# REPORT ON INVESTIGATIONS FOR CONSTRUCTION OF THE BURHIGANGA RIVER BRIDGE

# EAST PAKISTAN

NOVEMBER 1964

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO

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# FOREWORD

In response to the request made by the Government of Pakistan, the Government of Japan undertook to perform the field investigations for the construction of the Burhiganga river bridge, and entrusted the Overseas Technical Cooperation Agency (OTCA) with the execution of the investigations.

The OTCA, an executing agency of the Government of Japan, accordingly organized and despatched a survey team to East Pakistan.

The Government of Japan had already sent to Pakistan two survey missions, in 1960 and 1962, in order to cooperate in her roads and bridge construction programme.

The investigations of this time were conducted as a detailed survey surpassing in its scale the previous two investigations, with particular emphasis placed upon the soil survey required for the substructure of the proposed Burhiganga river bridge.

It is earnestly hoped that the present report, outcome of the joint endeavours of the two parties, would serve the purpose of contributing to the development programme of Pakistan and to the enhancement of the technical cooperation between Pakistan and Japan.

I avail myself of this opportunity to express my deepest gratitude to the competent authorities of the Government of Pakistan for their invaluable assistance and cooperation without which the investigations would not have been completed successfully as scheduled.

November 1964

S. Shibusawa

Shinichi Shibusawa
Director General
Overseas Technical Cooperation Agency

# INTRODUCTION

The present report consists of two parts, namely, Vol. 1 "Report on the Site Investigations for the Construction of the Burhiganga River Bridge" and Vol. 2 "Report on the Preliminary Design for the Burhiganga River Bridge."

Vol. 1 contains the outcome of site investigations relating chiefly to surveying, river survey, boring work and soil test, and further contains the technical data for preliminary designing, whereas Vol. 2 deals with the analysis of the results of site investigations as well as of various data, its the major contents being the comparative and preliminary designs, schedule of construction work and the estimation of construction cost, which are all based upon the results of such analysis.

The investigations of this time was materialized through the untiring efforts that have been made since 1960 by various quarters concerned. Among them are the Tatsugami Mission of 1960, the Inagaki Mission of 1962, International Engineering Consultants Association and East Pakistan Bridge Construction Project Group in Japan who made incessant efforts towards the materialization of the Project, officials in charge of the Ministry of Foreign Affairs and the Ministry of Construction, and Mr. Takenaka, the Japanese Consul-General at Dacca, who rendered years of valuable assistance.

The Tatsugami Mission of 1960 was dispatched in response to the request made by the Government of East Pakistan through the technical cooperation plan of the Ministry of Foreign Affairs. The Mission performed reconnaissance and investigations throughout East Pakistan on irrigation, drainage and power plans of "East Pakistan Water and

Power Development Authority" as well as on roads and bridge construction programme of the Roads and Highways Department of East Pakistan. The Mission paid particular attention to the bridge construction plan and submitted relevant recommendations and proposals (See Ref. 4), 5), and 6)).

Two years later, i.e., in 1962, the Inagaki Mission was dispatched, similarly through the technical cooperation plan of the Ministry of Foreign Affairs, in compliance with the request of the Government of Pakistan. The Mission conducted, with cooperation of the Roads and Highways Department, investigations to determine the technical feasibility for the construction of a bridge over the Burhiganga river in Dacca city, the Karnaphuli river in Chittagong and the Rupsa river in Khulna city. The investigations performed by the Inagaki Mission are the preliminary survey which forms a part of the pre-investment basic investigations. In its report submitted to the Government of East Pakistan (See Ref. 47), the Mission upheld the significance of the proposed bridge construction, stated that the proposed construction is technically feasible, prepared the general plans and the rough estimate of the construction cost, and further recommended, strongly and in a precise and concrete way, that the detailed investigations should be undertaken in the immediate future as a part of the pre-investment investigations.

The Government of East Pakistan studied the said report and formally requested the Government of Japan, early in 1964, through the Central Government at Karachi, to carry out the detailed investigations, to perform the preliminary and comparative designing, and to prepare the work schedule as well as the estimate of the construction cost for the proposed Burhiganga river bridge at Dacca city to which the Mission had attached the highest priority in its report.

In accordance with this request of the Government of East Pakistan, the Overseas Technical Cooperation Agency (OTCA), an executing agency of the Japanese Government, undertook to perform the pre-investment investigations and dispatched a survey team comprising 10 experts and equipped with surveying instrument, 2 boring machines and equipment for soil test, and further sent two Colombo Plan experts for investigations in the wet season. The Survey Team and the two Colombo Plan experts engaged in site investigations and collection of data and materials. Based on the results of these investigations, Japan Engineering Consultants Co., Ltd. performed, under contract with OTCA, the domestic works relative to the preliminary and comparative designing, the schedule of construction work, the estimation of construction cost and other related works.

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VOL. I

# REPORT ON SITE INVESTIGATIONS
# FOR THE CONSTRUCTION OF
# THE BURHIGANGA RIVER BRIDGE

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## 1. INTRODUCTION

### 1-1 General

The outcome of site investigations contained in this report (Vol. 1) forms a part of the engineering study for the proposed construction of the Burhiganga river bridge, and has been supported, together with the contents of Vol. 2, by the Overseas Technical Co-operation Agency of the Government of Japan.

The formation of the Survey Team was as follows:

| | Name | Assignment | Post |
|---|---|---|---|
| Leader: | Mr. Y. Maeda | Bridge engineering | Advisor, Japan Engineering Consultants Co., Ltd. |
| Member: | Mr. Y. Seki | Accounting & Liaison business | Staff, Development Div., OTCA |
| | Mr. H. Wakatabi | Soil engineering | Geological Dept., Japan Engineering Consultants Co., Ltd. |
| | Mr. H. Kuwata | Foundation engineering | Advisor, Japan Engineering Consultants Co., Ltd. |
| | Mr. R. Yoshida | Surveying | Roads Dept., Japan Engineering Consultants Co., Ltd. |
| | Mr. M. Komai | Ditto | Ditto |
| | Mr. Y. Fukui | Geology | Technical Dept., Tone Boring Co., Ltd. |
| | Mr. T. Zenke | Boring | Construction Dept., Tone Boring Co., Ltd. |
| | Mr. K. Yoshida | Ditto | Ditto |
| | Mr. K. Izumi | Ditto | Ditto |

Besides the above listed experts, the following two engineers were dispatched, as Colombo Plan experts, in compliance with the request of the Government of East Pakistan, for the purpose of conducting hydraulic investigations during the wet season.

| Name | Assignment | Post |
|---|---|---|
| Mr. A. Tsuchiya | River engineering | Civil Engineering Laboratory, Ministry of Construction |
| Mr. R. Yoshida | Surveying | Road Dept., Japan Engineering Consultants Co., Ltd. |

On the Pakistani side, Mr. Q. Islam, Additional Chief Secretary of the Government of East Pakistan who is in charge of planning, was the leading figure in carrying out the scheme for the proposed bridge construction inclusive of the arrangements for requesting the Government of Japan to dispatch a survey team; the overall plans were drawn up by Mr. Keramat Ali, who was held the post of Secretary of Planning Department at the time of mapping up plans, later Secretary of Roads and Highways Department and is currently Commissioner of Khulna Division and by Mr. A.H.S. Alam, member of the Planning Board; arrangement and assistance were offered to the Survey Team by Dacca Improvement Turst (D.I.T.) under the guidance of the Basic Democracies and Local Government Department (B.D. & L.G.D.) which assumed the overall responsibilities in carrying out the proposed bridge construction plan.

Deepest gratitude is hereby expressed to Mr. G.A. Madani, the newly assigned Chief of D.I.T. who not only accorded the Team most valuable assistance throughout its stay in East Pakistan but also was kind enough to comply, to the fullest extent, with the requests of the Team.

The following members of D.I.T. joined the Team during the investigations.

| Name | Post | Assignment |
|---|---|---|
| Mr. A. Hafiz | Chief, Planning Section | Planning |
| Mr. S.M.A. Ahsan | Chief Accountant | Liaison business |
| Mr. A. Rashid | Ass't Engineer | Ass't Engineer |
| Mr. S. Rahman | Ditto | Ditto |
| Mr. A. Rahman | Ass't Surveyor | Assistant |
| Mr. Md. Ahammed | Ditto | Ditto |

The above listed members of D.I.T. accompanied the Team during the investigations and extended to the Team most valuable cooperation in liaison business as well as in obtaining technical and other facilities. Heartfelt thanks are hereby expressed to all the above listed members of D.I.T., and in particular to Mr. Hafiz who unfortunately fell ill in the course of investigations but whose wholehearted cooperation enabled the Team to perform the investigations sucessfully as scheduled.

The Team also wishes to tender its thanks to Mr. M. Noman, Chief Engineer, for his cooperation for the overall construction project and designing, Mr. K.R. Choudhury for his unlimited assistance when the city plan and relevant drawings and maps were brought up for discussion and review, Mr. M.A. Jabbar and Mr. F. Ahmed who made all the necessary arrangements for vehicles and tax exemption procecures as well as for procuring tools and equipment required for investigations and for the transportation of boring machinees.

The Leader of the Team and Mr. Takenaka, the Japanese Consul-General at Dacca, had the opportunity to meet Mr. Abdul Monem Khan, the Governor, who was kind enough to express his thanks and extended nice words of encouragements to the Team. The Team wishes to express its thanks to the following officials of B.D. and L.G.D. -

Mr. A.M.S. Ahamed, Secretary, Mr. S.D. Khan, Joint Secretary, Mr. A.N. Haq, Deputy Secretary, Mr. S.J.A. Dighvi, and to Mr. M.A. Huq, Deputy Secretary of the Planning Department.

The Team further wishes to extend its gratitude to Mr. Ali Asghan, Chief Secretary, and Mr. H.T. Ali, Additional Chief Secretary (in charge of administration) for the constructive opinions they expressed in connection with the overall project, Mr. S. Rahman, Secretary of Works, Power and Irrigation Department, and Mr. H.A. Khan, Chief Engineer of the Roads and Highways Department for their adequate technical advices.

The Team had the opportunity to discuss at length about the proposed construction plan with Mr. M.A. Menon, Deputy Secretary, and Mr. O. Rabbani, at the Economic Affairs Division of the President's Secretariat at Karachi. In obtaining necessary data and materials, Mr. Faiz Ahamed, Chief Engineer of the Hydrological Div. of East Pakistan Water and Power Development Authority and Mr. A.B. Bhuiyan of the same Authority, and Messrs. The Engineers Ltd. extended their kind assistance to the Team.

Names of persons who offered the Team cooperation and assistance are given in Appendix 4.

The site investigations were conducted for a period of about 5.5 months, i.e., from February 24 to June 18 in the dry season from August 20 to October 12 in the wet season. The process of the investigation work is as outlined below.

| Period or Date | Work covered |
| --- | --- |
| Feb 25 - Mar 23 | Basic surveying, river survey (field and office work) |
| Mar 23 | 1st progress report submitted |
| Feb 24 - Apr 7 | Review and study of data and materials, consultations on designing, inspection of existing bridges |
| Apr 8 - Jun 3 | Boring work and soil survey |
| Apr 30 | 2nd progress report submitted |
| Jun 4 - Jun 18 | Calculation of construction cost, final consultations, report made to the Central Government and the Japanese Embassy at Karachi |
| Jun 11 | 3rd progress report submitted |
| Jun 20 - Jul 31 | Soil test at the laboratory in Japan |
| Aug 20 - Oct 13 | River survey during the wet season |
| Oct 9 | Report on river survey submitted |

A substantial quantity of undisturbed soil sample was sent to Tokyo by air for soil test at the laboratory in Japan (Soil Laboratory, Faculty of Engineering, Nihon University).

Analysis of data and materials obtained during the investigations were conducted, simultaneously with the designing work, by the Designing Dept. of Japan Engineering Consultants Co., Ltd. during the period from the end of June to the end of November.

1-2 Characteristics of Investigations

The investigations were conducted with the objective of determining the foundation conditions at the construction site of the proposed Burhiganga river bridge. The investigations of this time are the second detailed investigations for bridge construction that have ever been conducted in East Pakistan, the first being the investigations for the Sitalakhya river bridge construction of 1960.

The foundation conditions at the construction site are to be determined by two different factors, i.e., the soil conditions and the hydraulic conditions. This is for the reason that the proposed construction site is located in the alluvium, which makes the fluctuation in the soil conditions an important factor. Another reason is that the site investigations were considered absolutely necessary prior to the preparation of preliminary designs and the work schedule for the sub- and superstructure of the bridge, or to the estimation of the construction cost. The site investigations were strongly recommended by the Inagaki Mission in 1962, and the competent authorities of East Pakistan already approved of the Mission's recommendations.

Particular attention was paid during the investigation to the soil and hydraulic conditions in relation to the economical foundation work of the bridge other than the open caisson type that had conventionally been adopted in East Pakistan; and this was due to the fact that both the soil and hydraulic conditions have close effects upon machines and equipment to be required for construction.

In addition to the surveys made at the construction site, geological study was made in the area surrounding it together with the historical review of the numerous rivers running in the vicinity of the site. The present report contains the detailed description of the site investigations and tests performed with the results obtained therefrom.

The soil classification table based on JIS (Japan Industrial Standards) was utilized for microscopic soil classification during the investigation as well as for the preparation of the soil profiles at the laboratory in Japan. An integrated method applied to the mechanical analysis of soil was used both in classifying the soil by property and in describing the soil samples tested at the laboratory. These two methods are defined in Appendix 5.

## 2. SUMMARY AND CONCLUSION

Prior to its commencement of investigations, the Team submitted to the Government of East Pakistan and D.I.T. the following proposal which forms Appendix 1:

"Proposal of Survey Works to East Pakistan Government, by Japanese Bridge Survey Mission, for Burhiganga Bridge Construction",

and with the approval of both the Government of East Pakistan and D.I.T., the Team proceeded to conduct the investigations according to the schedule given in the above proposal. However, the schedule for the boring work and few other works were altered on account of the situations in East Pakistan after due consultations with the officers of D.I.T. In Appendix 2, expenses borne by the Government of Japan for site investigations and for the designing work in Japan are given for reference.

Today, the construction of the Burhiganga river bridge is widely recognized in East Pakistan as absolutely necessary for the future development of Great City Dacca; and it is so recognized without the least need of resorting to the examples set by large cities of the world such as New York, London, Tokyo, Paris, Bangkok, etc. During the investigations, the proposed construction site was re-confirmed as quite commendable from the standpoint of natural conditions including the conditions of river, soil, etc. It should be made clear, however, that the proposed Burhiganga river bridge would not fully function as a part of the city's communication route before the development programme of Keraniganj is implemented, the necessary land is expropriated at the bridge construction sites in Old Dacca, and the construction of the trunk road to run south to north is materialized.

The topographical conditions of the construction site were completely clarified by plane surveying, topographical survey and river sounding, and the map for respective survey was also prepared.

The velocity measurement and sounding in both wet and dry season were conducted. The inflow discharge from the Turag river and the scouring action at the Dhaleswari river were also measured. The analysis of the results of these measurements led to the conclusion that the Burhiganga river possesses sufficient stability from the viewpoint of river engineering, that the probable scouring depth of 7.34 ft after completion of the bridge is recommendable, and that the desired safety would be secured against the flood by adopting as estimated highest high water level the value of 23.25 ft (above P.W.D.) which is the highest high water level recorded in 1955.

On the other hand, the boring and soil tests have releaved the conditions of the subsurface, i.e., the layers present a comparatively regular formation and embodies no sectional irregularity, a boundary layer with N value of 25 is existent at the depth of about 25 m below the ground surface or the river bed, the ground conditions as a whole are stable enough to provide ample bearing power for the foundation work at points which registered N = 25, and there is no fear of sinking of the ground due to consolidation.

In addition to the above-mentioned surveys, such other surveys and studies as given below were performed as far as time permitted:

Meteorological survey, corrosion survey, traffic survey, study and review of data for designing, calculation of construction cost, study of data and materials, and review of the city plan.

In drawing up plans and designs for the structural layout of the bridge, it was considered quite important to take into account the situations in East Pakistan, and consultations were accordingly made with the officers in charge of D.I.T. as well as with the competent Government officials of East Pakistan.

It is believed that the site investigations briefed above have produced data and materials sufficient for drawing up plans, designs and the work schedule, whereby the general plan for the bridge construction, the comparative and preliminary designs and the work could safely be prepared for the materialization of the project.

## 3. SELECTION OF CONSTRUCTION SITE

### 3-1 The Development of Great City Dacca in Relation to the Construction of the Burhiganga River Bridge

Dacca city, which was the centre of East Bengal and is at present the capital of East Pakistan, has developed along the Burhiganga river. Old Dacca expanded along the same river, with the new section now developed in the area termed "Ramna Area" which is located in the northern part of the old city. Dacca city today extends over a substantially long distance between the Burhiganga river in the south to the Tongi river in the north, but the land available between the eastern and western end of the city, bordered by the Sitalakhya river and the Turag river respectively, is extremely narrow. The population of the city (556,712 according to the census taken in

1961; now presumed to reach approximately 700,000 with the floating population included) is concentrated in Old Dacca where slums are beginning to be formed. The population of 556,712 as compared with 338,762 registered by the census of 1951 shows an increase of about 64% in a matter of 10 years. This fast increase in population may be attributed to the rapid industrialization of Dacca and to the consequent inflow of population into the capital city from the neighbouring districts. In order to put into execution the city plan which is to cope with this rapid increase of population and to contribute to the development of the city, the Government of East Pakistan commissioned "Minoprio & Spencely & P.W. MacFarlane", a British consultants company to draft a Master Plan for Great City Dacca which was completed in 1959. In this Master Plan, it is recommended that the development of the land extending between the Burhiganga river and the Dhaleswari river be materialized together with the construction of the Burhiganga river bridge to help absorbing the increase of population expected as the industries and commerce of the city become more active in the future.

Recommendations contained in the Master Plan are briefed below:

1) Between the Burhiganga river and the Dhaleswari river, there lies Keraniganj district which has a total extension of 50 miles and covers an area of 10,000 acres. The Master Plan recommends that the 3,000 acres of low-lying land in this district be reclaied and that the land formation covering about 60% of the total area of this district be materialized so that the land thus formed be developed in an urban district.

2) The Master Plan also recommends that the roads be constructed

on the land thus formed, that large ferry boat service be realized on the Dhaleswari river, the Ganges river and on the Padma river, whereby the city's communication network may be expanded southward to Faridpur about 70 miles south to Dacca.

3) With the view to implementing the above two plans quickly and efficiently, the Master Plan approves of the construction of the Burhiganga river bridge as urgent project to be materialized.

Based on the above recommendations of the Master Plan, D.I.T. proposed in its Plan No. 36 to appropriate in the budget a sum of ¥150 million (20 Lakhs Rs.) for surveying, planning and designing, and ¥8.15 billion (1,130 Lakhs Rs.) for the bridge construction and land formation, both to be carried out under the joint control of B.D. & L.G.D. of East Pakistan and the Construction Department of the Central Government. Stress was placed on the development of the land on the opposite side of the river, and it is understood that the programme for the construction of roads has been worked out as a part of the Third Five-Year Plan.

The Team finds it quite needless to quote the examples set by the construction of the Menam river bridge in Bangkok to explain that the proposed Bruhiganga river bridge will undoubtedly contribute, in a large measure, to the reduction of freight of bricks, foodstuffs like fish, meat, rice and vegetables and other different materials, and to the smoother communication across the river, and in the ultimate to the development of Dacca city. It is the opinion of the Team that the proposed bridge would not function satisfactorily unless the city plan is put into full practice, whereby the demolishment of structures and streets in Old Dacca will be effected, the construction of the trunk road to run south to north will be purshed forward, the city district and the roads along the river will be improved, and the reclamation of the land on the opposite side of the river and the roads construction on the reclaimed land will be realized. It is therefore desired that the competent authorities of Pakistan would pay particular attention in this respect. It may as well as be added that the detailed recommendations in this connection are presented in Vol. II. (See Plate I - 1, 2 & 3).

3-2 Construction Site of Burhiganga River Bridge

(See Plate I - 3 & 4)

The construction of a permanent bridge over the Burhiganga river was found necessary when the long range prospect of this district was taken into consideration. Three points were accordingly selected as proposed construction sites. The first of the three points leads to Dacca - Narayaganj Diversion Road, the second leads to the trunk road now planned at Sadarghat, and the last connects the Golden Biscuit Factory on the Dacca side to Jinjira village on the other side of the river.

The first of the three selected sites which leads to Dacca - Narayanganj Diversion Road is advantageous in that it would contribute to the development of the national highways, but has the drawback of being located a little too far from the city district. The second is the most beneficial from the viewpoint of the desired development of Dacca city and can be connected to the trunk road which is planned to run south to north through Dacca. It is disadvantageous, however, in that it calls for the demolishment of slums in Old Dacca and for the readjustment of the demolished area. Bridge construction at the third selected point will immediately contribute to the development of Jinjira village but will not be effective for the development of Dacca since the low-lying marshy area formed by the tributaries of the Burhiganga river is found on the Dacca's side.

The question relating to the selection of the construction site was discussed and reviewed at the joint meeting held in 1962 with the attendance of the Japanese survey mission dispatched that year, C. & B. and D.I.T., and the conclusion was reached that the bridge construction would be necessary in the future at all of the three points but that the first priority should be given to the point near Sadarghat as the bridge constructed there would most largely contribute to the development of Dacca city.

Prior to the commencement of its work in East Pakistan, the Team found it necessary to determine the construction site as the basis of its site investigations.

It is a basic principle that a highway bridge is a part of the highway and its construction should therefore be the road construction programme. A bridge construction programme and a road construction programme should be most closely affiliated with each other and serve the purpose of improved road communication. This principle is always true whether the bridge construction comes before the road construction or it is carried out as a part of the road construction programme.

The layout given in the Master Plan for Dacca city is not a final one and there is sufficient room for alteration. This is true from the fact that the proposed route has not yet been finally decided for the trunk road to run south to north, and can therefore be altered to an extent at least near the Burhiganga river; no road construction programme has yet been worked out for Keraniganj side. It can therefore be said that the alignment of the Burhiganga river bridge is not bound by the road construction programme but can be determined without sacrificing the most rational structure and at the lowest possible cost.

Results of the reconnaissance made in the vicinity of Sadarghat (on both shores of the river) and of the review made on the city planning map are as given below.

1) The route of the bridge may pass through any point in Keraniganj district on the opposite side of the river. But it is recommendable to avoid the tributary that runs parallel to the Burhiganga river and the shoal-like section surrounded by the tributary (the Kaliganji river) which flows perpendicularly into the Burhiganga.

2) The route of the bridge would therefore be determined to run perpendicularly to the center line of the Burhiganga river, across as small river width as possible.

3) The vicinity of Sadarghat on the Dacca side is congested with houses of Old Dacca. Any route would have to pass through this area but it is advisable that the market area along the river is avoided so that an open area may be secured near the river bank where the materials and equipment for the construction work may be stored. With regard to the area near Water Works Road located beyond Simson Road, no excessive fluctuations are expected in the expenses required for the demolishment of Old buildings and for the expropriation of land whichever point in

the area the route may pass through.

4) It would be advisable to refrain from deciding upon the route of the bridge which would largely alter the route of the trunk road (road width: 100 ft).

