	1000.000	1100.000	1200.000	1300.000	1400.000	1500.000	1600.000	1671.520	1700.000
DISTANCE	0.000	22.040	77.960	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	71.520	28.480
STATION	0		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		17
CURVE BAND	I.A = 30°-00' R = 3.000m T.L = 803.850m C.L = 1570.800m																			

PLAN SCALE = 1 : 2 000



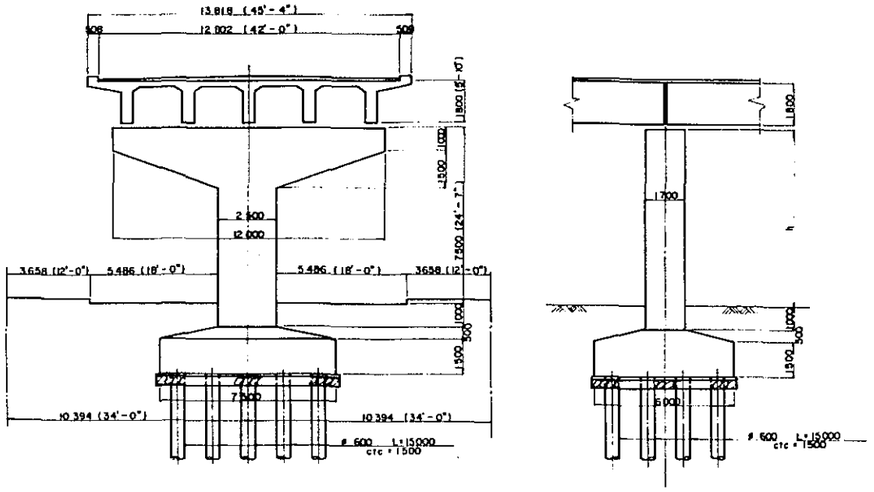
PROFILE SCALE = V = 1 : 200, H = 1 : 2000



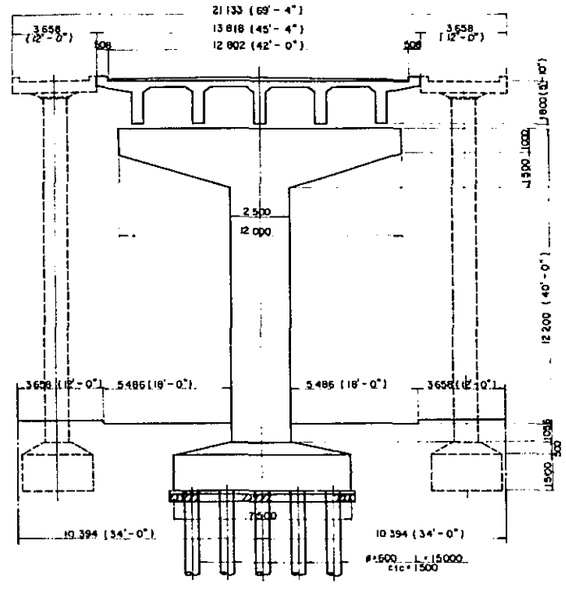
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN	
DACCA-FARIDPUR ROAD PROJECT	
DACCA NORTH-SOUTH ROAD PROJECT	
CASE B PLAN AND PROFILE	
CHIEF ENG.	SCALE 1:200 1:2000
CHECKED BY	SHEET NO 34
DESIGNED BY F. Murashi	DATE AUG. 1970
DR. BY	