From the results given above, the route of the bridge was planned to pass through the midway between Simson Road that runs south to north and Bulbul Academy and the point about 272,434 m upstream of the point where Sadarghat Road crosses Buckland Band, or the point about 5 m upstream of of the south-western end of B.R.S.L. Co.'s building, and it was further planned that the route would be perpendicular to the center line of the stream. This point on the Dacca side is called "Wiseghat." The above route was decided as a result of the consultations with the officers in charge of city planning of D.I.T., Chief Engineer, and Chairman of D.I.T., and was finally determined and confirmed at the joint meeting held with the attendance of Mr. Tsuchiya and Mr. Yoshida who engaged in the river survey during the wet season in October 1964 as Colombo Plan experts, Mr. Takenaka, the Japanese Consul-General at Dacca, Mr. H.A. Kahan, Chief Engineer of Roads and Highways Department, Mr. Noman, Chief Engineer of D.I.T., Mr. Hafiz, Executive Engineer of D.I.T., Mr. S.D. Khan, Joint Secretary of B.D. & L.G.D., Mr. Khoja, Chief Engineer of I.W.T.A.

3-3 Burhiganga River

The Burhiganga river, which runs in the south of Dacca city, is relatively stable when compared to numerous other rivers that flow through the delta area formed by the three international rivers, i.e., the Ganges, the Brahmabutra and the Meghna. At the proposed construction site, the river wide in the dry season marks 261.50 m, and there is a distance of 337.27 m between the retaining wall on the left shore (Dacca side) and the natural bank on the right shore (Keraniganj side), which indicates that the Burhiganga river is comparatively small when compared to many other rivers in this country. The maximum depth of the river can be detected closer to the Dacca side. The depth in the dry season is 7.51 m, and the maximum depth recorded in the past is 14.597 m which was registered during the wet season of 1955. The right shore of the river is a low-lying area which is submerged during every season. In the flood season of 1955, flooding of 70 cm above the street on the retaining wall on the left bank and 80 cm flooding above the ground in a village about 300 m away from the right shore were recorded. In its Inland Water Transport Programme, the Inland Water Transport Authority (I.W.T.A.) of East Pakistan demanded that there should be a clearance of 45 ft above the high water level and that the minimum channel width should be 150 ft.

Along the left shore of the river between the crossing point of Sadarghat Road and the center line of the proposed construction site, there are ports and small river boats are plying between the left and right banks. Large passenger boats are also operating travelling up- and downstream of the river.

The water depth becomes substantially deeper downstream of the center line, where cargo boats were found at anchor and various commodities such as cement, gravels, petroleum were unloaded. A number of warehouses was also found in this district. In the area north to the street on the left bank is the old city which is crowded with active markets. Most of the area on the right bank is the farm land, and there was found only one small shipyard. Villages are scattered far from the river bank.

## 4. SURVEYING

### 4-1 Introduction

The surveying described in this chapter involves the establishment of the center line of the bridge, installation of bench marks, triangulation, multi-angle survey, detailed survey by means of plane-table, levelling, and the office work (calculation and planning). The surveying work was carried out according to the following work process: preparations from February 25 to 28, the field work from February 29 to March 20, and the office work from March 21 to March 23. Simultaneously, the river survey in the dry season, which will be described later in detail in Chapter 5, was performed. 2 surveying engineers of the Team engaged in the surveying work with the cooperation of Mr. M.A. Hafiz, Executive Engineer (Proj.) and 2 assistant surveyors of D.I.T. D.I.T. was also kind enough to provide the Team with a room for office work, an office for field work, 5 labourers, 2 country boats, 1 motor-boat, piles for surveying work, picks, axes, hatchets, wooden mauls, anchors for boats. All of the surveying instrument utilized were Japanese made which were sent from Japan by air. Major items amont these instrument are as given below:

| Item | Q'ty |
|---|---|
| Transit (Type H5, w/extension legs) | 2 pcs |
| Level (Type E5, w/extension legs) | 2 pcs |
| Transceiver (Maker: NEC) | 1 set |
| Calculating machine | 1 unit |
| Binoculars | 2 pairs |

| Item | Q'ty |
|---|---|
| Range finder | 2 units |
| First-aid medicine | 1 set |
| Steel measuring tape (50 m) | 2 pcs |
| Vinyl measuring tape (100 m) | 2 pcs |
| Sounding rope (30 m) | 1 pce |
| Plane table | 1 set |
| Drawing borad and instrument | 1 set |
| Wire rope (200 m) | 1 pce |
| Staff | 2 pcs |
| Pole | 5 pcs |
| Measuring tape (100 m) | 1 pce |
| Work outfit and shoes | 6 sets |
| Office stationery | 1 set |
| Current-meter | 1 set |
| Echo-sounder | 1 set |

4-2 Surveying Work

4-2-1 Establishment of the center line for the proposed construction

According to the afore-mentioned determination of the route, the center line was first plotted on the aerial map and on the available plane, and was then established at the construction site by transferring it from the maps (See Plate I - 6). On the left bank, a steel rivet was driven into the top of the concrete retaining wall at the point slightly downstream of B.R.S.L. Co. and it was determined that the center of the rivet should be the central point on the left bank. Further, the locational inter-relation between the central point and the concrete distance marking stake installed about 1 m away from the rivet was measured to provide against the loss or breakage of the rivet. On the right bank, each station of triangulation was developed on the plane after conducting the triangulation, and Pile No. 3 was anchored, as the central point on the right bank, perpendicular to the flow direction from the central point on the left bank by surveying at the construction site as well as by locating on the plane.

4-2-2 Decision of bench mark

The bench mark shown in "Survey of Pakistan" is installed in the rotary near Hotel Shalbagh in the new section of the city. On account of the considerable distance between the rotary and the construction site and of the expected crowd of people, the said bench mark was not carried to the site but the one installed at the entrance of the pump house in front of D.I.T.'s surveying office was selected. The elevation of this bench mark which is 20.601 ft (6.279 m) was accordingly adopted. This elevation had been measured with P.W.D. fixed at El. 0 m. P.W.D. is 1.509 ft (0.460 m) below the mean sea level of the Indian Ocean.

4-2-3 Triangulation

a) Selection of stations

It was the intention of the Team to install 6 stations of triangulation. However, since it became clear that the road on the bank is flat enough to perform the distance survey by installing base lines, that even if the survey points were installed in the upper and lower reaches of the river, they would be quite useless, and that 4 stations are sufficient for the proposed bridge construction, two triangles were formed approximately perpendicular to the centre of the river.

As indicated in Plate I - 5, station △ No. 2 was installed about 3.6 m apart from the centre of the bridge, and △ No. 4 on the opposite bank was set up on the elevated ground which is comparatively solid (natural bank). △ No. 1 and No. 2 were installed about the middle of the road on the left bank. Piles were made of lauan material of fine quality, and their size was 10 cm x 10 cm x 60 cm. Rivets were driven into the top of the piles and the mark + was chisled on it. △ No. 4 was set up about 15 cm above the ground surface, but all the others were driven into the ground so that they may not shake or obstruct the traffic. Accordingly, the triangulation nets were formed with △ No. 2 - No. 3 serving as a base line and △ No. 1 - No. 2 as a check base line.

b) Erection

A pole with a flag, 2 m in length, was erected at △ No. 4 by anchoring supplementary piles around it and by winding the pole and the piles together tightly with wires. At the other 3 stations, poles were set up by labourers each time the collimation was performed.

c) Angle measurement

Measurement of angle was conducted twice by the direction method using a transit of 20 seconds reading. Further, the lightning-conductor on the D.I.T.'s field work office was observed from each station in order to supplement the angle measurement.

d) Distance survey

Since both of the base lines were installed near the port, the heavy pedestrian traffic rendered it impossible to perform the surveying work during the daytime. The survey was therefore conducted early in the morning when it was still dark. Flashlights were utilized in driving piles at intermediate points and also in conducting the repeating survey. Instrument used for the survey were officially approved steel measuring tapes, tensionmeters and thermometers, and the final values were decided after adjusting the invariables of the tapes, temperature and the gradient.

e) Calculation and results

The magnetic north at △ No. 1 was adopted as the azimuth. The origin of co-ordinates was plotted on Keraniganj district, and the co-ordiantes of △ No. 4 were assumed to be:

$X = +1,000^{m}.000, \quad Y = +1,000^{m}.000,$

and in order to make calculations easier, the entire survey area was assumed to be the quadrant N(+), E(+). The results of calculations were transferred into the records of distance survey, horizontal angle measurement, triangulation, as well as in the calculation records of azimuth, side length and corrdinates.

4-2-4 Traverse survey

a) Selection of stations

On the left bank, stations were installed over a distance of about 400 m from the bank in order to prepare a long topographical map with the centre line to appear in the middle as designed. 46 stations were installed by driving steel rivets where the road is paved, and at other places by anchoring wooden piles of the size 4.5 cm x 4.5 cm x 50 cm into the ground. The traverse survey net was a closed traverse but was partially an open traverse with △ No. 2 serving as the starting point.

On the right bank, where the visibility was not hindered, the centre line was extended and 10 piles were anchored between the shore and the village which was about 300 m apart from the shore. Rivets were driven in the piles to serve as stations. Inter-relation between the stations of triangulation and those of traverse survey is as shown in "Triangulation and Traverse Survey Net (Scale: 1/2,000)." (See Plate I - 5)

b) Distance survey

Repeating survey was conducted and the value was decided after adjusting the temperature, invariables of tapes and the gradient.

c) Angle measurement

The mean value of double angles based on double angle method was adopted.

d) Calculation and results

Coordinates of each station were obtained from the calculation table of stations of traverse survey. Distance between stations, direction angle of each station, size of pile at each station, and coordinates values were tabulated.

4-2-5 Detailed Survey

The detailed survey was conducted by means of plane-table survey. Coordinates values of stations of traverse survey were developed on the plane-table sheet, which served as supplementary controls for installing supplementary stations in open areas and alleys, and a topographical map (scale: 1/500) was prepared.

In the area where houses are congested, D.I.T.'s drawings (Scale: 1/800) were used in plotting buildings. Buildings were clasified into brick buildings and simple bamboo or wooden houses

(See Plate I - 6). After completion of the plane, levelling was conducted throughout the area from the elevation of the piles at stations of traverse survey at crossings and other necessary points, and the elevation and positions of such crossings and points were expressed in millimeters. The topography near the river banks was expressed by contours at intervals of 50 cm. The survey covered an area of 420 m x 200 m on the Dacca side and 360 x 130 m on the Keraniganj side.

4-2-6 Levelling

a) Determination of elevation of △ No. 2 on the left bank

The elevation was measured by repeating survey based on the above-mentioned bench marks.

b) Levelling across the river

This was performed to determine the elevation of △ No. 4 on the right bank from △ No. 2 on the left bank the elevation of which was already known. Levelling was conducted 10 times by the reciprocal levelling from either side and the mean value obtained was taken as the elevation of △ No. 4. As a result, it was discovered that the flat area on the Keraniganj side is lower by about 4 m than the area on the Dacca side.

c) Determination of the elevation of stations of triangulation and traverse survey.

The elevation of piles and the elevation of the stations of triangulation and traverse survey was determined on the basis of △ No. 2 and No. 4.

4-2-7 Installation of supplementary bench marks

In order to provide against the possible submersion of the bench marks at the time of a flood, the elevation of the foundation of the pillar at the entrance of B.R.S.L. Co.'s building was measured on the basis of △ No. 2, so that the pillar's foundation may serve as a supplementary bench mark. On the right bank, the elevation of the foundation of a concrete building was measured similarly on the basis of △ No. 4 whereby the foundation would also serve as a supplementary bench mark.

4-2-8 Installation of water-gauge

A large square pile, 2 m in length, was driven at the edge of the river, near the station of traverse survey No. 1 on the right bank. The pile was graduated in millimeters with red and white paint from 0 m (0.848 m above P.W.D.) to 1 m.

Table I - 1 shows the sizes of piles or the elevation of the ground surface of the water-gauge, stations of triangulation, bench marks, and central points.

## 5. RIVER SURVEY

### 5-1 River Survey

The river survey was conducted on March 13, 14 and 15 in the dry season and on September 3, 4, 5, 14 and 15 in the wet season. The river survey constitutes a major part of the river investigations. The Team performed the river survey to grasp the characteristics of the flow of the Burhiganga river, to collect data and materials on the Burhiganga and affiliated rivers, and to estimate the degree of the scouring action near the piers of the proposed bridge. It was intended that these findings will be used to meet the requirements in designing the brdige. The river survey during the dry season was conducted by Mr. Yoshida and Mr. Komai of the Team, and that of the wet season by Mr. Tsuchiya and Mr. Yoshida, the Colombo Plan experts.

5-1-1 Contour surveying of the river

The contour surveying, or the sounding, of the Burhiganga river had already been conducted in January 1959 by I.W.T.A. covering the distance from Red Fort to Kadamtoli. Further, in March 1962, the river section at Jinjira and Postogola had been determined on the basis of the sounding conducted by Road Survey Division II of C. & B. (See Plate I - 7, 8 & 9).

Review of the results of these past surveys led to the conclusion that the values obtained by these surveys are correct and generally free from any serious errors. The original plan to conduct a number of cross sectional surveys over the centre line of the proposed bridge as well as in the upper and lower reaches of the river was therefore dropped, and it was decided to perform one cross sectional survey along the center line of the bridge.

Brief description of the sounding conducted in the dry season is given below.

The river width at the time of survey was about 257 m and the maximum difference in the water levels marked about 60 cm. This effect of the tidal current was confirmed by observing the water gauge installed on the right bank every 5 minutes. The difference of water level during a two-day observation period marked 19 - 21 cm, and the mean value of 10 cm was adopted as the basis for adjusting the water level.

The survey work started with anchoring a large bearing pile for wire ropes and two supplementary piles behind it. All three piles were tightly tied up together with wires so as to be able to resist the tensile strength of the rope. Then the wire rope winder was loaded on the main boat which travelled to the approximate centre of the river while paying out the rope, and the boat was anchored on the centre line by means of two anchors. Two other boats between the main boat and the shore supported and strained the rope so that it would not be submerged. In addition, three additional boats cruised up- and downstream of the river during the survey work to regulate the traffic of the navigating boats. The sounding was conducted every 5 m between the shore and the main boat using a rope with the sounding lead. For the purpose of checking, an echo-sounder was used by Neon method from the main boat back to the shore, and it was discovered that the values thus obtained were consistent with each other. In sounding the other half width of the river, the same method was applied. The maximum depth of the river, which marked 7.30 m, was found near the left bank. The river bed was quite solid and this was easily detected by the sounding lead.

During the wet season, the sounding was conducted by boats which were instructed, by a transit installed at an appropriate place on the river bank, to form a line along the centre line at an interval of 5 m. Since there were very little effects of the tidal current during the wet season, the values obtained had not to be adjusted.

The cross section of the river during the dry season is shown in Plate I - 10.

5-1-2 Observation of water level by water gauge

The observation of the water level was conducted only at the time of sounding and measurement of flow velocity. This was due, firstly, to the availability of the detailed observation data of water level from 1900 to 1963 recorded by means of the water gauge at Dacca Water Works Pumping Station of the Mill Barracks which is controlled by the Hydrology Directorate of WAPDA, and secondly to the data recorded by the automatic gauge recorder which has been in operation since 1959 at the said Station. As regards the high water level during the wet season, the long range data of WAPDA were made available. Comparison was made between values recorded by WAPDA and those obtained by the water gauge installed by the Team on the centre line on the left bank. The elevation of this water gauge was 4.32 m (above P.W.D.) higher than that of WAPDA at the Mill Barracks. In Table I - 2, the maximum and minimum values of the water level recorded by the water gauge of WAPDA during the period from 1909 to 1964 are given; and in Table I - 4, the water level on the centre line is given in comparison with that recorded by WAPDA during the period from September 2 to 30, 1964.

The Turag river branches from the Bangsi river at Kaliakoir located about 27 miles from Dacca, and the Burhiganga river joins the Turag at Nawab char. The discharge of the Turag is therefore closely related to that of the Burhiganga. The discharge of the Turag river and its water level at Kaliakoir are given in Table I - 3 and also tabulated in Fig. I - 16.

5-1-3 Velocity measurement

In Dacca city which is located in the inland area about 200 km from the Bay of Bengal, the tidal current exerts a remarkable influence during the dry season when the river maintains the low water level, but in the wet season the effects of the tidal current on the high water level is negligible.

During the dry season, the tide rises and falls twice a day with a little lag in time. The water gauge reading in this season registered the highest of 0.99 m and the lowest of 0.40 m, the difference between the two being about 0.60 m. The elevation of this water gauge is 0.848 m above P.W.D. The temperature at the time of measurement was 38°, the water temperature 26°. In measuring the flow velocity, Price's electrophonic current-meter was used. No reaction was felt at first when it was tried with 5 revolutions per second. One revolution per second which was tried from the right bank did not succeed either because it coincided with the high tide. At 3.00 p.m. when the tide was low, the velocity was again measured from the centre of the river towards the right bank, in 4 different depths every 20 m. Velocity measurement towards the left bank was successively conducted in the same way. The maximum flow velocity recorded was 0.109 m/sec. It was noticed that the surface water flows backward and that the flow under the water was extremely sluggish. The flow velocity is tabulated in Plate I - 11.

Price's electrophonic current-meters were also used in measuring the high water level twice in September, and its results are given in Plate I - 12 and 13. The maximum flow velocity recorded was 0.98 m/sec or 3.05 ft/sec at the centre of the river.

5-2 Characteristics of River

5-2-1 Characteristics of the water level

At the point where the water gauge is set up (near the construction site), the Burhiganga river is considerably affected by the tidal current during the dry season, but the influence of the tidal current is almost negligible in the wet season. Occasionally, however, the fluctuation in the water levels exceeds 2 ft.

The above-mentioned fact can be easily traced in Fig. I - 1 - 12 which contain data recorded daily in 1962. According to these figures, the difference between the maximum and minimum water level curves recorded in June, July, August, September and October is exceedingly small, the only noticeable difference existing between the water level curvesof June and those of October. It can safely be said that there are no discrepancies among the water level curves of July, August and September, though there were small fluctuations due to precipitation or outflow.

The logarithmic probable value converted by Thomas method from the maximum probable value for the return period of 50 or 100 years, based on the afore-mentioned highest high water levels recorded each year from 1909 to 1964, is given in Fig. I - 13.

The data plotting by Thomas method is expressed by the following formula:

$$F = \frac{i}{N + 1}$$

where F = Probability function

N = Total number of values observed

i = A number in increasing order of data.

According to Fig. I - 13, the highest probable water level for the return period of 100 years can be estimated to reach 23.7 ft which does not exceed, even by one foot, the highest high water level of 23.25 ft above P.W.D. recorded in 1955, indicating that the Burhiganga river has an excellent stability. The highest high water level of a river over which a bridge is to be constructed is closely related to two important factors, i.e., the clearance and the scouring action around the piers. As regards the clearance, the bridge construction under a long return period would incur an increase in the cost required, but is advantageous becauses it ensures efficient navigation at the time of a severe flood, while the construction under a short return period can be performed with less cost, but has the drawback of obstructing the navigation of larger vessels during the flood season.

Based on data recorded from 1952 to 1961, the water level and its duration curve of the Burhiganga river at Dacca can be illustrated as given in Fig. I-14, and from this curve, the ideal water level - duration curve shown in Fig. I - 15 may be abstracted. It is possible to estimate, also from this curve, the duration of non-navigable period at the time of a flood stage higher than that estimated for designing the bridge. For example, the high water level for designing under a 20 year return period can be inferred from Fig. I - 13 to reach 22.2 ft. If a brdige is constructed to have the clearance based on this water level, such a bridge would be able to retain the designed clearance only for 22 days in case of a flood that would be expected under a 100 year return period.

As already described, the Burhiganga river joins the Turag river at Nawab char, and the discharge of the latter has a marked influence on that of the former. The inter-relation between the discharge and the water level of the Turag river can therefore be used in evaluating that of the Burhiganga river.

The discharge of the Turag river at Kaliakoi during the period from 1960 to 1963 is plotted in Fig. I - 16 from which the discharge and the water level curve can be evaluated as follows by the method of least squares:

$$Q = 33.15 H^2 - 3000$$

where Q = Discharge in cusecs

H = Water level in ft

5-2-2 Discharge characteristics

The results of the measurement of velocity conducted in the wet season of 1964, i.e., in September 1964, are given in Plate I - 12 and 13 which indicate that the maximum flow velocity is 3.05 ft/s and the discharge is 1,840.6 $m^3/s$ or 64,991.6 cusecs. The water levels measured at the construction site by the Team are shown in Fig. I - 17 in comparison with the water levels measured by WAPDA at the Mill Barracks. The average error in the above wet season registered 0.034 m, and the distance between the two water gauges was 1,360 m. Hence the surface slope:

$$\text{Surface slope} = \frac{34}{1360000} = \frac{1}{39,880} \doteqdot \frac{1}{40,000}$$

During the dry season, the surface slope was measured at points on the shore corresponding to station No. 1 and No. 3 and the difference between the values obtained at the two points was neglegible. From the fact that the distance between the Gulf of Bengal and Dacca is about 200 km and that the water level at Dacca at the time of measurement was +0.880 m (above the mean sea level of the Indian Ocean), the surface slope of 1:228,000 can be obtained.

Estimation of the maximum discharge in 1964, as indicated by Manning's formula, is given below. The discharge is expressed by Q.

$$Q = \frac{1}{n} \cdot A \cdot R^{\frac{2}{3}} I^{\frac{1}{2}}$$

where n = Manning's coefficient

A = Sectional area

R = Hydraulic radius

I = Slope of water surface

Values obtained by the two measurements performed in September are as follows:

1st measurement -

$Q = 1840.6\ m^3/s$, $V = 0.681\ m/s$

$A = 2702.3\ m^2$

$R = 8.16\ m$

Hence $n = 0.0298$

2nd measurement -

$Q = 1780.0\ m^3/s$, $V = 0.661\ m/s$

$A = 2692.6\ m^2$

$R = 8.13\ m$

Hence $n = 0.0306$

The mean value of the coefficients of roughness obtained by Manning's formula is: $n = 0.0302$ which may be considered quite reasonable from the fact that the river bed is covered with sand and the river has extremely stable flow conditions.

On August 12, 1964, the highest high water level of 21.66 ft (above P.W.D.) was recorded. Values of A and R corresponding to this highest high water level are 3017.4 $m^3$ and 9.12 m respectively. Accordingly, if the afore-mentioned values of n and I ($n = 0.0302$, $I = \frac{1}{39880}$) are adopted, the discharge or Q as computed by Manning's formula would be as follows:

$$Q = \frac{3017.4}{0.0302} \times 4.365 \times \frac{1}{(39880)^{\frac{1}{2}}} = 2185 \ m^3/s$$

The mean velocity at the time of the highest high water level would therefore be:

$$V = \frac{Q}{A} = 0.723 \ m/sec.$$

On the other hand, the highest high water level of the Turag river observed at Kaliakoir on August 13 marked 29.10 ft (above P.W.D.), and the discharge corresponding to this value, as calculated from the formula given above (Q in cusecs = $33.15 H^2 - 3000$; H in ft), would be as follows:

Q = 27,070 cusecs.

With regard to the water level of 25.10 ft measured on September 4, the discharge given below can be similarly calculated.

Q = 17,884 cusecs.

The reducing ratio of discharge obtained from these two values is 0.1713. If it is assumed that the discharge of the Burhiganga river at Dacca decreases at this ratio during the period from August 12 (when the highest high water level was marked) and September 4, the discharge at the time of the highest high water level would be as follows:

Discharge at the time of the highest high water level $= 1840.6 \ (m^3/sec) \times \frac{1}{0.713} = 2581.4 \ m^3/s.$

This value is larger than $Q = 2183 \ m^3/s$ which is given above. In case of ordinary rivers, the flood discharge curve is generally sharp in the upper reaches of the river and becomes milder in the lower reachew, and the reducing ratio of discharge should decrease along the course of the river. The discharge of 2581.4 $m^3/s$ of the Burhiganga river which is given above should therefore be decreased to an extent. It is accordingly suggested that Q = 2183 $m^3/s$ be adopted as the feasible highest discharge of the Burhiganga river. The highest flow velocity at the proposed sections, as calculated from the ratio among respective mean velocity, would be as follows:

$$\text{Highest flow velocity} = 0.98 \times \frac{0.723}{0.681} = 1.04 \text{ m/s.}$$

5-2-3 Observation of scouring action at the Dhaleswari river bridge

The Dhaleswari river bridge was constructed during the period from 1958 to 1963 over the Dhaleswari river at Manikganj which is located on the road connecting Dacca and Aricha. Its superstructure is a reinforced concrete girder bridge of balanced cantilever type, and the substructure consists of oval deep well foundations and reinforced concrete piers.

Measurement of water depth around the piers was conducted on September 9, 1964. The water level at the time of measurement was 2.5 ft below the highest high water level of 1964. In order to observe the highest flow velocity and the concentration of the water flow, the fourth span from the Dacca side was selected as the observing point. The sections measured are given, together with those of 1961, in Fig. I -18. The water depth around the piers and at the centre of the span showed a difference by 11.8 ft, which is considered to have been caused by the scouring action around the piers. According to the Model Study on Scouring Action around Piers by Mr. E.M. Laursen (Ref. data 54), the maximum scouring depth (Zs) is related, as shown in Fig. I - 19, to the water depth ($h_o$) of the uniform flow. In the said Fig., b indicates the width of the pier which is about 7.6 ft in the case of the Dhaleswari river bridge.

On the assumption that the water depth at the centre of the span is $h_o$, the following formula could be obtained:

$$\frac{h_o}{b} = \frac{22.6 \text{ ft}}{7.6 \text{ ft}} = 3.0$$

And from the designed curve in Fig. I - 19, the value of $\frac{Zs}{b}$ (which is 2.1) corresponding to $\frac{h_o}{b}$ can be obtained. Consequently, the value of Zs is as given below:

$$Zs = 2.1 \times b = 2.1 \times 7.6 = 15.96 \text{ ft}$$

This is in fair conformity with the value obtained by the actual measurement, and indicates that the value obrained from the desinged curve ensures safety.

Sections of the Dhaleswari river in 1961 when the bridge was under construftion are given in Fig I - 18. These sections indicate that the river bed underwent, after completion of the bridge, the scouring action of 6 ft depth at the center of the span. It would be reasonable to attribute this scouring action to the change in the river flow rather than to the structural reasons of the bridge. As a matter of fact, reports have already been submitted regarding the extensive change in the flow of the Dhaleswari river around the bridge.

5-2-4 Estimation of scouring depth expected for the Burhiganga river bridge

In designing the substructure of a bridge, the severest and worst conditions conceivable should be taken into account for safety's sake. If the designing were performed for flood conditions conceivable in a 500 year return period, the bridge constructed would have an extremely high safe rate against the flood. From Fig. I - 13, the water level of the Burhiganga river within a 500 year return period can be estimated to reach 25.0 ft. With this water level, the mean water depth at the section in the construction site would be about 33.2 ft.

Method applied to the Dhaleswari river bridge is used in estimating the depth of scouring action expected around the piers of the proposed bridge. The hydraulic conditions of the Dhaleswari river, including soil conditions of the river bed, flow velocity and surface slope, are similar to those of the Burhiganga river. Supposing that the width of the pier is 20 ft, the scouring depth would be:

$$\frac{h_o}{b} = 33.2/20 = 1.66$$

Consequently, the following value can be obtained from Fig. I - 19.

$$\frac{Zs}{b} = 1.7$$

The value of Zs or the probable scouring depth around the pier can therefore be calculated as follows:

$$Zs = b \times 1.7 = 20 \text{ ft} \times 1.7 = 34 \text{ ft}$$

For comparison's sake, sections obtained by measurement made in March 1964 are given in Plate I - 12 which indicate that the river bed underwent the scouring action which is a little heavier in the flood season than in the dry season. This, however, can be neglected

when the considerable scouring depth around the piers and the possible errors in measurement are taken into consideration.
The flow of the river along the city area of Dacca maintains stability, and no great changes at the center of the stream can be expected with the exception of dredging works or similar artificial effects that may be imposed upon the river.

5-2-5 Conclusion

The outcome of the river survey described above is briefed below:

1) Data on the water level of the Burhiganga river at Dacca were analyzed and the results were found satisfactory.

2) Water level - duration curve of the Burhiganga river was obtained.

3) It was discovered that the discharge and velocity can be obtained by Manning's formula with the values of the coefficient of roughness and the surface slope, 0.0302 and 1/39,880 respectively, having been made available.

4) The value of scouring depth measured at the Dhaleswari bridge was found to be in excellent conformity with that obtained by Mr. Laursen.

5) It was discovered that the scouring depth around the piers of the Burhiganga river bridge could be estimated based on the Model Study by Mr. Laursen.

As a result, the following conclusions were reached:

1) The Burhiganga has the centre line at about the middle of the river and its stability is excellent. It is affected by the

Turag river and by the precipitation near it, but is free from any influences from the Himalayan mountains. The water level shows two peaks, one in June and the other in August or September. From August 20 to September 20, it maintains an approximately same water level with the discharge of 2000 $m^3$/sec, the highest velocity of 1.0 m/sec on the surface and at the centre of the river section, and the mean velocity of 0.6 m/sec. It was discovered that towards the end of September, the water level drops. It was also discovered, from the data recorded during the past 10 years, that about 3 months elapse of time witnesses a fall of only about 10 ft as compared to the highest high water level.

2) As the designed highest high water level, 23.25 ft above P.W.D. recorded in 1955 would be suitable. This level is close to the maximum probable water level for a 50 year return period.

3) Since it was proposed that the depth of scouring action around the piers would be about 34 ft, the open well caisson works are recommendable for the substructure of the channel span.

Apart from the above three items, there remains the question of the clearance. According to the investigations conducted by I.W.T.A., the largest vessel is expected to be 6.5 ft in draught, 440 ft in maximum height, and have the size of 300 ft x 71.5 ft x 10.5 ft. I.W.T.A. expects that there will occasionally be ocean-going boats with the draught as high as 12 ft. I.W.T.A. proposed the clearance of 45 ft above the normal high flood level and the minimum channel width of 150 ft. The Team considers that the clearance of 45 ft x 250 ft proposed by the Survey Mission of 1962 is quite recommendable.

The Team was informed by the members of the said Mission that I.W.T.A. has the plan to dredge the river to a depth of 16 ft below the lowest low water level. In this connection, the Team wishes to suggest that further review and study be made in relation to the scouring depth which is an important factor in designing the substructure of the proposed bridge.

## 6. SOIL SURVEY

### 6-1 Introduction

The soil survey, which aimed at securing basic data for designing the substructure of the bridge, was conducted by mechanical boring work at 7 points (originally planned to be performed at 6 points) which served as the standard penetration test as well. The boring work was performed to clarify the geological composition of the proposed construction site, to conduct sampling and soil test, and to find out the properties of the soil.

Due to the congestions and the scale of Chittagong port, the boring machines arrived 36 days after the scheduled date. The field work was started on April 7 and completed on June 3. During this 57 day period, 6 days were spent for unpacking the boring machines and putting them in working order, 41 days for the boring work and soil test, and 10 days for packing and shipping the boring machines. After this period, the domestic work for soil test was conducted in Japan from June 10 to July 31. The total bore length was 390 m.

The Japanese engineers who engaged in the boring work were

Mr. Y. Fukui, Mr. T. Zenke, Mr. K. Yoshida, Mr. K. Izumi, who were all from Tone Boring Co. Mr. Fukui engaged in the geological survey and soil test on the field, and further assumed the responsibility for the domestic work performed on samples transported to Japan by air. The boring work was controlled by Mr. H. Wakatabi of Japan Engineering Consultants Co., Ltd. for the first half of the period and by Mr. Kuwata of the same company during the remaining half of the period.

From the Pakistani side, services of 2 assistant engineers and 2 surveyors from D.I.T. was offered to the Team. The Team employed 1 assistant, 5 labourers and 4 night guards. The assistant engineers worked for the preparation of the boring work, solution of misunderstanding or troubles between the Team and local people or the boats at anchor, procurement of jeeps, boats and labourers. Their services were of great help to the Japanese engineers who were not acquainted with the local customs and situations. Surveyors engaged in calculation and management of labourers. Assistants engaged in miscellaenous work including the arrangment of tools and equipment. The performance of the soil test was made possible through the cooperation of D.I.T. who were good enough to install power distributing facilities at its surveying office at Sadarghat. The Team hereby wishes to render its sincere thanks to Dacca Development Authority for D.I.T.'s most valuable assistance in arranging for trucks to carry the boring machines from Chittagong to the boring site and back to Chittagong after completion of the boring work.

Major items among the Japanese machines used for the boring work were:

| Item | Q'ty |
| --- | --- |
| Tone's Type UD-5 Drilling Machine | 2 units |
| Tone's Type NB3-60A Pump | 1 unit |
| Tone's Type BN Pump | 1 unit |
| Yanmar Diesel Engine | 5 units |
| Tone's Automatic Penetration Tester | 2 units |

6-2 Boring Work and Soil Test on the Field

6-2-1 Machines, equipment and materials

Sufficient quantities of machines and materials, inclusive of the above-listed items, were packed in 18 wooden cases (gross tonnage: 14 t, total measurement: 1183 cft) and sent by sea to Chittagong whence 5 5-ton trucks were utilized for the trasnportation to the boring site at Dacca. Machines and materials utilized are given in detail in Appendix 3. Materials obtained in Pakistan were wires, bamboos, lighting equipment for night work, operation boats to carry machines for boring from the water surface, 2 boats for conveying materials.

It was noted that full preparations should be made because the boring from the water surface is affected by the tidal current. Protection of operation boats against storms and navigating boats should also be taken into account. Further, it must be borne in mind that some of the necessary materials are not obtainable in Pakistan.

6-2-2 Boring work

a) Planning and performance

The plan for the soil survey should be first outlined for the preliminary investigations to be performed prior to the soil survey (preliminary investigations are for soil conditions, structures and other general conditions). The detailed plan should be decided or altered with due attention paid to various conditions of the work field.

The locations of boring work and the bore depth were planned as follows in accordance with the suggestions of the Mission of 1962.

| Boring No. | Land or Water surface | Bore length (m) | Remarks |
|---|---|---|---|
| No. 1 | Land | 30 | Dacca side |
| No. 2 | Water surface | 70 | |
| No. 3 | " | 100 | |
| No. 4 | " | 100 | |
| No. 5 | " | 60 | |
| No. 6 | Land | 30 | Keraganj side |

Upon arrival at Dacca, however, it became evident that the following should be taken into consideration.

First: the auto-rickshaws which constitute a considerable percentage of all the transport facilities cannot be disregarded, and this fact limits the gradient of the approach to a maximum of 3.0%. Also, the clearance of 250 ft x 45 ft demands that the central part of the bridge should be higher than was planned, and that the overall length of the bridge should consequently become longer. The approach on land as against the entire bridge must therefore become important. In fact, the general plan shows that the channel span over the river part is about one third of the entire bridge. The soil conditions on land should not be neglected.

Second: A deep portion with the width of 80 - 90 m was found across the river. It was discovered by checking the plan of the construction site, the profile of the river along the centre line, and the results of sounding and velocity measurement. For the structure of the bridge, therefore, it is advisable to adopt the 3 continuous spans (e.g., 70 m + 110 - 130 m + 70 m) whereby the pier would not have to be in the deeper portion of the river.

Third: after completion of a single boring, it was almost confirmed that the layers in this district are bedded.

In order to obtain more precise and accurate knowledge on these 3 points, 2 borings (No. 2 and No. 5) which were planned to be conducted from the water surface were shifted to the shore near the originally planned points. This alteration war made for reason that a) the boring should be performed at points as close to the planned position of the pier as possible, b) a little change in the boring point does not cause any serious problems because the layers are bedded, c) the boring on land should be given more importance, and d) the frequent attacks of storm and the process of the entire survey work should be taken into consideration. Boring point No. 2 and No. 5 were shifted to the new points on the shore which would be submerged when the water level rises.

Fourth: after completion of boring No. 4, it was discovered that the bore length of 100 m planned for boring No. 3 was unnessary from the geological point of view. Simultaneously, it was found that the layers in this district are dipping, deeper on the Keraniganj side than on the Dacca side. In consequence, the bore length of No. 3 was cut down to 65 m and that of No. 6 increased to 65 m.

Fifth: while drilling at bore No. 1 on the Dacca side, an extremely solid layer of clay was found underlying the surface layer in which bricks and fragments of earthenwares were found. This was attributed to a brick building which was allegedly built in the area about 400 - 500 years ago. A new bore No. 0 was therefore added to obtain further results.

As a result of the engineering discussions relating to these findings, the original plan was altered and 5 borings on land and 2 from the water surface, with the total bore length of 390 m, was finally decided to be carried out. See the following table and the soil profile with the boring results (Plate I - 14).

| Boring No. | Distance (m) | Bore length (m) | Condition in the dry season | Remarks |
|---|---|---|---|---|
| No. 0 | 0 | 10 | Open space | Surrounded by commercial district, Dacca |
| No. 1 | 35 | 30 | " | Ditto |
| No. 2 | 90 | 70 | Shore | Submerged in the wet season |
| No. 3 | 76 | 65 | Under-water | Depth at the time of boring: 8 m |
| No. 4 | 137 | 100 | " | Depth at the time of boring: 6 m |
| No. 5 | 71 | 61 | Shore | Submerged in the wet season |
| No. 6 | 135 | 55 | Farm-land | Ditto (on the Keranaganj side) |

b) Mechanical boring (performed for penetration test also) - its method and performance

Utilizing Tone's type UD-5 drilling machine, the muddy liquid containing bentonite was sent forth from the tip of the cross bit with 86 mm dia., thereby to protect the wall of the bore, to eliminate the slime, make precise observation of the geological composition, perform the standard penetration test, and to obtain the undisturbed soil samples and conduct Bane's test.

The standard penetration test was conducted by means of a Raymond sampler (total length: 81 cm, outside dia.: 5.1 cm, inside dia.: 3.5 cm, mfrd. in accordance with JIS 1219. See Appendix 5 for JIS) which was brought down to the bottom of the bore with a rod passed through it. A specified rate of impact (weight: 63.5 kg, falling distance: 75 cm - free falling) was repeatedly given until the percussion frequency (N frequency/30 cm) required to let the sampler penetrate for a specified length (30 cm), and by the frequency thus obtained, the solidness and cohesiveness of the soil at the original point were checked. This test was conducted at intervals of 1 - 3 m down to the depth of 70 m, and the samples for specimen and soil test were also obtained.

Undistrubed samples were obtained using a thinwall sampler and Tennyson type sampler. The thinwall sampler had the inside dia. of 72.5 mm, outside dia. of 75 mm, length of 800 mm, area ratio of 10%, ratio of outside diameter of 3.3%, and the ratio of inside diameter of 1.1%.

The Bane's test was conducted in order to determine the shearing strength and sensitivity ratio in the soft clay. The tester used was a small type Bane shearing tester for field work, a product of Tanifuji Machinery Mfg. Co. (strain control type, gear winding, maximum rotational power 750 kg/cm, 4 wings, height 10 cm, width 5 cm, and thickness 1.5 mm). The wings were rotated at the rate of 10° per minute and the maximum rotational power was recorded. This was followed by rotating the wings 20 times to disturb the soil along the shearing face, then the test mentioned above was repeated.

Since the layers were bedded, it was often possible to predict the shifting from one layer to the other. This resulted in concentrating the test upon the contact zone where layers shift from one kind to the other, which allowed to keep the distance between each testing point not shorter than necessary. In the course of the work, the number of Bane's test on the cohesive soil and the frequency of thinwall sampling were decreased as it was discovered that the soil was rather sandy though the grains were fine.

In the boring work from the water surface, which was not quite easy, a base on which to place the boring machine was set up on two 5 ton boats which were tightly fastened to each other. Though the construction site is located 300 km upstream of the Gulf of Bengal, the fluctuations in the water level of the Burhiganga river, which was cuased by the tidal current, ranges between 30 - 60 cm. It was therefore necessary to prepare short drive pipes at the boring site which were used according to the flux and reflux. During the period from mid-April to the beginning of May, the boring site was subject to frequent cyclones, the heaviest of which hit the bamboo bundles (1,000 bamboos per bundle) from which rafts were made and moored to the shore. The bamboos were loosened and hit the anchors of the operation boats. Fortunately, however, the cyclone passed without incurring any serious damages except upon the drive pipes which were slightly bent. The cyclones, which usually last for one to one and half hours, comes in a matter of 10 minutes or so after the clouds rise, and cannot be forecast beforehand. When the sky was overspread by clouds, the rods were lifted swiftly and everyone had to take shelter on land. Occasionally, however, it ocurred that the lifting of 30 rods from the depth of some 100 m could not be completed before the cyclone attacked. In order to complete the boring work from the water surface(which is quite dangerous) within the shortest possible period, the boring work on land was temporarily suspended, and the entire staff and workers were divided into two groups and worked for the boring from the water surface from early morning until the sunset. The boring work at night when the sky cannot be observed was avoided because of the danger. On account of the frequent navigation of boats at night, the operation boats were guarded by 2 night guards and equipped with lamps, with 2 more guards on a small boat patrolling around them.

c) Soil test

The following tests were conducted on samples obtained during the boring work according to JIS (See Appendix 5).

Classification test: Moisture content ratio test (JIS A1203)
Bulk density test
Test on specific gravity of grain (JIS A1202)
Mechanical analysis of soil (JIS A1204)
Liquid limit test (JIS A1205)

| | |
|---|---|
| | Plastic limit test (JIS A1206) |
| Physical test: | Uniaxial compression test (JIS A1216) |
| | Triaxial compression test |
| | Consolidation test (JIS A 1217) |
| | (Direct shearing test) |

Of the above listed tests, it was originally intended to conduct only the moisture content ratio test, the bulk density test and the uniaxial test. As additional testing equipment were sent from Japan, the sieve analysis and the test on the specific gravity of grain were conducted at D.I.T.'s surveying office at Sadarghat.

For the tests conducted in Japan, 11 samples of clay and clayey soil were put in containers sealed with paraffin wax containing pine resin, and packed with the foam rubber packings to absorb the shock, and sent to Japan by air.

In Japan, the mechanical analysis of soil, the liquid limit test, the plastic limit test, the triaxial compression test, and the consolidation test were performed at the Soil Laboratory, Faculty of Engineering, Nihon University. As to the samples on which triaxial compression test could not be performed, the direct shearing test was conducted to determine the cohesiveness and the angle of internal friction. No disturbance nor the change in the moisture content during air transportation was noticed in the samples.

6-2-3 Results of boring work and soil test

1) Geological composition of the boring site

The surface layers of the area in which 7 borings were conducted are alluvial deposits on the Keraniganj side and diluvial deposits on the Sadarghat side, the demarkation line between the two being the left bank of the Burhiganga river.

The alluvial deposits (which is an aqueous alluvium) is about 14 m in thickness on the left bank and becomes thicker towards the right bank, registering more than 40 m thickness at boring No. 5. Soils composing it are sandy silt, silty sand, sand of fine or medium grain, and very small quantities of gravels scattered in it. The soil in the surface layer is the sand of fine grain in the river, but along the watercourse is found alluvial clayey soil of finer grain. This may indicate that the present centre line of stream will not change so long as this clayey soil continues to be accumulated along the watercourse.

Under these alluvial deposits are found sand of fine and medium grain of diluvim which extends to a depth of EL -103 m, the deepest elevation recorded by the boring work, with gravels and thin solidified clays scattered here and there. The diluvial upland at Sadarghat is composed of the sand of fine and medium grain.

The stratigraphic order based on the results of the boring work is as given in the table on the next page (Also see Plate I - 14).

2) Geology

A. Aqueous alluvial deposits

1. Clayey soil with organic matters

The clayey soil with organic matters, found in the area surrounding the Burhiganga river, is still being accumulated. The thickness of the layer is about 3 - 5 m, and its colour ranges from dark blue to dark grey. This layer is found to be extremely loose.

| Stratum | Boring No. 0 | Boring No. 1 | Boring No. 2 | Boring No. 3 | Boring No. 4 | Boring No. 5 | Boring No. 6 |
|---|---|---|---|---|---|---|---|
| Alluvial Deposits | | | 1. Clayey soil w/ organic matters | 2. Upper sand of fine grain | 2. Upper sand of fine grain | 1. Clayey soil w/ organic matters | 1. Clayey soil w/ organic matters |
| | | | 3. Clayey sandy soil | 3. Clayey sandy soil | 3. Clayey sandy soil | 3. Clayey sandy soil | 3. Clayey sandy soil |
| | | | 4. Lower sand of fine grain | 4. Lower sand of fine grain | 4. Lower sand of fine grain | 4. Lower sand of fine grain | 4. Lower sand of fine grain |
| Lower alluvial deposits ~ Upper diluvial deposits | | | | | 5. Lower alluvial deposits ~ Diluvial sand | 5. Lower alluvial deposits ~ Diluvial sand | 5. Lower alluvial deposits ~ Diluvial sand |
| Diluvial deposits | 6. Diluvial clay | 6. Diluvial clay | | | | | |
| | 7. Diluvial sand | 7. Diluvial sand | 7. Diluvial sand | 7. Diluvial sand | 7. Diluvial sand | 7. Diluvial sand | 7. Diluvial sand |

2. Upper sand of fine grain

The upper sand of fine grain is found under the clayey soil with organic matters on the river bed and on the right bank of the Burhiganga river. Dark grey in colour, it embodies clayey soil in small quantities. This layer is about 12 m in thickness at Boring No. 4, 5 and 6, and towards Sadarghat it becomes thinner registering 4 m at boring No. 3. At boring No. 2, it cannot be detected at all. This layer is also very loose like the above mentioned clayey soil.

3. Clayey sandy soil

This is found at boring No. 2 under the clayey soil with organic matters, and at boring No. 3 - 6, it is found underlying upper sand of fine grain. It comprises clayey soil and sandy soil, and has dark greyish colour. Thickness of this layer is, contrary to the upper sand of fine grain, thin on the left bank and becomes thicker towards the right bank. At boring No. 6, the thickness marks 4 m.

4. Lower sand of fine grain

Found under the clayey sandy soil at boring No. 4 - 6, it includes clayey soil which presents a seam-like shape. It has dark greyish colour and is comparatively solid.

B. Alluvial deposits - Diluvial deposits

5. Alluvial - deluvial sand

Found around boring No. 4 - 6 like the above-mentioned lower sand of fine grain, it is considered to be in between the lower alluvial deposits and upper diluvial deposits. Dark grey to yellowish grey in colour, it has the thickness of 11 m at boring No. 4, becoming thicker at boring No. 5 and 6. The mean moisture content ratio is below 25% which is about 7% lower than that of the lower sand of fine grain. Its relative density is "dense."

C. Diluvial deposits

6. Diluvial clay

This clay is found accumulated on the diluvial sand. It has been eroded and is not found at all on the Keranaganj side. It has a reddish brown colour, and its consistency is "very solid."

7. Diluvial sand

This sand is the only layer found throughout the surveyed area. Brown to yellowish brown in colour, it is composed of sand of fine grain in the upper part, but in the lower part of the layer the sand of medium grain becomes predominant. It includes solidified clay like a lense and occasionally embodies gravles.

3) Characteristics of soil

As a result of the soil test conducted on the field as well as in Japan (See Plate I - 15 - 1 - 7 and Table I - 5 - I - 21), the following features have been clarified.

1. Clayey soil with organic matters

This is a fertile soil involving organic matters like wooden chips and forms the farm-land. Its consistency is "soft."