DACCA NORTH-SOUTH ROAD GENERAL SECTION
CASE — B

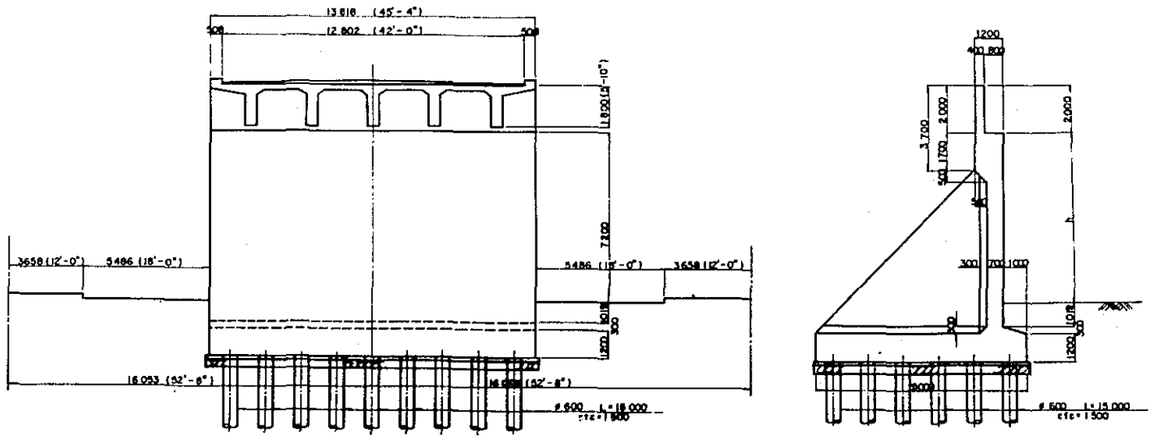
SECTION Ⓔ~Ⓔ'
STA 12+0.00



SECTION Ⓓ~Ⓓ'
STA 19+0.00

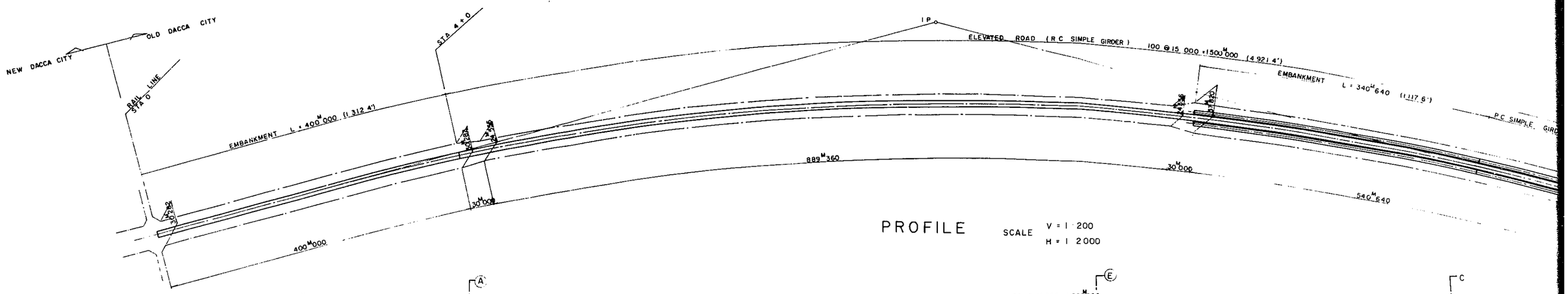


SECTION Ⓐ~Ⓐ'
STA 4+0.00

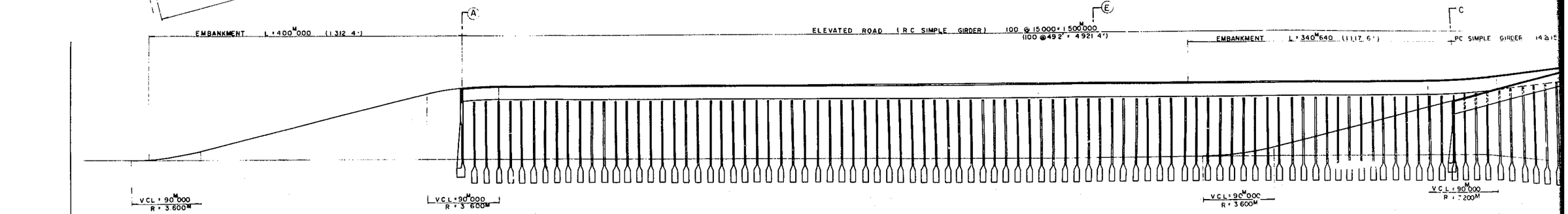


OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN	
DACCA-FARIDPUR ROAD PROJECT	
DACCA NORTH-SOUTH ROAD PROJECT	
CASE B GENERAL SECTION	
CHIEF ENG.	SCALE 1' 100
CHECKED BY	SHEET NO 35
DESIGNED BY	DATE AUG. 1970
DRAWN BY	