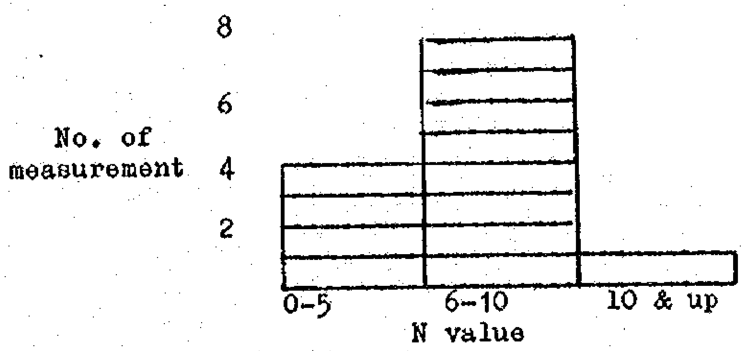
Results of soil test are as outlined below:

| Test | Boring #2 | Boring #5 | Boring #6 |
|---|---|---|---|
| Moisture content ratio (%) | 35 | 45 | 44 |
| Bulk density ($g/m^3$) | 1.72 | 1.60 | 1.76 |
| Uniaxial compression ($kg/cm^2$) | 0.46 | 0.26 | 0.34 |
| Cohesion test ($kg/m^2$) | 0.31 | / | 0.17 |

| Test | Boring #2 | Boring #5 | Boring #6 |
|---|---|---|---|
| Angle of internal friction (°) | 33 | / | 8.30 |

2. Upper sand of fine grain

Found at boring No. 3 - 6, this sand partially embodies thin layers of silt. Its mean moisture content ratio is 33%, N value 5. At boring No. 6, N value becomes a little higher, marking 10 or more. Its relative density is "loose." Frequency distribution of N value is as given below.




3. Clayey sandy soil

This sand is found in the area covering boring No. 2 - 6, and like the above-mentioned two layers, it is a loose layer registering N value of 6. At some points, sinking was noticed. Its consistency ranges from "soft" to "medium."

Results of the soil test are as outlined below.

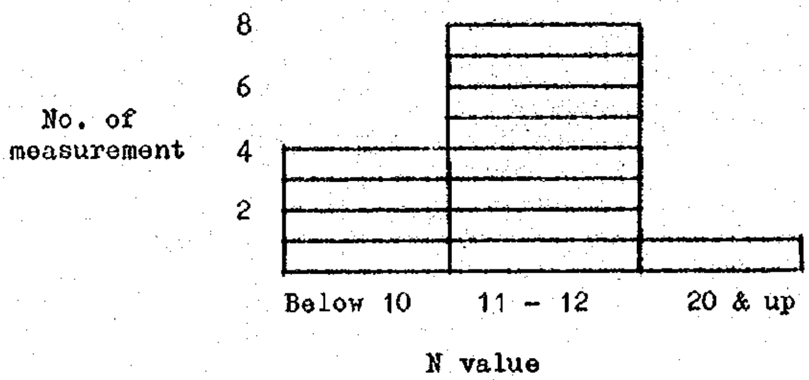
| Test | Boring #2 | Boring #3 | Boring #4 | Boring #5 | Boring #6 |
|---|---|---|---|---|---|
| Moisture content ratio (%) | 40 | 37 | 38 | 38 | 37 |
| Bulk density ($g/cm^3$) | 1.66 | 1.77 | 1.63 | 1.76 | 1.74 |
| Uniaxial compression ($kg/cm^2$) | 0.48 | 0.27 | 0.57 | 0.38 | 0.40 |

| Test | Boring #2 | Boring #3 | Boring #4 | Boring #5 | Boring #6 |
| --- | --- | --- | --- | --- | --- |
| Cohesion (kg/m$^2$) | 0.20 | 0.24 | 0.18 | / | 0.17 |
| Angle of internal friction (°) | 6 | 6 | 20 | / | 8 |

4. Lower sand of fine grain

Found over boring No. 4 - 6, this sand has the moisture content ratio of 32% which is about the same as that of the upper sand of fine grain. Its mean N value is 18, and the relative density is "medium."

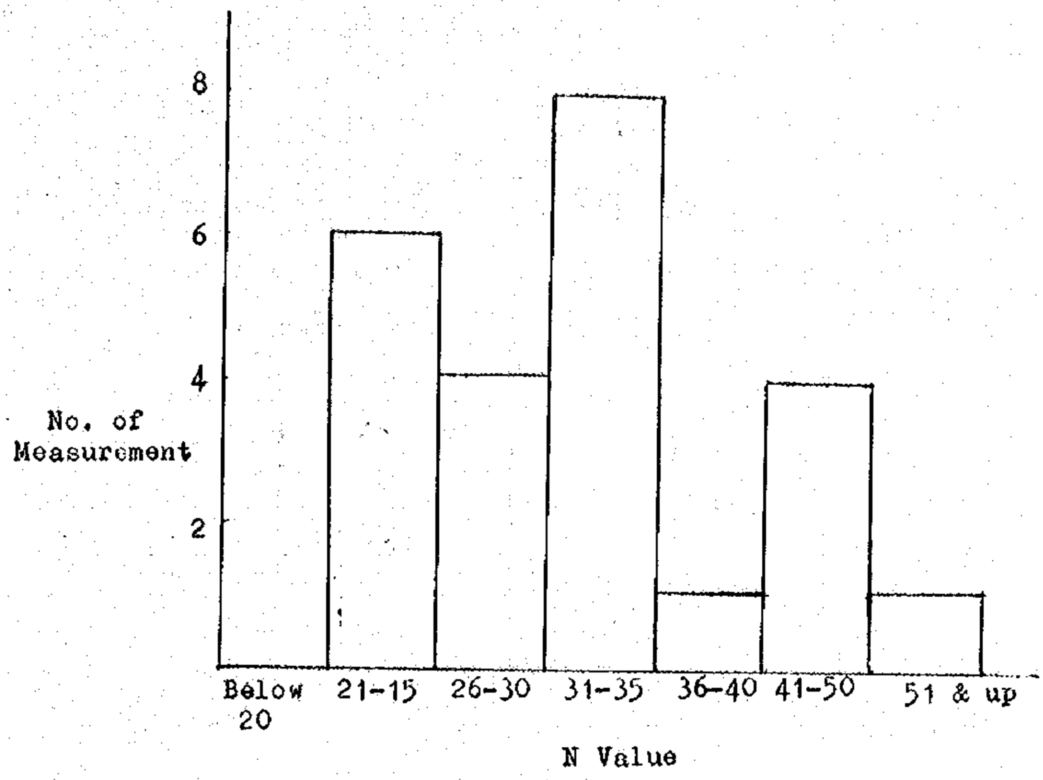
Frequency distribution of N value is as shown below.




5. Alluvial - Diluvial sand

This sand is found over boring No. 4 - 6 and is considered to be between the lower alluvial deposits and the upper diluvial deposits. Its mean moisture content ratio is 25%, with its lowest ratio marking 18%. As compared with the lower sand of fine grain, its moisture content ratio is about 7% lower. N value is 20 - 55, averaging 32, and its relative density is "dense."

Frequency distribution of N value is as given on the next page.



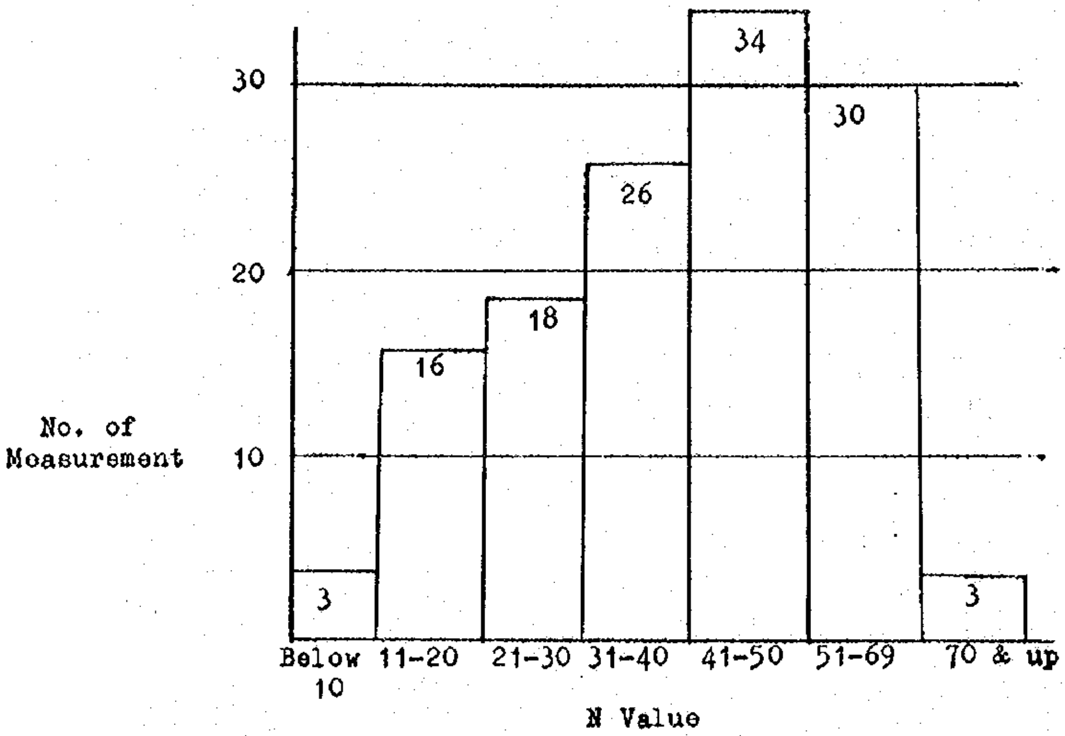

6. Diluvial clay

This clay is found at boring No. 1 and 2. Its N value is more than 20, and the consistency is "very solid." The moisture content ratio is about 25%, bulk density 1.85, cohesion 0.22 kg/cm$^2$, and the angle of internal friction 10$^\circ$.

7. Diluvial sand

Found in the entire area covering boring No. 0 - 6, it shows a very small N value immediately below the diluvial clay. But in general, it has a comparatively high N value, averaging 40, occasionally marking more than 70. Its relative density ranges from "dense" to "extremely dense."

The frequency distribution of N value is given on the next page.


No. of Measurement
30
20
10
34
30
26
18
16
3
3
Below 10
11-20
21-30
31-40
41-50
51-69
70 & up
N Value

6-2-4 Geology of East Pakistan

Since the boring work and the soil test were conducted within a limited area, it would be quite useful to judge the geological composition of the bed of the Burhiganga river by an overall study and review of the geology of entire East Pakistan.

"Geological Map of East Pakistan (Plate I -16)" which was offered to the Team by Geological Survey of Pakistan, Dacca, and "Quarterly Geology of the Bengal Basin, East Pakistan and India" by Messrs. J.P. Morgan and W.G. McIntire (See Ref. 42) are of great help in grasping the general geological conditions required.

According to the above data, the entire areas, with the exception of Assam district in India and the border line with Burma which are covered by sand stone, limestone, etc. that belong to the Tertiary period (15 - 7 million years ago), are covered by the alluvial deposits (about 10 thousand years ago - present time) which were formed by the system of the Ganges, the Brahmaputra and Meghan. The data further provided an interesting fact that there are some districts, inclusive of Dacca area, where diluvial uplands (1 million - 10 thousand years ago) are found, and this fact was confirmed when the Team had the opportunity to discuss with Dr. A.F.M. Mohsenul Haque, Director of Geological Survey of Pakistan.

The aqueous alluvial deposits consits of clay, silt and sand, but gravels are hardly found embodied in it. Diluvial deposits are found as uplands north to Rajshahi and Comilla districts located in the north of Dacca. These alluvial and diluvial deposits or older alluvial deposits derive from the rocks of Deccan plateau and of Himalayan mountains which belong to Precambrian era or Paleozoic era (850 - 500 million years ago), and contain, in quantities, biotite that forms granite, gneiss, chrystalline schist, etc.

The said data also clarified that the diluvial deposits are found in the south-east of Dacca and that diluvial benches extend in the north of the city. The fact that diluvial deposits are existent as substratum was confirmed by the geological survey performed by the Team. In the area where the present investigations were conducted, clay or clayey soil were found in limited quantities and more than 80% was the sand layers. Gravels were found in a very limited quantity in the diluvial deposits.

6-2-5 **Study on foundation work**

Based on the geological feature and mechanical properties of the site which were resulted from the standard penetration test boring at 7 points, the study is made on the foundation work of the proposed structure, as follows:-

Bearing ground to be suitable:

| | |
|---|---|
| $B_1$ ... G.L. - 31.00 m | $B_2$ ... G.L. - 37.00 m |
| $B_3$ ... G.L. - 39.00 m | $B_4$ ... G.L. - 44.00 m |
| $B_5$ ... G.L. - 46.00 m | $B_6$ ... G.L. - 41.00 m |

The steel pipe pile or the pile foundation of the field casting, except for the channel span, would be suitable for the foundation work. Judging from the possible shortened construction period, the steel pipe pile should be best suitable. According to the provision 2,20th formula of the Construction Steel Pile Foundation Design Standard, Japan Institute of Architectural Engineering, the static bearing capacity of the pile foundation is calculated for the specific point:

**Formula:**

$$Ra = 1/3 \left\{ 40NA_p + \left( \frac{\bar{N}sLs}{5} + \frac{NcLc}{2} \right) \psi p \right\}$$

**Mark** Ra : Long-period allowable bearing force (t)

Ap : Closed area of pile end ($m^2$)

$\psi$ p : Closed Circumference of pipe (m)

$$N = \frac{N1 + \bar{N}2}{2}$$

$N_1$ : N value of pile-end location

$\bar{N}_2$ : Mean N value for the range from pile-end up to 10B

B : Diameter of pile

$\overline{Ns}$ : Mean N in sandy layer around pile

Ls : Pile length in sandy layer around pile

$\overline{Nc}$ : Mean N in clayey layer around pile

Lc : Pile length in clayey layer around pile

The calculation is made at the specific points, as follows:-

$B_1$

1) Presumed conditions

Type of pile: Steel pipe pile

Diameter of pile: ϕ812.8 x 12.7 mm

Length of pile: 31.00 m

Pile head level: G.L. ± 0.00 (P.W.D. ± 7.60 m)

Pile end level: G.L. - 31.00 m (P.W.D. - 23.40 m)

Closed Area of Pile: $A_p = \pi/4 \times (0.8128)^2 = 0.5186\ m^2$

Closed Circumference of pile: $\psi p = \pi \times 0.8128 = 2.5521$ m

2) Pile-end Resistance

$N_1 = 30$, $\overline{N}_2 = 25$

$$N = \frac{30 + 25}{2} = 27.5$$

$$40NA_p = 40 \times 27.5 \times 0.5186 \fallingdotseq 570\ t$$

3) Circumference Friction

In sandy part:

Depth (m) = 7.10 - 31.00 Layer thickness h (m) = 23.90

N value = 15 hN = 358.5

∴ Ls = 23.9 $\overline{Ns}Ls$ = 358.5

In clayey part:

Depth (m) = 3.45 - 7.10 Layer thickness h (m) = 3.65

N value = 22 hN = 80.3

$\therefore$ Lc = 3.65 $\quad\quad\quad$ $\overline{N}cLc$ = 80.3

$$\therefore \left(\frac{\overline{N}sLs}{5} + \frac{\overline{N}cLc}{2}\right) p$$

$$= \left(\frac{358.5}{5} + \frac{80.3}{2}\right) \times 2.5521$$

$$= (71.7 + 40.1) \times 2.5521$$

$$\doteqdot 285 \text{ t}$$

4) Allowable Bearing Force

Ra = 1/3 (570 + 285) = 285 t

For safety, the circumference friction in the clayey part is neglected.

Ra = 1/3 (570 + 211) $\doteqdot$ 260 t/pile

5) Sectional Allowable Bearing Force

Actual sectional area of pile $\quad$ A = 319.2 $cm^2$

Long-period allowable compressive stress of welded joint in the actual sectional area of pile. $\sigma$ = 1.4 $t/cm^2$

$R\sigma$ = 1.4 x 319.2 = 446.88 t

$\therefore$ Ra < $R\sigma$

$\therefore$ Ra = 260 t/pile

6) Decrease by Slenderness Ratio

As 0.8128 x 120 = 97.52 > 31, the decrease by slenderness ratio is not considered. Therefore, the allowable bearing force is calculated to be at 260 t/pile.

$B_2$

1) Presumed conditions

Type of pile: $\quad$ Steel pipe pile

Diameter of pile: $\quad$ ø812.8 x 12.7 mm

Length of pile: 37.00 m

Pile head level: G.L. $\pm$ 0.00 m (P.W.D. + 3.50 m)

Pile end level: G.L. $\pm$ 37.00 m (P.W.D. - 33.50 m)

Closed Area of Pile: $Ap = \pi/4 \times (0.8128)^2 = 0.5186\ m^2$

Closed circumference of pile: $\psi p = \pi \times 0.8128 = 2.5521$

2) Pile-end Resistance

$N1 = 47, \quad \overline{N}2 = 34$

$$N = \frac{47 + 34}{2} = 40.5$$

$$40NAP = 40 \times 40.5 \times 0.5186 \doteq 840\ t$$

3) Circumference Friction

In sandy part:

Depth (m) = 14.48 - 37.00 Layer thickness h (m) = 22.52

N value = 27.95 hN = 629.43

$\therefore$ Ls = 22.52 $\overline{N}sLs$ = 629.43

In clayey part:

Depth (m) = 0.00 - 14.48 Layer thickness h (m) = 14.48

N value = 4.25 hN = 61.54

$\therefore$ Lc = 14.48 $\overline{N}cLc$ = 61.54

$$\therefore \left(\frac{\overline{N}sLs}{5} + \frac{\overline{N}cLc}{2}\right) \psi p$$

$$= \left(\frac{629.43}{5} + \frac{61.54}{2}\right) \times 2.5521$$

$$= (125.88 + 30.77) \times 2.5521$$

$$\doteq 399$$

4) Allowable Bearing Force

Ra = 1/3 (840 + 399) = 413

For safety, the circumference friction in the clayey part is neglected.

Ra = 1/3 (840 + 321) = 387 t/pile

5) Sectional Allowable Bearing Force

Actual sectional area of pile. $A = 319.2\ cm^2$

Long-period allowable compressive stress of welded joint in the actual sectional area of pile.

$\sigma = 1.4\ t/cm^2$

$R_\sigma = 1.4 \times 319.2 = 446.88\ t$

$\therefore\ Ra < R_\sigma$

$\therefore$ Ra = 387 t/pile

6) Decrease by Slenderness ratio

As $0.8128 \times 120 = 97.52 > 37$ m, the decrease by slenderness ratio is not considered. Therefore, the allowable bearing force is calculated to be at 387 t/pile.

$B_3$

1) Presumed Conditions

| | |
|---|---|
| Type of pile: | Steel pipe pile |
| Diameter of pile: | ϕ812.8 x 12.7 mm |
| Length of pile: | 44.50 m |
| Pile head level: | G.L. + 5.50 m (P.W.D. ± 0.00 m) |
| Pile end level: | G.L. - 39.0 m (P.W.D. - 44.50 m) |

Closed Area of Pile: $Ap = \pi/4 \times (0.8128)^2 = 0.5186\ m^2$

Closed Circumference of Pile: $\psi p = \pi \times 0.8128 = 2.5521$ m

2) Pile-end Resistance

$N_1 = 42, \quad \overline{N}2 = 40$

$N = \frac{42 + 40}{2} = 41$

$40NA_p = 40 \times 41 \times 0.5186 = 850$ t

3) Circumference Friction

In sandy part:

| Depth (m) | Layer Thickness h (m) | N value | hN |
|---|---|---|---|
| 0.00 - 4.40 | 4.40 | | |
| 12.60 - 13.70 | 1.10 | 8.0 | 8.0 |
| 15.30 - 39.00 | 23.70 | 32.85 | 778.54 |

∴ Ls = 29.20 $\bar{N}sLs$ = 787.34

In clayey part:

| Depth (m) | Layer Thickness h (m) | N value | hN |
|---|---|---|---|
| 4.40 - 12.60 | 8.20 | 6.0 | 49.20 |
| 13.70 - 16.00 | 2.30 | 7.0 | 16.10 |

∴ Lc = 10.50 $\bar{N}cLc$ = 65.30

$$\therefore \left(\frac{NsLs}{5} + \frac{NcLc}{2}\right) \phi p$$

$$= \left(\frac{787.34}{5} + \frac{65.30}{2}\right) \times 2.5521$$

$$= (157.46 + 32.65) \times 2.5521 \doteqdot 485$$

4) Allowable Bearing Force

Ra = 1/3 (850 + 485) = 445

For safety, the circumference friction in the clayey part is neglected.

Ra = 1/3 (850 + 401) = 417 t/pile

5) Sectional Allowable Bearing Force

Actual sectional area of pile. $A = 319.2$ cm$^2$

Long-period allowable compressive stress of welded joint in the actual sectional area of pile.

$\sigma = 1.4 \ t/cm^2$

$R\sigma = 1.4 \times 319.2 = 446.88 \ t$

$\therefore Ra < R\sigma$

$\therefore Ra = 417 \ t/pile$

6) Decrease by Slenderness Ratio

As 0.8128 x 120 = 97.52 > 44.50 m, the decrease by slenderness ratio is not considered. Therefore, the allowable bearing force is calculated to be at 417 t/pile.

$B_4$

1) Presumed Conditions

| | |
|---|---|
| Type of pile: | Steel pipe pile |
| Diameter of pile: | ∅812.8 x 12.7 mm |
| Length of pile: | 44 m |
| Pile Head Level: | G.L. + 3.20 m (P.W.D. ± 0.00 m) |
| Pile End Level: | G.L. - 44.00 m (P.W.D. - 47.20 m) |
| Closed Area of Pile: | $Ap = \pi/4 \times (0.8128)^2 = 0.5186 \ m^2$ |

Closed Circumference of Pile: $\phi p = \pi \times 0.8128 = 2.5521 \ m$

2) Pile-end Resistance

$N_1 = 41, \quad \overline{N}2 = 36 \qquad N = \frac{41 + 36}{2} = 38.5$

$40NA_p = 40 \times 38.5 \times 0.5186 = 798 \ t$

3) Circumference Friction

In sandy part:

| Depth (m) | Layer Thickness h (m) | N value | hN |
|---|---|---|---|
| 0 - 12.05 | 12.05 | 5.00 | 60.25 |
| 17.50 - 44.00 | 26.50 | 23.81 | 630.96 |
| Ls = 38.55 | $\overline{N}sLs$ = 691.21 | | |

In clayey part:

| Depth (m) | Layer Thickness h (m) | N value | hN |
|---|---|---|---|
| 12.05 - 17.50 | 5.45 | 7 | 38.15 |
| ∴ Lc = 5.45 | $\overline{N}cLc$ = 38.15 | | |

$$\left(\frac{NsLs}{5} + \frac{38.15}{2}\right) \quad p = \left(\frac{691.21}{5} + \frac{38.15}{2}\right) \times 2.5521$$

$= (138.24 + 19.07) \times 2.5521$

$\doteqdot 401$

4) Allowable Bearing Force

$Ra = 1/3\ (798 + 401) \doteqdot 399$

For safety, the circumference friction in the clayey part is neglected.

$Ra = 1/3\ (398 + 352) \doteqdot 383$ t/pile

5) Sectional Allowable Bearing Force

Actual sectional area of pile. $A = 319.2\ cm^2$

Long-period allowable compressive stress of welded joint in the actual sectional area of pile.

$\sigma = 1.4\ t/cm^2$

$R\sigma = 1.4 \times 319.2 = 446.88$ t

$\therefore Ra < R\sigma$

$\therefore Ra = 383$ t/pile

6) Decrease by Slenderness ratio

As 0.8128 x 120 = 97.52 > 44m, the decrease by slenderness ratio is not considered. Therefore, the allowable bearing force is calculated to be at 383 t/pile.

$B_5$

1) Presumed Conditions

| | |
|---|---|
| Type of Pile: | Steel pipe pile |
| Diameter of Pile: | ø812.8 x 12.7 mm |
| Length of Pile: | 46.00 m |
| Pile Head Level: | G.L. $\pm$ 0.00 m (P.W.D. + 2.80 m) |
| Pile End Level: | G.L. - 46.00 m (P.W.D. - 43.20 m) |
| Closed Area of Pile: | $Ap = \pi/4 \times (0.8128)^2 = 0.5186\ m^2$ |

Closed Circumference of Pile: $\psi p = \pi \times 0.8128 = 2.5521$ m

2) Pile-end Resistance

$N_1 = 58$, $\overline{N}2 = 39$, $N = \frac{58 + 39}{2} = 48.5$

$40NAp = 40 \times 48.5 \times 0.5186 \doteqdot 1006$

3) Circumference Friction

In sandy part:

| Depth (m) | Layer Thickness h (m) | N value | hN |
|---|---|---|---|
| 3.10 - 16.00 | 12.90 | 6.00 | 77.40 |
| 20.00 - 46.00 | 26.00 | 30.66 | 797.16 |

$\therefore Ls = 38.9$ $\overline{N}sLs = 874.56$

$$\left(\frac{NsLs}{5} + \frac{\overline{N}cLc}{2}\right) \psi p$$

$$= \left(\frac{874.56}{5} + \frac{37.30}{2}\right) \times 2.5521$$

$$= (174.91 + 18.65) \times 2.5521 \doteqdot 493$$

4) Allowable Bearing Force

Ra = 1/3 (1006 + 496) ≑ 499

For safety, the circumference friction in the clayey part is neglected.

Ra = 1/3 (1006 + 446) ≑ 483 t/pile

5) Sectional Allowable Bearing Force

Actual sectional area of pile. $A = 319.2\ cm^2$

Long-period allowable compressive stress of welded joint in the actual sectional area of pile.

$\sigma = 1.4\ t/cm^2$

$R\sigma = 1.4 \times 319.2 = 446.88$ t

$\therefore Ra > R\sigma$

$\therefore Ra = 446$ t/pile

6) Decrease by Slenderness ratio

As 0.8128 x 120 = 97.52 m > 46 m, the decrease by slenderness ratio is not considered. Therefore, the allowable bearing force is calculated to be at 446 t/pile.

$B_6$

1) Presumed Conditions

| | |
|---|---|
| Type of Pile: | Steel Pipe Pile |
| Diameter of Pile: | ϕ812.8 x 12.7 mm |
| Length of Pile: | 41.00 m |
| Pile Head Level: | G.L. ± 0 m (P.W.D. + 4.40 m) |
| Pile End Level: | G.L. - 41.00 m (P.W.D. - 37.40 m) |
| Closed Area of Pile: | $Ap = \pi/4 \times (0.8128)^2 = 0.5186\ m^2$ |

Closed Circumference of Pile: $\phi p = \pi \times 0.8128 = 2.5521$ m

2) Pile-end Resistance

$N_1 = 55, \quad \overline{N}2 = 22$

$N = \frac{55 + 22}{2} = 38.5$

$40NAp = 40 \times 38.5 \times 0.5186 = 798$ t

3) Circumference Friction

In sandy part:

| Depth (m) | Layer Thickness h (m) | N value | hN |
|---|---|---|---|
| 1.80 - 14.00 | 12.20 | 8.0 | 97.6 |
| 18.50 - 41.00 | 22.50 | 23.7 | 533.25 |

$\therefore Ls = 34.70 \qquad \overline{N}sLs = 630.85$

In clayey part:

Depth (m) = 14.00 - 18.50   Layer Thickness h (m) = 4.50

N value = 4.6   hN = 20.7

$\therefore Lc = 4.50 \qquad \overline{N}cLc = 20.7$

$$\left(\frac{\overline{N}sLs}{5} + \frac{NcLc}{2}\right) \psi p = \left(\frac{630.85}{5} + \frac{20.7}{2}\right) \times 2.5521$$

$= (126.17 + 10.35) \times 2.5521$

$\doteqdot 348$ t

4) Allowable Bearing Force

Ra = 1/3 (798 + 348) = 382

For safety, the circumference friction in the clayey part is neglected.

Ra = 1/3 (798 + 321) $\doteqdot$ 373 t/pile

5) Sectional Allowable Bearing Force

Actual sectional area of pile.   $A = 319.2\ cm^2$

Long-period allowable compressive stress of welded joint in the actual sectional area of pile.   $\sigma = 1.4\ t/cm^2$

$R\sigma = 1.4 \times 319.2 = 446.88$ t

$\therefore Ra < R\sigma$

$\therefore Ra = 373$ t/pile

6) Decrease by Slenderness ratio

As $0.8128 \times 120 = 97.52 > 41$ m, the decrease by slenderness ratio is not considered. Therefore, the allowable bearing force is calculated to be at 446 t/pile.

## 7. METEOROLOGICAL SURVEY

### 7-1 Introduction

The meteorological survey is indispensable for the construction plan, procurement of materials and preparatory arrangements. The correct data were not available in the short time of the survey period, so they were provided by the favour of the authorities concerned such as Metorological Department, Agriculture Department, EPWAPDA Hydrology Directorate, etc.

The Dacca area is located in the middle of the tropical belt, and the tropical monsoon climate prevails. The northern part of the Dacca area is drier than the southern part, and the temperature is almost the same throughout the area. According to the record of "Regional Meteorological Center, Chittagong", the average temperature is 84°F in summer, and 67°F in winter. From May to September, the humidity is especially high. In 4 months of winter season; November, December, January and February, the climate is dry. Through the year, the average rainfall has been recorded under 3 inches. For the past several years, the mean temperatures in the Dacca area are:-

| Season | Maximum Mean | Minimum Mean |
|---|---|---|
| Summer | | |
| Dry Summer (March to June) | 90.6°F | 74.1°F |
| Monsoon (July to Oct.) | 88.2°F | 77.9°F |
| Winter (Nov. to Feb.) | 80.5°F | 57.0°F |

During the period from 1958 to 1959, the average monthly rainfall was 6.13 inches through the year, and the total rainfall for the year was 73.57 inches. During 10 years preceding 1961, the average yearly rainfall was recorded to be 69.64 inches.

The cyclone which breaks out in the Bay of Bengal would hit the Dacca area occasionally at the beginning and the end of the monsoon only. As for the cyclone which struck the area recently, not so large damage took place. The damage of the flood is rare in the area. In 1955, when the highest flood level was recorded for the Burhiganga River, a part of Dacca City was submerged for a short time.

7-2 Temperature

The cooler weather starts from November and continues till the end of February. During the period, the temperature would vary from 100°F at the maximum to 42°F at the minimum, and almost nothing of rain would fall. Toward March the warm weather begins, continuing till the middle of June. The period would be the hottest season throughout the year, the temperature change ranges from 108°F to

$50^{\circ}F$, and the rain falls sometimes, with the hail and strong northwest winds prevailing in the district. The period from the middle of June to the middle of October would be so called "monsoon season" or "rainy season", and the temperature would change between $102^{\circ}F$ and $62^{\circ}F$. According to the data given by the favour of Dacca Agricultural Farm, the temperatures in Dacca City from 1947 to 1960 were recorded as follows:

DACCA MONTHLY TEMPERATURE IN DEGREES F. (1947 - 60)

| Month | Highest Max. | Mean Max. | Monthly Mean | Mean Min. | Lowest Min. |
|---|---|---|---|---|---|
| January | 85.5 | 77.2 | 63.5 | 49.9 | 43.0 |
| February | 95.3 | 81.7 | 68.5 | 55.2 | 41.0 |
| March | 100.2 | 88.5 | 76.3 | 64.1 | 50.5 |
| April | 107.5 | 93.8 | 83.1 | 72.3 | 54.0 |
| May | 108.0 | 90.8 | 82.5 | 74.3 | 56.0 |
| June | 99.5 | 87.9 | 82.4 | 77.0 | 62.0 |
| July | 97.0 | 81.1 | 79.5 | 77.8 | 72.0 |
| August | 100.0 | 87.4 | 82.8 | 78.2 | 60.0 |
| September | 96.8 | 88.0 | 82.9 | 77.7 | 68.0 |
| October | 101.5 | 87.2 | 80.2 | 73.2 | 53.0 |
| November | 100.4 | 84.4 | 74.1 | 63.9 | 47.7 |
| December | 85.9 | 78.9 | 66.7 | 54.4 | 42.0 |

7-3 Rainfall

The following table is based on the records of the Rain Gauge Stations set up in the Dacca district. The detail of location and period is:-

| | |
|---|---|
| Dacca Station: | 1900 - 1959 |
| Joydebpur Station: | 1900 - 1959 |
| Kapasia Station: | 1908 - 1959 |
| Manikganj Station: | 1900 - 1959 |
| Munshiganj Station: | 1900 - 1959 |
| Narayanganj Station: | 1900 - 1959 |
| Narsingdi Station: | 1908 - 1959 |
| Nawabganj Station: | 1908 - 1959 |
| Baliakandi Station: | 1908 - 1959 (See Reference 35) |

RAINFALL IN DACCA DISTRICT (in inches)

| Month | Maximum | Average | Minimum | 90% Dry |
|---|---|---|---|---|
| January | 3.57 | 0.35 | 0.00 | 0.00 |
| February | 4.82 | 1.11 | 0.00 | 0.03 |
| March | 14.38 | 2.20 | 0.00 | 0.13 |
| April | 29.11 | 5.58 | 0.11 | 2.14 |
| May | 40.37 | 8.96 | 0.31 | 4.35 |
| June | 45.60 | 13.28 | 1.69 | 7.14 |
| July | 45.22 | 12.63 | 2.71 | 7.75 |
| August | 37.22 | 13.07 | 2.55 | 8.27 |
| September | 25.53 | 9.60 | 0.00 | 5.36 |
| October | 26.05 | 5.70 | 0.00 | 2.06 |
| November | 13.92 | 0.81 | 0.00 | 0.00 |
| December | 5.99 | 0.23 | 0.00 | 0.00 |

Total: 73.52"

In the table, the monthly precipitation in a 90% dry year is calculated and shown. The definition of "90% dry year" is to mean the year in which the rainfall would exceed the specific volume in nine years out of ten.

Accordingly, more than 75% of the average annual rainfall in the Dacca district would be brought during May to September, namely in the rainy season. Further, the torrential rainfall upto 8 inches would also come in the season, making the total monthly rainfall of 45.60 inches.

Based on the records with the automatic rain gauge of the Dacca Rain Gauge Station from 1957 to 1960, the number of wet-weather day and rainfall per month are checked up as follows: (See Reference 38)

MONTHLY RAINY DAY AND RAINFALL AT DACCA

| Month | 1957 Rainy Day (days) | 1957 Monthly Rainfall (inches) | 1958 Rainy Day (") | 1958 Monthly Rainfall (") | 1959 Rainy Day (") | 1959 Monthly Rainfall (") | 1960 Rainy Day (") | 1960 Monthly Rainfall (") | Mean Rainy Day (") | Mean Monthly Rainfall (") |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 4 | 2.58 | 9 | 0.09 | 6 | 2.41 | 0 | 0.00 | 5 | 1.27 |
| Feb. | 4 | 2.25 | - | - | 9 | 0.81 | 0 | 0.00 | 4 | 1.02 |
| Mar. | 4 | 0.59 | 2 | 0.44 | 5 | 3.79 | 5 | 0.55 | 4 | 1.34 |
| Apr. | 7 | 4.63 | 8 | 1.05 | 7 | 0.51 | 3 | 2.74 | 6 | 2.23 |
| May | 10 | 2.77 | 13 | 4.91 | 17 | 4.68 | 13 | 11.14 | 13 | 5.88 |
| June | 17 | 13.63 | 18 | 3.48 | 13 | 10.77 | 18 | 9.65 | 17 | 9.39 |
| July | 20 | 11.85 | 27 | 6.83 | 26 | 9.58 | 26 | 20.26 | 25 | 12.13 |
| Aug. | 19 | 4.05 | 24 | 10.93 | 23 | 13.08 | 26 | 7.78 | 23 | 8.96 |
| Sep. | 13 | 5.35 | 16 | 1.68 | 20 | 17.60 | 21 | 8.18 | 18 | 8.20 |
| Oct. | 3 | 0.91 | 13 | 6.09 | 17 | 20.00 | 6 | 1.98 | 10 | 7.25 |
| Nov. | 0 | 0.00 | 5 | 0.05 | 0 | 0.00 | 0 | 0.00 | 1 | 0.01 |
| Dec. | 6 | 0.06 | 9 | 0.09 | 0 | 0.00 | 0 | 0.00 | 4 | 0.04 |

Entering into detail of the record of July in which many rainy days and much rainfall were registered, the rain would not necessary continue all day long, but for 7, 8 or 9 hours at longest and just 1 hour at shortest. Consequently, even in the rainy season, the execution work would not necessarily suspended. Dependent upon the conditions of the river, the construction work of the superstructure would be able to be carried out at least. Further analystic study should be made on the rainfall intensity and its continuing hours in planning up of the exeotion work.

7-4 Humidity

According to the data obtained from the observation of the

Dacca Agricultural Farm from 1947 to 1960, the maximum, minimum and average value of humidity in Dacca are shown in the following table.

MAXIMUM, MINIMUM AND AVERAGE PERCENTAGES
OF HUMIDITY FOR DACCA, 1947 - 60

| Month | Maximum | Minimum | Average |
|---|---|---|---|
| January | 100 | 22 | 75.15 |
| February | 100 | 14 | 72.15 |
| March | 100 | 10 | 71.69 |
| April | 100 | 8 | 76.52 |
| May | 100 | 20 | 82.22 |
| June | 100 | 55 | 90.34 |
| July | 100 | 64 | 91.28 |
| August | 100 | 61 | 89.49 |
| September | 100 | 52 | 89.62 |
| October | 100 | 42 | 86.29 |
| November | 100 | 27 | 79.73 |
| December | 100 | 30 | 75.80 |

The table indicates a considerable change in humidity throughout a year. It is also made clear that the humidity during the monsoon season from June to September is very high in comparison with the other months. The sufficient preservative measure should be taken for the surveying instruments against humidity in the rainy season.

7-5 Wind

According to the data observed by the Dacca Agricultural Farm, the maximum, minimum and average wind velocities (in miles/hours) in each month from 1950 to 1960 are as follows: The table shows that the wind velocity is larger in the period from April to September than the other months.

WIND VELOCITIES IN MILES PER HOUR - DACCA

| Month | Maximum | Average | Minimum |
|---|---|---|---|
| January | 6 | 1.88 | 1 |
| February | 16 | 2.60 | 1 |
| March | 17 | 4.50 | 1 |
| April | 20 | 6.95 | 1 |
| May | 17 | 7.77 | 1 |
| June | 16 | 6.25 | 1 |
| July | 12 | 6.30 | 1 |
| August | 13 | 5.39 | 1 |
| September | 18 | 4.09 | 1 |
| October | 13 | 2.32 | 1 |
| November | 10 | 1.57 | 1 |
| December | 5 | 1.46 | 1 |

However, the maximum momentary wind velocity of 100 mile per hour was reported to be recorded among the hail and stong northwest wind which hit Dacca.

7-6 Day Length and Sunshine.

The day length and sunshine are given as follows: In the monsoon season, the actual sunshine varies from 36% to 50%. In the dry season, the actual sunshine is by far larger to become 84% in December than the monsoon season.

DAY LENGTH AND SUNSHINE IN HOURS

| Month | Day Length | Sunshine | Percentage |
|---|---|---|---|
| January | 10.80 | 8.51 | 79 |
| February | 11.33 | 8.88 | 78 |
| March | 11.93 | 8.78 | 74 |
| April | 12.67 | 8.82 | 70 |
| May | 13.25 | 8.16 | 62 |
| June | 13.60 | 4.91 | 36 |
| July | 13.50 | 5.52 | 41 |
| August | 13.00 | 5.57 | 43 |
| September | 12.35 | 6.17 | 50 |
| October | 11.65 | 5.86 | 51 |
| November | 11.33 | 9.18 | 81 |
| December | 10.70 | 9.00 | 84 |

## 8. OTHER SURVEYS

So far has been stated the chief surveys, and the followings were among the other surveys:-

### 8-1 Corrosiveness Survey

The water of the Burhiganga River was examined with the irrigation water examination instrument made by Fujidaira Kogyo K.K. to prove PH 6.0 - 6.5. In the site survey, the both banks of the river were investigated from board a boat, and there was found the only one water intake pipe of Dacca city fitted some upperstreams from the curve point of the river. The intake pipe was made of steel and 50 cm in diameter, which was probably fitted about 100 years ago by the British. The slight corrosion only was observed on the surface of the steel pipe, so it may be safely said that no corrosion might be caused by the river water. Further, it is desirous that the corrosiveness of the ground foundation should be surveyed in planning the execution.

8-2 Traffic Census

The traffic census is very important in determining the bridge width, number of traffic lane, sidewalk, and effective period in future, etc. The traffic census report of Dacca University, 1963, was taken in for references. The report is titled "Anticipated Impact of Highway Transportation in the Development of Dacca City and its Suggestive Improvements", and its contents are:-

A Brief History of the Development of Dacca City through Ages.

Present Route System in Dacca City.

Present Traffic Problem of Dacca City. --Traffic Census, Analysis of Traffic Census, Yearly Registration Numbers of Different types of Vehicles at Dacca, Statistics of Rickshaw etc., Motor Spirit Consumption in Dacca City, Total Milage of Road During 1958 - 1962, population in Different Years.

Traffic Accident in Dacca City.

In the report, the data upto 1962 are collected and analized.

8-3 Survey on Use of Burhiganga River

Reference was made to the survey on the Dacca Port in the Burhiganga River in "Preliminary Project Report for the Development of Inland River Ports in the Greater Dacca Area" of Netherlands Engineering Consultants.

8-4 Survey on Flood in Various Rivers of East Pakistan

To make clear the characteristics of the Burhiganga River as well as to obtain a wide viewpoint for the project, reference was made to "Flood Report of East Pakistan for the Year 1960", "Flood Report of East Pakistan for the Year 1961" and "Annual Report on Flood in East Pakistan for 1963, all of which were published by the Hydrology Directorate of EPWAPDA.

8-5 Survey on Data for Design

For the design of the bridge and connecting roads, references were made to "Highway Bridge Code for East Pakistan, 1962" and "Basic Road Statistics Required by the Road Policy Committee Set-up by the Central Government to Recommend Measure Necessary for Improvement of Standards of Construction and Maintenance of Roads of all Categories", which were published by C & B of Government of East Pakistan, and to "Standard Specification for Highway Bridges, 1961" of The American Association of State Highway Officials. Further, the blueprints of the reinforced concrete bridge (Dhaleswar River Bridge) which was recently built, were also examined, and site investigation was made to observe the roads and road bridges existing between Dacca and Aricha. The study work was conducted on the reports of "Ammann & Whitney International Ltd." and "Berger Engineers-Pakistan, etc.

8-6 Survey on Construction Cost Squaring Data

For the construction cost squaring, the present status of East Pakistan was studied, when references were made to:-

"Schedule of Rates of Dacca Circle I, II, 1958" of C & B, Government of East Pakistan.

and "Schedule of Rates of Eastern Zone", 1960 of EPWAPDA, and

"Tax in Pakistan, a Brief Outline" of Karachi Central Board of Revenue.

Among the other data were the examples of Dacca Improvement Trust's construction cost squaring, and the data for the transportation costs or all transportation media between Dacca and Chittagon.

8-7 Economic and Other General Survey

The study works were made in accordance with:-

"East Pakistan Annual, 1961", "East Pakistan Annual 1963-64," "District Census Report, Dacca, 1961", and Professor Geddes's (The Royal College of Science and Technology, London) "Report on the Town of Dacca, 1916.

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VOL. II

# REPORT ON PRELIMINARY DESIGNS
# FOR THE BURHIGANGA RIVER BRIDGE

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# PREFACE

The Report constitutes volume II of the Feasibility Study Report on the projected Burhiganga Bridge. Following volume I on the site investigation, the domestic work in Japan was performed to draw up the preliminary design for the following itomized subjects.

Consequently, Vol. II would not be concerned with the detailed design. In the extent of the preliminary design, the study was carried out as detailed as possible.

(1) The land project of South Dacca(temporarily termed for the city planning area along the south bank of the Burhiganga River across Dacca City) which would make significant of the bridge construction, the street planning, and the selection of the bridge construction site.

(2) The flood prevention plan in the south bank area, the necessary width of river, the embankment planning for flood control and the extension of the bridge.

(3) The expected traffic volume on the proposed bridge, the necessary traffic lanes on the bridge, and the width of bridge.

(4) The anticipated relative works, and their conditions for execution time.

(So far treated in chapter 1)

(5) The outline of the preliminary design, especially relating to the span division, navigation channel width, under-clearance, and longtitudinal slope.

(So far treated in chapter II)

(6) The comparison study on various design specifications to be conformed to.

(7) The comparison study on the preliminary design for three kinds of superstructure type to be built on the main span.

(8) The preliminary design of the superstructure to be the P.C. girder on the approach span.

(So far treated in chapter III)

(9) The preliminary design of the substructure and foundation on the main and approach spans.

(So far treated in chapter IV)

(10) The estimation of the construction cost. (Chapter V)

(11) The drawing of the construction specifications (Chapter VI)

(12) The construction plan (Chapter VII)

(13) Expected incomings and outgoings, and the fund plan. (Chapter VIII)

(14) Recommendations.

GENERAL

After the World War II, Dacca City has made a rapid development, but without a bridge over the Burhiganga River the city's growth has been hindered in the direction of the south of the river. (The area is a part of Keraniganj, and hereinafter tentatively called South Dacca). Over the Burhiganga River there is a lot of ship services plying in the area. All along Sadarghat (ferryport) to the north of the city side, no less than 50 ferry boats are always at work, (a ship's payload is approximately 100-150 passengers), and their total passenger conveyance for a year would amount to about two millions covering various places along the river, and at Sadarghat the shipping and discharging volume of cargo, inclusive of the navigational service from and to Chittagon, would total up to 600 millions tons annually.

In order to plan the city development on the south, to avoid the navigation crossing this river, and further to extend the national highway from Dacca to Faridpur in the future, there has been no such a time as today when the necessity of the bridge across the Burhiganga at Sadarghat is so keenly demanded.

Upon completion of the bridge scheduled, in 1982, a city with the population of about 100 thousand will be constructed for the area of 1,250 ha., in the South Dacca, making a part of Great City Dacca, and will play a vital role in adding the urbanity to the largest city of East Pakistan.

The bridge construction will be necessitanted in several places along the river in the future. However, the bridge around Sadarghat will be initially demanded, and hereinafter it will be tentatively termed Burhiganga Memorial Bridge or abbreviately Burhiganga Bridge.

In this report of preliminary design, the survey extent was confined to the overall length of the bridge between the abutments on the both banks, and as the proposition necessary to the bridge construction, the following relative construction works should be carried out:-

(1) The Burhiganga River is very stable around Dacca, but is an unimproved river. As recommended in the report, therefore, in the opposite bank of South Dacca, the flood-control embankment should be constructed as part of a separate city planning or flood prevention plan, so that the precautious measure of city protection should be taken against the flood submergence. The embankment may serve as a riverside driveway.