PLAN SCALE = 1:2 000

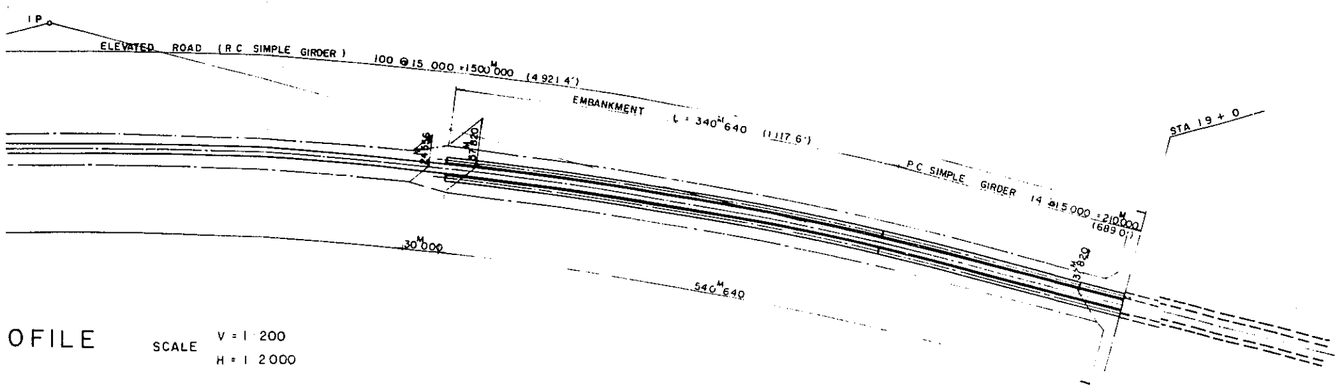


PROFILE SCALE V = 1:200 H = 1 2000

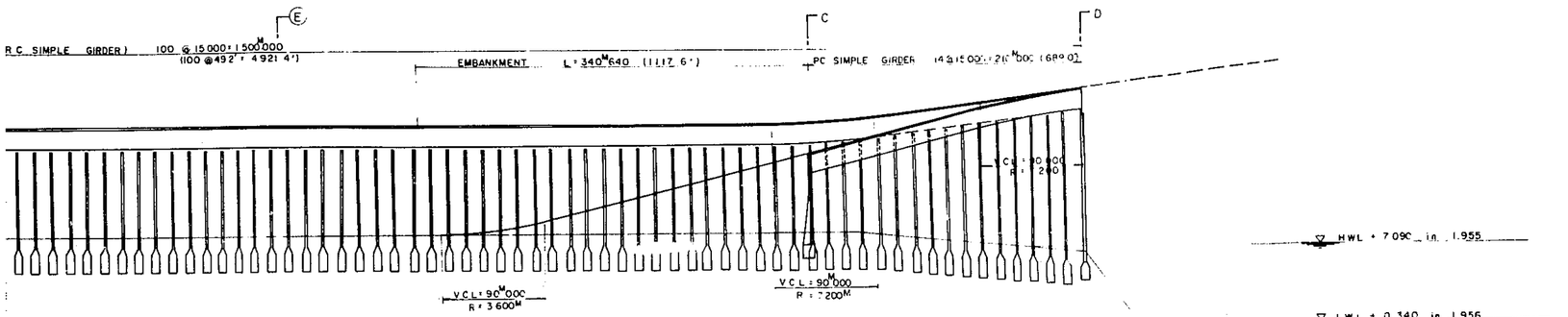


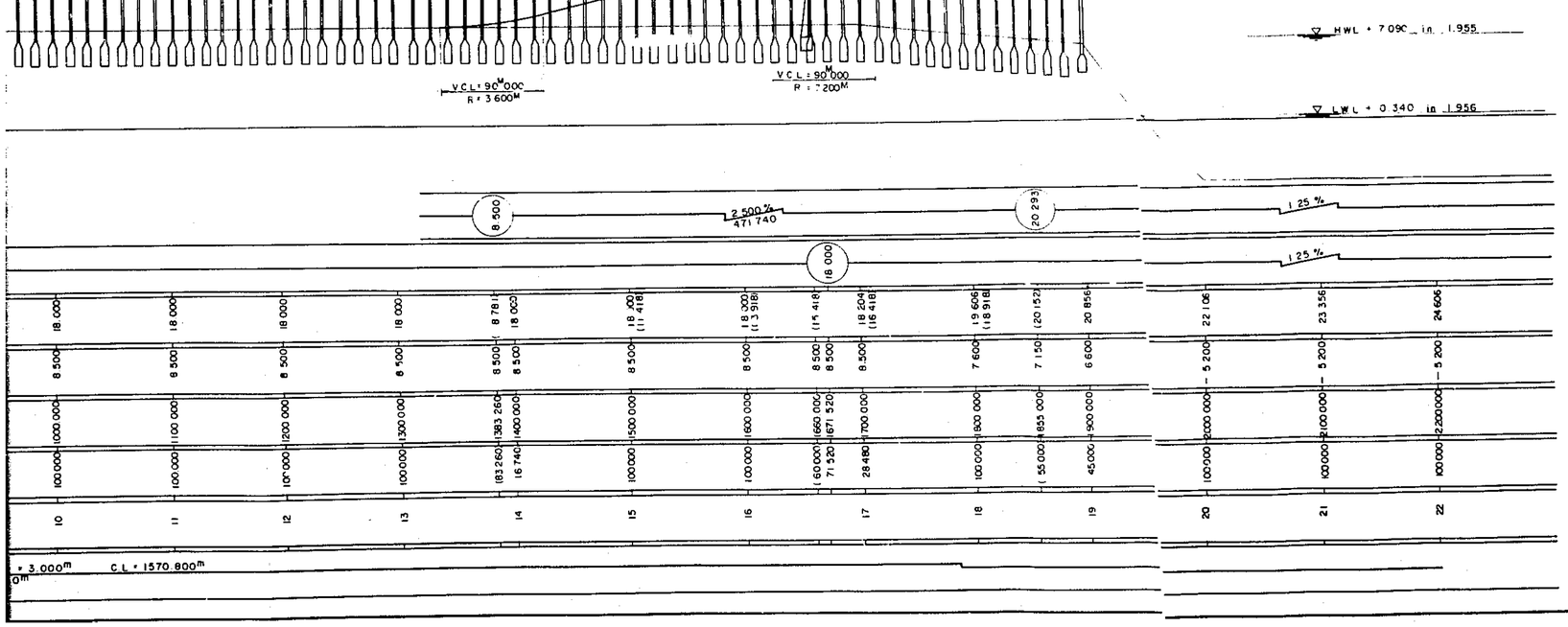
SLOPE	(8 551)		2 500 % 377 960		(18 000)					Level 1 211 520								
PROPOSED HEIGHT	8 628	8 811	10 500	13 000	15 500	17 719	18 000	18 000	18 000	18 000	18 000	18 000	18 000	18 000	18 000	18 000	18 000	18 204
GROUND HEIGHT	8 551	8 530	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500	8 500
ACCUMULATIVE DISTANCE	0 000	22 040	100 000	200 000	300 000	400 000	500 000	600 000	700 000	800 000	900 000	1000 000	1100 000	1200 000	1300 000	1383 260	1400 000	1500 000	1600 000	1660 000	1671 520	1700 000
DISTANCE	0 000	22 040	77 960	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	83 260	16 740	100 000	100 000	60 000	11 520	28 480
STATION	0		1	2	3	4	5	6	7	8	9	10	11	12	13	14		15	16			17
CURVE BAND	I.A = 30°-00' R = 3.000m C L = 1570.800m T.L = 803.850m																					