The submerged area in the opposite bank extends so largely that the reclamation work should be very uneconomical for the city planning. For each area of yearly planning work, this sort of levee should be carried out, equipped with the suitable draining pump system.

(2) On the Dacca side, the approach, as an elevated bridge, will stretch onto the Water Work Road, so the interchange with the Road should be set to construction at the same time, but as a separate city planning work or road construction.

(3) A 100 feet wide north-to-south trunk road which is drawn up in the Dacca's city planning master plan, will be connected to the projected bridge at the Water Work Road interchange. The trunk road construction work will involve a house removal problem and no immediate execution might be expected to start at the same time as the proposed bridge construction. However, the sooner work will bring the better effect on the bridge.

The outline of Burhiganga Bridge is as follows:-

Width: 66' (Sidewalk 12' + Traffic road 42' (4 lanes) + Sidewalk 12')

Overall Length: 2,883' - 6" (Length between abutment parapet walls)

Details: (i) Approach to Dacca: 701'-8"(P.C. Girder Bridge)

(ii) Main Span: 977' (Steel Bridge)

(iii) Approach to South Dacca: 1,204'-10 (P.C. Girder Br.)

Longitudinal Slope: 2.5% (Parabolic curve for the main span)

Channel Under Girder: Under clearance 45' (Above high flood level in 1955)

Channel Width 250'

Design Maximum Flood Level: 23'25 (Over P.W. datum)
Final Design Period: 9 months
Construction period: 23 months (from the material transportation to bridge completion)

26 months (including preparatory period)

Total Construction Cost: 4,941,000 US$

| | |
|---|---|
| Steel & R.C. Pilings | 648,000 US |
| Caisson Works | 399,000 " |
| Pier & Abutment Works | 487,000 " |
| P.C. Girder Works | 1242,000 " |
| Steel Bridge Works | 1479,000 " |
| Pavement Works | 54,000 " |
| Lightening, Stair, Fender, Handrailing, Toll Gate | 196,000 " |
| Temporary Works | 436,000 " |

Outline of Construction Volume:

(1) Superstructure (Main Span)

| | |
|---|---|
| Steel Material | 1,834 t (Type A), 1,660 t (Type B), 1,885 5 (Type C) |
| Concrete Slab | 14,524 sq.ft. (Type A) |
| | 13,125 " (Type B) |
| | 14,416 " (Type C) |

(2) Superstructure (Approach Span)

| | |
|---|---|
| Concrete | 94,601 sq. ft. |
| Steel Wire | 309.7 t |
| Reinforcing Bar | 235.6 t |
| Mould | 273,984 sq. ft. |

(3) Asphalt Concrete for Pavement

206,017 sq. ft. (Type A)
205,296 " (Type B)
206,232 " (Type C)

(4) Pier and Abutment

| | |
|---|---|
| Concrete | 289,104 cft |
| Reinforcing Bar | 588 t |
| Mould | 111,263 sq. ft. |
| Earth Excavation | 632,424 cft. |

(5) Caisson

| | |
|---|---|
| Concrete | 34,963 cft |
| Reinforcing Bar | 79.3 t |
| Mould | 19,688 sq. ft. |

| | | |
|---|---|---|
| (6) Steel Pipe Pile | ∅ 609.6 (mm) x 12 (mm) | :87ft x 368Piles |
| R.C. Pile | ∅ 600 (mm) | :72ft x 219 " |
| | | 87ft x 30 " |

It is unknown yet whether the bridge will be opened free of charge under the support of the public work expenses of the East Pakistan Government, or will be a toll bridge. Judging from the expected traffic volume, it is economically feasible that it can be a toll bridge.

## I. SOUTH DACCA CITY PLANNING AND BURHIGANGA BRIDGE PROJECT.

### 1-1. Change in Population in Dacca City and Its Neighbouring Districts.

According to the statistics, the change in population in Dacca City and Its Neighbouring Districts is as follows:-

TABLE 1. Population Change in Dacca

| | Dacca Municipality | Great City Dacca | Dacca District |
|---|---|---|---|
| 1901 | 87,733 | 104,385 | |
| 1911 | 108,551 | 125,733 | |
| 1921 | 119,450 | 137,908 | |
| 1931 | 141,462 | 161,922 | |
| 1941 | 213,218 | 239,728 | |
| 1951 | 276,033 | 338,762 | 4,072,781 |
| 1961 | 362,006 | 556,712 | 5,095,745 |

The Dacca Municipality Area consists of old and new towns, making the present Dacca University as its civil center, and developing along the north bank of the Burhiganga River. As the population index is made 100 as of 1901, it reached 417 as of 1961, and especially in the past 10 years from 1951 to 1961, the population increased by 86,000 and the growth rate is 3.12% on the annual average.

The Great City Dacca is administratively under the control of the Dacca Improvement Trust (abbreviatedly D.I.T.), and geometrically situated up to 12 miles north from Tungi and in its southern direction extends all the way to the north bank of the Burhiganga River, including the Dacca Municipality Area. The population index is made 100 as of 1901, it is shown 325 as of 1951; and 533 as of 1961. In 10 years from 1951 to 1961, the increase shows 6.6% on the annual average.

For all East Pakistan with the territory area of 54,501 square miles, its population was 42,063,000 as of 1951, and 50,844,000 as of 1961, showing the average yearly increase of 3.0% in the cities and towns and at least 2.0% in the agricultural districts.

In 1961, the distribution of the inhabitants of Great City Dacca was:-

| | |
|---|---|
| Dacca Urban | 188,137 |
| Dacca Municipality | 362,006 |
| Dacca Cantonment | 6,869 |
| Total: | 556,712 |

65% of the Great City Dacca population gathered in the city area; 33.8% in the agricultural area; and 1.2% in the military forces. However, the city area is only 8 square miles, so the population density shows a remarkable 45,200 heads per square mile.

The south bank area of the Burhiganga River, temporarily called South Dacca, which was recently closed up in the bridge construction project, is neither included in Dacca municipality nor in Great City Dacca. The insular area lying between the Dhaleswari River and Burhiganga River covers the land of 71 square miles. It is called Karaniganj where no urban life has so far been found. In 1961, its agricultural population was 170,489, showing the annual growth of 2.9% on the average in the period from 1951 to 1961.

Should the riparian area of Karaniganj along the Burhiganga River be incorporated in the Great City Dacca to make out a comprehensive city planning, the distressed present-day Great City Dacca will be able to absorb the majority of the increased population, which is anticipated to reach one million people in 1980. No other area than South Dacca along the south bank of the Burhiganga River could afford to accomodate such a rapid and large growth.

1-2 Present Status of Dacca City.

The Dacca City master plan of Dacca Improvement Trust was drawn up in 1959 by a British consultant, Minopolis Spencery & P.W. MacFairlane. This city planning covers the area beginning from the north bank of the Burhiganga River and stretching to the north. It is so planned that the railroad passing through the city at present should be detoured in the northeast of the city, the confusion of the city center be removed, the industrial site be built around Teigaon east of the airport, and the zoning of city area should be worked out into a commercial, official and residential districts. In this master plan, the city growth was directed to the north and south, the population would necessarily be heavy on Sadarghat north of the Burhiganga River, and the further development has been in fact impeded by the river.

With the swift growth of commerce and industries after the end of the World War II, the demand for the 100 feet wide trunk road construction to extend the Simson Road in the master plan, has been realized more and more. The projected trunk road will reach Buckland Bund, running across the river by a bridge and down to South Dacca. Today, D.I.T. and Dacca city people as well fully recognize that the rapid expansion of Great City Dacca should be absorbed by means of the trunk road construction.

Therefore, making it more significant to construct the Burhiganga Bridge, it would be necessary that the city planning of South Dacca should be drawn up at first, and that the location of the construction site should be decided accordingly to the street design. Thus, the development project should be mapped up for South Dacca, and the re-study should be carried out on the integral city functions of the Great City Dacca.

1-3 Flood Control Plan of South Dacca.

South Dacca, where a new town construction is to be undertaken, is a part of the vast Karaniganj, and compared to the elevated north bank area, it is likely to get submerged for the most part in the flood because of the unimproved Burhiganga River. In the flood of 1964, the agricultual district was submerged by 1.7' - 2.7'. In the plan, the total reclamation for all the new city planning area is not designed, but a flood-control embankment will be built all along the river enough to stand against the disasterous flood volume in 1955. The levee might be carried out to enclose each yearly city planning area so that the city protection should be secured.

However, in case ofthe flood-control embankment construction, it is necessary to start to work at the same time as the bridge construction, but should be taken up as part of a separate road construction project. The top surface of the embankment should be preferably available for a highway of South Dacca.

The location of the embankment should be in the Burhiganga Bridge construction site. The levee should be higher by 5' than the flood level in 1955, making an altitude of 28.25 P.W. datum near the proposed bridge location. The top surface should be more than 17' in width, matching the necessary width of the road, which is to be built on it. It would be proper that the face of slope should be 1:2 on the riverside and 1.25 on the city side. Based on the site investigation, the flood volume of 1955, of which frequency would be once in 50 years, should be presumed and given in approximate figures as follows:-

According to Manning's formula:

Q : 2080 $m^3$/sec.

N : 0.0302

A : 3090 $m^2$

V : 0.675 m/sec.

I : 1:39880

R : 8.13 m

The flow in the high water channel might be a little more than 10% of the total flow, and in the interior of the embankment there is only a difference of within 3' between the designed water level and the ground surface; and in addition the woods, plains and the cultivated land of the interior should largely slow down the flow velocity in the flood season. Therefore, as shown in the general drawing, if the flood-control embankment is built near the abutment on the South Dacca side, it could be negligible of the decreasing extent of the total outflow capacity.

According to the on-the-spot survey of the upper and lower reaches of the Burhiganga River, there were found locally narrow places, but generally kept the almost same sectional flow area as the proposed bridge site all the way up and down the river. Consequently, it is considered that the river should need the high water channel to such a degree as specified before. Furthermore, the detention of this high water channel would meet the increase in the discharge from the river basin, if any in future, by means of expanding the lower channels. It is therefore concluded that the river bed width should be enough to be 865 - 870 m.

## 1-4 Land Project of South Dacca Area.

Provided with the completion at the same time of the planned bridge, the north-to-south trunk road and the flood control embankment, the urbanity of South Dacca will be brought into full swing as part of Great Dacca Area, making its center at the north bank of the Burhiganga River. At present, several villages are scattered in South Dacca, where the residentiality will be developed. The area, therefore, should be studied to grow into a city characteristic of the residential quarters.

Taking into consideration the topography of the present South Dacca, the land project is drawn up as shown in the appendix drawing II-1.

TABLE 2 South Dacca Land Use Project

| Kind | Area | Proportion | Planned Population |
|---|---|---|---|
| Residential | 820 (ha) | 65% | (Approx.) 70,000 |
| Commercial | 50 | 5 | 10,000 |
| Industrial | 380 | 30 | 20,000 |
| Total | 1,250 ha. | 100% | Approx. 100,000 |

Consequently, it will be possible that the planned city can afford to house more than 100,000 people in the population make-up.

1-4-1 Industrial District.

In consideration of the navigational and traffic conveniences, the industrial area of South Dacca will be located on the eastern part of the south bank. The place is namely about one or two miles downstream of the proposed bridge site, covering the area of approximately 380 ha. In the event of the future possible development, both commercial and residential area should not be checked by the expansion of the industrial zone.

The river would probably be dredged to some degree along a part of the south bank in order that the ships may be able to come alongside the quay.

1-4-2 Residential & Commercial District.

The 100 feet wide north-to-south trunk road in Dacca City runs across the river, and extends on the southwest. Both sides of the road are planned chiefly to build the commercial zone in the area of about 50 ha., and surrounding it the residential block in about 820 ha.

As to the park and green district project, it is dependent upon the detailed design of the residential area, but in principle the existing water channels in the lower area should be utilized to make a continuous systimatic green belt. In so doing the maintenance of the channels and landscope might be achieved.

In the industrial zone, it is necessary to set the parks for the protection of the circumstances or in order to give the rest places to the workmen. The park project should be carried out so as to bring the most effect out of the roads and green belts.

1-4-3 Street Plan.

In order to make such a zoning as descibed, the 100 feet wide road extension line should be the main trunk road, and the streets should be drawn and built to run in parallel with it or to cross it right-angled. The north-to-south road will become a national highway in its nature, which will stretch in the future through the Karaniganj Area and across the Dhaleswari River towards Faridpur.

With the future development of South Dacca, the Burhiganga River would be needed to have the more cross-bridges, for instance, at Jinjira, Postogala, Gandaria, etc., besides the proposed bridge construction site.

1-5 Expected Traffic Volume on Burhiganga Memorial Bridge.

In an attempt to estimate the expected traffic volume on the bridge after its completion, few data were available for the statistics of the present traffic volume by the ferry boat transportation. Therefore, the traffic volume to be generated was estimated inclusively of the evocated traffic, as follows:-

1-5-1 Investigation Results of the Traffic Volume in the Neighbouring Districts.

According to the investigation of Dacca University on 13th May, 1963 for the traffic in Dacca City, the 24-hour traffic volume in the north and south direction of the Jinnah Avenue, running about half a mile upperstream of the proposed bridge site, is given in the following table. The proportion between rapid-vehicle and slow-vehicle was 1:1.66.

TABLE 3, Traffic Investigation in Jinnah Avenue

| Kind | | Traffic Volume | |
|---|---|---|---|
| | | South to North | North to South |
| Automobile | Truck | 310 | 306 |
| | Bus | 1,137 | 1,122 |
| | Car (incl. Taxi & Autobycicle) | 5,359 | 5,360 |
| Subtotal: | | 6,866 | 6,778 |
| Slow-Vehicle | Oxcart | 16 | 9 |
| | Rickshaw | 6,585 | 6,921 |
| | Passenger horsecart | 118 | 6 |
| | Bycicle | 2,871 | 3,872 |
| | Others | 127 | 83 |
| Subtotal: | | 11,210 | 11,391 |
| Pedestrian | | 330,920 | 156,547 |

In fact, the traffic volume includes the passengers who come by ferry boat from the opposite bank area, but its number and percentage are left unknown.

1-5-2 Number of Registered Vehicles of Dacca City.

The number of vehicles of Dacca city in 1961 is as follows:-

TABLE 4

Number of Vehicle

Registered in Dacca

| KIND | NUMBER |
|---|---|
| AUTOMOBILE (4-wheel) | |
| Truck | 1,776 |
| Bus | 776 |
| Private Car | 3,252 |
| Taxi | 1,396 |
| Subtotal: | 7,200 |
| AUTOBYCICLE & THREE-WHEEL | |
| Motor-Ricksaw | 1,223 |
| Scooter | 1,447 |
| Subtotal: | 2,670 |
| Grand Total: | 9,870 |

From 1951 to 1961, the yearly increase in the number of vehicles was about 600 - 700 on an average. The proportion of the vehicle number to the population of Dacca Municipality Area as of 1961, 362,006 persons, was 1 to 36, which is a rather low rate. According to the investigation of Dacca University, the vehicle number in 1982 is expected to be 40,000, and the population of Greater Dacca is accordingly presumed to reach 1,000,000. The proportion of vehicle to the population will be one to twenty five.

1-5-3 Expected Passing Vehicle.

(1) Supposed that the population of Greater Dacca City in 1982 were 1,000,000 and that of Karaniganj 400,000 (100,000 in South Dacca), it is presumed that the vehicle holdings of Karaniganj (including motor-bycicles and three-wheel vehicles) should be some 6,000. (4,000 in South Dacca).

As for South Dacca alone, an average on family member consisting of 5 persons, making a total 20,000 families, the vehicle holding rate would be 1 to 5.

The passing vehicle on the proposed bridge would be given by making the functions from the vehicle number of South Dacca and that of Karaniganj:-

| | |
|---|---|
| Vehicle of South Dacca | 0.8 ply/vehicle/day |
| Vehicle of Karaniganj (Exclusive of South Dacca) | 0.2 ply/vehicle/day |

Consequently, the number of vehicles passing on the proposed bridge would be:-

$$\{0.5 \times 4,000 + 0.2 \times (6,000 - 4,000)\} \times 2 = 4,800 \text{ vehicles/day}$$

(2) Provided that in 1982 all the factories were completed in the industrial area of South Dacca.
The generated truck traffic volume is calculated as follows:
The loading and unloading cargo is estimated to be 0.2 tons

per day for one working man, and among the figure the share of the road traffic volume to be 0.15 t/day, the total handling transportation volume is given to be 3,000 tons. With the payload of a truck being about one ton on an average, the number of trucks necessary is about 3,000. Judging from the economic sphere concerned, all these vehicles would be passing across the Burhiganga Bridge.

The number of vehicles for bussiness and private use is expected to amount to 30% of the number of trucks, making a total 900 vehicles a day.

(3) The evocated traffic volume is presumed to be 3000 vehicles a day, coming to South Dacca Area from the various parts within the Dacca economic sphere north from the river.

(4) On the assumption that the national highway was opened between Dacca and Faridpur and that the cross-bridge or ferry boats was completed across the Ganges and Dhaleswari River, the long-distance traffic should be expected, of which volume is presumed to be 2,000 vehicles a day.

Making the total of the above figures, the traffic volume across the Burhiganga River, even if limited to the vehicle passage, should reach 13,700 for a day in 1982. In 1982, the share of the slow-vehicle would be decreased presumably to 0.8 times as many as the rapid-vehicle.

Should the Burhiganga Bridge be completed in 1968, the expected specific yearly traffic volume would be as shown in the following table:-

TABLE 5 Passing Vehicle Number by Specific Year

(Truck, Car, Taxi, Auto-bycicle, Three-Wheel)

| Year | Traffic Volume per Day | Detail | | |
|---|---|---|---|---|
| | Total | Rapid-Vehicle | Slow-Vehicle | Pedestrian |
| 1968 | 1,600 | 600 | 1,000 | 15,000 |
| 1969 | 4,160 | 1,600 | 2,560 | 38,400 |
| 1970 | 6,600 | 2,600 | 4,000 | 59,800 |
| 1971 | 8,930 | 3,600 | 5,332 | 79,200 |
| 1972 | 12,550 | 4,600 | 7,950 | 96,600 |
| 1973 | 13,210 | 5,600 | 7,610 | 111,200 |
| 1974 | 15,180 | 6,600 | 8,580 | 125,400 |
| 1975 | 17,020 | 7,600 | 9,420 | 136,800 |
| 1976 | 17,770 | 8,470 | 9,570 | 144,000 |
| 1977 | 19,800 | 9,340 | 10,460 | 149,400 |
| 1978 | 21,030 | 10,210 | 10,820 | 153,200 |
| 1979 | 22,160 | 11,080 | 11,080 | 155,100 |
| 1980 | 23,180 | 11,950 | 11,230 | 155,400 |
| 1981 | 24,110 | 12,820 | 11,290 | 153,800 |
| 1982 | 24,660 | 13,700 | 10,960 | 150,700 |
| 1983 | 25,350 | 14,570 | 10,780 | 145,700 |
| 1984 | 26,240 | 15,440 | 10,800 | 138,900 |
| 1985 | 27,070 | 16,310 | 10,760 | 130,500 |

1-5-4 Necessary Traffic Lane and Road Width.

In presuming the 24-hour allowable traffic volume for one lane, it should be taken into consideration that the road is not limited to any of rapid-vehicle or slow-vehicle. The allowable traffic would be 8,000 vehicles a day. With the 4-lane bridge given, the allowable volume should become saturated by 1988.

On the other hand, taking into account the access roads and other factors, it would be recommendable to construct the maximum 4-lane bridge (4 x 10'), not a 6-lane one, and newly to build a second bridge somewhere around Jinjira, or Postgola, or Gandaria in 1986 to be in time for the opening in 1989.

At the beginning, not so many vehicles should be passing on the bridge, though many pedestrians are expected, so the segregation of traffic each for rapid- and slow vehicles should be employed thoroughly.

With the increasing spread of the automobiles, the pedestrian passage should be shifted into the car traffic. The sidewalk should be made to be 12' wide on the both sides of the road.

## 2. OUTLINE OF DESIGN PLAN

### 2-1 Extent and Contents of Preliminary Design.

The extent of the preliminary design taken up in this report is in principle confined to the range covering the overall length of the bridge from abutment to abutment, but the access roads, especially the ramp on the Dacca side and the connection to the planned 100 feet wide north-to-south trunk road, would be taken up just for references as shown in the appendix drawing II-5, not entering into the construction cost estimation.

Since it is the feasible report, the structural designs are made only within the limit necessary for the preparatory design, and the drawings are prepared only for those of general and typical details. The execution design being not included, the specific designs are not carried out in this report. Therefore, the construction cost estimation was made out as detailed as possible but to such a degree as the data is available for the preparatory design.

### 2-2 Relative Works

The proposed bridge construction would involve the relative works as follows:-

#### 2-2-1 Access Ramp Works on Dacca Side.

The north abutment confronts with the north side of the Water Works Road on the Dacca side. From this point on the north, the earth works block is to be set to connect with the Waterworks Road by the ramp. The connecting work should be separately carried out, but to start at the same time as the bridge construction.

2-2-2 Connecting Works with 100 Feet Wide North-to-South Trunk Road.

It is indicated in the city planning master plan that the bridge should be connected with the 100' wide trunk road on the Dacca side. However, it is not included in the bridge construction project. The connecting works would preferably be set to start at the same time as the ramp construction, but some retard might not help but happen. The work would involve the removal of the houses in the site, where is thickly-populated zone of Sadarghat, so as a matter of fact the start to work would be delayed more or less.

2-2-3 Flood-Control Embankment in South Dacca.

As referred in 1-3, the flood plan embankment should be completed prior to or at the same time at least as the bridge construction. Otherwise, it may happen that the bridge should have to be built towards the submerged land in the flood time. However, the flood-control embankment should be conducted separately from the bridge construction as one of the city planning or flood prevention works.

As there was no available map of contour lines for a wide range of South Dacca Area, the Survey Team could not make clear the area where the flood control embankment should be needed.

2-3 Span Division

2-3-1 Main Span.

A point away 1088-6" from the station 0 on the Dacca side, which was made the basic station for measuring the center line of the bridge, approximately fell on the center of the low water channel. Making use of it as the central point of tho main span, the symmetrical design was mapped up in the north-south direction so as to divide the spans. The length between the bridgepier $P_8$ - $P_9$ was made to be a channel span, and taking into account the passage of 1,000-ton class ships and the maximum flood level 23'50 P.W. datum, it is so desighed that the under clearance of the bridge is to be 45' high and the height to be secured for all the width of the channel 250'.

On the low water channel, between the bridgepiers $P_7$ - $P_{11}$, is to be made the steel structure, and then the next three draft plans are studied. As to the bloc $P_{10}$ - $P_{11}$, the same type and steel box girder between spans are used common to three plans;

A plan: 3 span continuous truss + Steel box girder
(232' + 348' + 238') (162')

B plan: Steel Box Girder + Girder with Stiffening Arch + Steel Box Girder
(203') (406') (203' + 162')

C plan: Balanced Tied-Arch + Steel Box Girder
(203' + 406' + 203') (162')

On to the channel side of the bridgepiers $P_8$ - $P_9$ are fitted by the steel sheet pile fender, so that the bridgepiers could be protected against the collision with the navigating carriers.

2-3-2 Approach Span.

The spans from the abutment $A_1$ on the Dacca side to bridgepier $P_7$ are made an elevated bridge of P.C. girder (7 span x 100' -2") over the houses, so those built in the place of the bridgepiers or the construction site must be removed or partly demolished.

Further, the stairway will be built near the bridgepier $P_7$ inorder to allow pedestrians up and down directly from the riverside Buckland Bund.

The block between the bridgepier $P_{11}$ - abutment $A_2$, where is on the high water channel, is made the P.C. girder (12 x 100' -2") as same as the northern approach span.