PLAN SCALE = 1 2000



OFILE SCALE V = 1 200 H = 1 2000

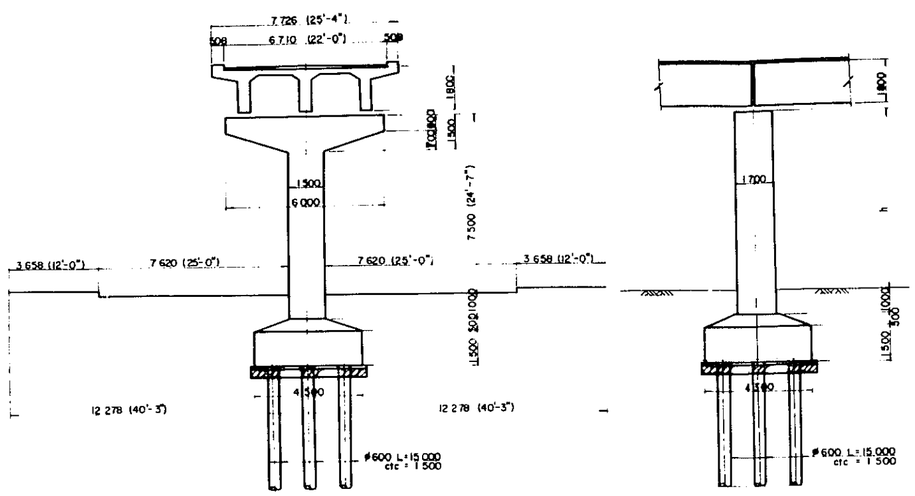




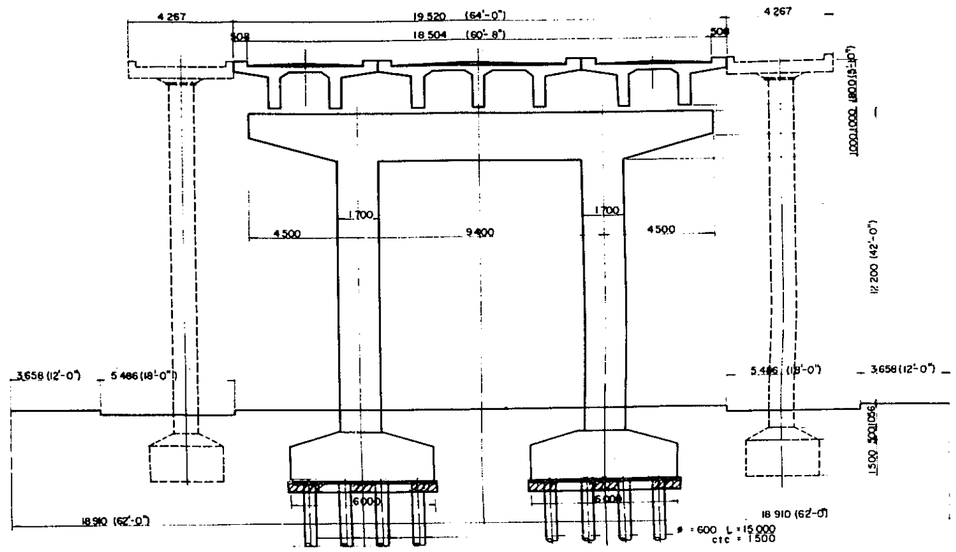
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
HIGHWAY ENGINEERING INSTITUTE, TOKYO	
EAST PAKISTAN	
DACCA-FARIDPUR ROAD PROJECT	
DACCA NORTH-SOUTH ROAD PROTECT	
CASE C PLAN AND PROFILE	
CHIEF ENG	SCALE 1 200 , 1 2000
CHECKED BY	SHEET NO 36
DESIGNED BY	DATE AUG. 1970
DRAWN BY	

DACCA NORTH-SOUTH ROAD GENERAL SECTION
CASE — C

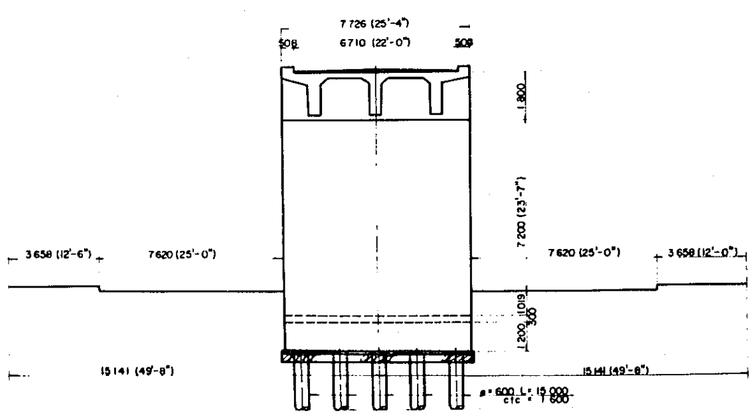
SECTION Ⓔ~Ⓔ SCALE 1:100
STA 12+0.00

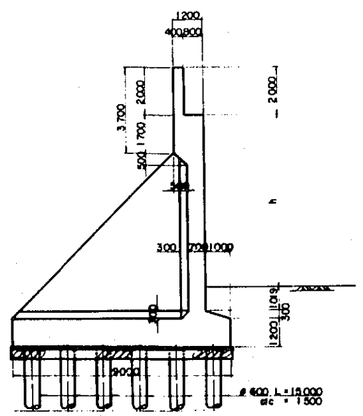


SECTION Ⓓ~Ⓓ SCALE 1:100
STA 19+0.00

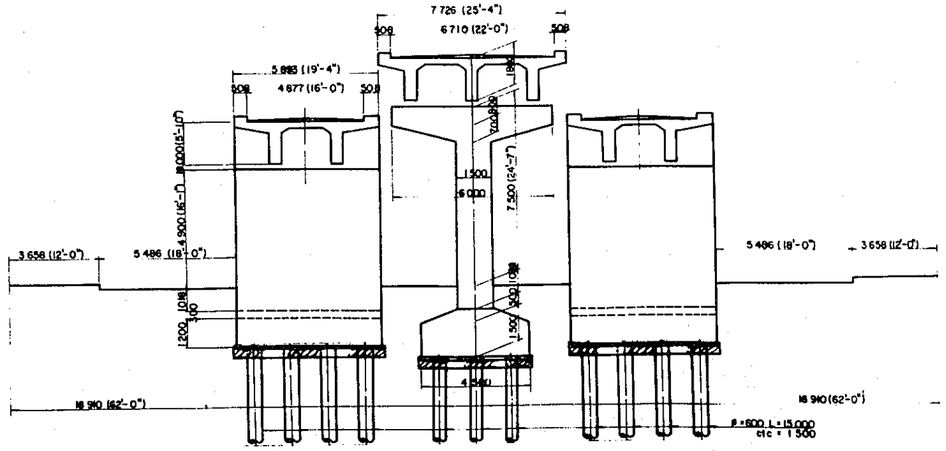


SECTION Ⓐ~Ⓐ SCALE 1:100
STA 4+0.00



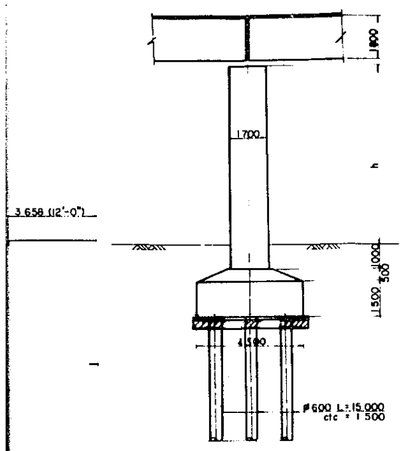


SECTION Ⓒ~Ⓒ SCALA 1:100