2-3-3 Bridge Overall Length.

The distance from the parapet walls between the abutment $A_1$ to $A_2$ is accordingly 2,883' - 6", so that the adequate flow sectional area may be secured enough to stand against a flood volume in 1955.

2-4 Longitudinal Slope.

The longitudinal slope of the surface is made parabolic of 1.25% between the bridgepier $P_8$ - $P_9$, and linear of 2.5% on the north of the pier $P_7$ and south of the pier $P_9$ for the safety passage of auto-rickshaws. On the north side, the under clearance of the girder is kept to be 15' in building the interchange with the Waterworks Road.

At the connecting parts on the ramp between the abutment $A_1$ and the Waterworks Road and onto the planned 100' wide north-to-south trunk road, the extension of 2.5% slopes will be made and further a certain proper longitudinal curves will be used to reach the ground surface.

## 3. PRELIMINARY DESIGN OF SUPERSTRUCTURE.

### 3-1 Design Specification.

#### 3-1-1 Road Width.

Driveway (4-lane): 42' - 0"

Sidewalk: 12' - 0"

#### 3-1-2 Pavement: Asphalt pavement

Driveway: 2" thick

Sidewalk: 1¼" thick

#### 3-1-3 Longitudinal Slope of Surface.

Length of central part, 426' - 6" : 1.25% parabolic slope

Both sides : 2.5% linear slope

#### 3-1-4 Cross-grade of Surface.

Driveway: 1.5% Linear slope (bilateral from the center line)

Sidewalk: 1.5% Linear slope (from curbstone to driveway)

#### 3-1-5 Construction Gauge on Bridge.

Width: 43' - 6"

Height: 14' - 0"

#### 3-1-6 Navigation Clearance

Width: 250' - 0"

Height: 45' - 0" (Above H.W.L. in 1955)

#### 3-1-7 Specification to be conformed to.

Specification for Steel Road Bridge Design,

(Japan Road Association, July 1964)

Highwway Bridge Code for East Pakistan 1st Ed. 1962

Specification for Welded Steel Road Bridge

(Japan Road Association, May 1964)

Guide for Prestressed Concrete Design & Work

(Japan Society of Civil Engineers, Revised Ed. 1961)

Standard for Prestressed Concrete Design & Work

(Japan Institute of Architectural Engineering, 1961)

Guide for Composite Girder Design & Execution

(Japan Road Association, Latest Revision, Feb. 1964)

Japan Industrial Standard (JIS), Steel and Iron

Since there is no applicable article concerning steel bridge in the East Pakistan Road Bridge Specification, the comparison study was made between the U.S. road bridge specification (abbreviatedly AASHO) and the Japanese road bridge specification, and it was then found that not so much differences are stipulated concerning design load, allowable stress, etc., so the specification of Japan Road Association was chosen to be applicable for the stage of the preliminary design (C. Table 3, Page II-45).

The design of P.C. girder bridge was made in conformity of the Guide for the prestressed concrete design and work, and the standard of the prestressed concrete design and work, established by Japan Society of Civil Engineers and Japan Institute of Architectural Engineering respectively.

3-2 Preliminary Design Draft of Main Span.

Concerning the span division and type of the bridge over the main flow channel, three draft plans were made out as the result of the site survey on the topograph, circumstances, navigation status, etc.

The central location of the navigation clearance was chosen to be the center of the deeper flow of the river sectional areas which were obtained from the profile leveling, being decided to be 1,089.5' from the principal point on the longitudinal section. Further, the center line of the middle span of the bridge was made to accord with this center.

According to the basic determination, the span division was so carried out as that the total effectige span 977' - 0" over the main flow would be made 4-span, and the main span made 348' - 0" or 406' - 0", taken it into account that the main span should be enough wide for the navigation clearance and that the more space needed for setting the protection material on the bridgepiers.

3-2-1 TYPE A.

The span division of Type A is as follows:-

| | |
|---|---|
| 3 span continuous truss bridge, (232') + (348') + (232') | 1 |
| Simple composite box girder bridge (162') | 1 |

3-2-1-1 3 Span Continuous Truss Bridge.

(1) Major dimensions.

Panel Number: 8 + 12 + 8

Panel Length: 29' - 0"

Center-to-center distance of Main Truss: 45' - 8"

Main Truss Height:

At Portal Bracing 29' - 0"

At Intermediate Bearing 56' - 0"

At Center of Central Span 40' - 0"

(2) Outline of Structure.

(i) Each member of the truss will be a box or I-section. The factory work will be conducted in the electric are welding process. The splice or connection at the construction site will be done in the rivet connection method.

(ii) The stringer and cross beam are used I-beam, and the factory work will be conducted in the electric are welding. The number of stringer is 5 on the driveway, and 2 on the side-walk. The stringers on the sidewalk will be put on the brackets protruded from the truss.

(iii) The floor slab will be made of the reinforced concrete, and its thickness is made $7\frac{1}{4}$" on the driveway and 6" on the sidewalk.

(iv) In order to maintain the horizontal rididity against the wind load, the upper lateral bracing will be applied onto the upper chord; and the lower lateral bracing be applied onto the lower chord. The lateral member is used T-beam.

(v) On the end post of the side span will be set the portal bracing which will enable transfer the wind load borne by the upper lateral to the support. The portal bracing has a I-section, and held in the height enough to clear the bridge construction gauge.

(vi) The shoes of supports will be all made of cast iron, and the bottom size of the intermediate supports' shoe will be made 65½" x 63" for both fixed and movable ends. For the expansion of the movable end, 4 rollers of 14" diameter are equipped.

3-2-1-2 Simple Composite Box Girder Bridge.

(1) Major Dimensions.

| | |
|---|---|
| Effective span: | 162' - 0" |
| Number of box girder: | 3 |
| Size of box girder: | Height 86½" |
| | Width 122½" |

Center-to-center distance of web plate of box girder: 8' - 3"

(2) Outline of Structure.

(i) The top flange of box girder is 24" wide. It is deviced that the box is open on the top before composited, but that after the reinforced concretefloor slab depositing and hardening, the composite girder will be formed against the live load.

(ii) The box girder will be assembled with the plates to make the section in the arc welding. For the conveniences of transportation, the lower flange is devided into three parts and carried to the bridge site, where the rivet connection will be conducted to form the box girder.

(iii) The floor slab will be made of the reinforced concrete, and 7¼ thick on the driveway and 6" on the sidewalk. The floor slab on the sidewalk will be placed on the bracket protruded from the outside of the box girder.

(iv) Onto the top of the upper flange of box girder will be welded the shear connector, enabling to resist against the horizontal shearing force effective on the composite section made by the floor slab and steel box girder.

3-2-1-3 Review of "Type A".

(1) Span Design.

The central-span length of the continuous truss bridge will be made 348' - 0" to secure the navigation clearance width of 250' - 0", and the side-span length will be 232' - 0", taken into consideration a balanced proportion of the 3 span continuous truss to be 1:1.5:1.

The span adjacent to the continuous truss will be made 162' - 0", being decided upon the relation of the bridgepeir height and the span length of the continous truss.

(2) Configuration of Main Truss.

The appearance of the main truss is represented with a gentle curve drawn against the sky by the parabolics of three upper chords of which principal axis are made of the posts (56' - 0" high) on the 2 intermediate supports. The bridge is intended to give the impression of being strong and encourageous as well.

(3) Erection.

The erection of the 3 span continuous truss will be carried out by assembling the members on three steel bents which have been prepared on the both side spans.

The number of central span will be assembled upon the receiving beam hung on the main cable stretched between the steel posts on the bridgepeirs.

After completion of the rivet connection of all spans, the cables and steel posts for the erection work should be removed.

The feature of the cable erection method lied in that no obstacle should occur to the navigation channel under the central span even during the erection work period.

(4) Steel Weight.

| | | |
|---|---|---|
| 3 Span Continous Truss Bridge | 1 | 1,592 t. |
| Simple Composite Box Girder Bridge | 1 | 242 t. |
| Total: | | 1,834 t. |

3-2-2 TYPE B.

The span division of Type B is as follows:-

| | | | |
|---|---|---|---|
| Plate Girder Bridge with Stiffening Arch, | Span | 406' - 0", | 1 |
| Simple Composite Box Girder, | " | 200' - 0", | 2 |
| Simple Composite Box Girder, | " | 162' - 0", | 1 |

3-2-2-1 Plate Girder Bridge with Stiffening Arch.

(1) Major Dimensions:

| | |
|---|---|
| Number of panel: | 14 |
| Length of panel: | 29' - 0" |
| Center-to-center distance of Main girder: | 45' - 11" |
| Arch rise of Stiffening arch: | 65' - 0" |
| Height of main girder: | 9' - 10" |

(2) Outline of Structure.

(i) The section of the stiffening arch member forms a box shape, and the factory work will be conducted in the electric arc welding.

(ii) The splice and connection of the members in the construction site will be done in the rivet work. The sectional forms of the stringer and cross-beam, and the working method will be same as Type A.

The number of stringer is same as Type A.

(iii) Concerning the floor slab, same as Type A.

(iv) In order to maintain the horigontal rigidity of the bridge against wind load, the upper and lower laterals are fitted in the same way as Type A.

(v) On 2 end-panels of the stiffening arch is set the portal bracing to transfer the wind load from the upper lateral down to the supports. The portal bracing has an I-shape section and hold high enough to allow the clearance limit on the bridge.

(iv) The shoes of supports are all made of cast iron, and the size of their bottom plate is made 39½" x 67" for both fixed and movable ends.

For the expansion of the movable end, 6 rollers with 10" diameter are equipped.

3-2-2-2 Simple Composite Box Girder Bridge.

(As regards the box girder of span length 162' - 0", the same as Type A will be applicable, and the description is so ommited.)

(1) Major Dimensions:

Span: 200' - 0"

Number of box girder: 2

| | | |
|---|---|---|
| Size of box girder: | Height | 118" |
| | Width | 220½" |
| Center-to-center distance of box girder web slab: | | 9' - 0" |

(2) Outline of Structure.

(i) The top flange is 27½" wide, and before composited it is in the shape of a box of 3 web plates without top. After the reinforced concrete floor slab is deposited and hardened, the composite girder will be formed against the live load.

(ii) The composition of the box girder and executing method is same as in the case of Type A.

There is a limit to the width and length of the materials in their transportation and erection, the overall length of the box girder will be therefore divided, and further the bottom flange will be longitudinally divided into three parts. At the erection site, the box girder will be built up by the rivet connection work.

(iii) Concerning the floor slab, same as Type A.

(iv) Concerning the shear connector, same as Type A.

3-2-2-3 Review of Type B.

(1) Span Division.

The length of the central span of the plate girder bridge is made 406' - 0" in order to secure the navigation clearance width of 250' - 0", and taken into account the low-water channel the side spans are made to be the simple composite box girder of span length of 200' - 0" on the both sides. On the further south, one simple composite box girder of span length of 162' - 0" is fitted.

(2) Configruration of Stiffening Arch.

The stiffening arch will be straight between the panels so as to only bear the axial compressive force of the member. The horizontal distqnce is each 406' - 0" between the panel points which will come on the secondary parabolic curve of arch rise 65' - 0".

The vertical member, namely the hanger, is a comperatively thin I-sectional tension member. Compared with the tied-arch of Type C, therefore, the structure on the bridge surface looks slender, giving the impression of being graceful and rather feminine.

In case that the plate girder should be placed under the bridge surface, the more effect would be resulted for this type of bridge. However, it would make higher the distance from the bridge surface to the bottom of the bridge girder, namely the structural height. The larger structural height would influence upon the surface altitude to be higher for the overall length of the bridge, which should be uneconomical from the viewpoint of construction cost. Accordingly, in the design of Type B, the plate girders come out partly above the bridge surface.

(3) Erection.

The cable erection process should be the most suitable for the plate girder with stiffening arch to be erected without interference to the navigation pass.

The main cable will be at first extended between the steel posts built on two bridgepiers, and the ends of the cable will be connected with the pre-set anchor blocks. The plate girder will be put upon the receiving beam suspended from the main cable by hanging cables. The floor slab and lower lateral will be built up with the hangers fitted onto them. The stiffening arch members will be so assembled successively from the both ends of the plate girder as to be symmetrical, and finally the arch members will be closed at the center of the span. After the portal bracing and upper lateral being fitted, and the camber adjusted, the riveting work will be finished. And finally, the erection cable will be taken out.

(4) Estimated Steel Weight.

| | | |
|---|---|---|
| Plate girder with stiffening arch (406'), | 1: | 1,030 t. |
| Simple composite box girder (200'), | 2: | 588 |
| Simple composite box girder (162'), | 1: | 242 |
| Total: | | 1,860 t. |

3-2-3 TYPE C.

The span division of Type C is as follows:

Balanced Tied-Arch Bridge, 1 Span (203' + 406' + 203')

Simple Composite Box Girder, 1 " (162')

3-2-3-1 Balanced Tied-Arch Bridge.

(1) Major Dimensions:

| | | |
|---|---|---|
| Central span: 406' - 0", | Number of panel | 14 |
| Cantilever arm: 58' - 0" | " | 2 |
| Suspended truss span: 145' - 0" | " | 5 |
| Panel length: 29' - 0" | | |

Center-to-center distance
of main structure: 45' - 9½"

Arch Height: 75' - 0"

(2) Outline of Structure.

This type of bridge features the cantilever arms protruded outwardly for 2 panels from the bearing points of an ordinary tied-arch type bridge. At the ends of the protruded cantilever arms is erected the suspended truss, decreasing the load on the tied-arch of the central span by the cantilever arm and suspended truss.

Generally, most of the horizontal coupling member would connect the both bearing points. In the case of this type, however, a through bridge is built in order that the height from the bridge girder might be held within approximately 6' - 6½" as same as the other draft plans, and the horizontal coupling members are to connect the panel points next to the bearing points, having the support shoe put on as lower a level as possible to decrease the bridgepier height and reduce the construction cost of the substructure.

Concerning the structure, there are plenty of similarity to the other two draft plans, and the description is omitted.

3-2-3-2 Simple Composite Box Girder Bridge.

The structure is almost same as in the case of Type A, and the description is omitted.

3-2-3-3 Review of Type C.

(1) Span Division.

The length of central span of the balanced tied-arch bridge is same as Type B, but the span length is 406' - 0", and its side spans are made 203' - 0" each.

One span on the opposite side to Dacca City is the same as Type A, and the simple composite box girder bridge of 162' - 0" span length will be constructed.

(2) Configuration of Arch.

The arch is the truss consisting of upper and lower chords, diagonal member and vertical member, all of which have the box or I-section fabricated in the electric welding.

The panel points of the upper and lower chord members are on a parabolic curve, showing a gentle camber at the joint with the suspended truss. The vertical member, namely the hanger, is the same I-sectional tension member as Type B.

The type is characteristic of the parabolic curve rising at the center of span, appearing magnificient. In the sense of the city's monument, this type would be suitable for the environment of the bridge site.

(3) Erection.

The cable erection process should be the most suitable for the balanced tied-arch bridge to be constructed without interference to the navigation pass. The method is almost same as described in Type B.

After completion of the erection of the central span, the 2-panel cantilever arms outward the intermediate supposts will be built up in a cantilever method, and the suspended truss span will be assembled in a simple cable or staging erection.

(4) Estimated Steel Weight.

| | | |
|---|---|---|
| Balanced Tied-arch Bridge (977') | 1 | 1,643 t. |
| Simple Composite Girder Bridge (162') | 1 | 242 |
| | Total: | 1,885 t. |

3-3 Comparison of Type A, B, C.

The detail of steel weight, and the quantity of materials necessary for the floor slab and pavement is as shown in the Table 6.

The three plans are studied from the viewpoints of:-

(1) The cost of steel material and its manufacture.

(2) The cost of transportation and construction.

(3) The suitability for the environment.

(4) Apperance.

And, the study results are marked as A, B, C, as shown in the Table 7.

As the conclusion from the standpoint of the total construction cost, (1) and (2), Type A should be recommended. On the other hand, from the suitability for environment and good-looking appearance, Type C is recommendable as the best of all.

TABLE 6.

| ITEM | TYPE A | | TYPE B |
|---|---|---|---|
| | 3 span continuous truss bridge (232' + 348' + 232') | Simple composite box girder bridge (162') | Plate girder bridge with stiffening arch (406') |
| Main structure or main girder | 982 t (738t) | | 614 t (482 t) |
| Floor system | 472 (148) | | 317 (103) |
| Lateral | 73 | | 32 |
| Box girder | | 217 (167) | |
| Foot & others | 65 | 25 | 67 |
| Sub-total | 1,592 (886) | 242 (167) | 1,030 (585) |
| Total | 1,834 t. (1,053 t.) | | |

| | |
|---|---|
| Floor slab concrete volume | 47,685 cft. |
| Floor slab Reinforcing Bar Weight | 216 t. |
| Asphalt pavement Area (volume) | Sidewalk 77,939 sq.ft.<br>Driveway 128,078 sq.ft.<br>(9,796 sq.ft.) |

Note: T for Long Ton
In parentheses, the weight of high-tensile steel used among the total.

re.: STEEL WEIGHT AND QUANTITY OF FLOOR SLAB CONCRETE, REINFORCING BAR & PAVEMENT OF TYPE A, B, C.

| TYPE B | | TYPE C | |
|---|---|---|---|
| Simple composite box girder bridge (200' x 2) | Simple composite box girder bridge (162') | Balanced Tied-Arch bridge (203' + 406' + 203") | Simple composite box girder bridge (162') |
| | | 992 t. (797 t.) | |
| | | 551 (226) | |
| | | 75 | |
| 588 (394) | 217 (167) | | 217 (167) |
| | 25 | 66 | 25 |
| 588 (394) | 242 (167) | 1,643 (1,023) | 242 (167) |
| 1,860 t. (1,146 t.) | | 1,885 t. (1,190 t.) | |
| | | | |
| 42,897 cft. | | 47,360 t. | |
| 197 t. | | 256 t. | |
| Sidewalk 76,325 sq.ft.<br>Driveway 128,971 " (8,211 sq.ft.) | | Sidewalk 78,154 sq.ft.<br>Driveway 128,078 " (9,938 sq.ft.) | |

TABLE 7: Comparison of Design Drafts for Superstructure of Bridge across Main River Flow

| ITEM | TYPE A | TYPE B | TYPE C |
|---|---|---|---|
| (1) Cost of Steel Materials & Manufacture | A | B | C |
| (2) Cost of Transportation & Construction | A | C | B |
| (3) Suitability for environment of bridge site | A | B | A |
| (4) Appearance | B | B | A |

Note: A... 1st rating

B... 2nd rating

C... 3rd rating

3-4 Preliminary Design of Approach Span.

The approach span will be made for the length except for the main span that covers 977' of the water channel width of the Burhiganga River in the dry season. In consideration of the conditions of location, safety, economical construction, prompt execution, and beautiful appearance, the simple-span prestressed concrete girder of span length 98' (girder length 100') is decided to be constructed.

The reasons why the prestressed concrete girder is preferred to the reinforced concrete girder are given as follows:-

(a) The larger span length could be obtainable.

(b) Compared to the R.C. structure, the less number of the expansion joint will be needed which causes the vibration to the automobile running.

(c) Should the superstructure be made the P.C. girder, the superstructure and substructure could be set to manufacture separately at the same time, and the erection could be so easy and the construction prompt.

(d) Compared to the R.C. girder, the P.C. girder will need the less number of bridgepier, being most economical.

(e) The dead weight of the P.C. girder will be smaller than that of the R.C. one, so the bridgepier and foundation can be accordingly smaller, which is most economical from the viewpoint of the cost.

(1) Major Dimensions:

Span: 98' - 0" (Girder length: 100' - 0")

Number of Span: 19 (12 spans on Dacca side; 7 spans on South Dacca side)

Number of stringer in one span: 12 ( 8 on the driveway; 4 on the sidewalk)

Size of girder: Height 5' - 7"

Width 4' - 7½"

Center-to-center distance of girder: 6' - 0"

Weight per span: 64 t.

Pavement; same as 3-1-2

Surface slope: same as 3-1-3 and 3-1-4.

(2) Outline of structure.

The preliminary design of the structure are drawn in accordance with the P.C. T-type simple span form of the JIS standard, and made the girder length of 100' - 0" (span length: 98' - 0"). In the post-tensioning, the erection will be conducted from both abutments by cable suspension.

The material necessary for the span:-

Concrete: (462.8 $m^3$) 16,331 cft.

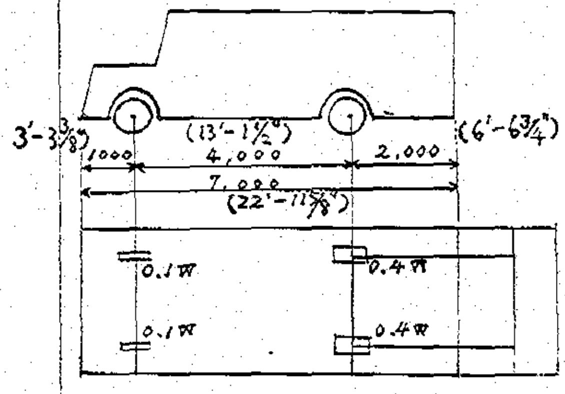
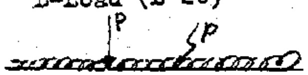
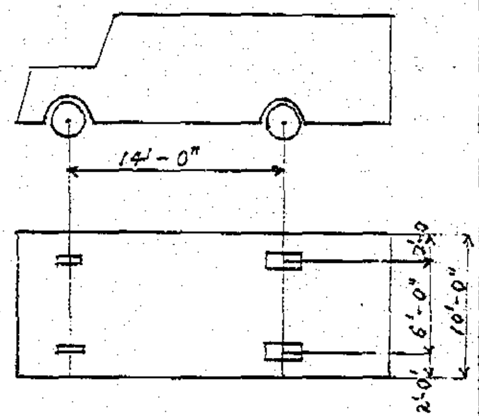
Steel Wire: (16.3 t) 16.1 long ton

Reinforcing Bar: (12.4 t) 12.2 long ton

Mould: (1,340.4 $m^2$) 13,672 sq.ft.

The manufacture of girder will be carried out near the abutments on both bank, 12 girders for a span will be tied transversely.