STA 16+60.00

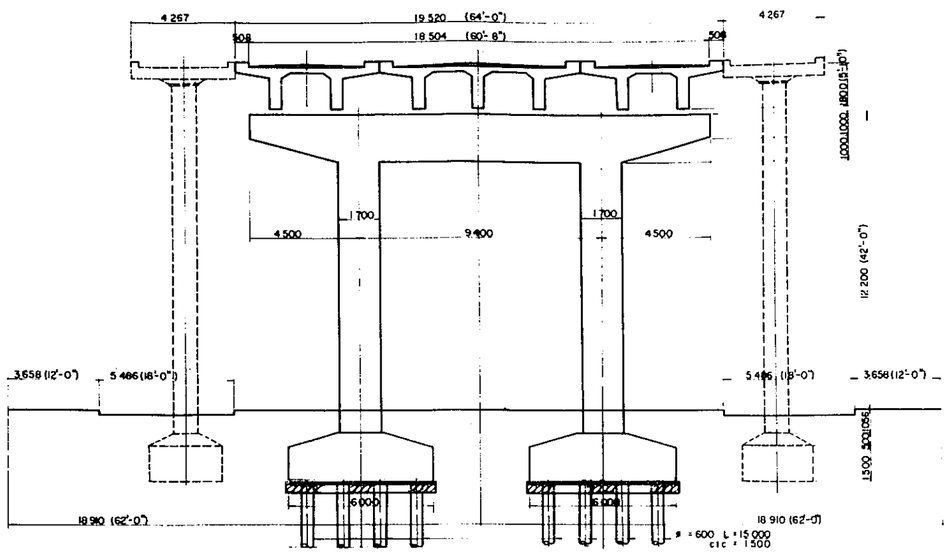


DACCA NORTH-SOUTH ROAD GENERAL SECTION
CASE — C

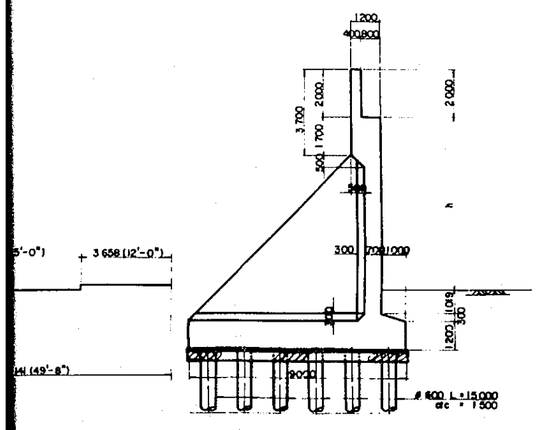
CTION Ⓔ~Ⓔ SCALE 1:100
STA 12+0.00



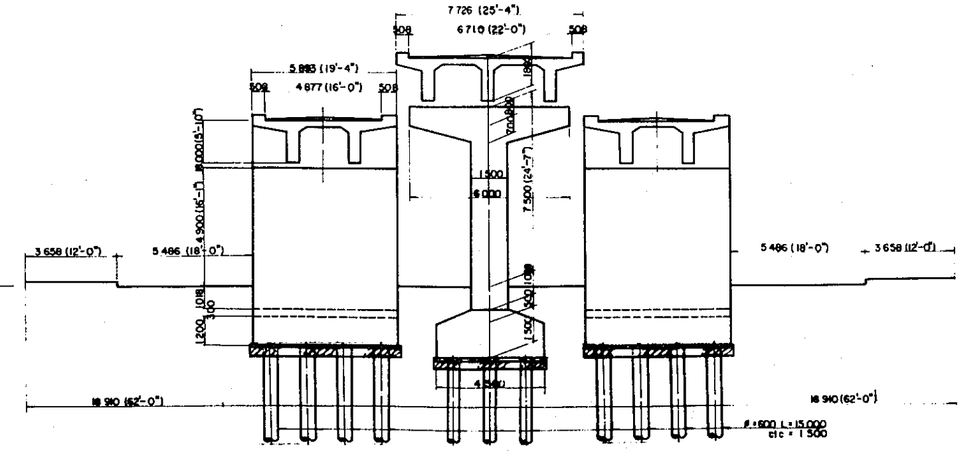
SECTION Ⓓ~Ⓓ SCALE 1:100
STA 19+0.00

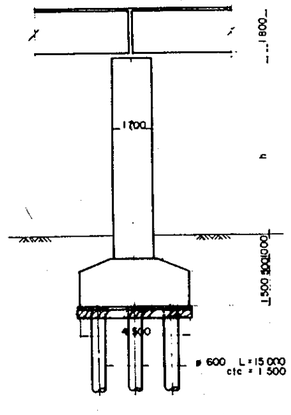


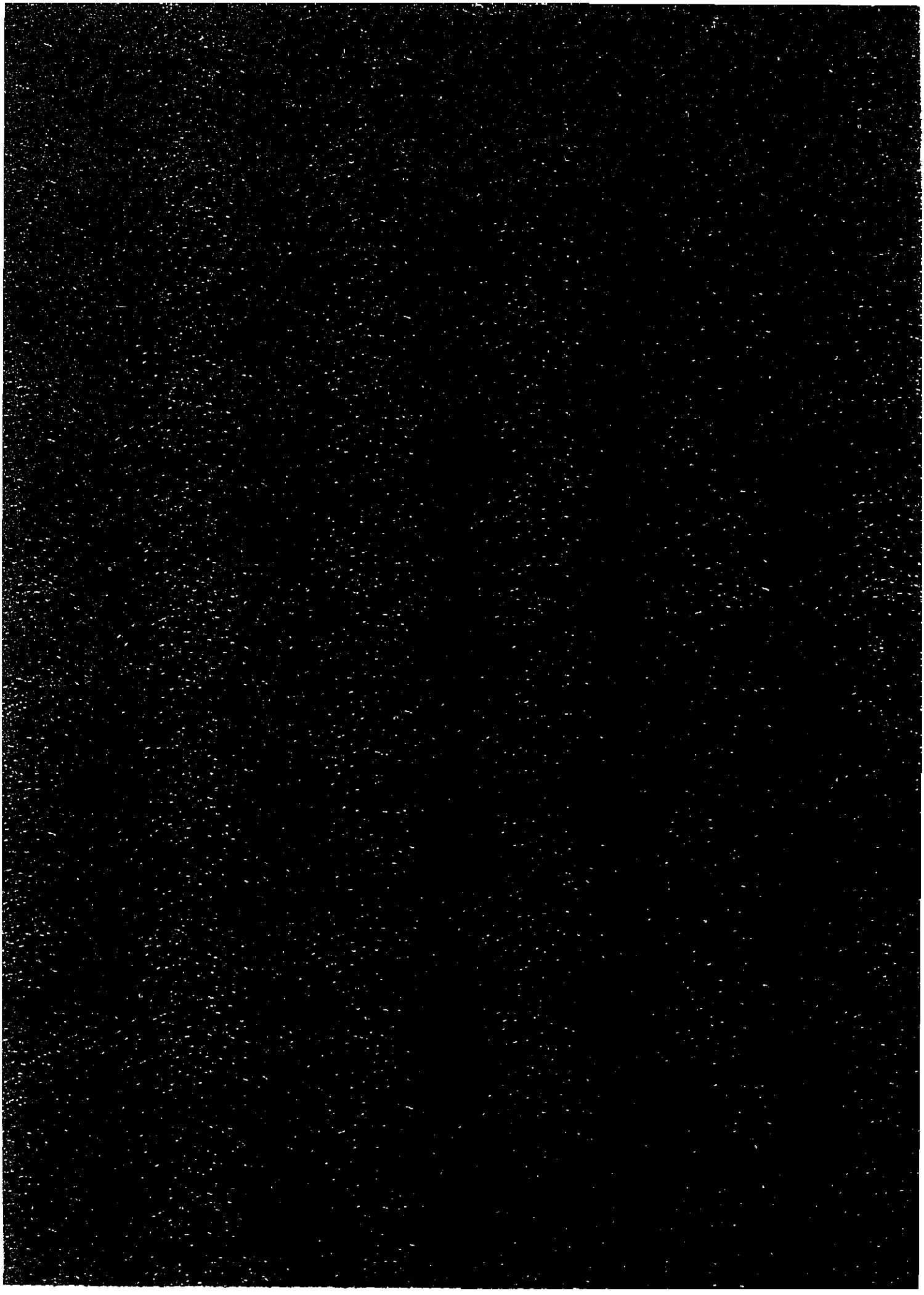
SECTION Ⓐ~Ⓐ SCALE 1:100
STA 4+0.00



SECTION Ⓒ~Ⓒ SCALA 1:100
STA 16+60.00





OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
HIGHWAY ENGINEERING INSTITUTE, TOKYO
EAST PAKISTAN
DACCA-FARIDPUR ROAD PROJECT
DACCA NORTH-SOUTH ROAD PROJECT
CASE C GENERAL SECTION

CHIEF ENG.	SCALE 1:100
CHECKED BY	SHEET NO 37
DESIGNED BY	DATE AUG. 1970
DRAWN BY