TABLE 3. COMPARISON AMONG ROAD BRIDGE DESIGN SPECIFICATIONS OF PAKISTAN, JAPAN & U.S.A. (EXTRACT)

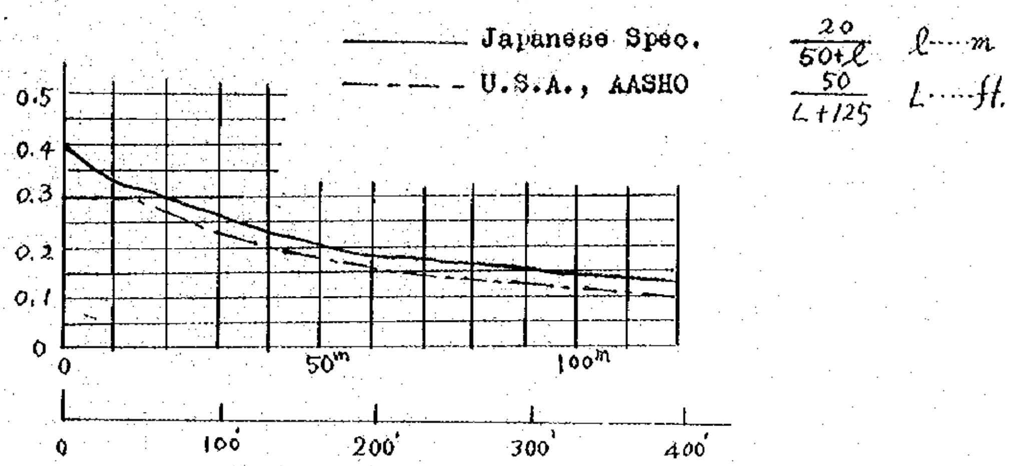
| Item | Steel Road Bridge Spec. (Japan) | AASHO (U.S.A.) | Road Bridge Spec. (Pakistan) |
|---|---|---|---|
| Driveway Load | T-Load (T-20)<br><br>1 - Front-wheel load 2,000 kg (4,400 #)<br>1 - Rear-wheel load 8,000 (17,600#)<br>L-Load (L-20)<br><br>P= 5,000 kg/m (3360 #/ft)<br>P= 350 kg/m² (71.7 #/ft) | Truck Load (H-20)<br><br>1 - Front-wheel load 4,000#<br>1 - Rear-wheel load 16,000#<br>LANE LOAD (H-20)<br> 1 lane<br>P= 18,000 # Against bending moment<br>26,000 # Against shearing force<br>P= 640 #/ft (64 #/ft²) | Same as AASHO |
| | Increase and decrease stipulated according to the width of driveway to the same degree. (Refer to the specifications for further details) | | |

| Item | Steel Road Bridge Spec. (Japan) | AASHO (U.S.A.) | Road Bridge Spec. (Pakistan) |
|---|---|---|---|
| Sidewalk Load | Floor system<br>500 $kg/m^2$ (102 $\#/ft^2$)<br>Main structure<br>350 " (71.7 " ) | Floor system 85 $\#/ft^2$<br>Main structure<br>$0' < L < 25'$ 85 $\#/ft^2$<br>$26' < L < 100'$ 60 "<br>$101' < (30 + \frac{3000}{L})(\frac{55-W}{50})$ | Same as AASHO |
| Impact co-efficient (cf. table) | $i = \frac{20}{50 + \ell}$ | $i = \frac{50}{L + 125} = 30\ \%$ | Same as AASHO |
| Temperature stress | $-10^\circ \sim +50^\circ$ (C) Extent of Temp. Change (140°F) | $+0^\circ \sim +120^\circ$ (F) (120°F) | $40^\circ \sim 110^\circ$ (F) (70°F) |
| Steel Material | (SS41) (SM41)<br>Axial tension 1,400 $kg/cm^2$ (19,912 #/□")<br>Axial compression<br>$\ell/r \leqq 110$ $1300-0.06(\ /r)^2$ $kg/cm^2$<br>$\geqq 110$ $\frac{7,200,000}{(\ell/r)^2}$ $kg/cm^2$<br>Bending tension<br>1,400 $kg/cm^2$ (19,912 #/□")<br>Bending compression<br>Fixed flange 1,300 $kg/cm^2$ (18,490 #/□")<br>$1,300-0.6(\frac{\ell}{b})^2$ $kg/cm^2$<br>Shearing 800 $kg/cm^2$ (11,378 #/□") | (ASTM-A7) (ASTM-A373)<br>Axial tension 18,000 #/□"<br>Axial compression 18,000 #/□"<br>$\ell/r$ 140 Rivet end<br>$15,000-\frac{1}{4}(\frac{L}{r})^2$ #/□"<br>Pin end<br>$15,000-1/3(\frac{L}{r})^2$<br>Bending tension 18,000 #/□"<br>Bending compression<br>Fixed flange 18,000 #/□"<br>$18,000-5(\frac{L}{b})^2$ #/□"<br>Shearing 11,000 #/□" | No spec. |

| Item | Steel Road Bridge Spec. (Japan) | AASHO (U.S.A.) | Road Bridge Spec. (Pakistan) |
|---|---|---|---|
| | (SM50)<br>Axial tension<br>1,900 kg/cm$^2$ (27,024 #/□")<br><br>Axial compression<br>$\ell/r \leq 90$ 1,800-0.11$(\ell/r)^2$ kg/cm$^2$<br>$\frac{\ell}{r} > 90$ 7,200,000 x $(r/\ell)^2$ kg/cm$^2$<br>Bending tension<br>1,900 kg/cm$^2$(27,024 #/□")<br><br>Bending compression<br>Fixed flange 1800 kg/cm$^2$ (25,600 #/□")<br>1,800-1.1$(\frac{\ell}{b})^2$ kg/cm$^2$<br><br>Shearing<br>1,100 kg/cm$^2$(15,645 #/□") | (ASTM A-242) High-tensile low-alloy structural steel<br><br>Axial tension<br>thickness $\frac{3}{4}$" or less 27,000#/□"<br>" $\frac{3}{4}$" - $1\frac{1}{2}$" 24,000<br>" $1\frac{1}{2}$" - 4" 22,000<br>Axial compression<br>thickness $\frac{3}{4}$" or less 27,000<br>" $\frac{3}{4}$" - $1\frac{1}{2}$" 24,000<br>" $1\frac{1}{2}$" - 4" 22,000<br>$\ell/r < 125$<br>Rivet end<br>thickness $\frac{1}{4}$" or less 22,000-0.56 $(L/r)^2$#/□"<br>" $\frac{3}{4}$" - $1\frac{1}{2}$" 20,000-0.46 (")<br>" $1\frac{1}{2}$" - 4" 18,000-0.89 (")<br>Pin end<br>thickness $\frac{3}{4}$" or less 22,000-0.73 (")<br>" $\frac{3}{4}$" - $1\frac{1}{2}$" 20,000-0.61 (")<br>" $1\frac{1}{2}$" - 4" 18,000-0.48 (")<br>Shearing<br>thickness $\frac{3}{4}$" or less 15,000 #/□"<br>" $\frac{3}{4}$" - $1\frac{1}{2}$" 14,000<br>" $1\frac{1}{2}$" - 4" 12,000<br>(ASTM A-94) silicon steel<br>Axial tension 24,000#/□"<br>Axial compression<br>Rivet end 20,000-0.46$(\frac{L}{r})^2$ #/□"<br>Pin end 20,000-0.61 (")<br>Bending tension 24,000<br>Bending compression<br>Fixed flange 24,000 24,000-6.67$(L/b)^2$#/□" | No spec.<br><br>Shearing 14,000 |

| Item | Steel Road Bridge Spec. (Japan) | AASHO (U.S.A.) | Road Bridge Spec. (Pakistan) |
|---|---|---|---|
| | | (ASTM A-8) Nickel steel<br>Axial tension 30,000 #/□"<br>Axial compression<br>Rivet end $24{,}000-0.66(\frac{L}{r})^2$<br>Pin end 24,000-0.86(")<br>Bending tension 30,000<br>Bending compression<br>Fixed flange 30,000<br>$30{,}000-8.33(L/b)^2$ #/□"<br>Shearing 17,500 #/□" | |
| | Reinforced Concrete Road Bridge Spec. (Japan) | AASHO (U.S.A.) | Road Bridge Spec. (Pakistan) |
| Earthquake Load | Horizontal load<br>Dead load x 10%<br>Vertical load<br>Dead load x 20% | Horizontal load<br>Dead load x 5 %<br>Vertical load<br>Not considered | Horizontal load<br>Live & Dead load x 5 %<br>Vertical load<br>Not considered |

Comparison of Impact Coefficient



3-6 Design Conditions of P.C. Girder.

1, Kind: Prestressed Concrete Road Bridge

2, Type: Post-tensioning T-type simple girder

3, Live Load: TL - 20

4, Impact coefficient: $i = \frac{20}{50 + 1}$

5, Bridge length: 100' - 2"

6, Girder length: 100' - 0"

7, Span: 98' - 0"

Material Strength per Unit Area.

Concret: $\sigma_{28} = 400\ kg/cm^2$

P.C. Steel Wire $\phi 7$ $\sigma_{pu} = 160\ kg/mm^2$

## 4, PRELIMINARY DESIGN OF SUBSTRUCTURE AND FOUNDATION

### 4-1 Selection of Foundation Type.

#### 4-1-1 Soil and Foundation Type.

According to the survey report on soil, the geological feature of the subsurface is alluvial on South Dacca side and diluvial on Dacca side. The soil consists of sandy silt, silty and, fine sand and medium sand, and there is almost nothing of gravel. Within the reach of the foundation depth, no rocky layer is found, either. The diluvium should, therefore, be taken up for the bearing stratum of the proposed bridge foundation.

On Dacca side, standard penetration test index N is shown 25 at 82' under the river-bed, and on South Dacca side, approximately N-25 at 100' under the river-bed. Consequently, a rather deep layer should be made the bearing stratum.

Therefore, to shorten the construction period and to reduce the construction cost, the steel pipe pile foundation should be built covering the range of the approach span, (except for the Dacca riverside where the R.C. pile foundation is used.) For the range of the main span, where the scouring by the flow may take place, the concrete caisson should be used.

Under the foundation bearing stratum, there is not any formation of possible secondary consolidation.

#### 4-1-2 Calculation Formula for Pile Foundation.

The calculation formula for pile bearing would be in accordance with the theory of which subject should be a deep foundation built in a sand layer.

Mr. G.G. Meyerhof's formula re used:-

$Ru = q_c A_c + 1/200 \bar{q}_c A_s + q_u/2 \cdot A_c$

or $Ru = 40NA_p + 1/5\ \bar{N}_s A_s + Nc/2 \cdot A_c$

In the formula:

$Ru$ = Ulitimate bearing capacity of pile

$A_p$ = Area of pile end

$q_c$ = Cone bearing capacity of pile end in foundation

$\bar{q}_c$ = Cone bearing capacity of pile end in sandy layer.

$A_s = U \times l_s$

$l_s$ = Pile length in saydy layer

$U$ = Circumference of pile

$q_u$ = Axial conpression strength of clayey layer for pile end

$N$ = N index of pile end foundation

$N_s$ = Mean N index of sandy layer for pile end

$N_c$ = Mean N index of clayey layer for pile end

$A_c = U \times l_c$

$l_c$ = Pile length in clayey layer

G.G. Meyerhof:

"Penetration test and bearing capacity of cohesionless soils"

Proc. American Society of Civil Engineers, Vol. 182, 1956 Paper No. 866.

4-1-3 Pnuematic Reinforced Concrete Caisson.

The type of pneumatic reinforced concrete caisson is recommended. In this case, the friction arisen between the caisson with the surrouding sand will be negligible in the stability calculation of the vertical force. The design is, therefore, made out that the support will stand only with the bearing capacity of the foundation at the bottom end. It is because the cohesion is neglected, for the bottom of caisson is in rather compact medium sand with fine sand on it.

The scouring volume is estimated to be 33' as indicated in the chapter 1, 5- (2) of this Report. The estimated volume includes an adequate safety factor expected in the design.

Against the horizontal force, it is designed to stand enough with the passive earth pressure of the foundation at the location.

The formula used for the stability calculation are in accordance with the theory of Messrs. Ikehara and Yokoyama which was made public in the December issue of 1963 of Journal of the Japan Society of Civil Engineers.

4-2 Selection for Configuration of Abutment and Bridgepier.

4-2-1 Abutment.

As the height is comparatively low, the semi-gravity type would be adapted.

4-2-2 Bridgepier

Among the types that may be suitable are:-

a, Trestle bent

b, Rahmen (rigid-frame) pier

c, Post pier

d, Wall pier

e, Rocker pier

f, Pile bent

In the case of this bridge, taken into account the influence of the river flow, good apperance and stability, and dead weight to be decreased as much as possible, the Rahmen pier would be used, which consists of the horizontal protruding part and 2 round-sectional post with small flow resistance.

Furthermore, to decrease the dead weight, the pier is made hollow in the section, with an adequate safety factor anticipated.

The post pier will be good enough from the aesthetic, economical and constructional points of view. However, owing to the P.C. girder made for the approach span, there must be cross-beams to protrude outwardly from the post under the sidewalk at the bearing part. Since the main span will be made with two shoes, the same Rahmen pier as the approach spans shall be adapted to bring about a good balance with the side spans. The bilateral protruding parts, however, are omitted.

Regarding the trestle, wall and pile bents, there are some drawbacks in their appearances.

4-3 Outline of Preliminary Design of Abutment and Bridgepier.

The design specification was in conformity with "East Pakistan Bridge Code." Compared to the "Standard Specification for Highway Bridge of A.A.S.H.O.", the Code stipulates the same for the bridge substructure and foundation, except for the earthquake load only. The design calculation was carried out only for the longitudinal load ( the bridge axial load ). The lateral load, which has little effect, will be calculated in detail, and omitted in this preliminary design.

The design of abutment, bridgepier and foundation shall be made common to the three draft plans of the main span, Type A, B and C, and the calculation in all meteric unit.

i) The stiffening reinforcing bar shall be put in the bearing and around the anchor bolts.

ii) The concrete coat shall be 6 inches thick at least from the shoe anchor bolts to the external surface of bridgepier.

iii) In case of the earthquake and change in temperature, the horizontal force on the foot shall be transferred to work upon the hinge of shoe.

iv) The sectional shape of bridgepier in the approach spans shall be decided upon the pier at the most dangerous location, making the remaining part to have the same sectional area and adjusted by the volume of reinforcing bar. It is desirable to keep the same size of the section for all the piers to produce a good appearance.

v) Owing that the piers under the main span are 2-post round hollow Rahmen bents, there may be some possibility that the scouring volume increases compared to the one-post round bent type. Therefore, the scouring volume was calculated based upon the model test result on scour by Mr. Laursen, and made to be 33' from the present river-bed level with an adequate safety factor added.

## 4-4 Conditions of Design.

1, Allowable Stress

| | | | |
|---|---|---|---|
| Concrete $\sigma_{28}$ | = 180 | kg/cm$^2$ | (or 2,560 p.s.i.) |
| Compressive stress | = 60 | " | (or 853 " ) |
| Bearing stress | = 60 | " | (or 853 " ) |
| Shearing stress | = 5 | " | (or 71 " ) |
| Bond stress | = 13 | " | (or 180 " ) |

Reinforcing Bar (SSD49)

Tensile stress = 1,600 kg/cm$^2$ (or 22,750 p.s.i.)

2, Formula for Earth Pressure.

Made in accordance with the Raukine's Formula.

3, Seismic Coefficient.

Vertical seismic coefficient Kv = 0.00

Horizontal seismic coefficient Kh = 0.05

4, Weight of Materials per unit volume.

| | | |
|---|---|---|
| Concrete | 2.3 t/m$^3$ | (or 140 lbs/cft) |
| Reinforced Concrete | 2.5 " | ( 150 " ) |
| Soil | 1.8 " | ( 110 " ) |
| Gravel | 1.8 " | ( 110 " ) |
| Sand | 1.4 " | ( 90 " ) |

5, Increased Rate of Allowable Stress.

In case the influence of the change in temperature is considered, the specified allowable stresses will be increased 15% additionally; and 50% in case the influence of earthquake is taken into account. Even in case of the influences of both temperature change and earthquake is taken into account at the same time, the increased rate should remain 50% but never exceed the rate.

6, Change in Temperature.

Change in temperature: $\pm 15^{\circ}C$.

Drying shrinkage: $- 15^{\circ}C$.

The calculation of basic stress and stability for the following structure only will be chown in the Part II, Appendix.

Main span.

(1) Fixed Pier $P_9$ (including caisson)

(2) Movable Pier $P_8$ (including caisson)

Approach span.

| | | | |
|---|---|---|---|
| (1) | Pier | $P_7$ | (including steel pipe foundation) |
| (2) | " | $P_{11}$ | ( " ) |
| (3) | Pier for P.C. girders | | ( " ) |
| (4) | Abutment $A_1$ | | ( " ) |

5. <u>ESTIMATION OF CONSTRUCTION COST</u>

The main conditions for estimation of the necessary construction cost are given as follows:-

1) The execution shall be carried out by the joint-venture incorporated between a foreign and domestic contractors.

2) To proceed with the execution work, the foreign contractor shall be in charge of the technical leading works; the domestic contractor in the administration of labour.
However, for the steel structure work, the experienced skillful labour must be demanded, so the total necessary members shall be brought from abroad by the foreign contractor.

3) In this case of cost estimation, the foreign contractor is presumed to be a Japanese contractor.

4) The estimate amounts in both foreign and domestic currencies are converted into the U.S. Dollar.

The contents of the itemized estimate are shown as follows:-

Material Cost:

(To be paid in foreign currency)
Steel material, mould, staging, blower equipments, rope, hose, etc.
(To be paid in domestic currency)
R.C. pile, material for concrete, electric power, oil fuel and grease, electric appliances, material for temporary buildings, etc.

Labour Cost:

(To be paid in foreign currency)

Mechanic operators, Instructor workmen.

(To be paid in domestic currency)

Job men $1.00 per day

Equipment Cost:

(To be paid in foreign currency)

Depreciation of construction equipments (including the charges for overhaul)

(To be paid in domestic currency)

Charterage of ships.

Transportation Cost.

(To be paid in foreign currency)

From Yokohama to Chittagon

(To be paid in domestic currency)

From Chittagon to Dacca

Freight Rate from Yokohama to Chittagon:

| | |
|---|---|
| Construction Equipments | @$50 per ton. |
| Materials | @$40 " |

Freight Rate from Chittagon to Dacca:

Both construction equipments and materials @$15 per ton (including packing charges)

Tax: Import duty (in domestic currency): 10% on CIF cost of equipments and materials

Income Tax (in domestic currency): 3% on Labour cost in the amount of foreign currency)

Corporation Tax (in domestic c urrency): 1.2% on total construction cost exclusive of taxes and other expenditures.

Other expenditures:

Foreign Currency: About 10% on the total construction cost exclusive of taxes.

Domestic Currency: About 10% on the total expenditures payable in domestic currency, to be allocated for the fee for the domestic contractor.

5) The travelling expenses of the foreign contractor employees shall cover the trip from Tokyo to Dacca. A round-trip is estimated to set at $700.- (¥250,000.-), and the expenses for two round-trip shall be covered.

6) The necessary construction period shall be 12 months for the execution design, bidding and preparations for construction; 23 months for transportation and execution work, making the total period of 35 months.

7) The steel sheet-pile and metal form staging shall be depreciated for the full amount during the construction period.

8) The P.C. girder party shall be made a joint venture, upon study on the patent law applicable in East Pakistan. The girder production yards shall be prepared on both banks of the river.

9) The estimation shall be made on the assumption that the transportation of equipment and materials and the electricity source will be available on the South Dacca side, and that the batcher plant will be movable.

10) All the construction equipments which the foreign contractor brought in East Pakistan, shall be brought back home to Japan. However, when

DETAILS OF CONSTRUCTION COST (For Type A)

In U.S. Dollars

| Item | Kind | Q'ty | Foreign Currency | Local Currency | Total |
|---|---|---|---|---|---|
| Management Fee for Local Contractor | | | ---- | 101,000 | 101,000 |
| Equipments | | | 436,000 | 47,000 | 483,000 |
| | Machinery | 1 set | 376,000 | 1,400 | 377,400 |
| | Housing | " | ---- | 7,500 | 7,500 |
| | Electricity | " | ---- | 8,800 | 8,800 |
| | Water | " | ---- | 1,000 | 1,000 |
| | Others | " | 60,000 | 28,300 | 88,300 |
| Materials | | | 1,047,000 | 585,000 | 1,632,000 |
| | Steel | 2,337 t | 387,000 | 100 | 387,100 |
| | Reinforcing Bar | 1,066 t | 260,000 | 800 | 260,800 |
| | Foundation Pile | 1,792 t* | 293,000 | 121,500 | 414,500 |
| | Sheet Pile | 986 t | 78,000 | ---- | 78,000 |
| | Cement | 6,054 t | ---- | 207,300 | 207,300 |
| | Sand | 8,860 $m^3$ | ---- | 22,000 | 22,000 |
| | Gravel | 17,460 $m^3$ | ---- | 170,000 | 170,000 |
| | Timber | 270 $m^3$ | ---- | 6,500 | 6,500 |
| | Others | 1 set | 29,000 | 56,800 | 85,800 |
| Labour Cost | | | 987,000 | 235,000 | 1,222,000 |
| Power | | | ---- | 33,000 | 33,000 |
| | Electric Power | | ---- | 22,000 | 22,000 |
| | Fuel | | ---- | 11,000 | 11,000 |
| Transportation | | | 537,000 | 122,000 | 659,000 |
| Tax | | | ---- | 300,000 | 300,000 |
| | Import Duties | | ---- | 217,000 | 217,000 |
| | Income Tax | | ---- | 30,000 | 30,000 |
| | Corporation Tax | | ---- | 53,000 | 53,000 |
| Miscellaneous Expenses | | | 511,000 | ---- | 511,000 |
| Total: | | | 3,518,000 | 1,423,000 | 4,941,000 |

Construction Cost for Type B: US$5,400,000

Construction Cost for Type C: US$5,040,000

* For Steel Pipe Piles

brought in East Pakistan, it is estimated that the import duty will be paid for the legal amount.

Based on the abovementioned conditions, the estimation of the approximate construction cost is made out, as shown in the following table, for the case of Type A superstructure to be at US$4,941,000.-; Type B to be at US$5,400,000.-; and Type C to be at US$5,040,000.-.

## 6. SPECIFICATION FOR CONSTRUCTION

### 6-1, Outline.

At the stage of the preliminary design, the specification for construction was worked at to describe the construction cost estimation, the extent necessary for construction work plan and the outline of construction, which, however, is omitted from the Report.

At the stage of the execution design to be drawn up, a further detailed specification will be made out so that the contents of specification may be clarified.

The specification will be dependent upon the decision of the superstructure to be selected among Type A, B and C, when the detailed design will be carried out.

## 7. CONSTRUCTION PLAN

### 7-1 Conditions for Making Progress Schedule.

#### 7-1-1 Bidding for Detailed Design, Preparations for Construction. (12 months)

The detailed final design will be drawn up; the construction specification made out; the execution budget made out; and all the necessary technical drawing and papers for bidding for construction will be prepared.

7-1-2 Period for Construction Work (23 months)

(1) In the rainy season of June, July and August, the work shall not be suspended, and carried out in two successive dry seasons. (Actual working period of 21 months, and total period of 23 months including the preparations, transportation and suspension work in the flood.)

(2) In the first year, the equipment and materials shall be despatched in the rainy season and in September, when broken out from the rainy season, the immediate work shall be set to start. All the works shall be completed before the rainy season of the 3rd year.

7-1-3 Coffering Work of Foundation.

(1) The coffering work will be carried out at 4 places of bridgepier $P_8$, $P_9$, $P_{10}$ and $P_{11}$. The steel sheet pile of Y.S.D. III type will be used.

(2) At the bridgepiers $P_8$, $P_9$, $P_{10}$, the pile-driving will be carried out by the diesel pile hammer D-22 from board a boat; at the pier $P_{11}$ the driving by the vibro-pile driver D.V.T. -50 from the shore.

(3) The pull-out will generally be carried out by the D.V.T. -50; and that at the pier $P_{11}$ by the winch.

(4) The working rate for both driving and pull-out shall be 4 sheets a day on an average.

(5) The cofferdams at $P_9$ and $P_{10}$ shall not be pulled out, but reconstructed as the fender for protection of the bridgepier at the end of the work.

7-1-4 Steel Pipe Pile and R.C. Pile Driving.

(1) One set of diesel pile hammer only will be used for the steel pipe pile and R.C. pile driving, and one party will be in charge of the successive work.

(2) The one working party consists of:

| | |
|---|---|
| Foreign driver | 1 |
| Foreign scaffolding man | 2 |
| Domestic " | 3 |
| " Labourer | 5 |

(3) A day's working rate is scheduled to be 3 piles. One day will be needed for moving location-to-location, and 5 days for moving to the opposite bank.

The availability of the coarse aggregate for concrete work and of the aggregate for asphalt pavement and the filler:- These materials would hardly be available in East Pakistan, so an early preparation and inspection on material quality should be made well before in time for the construction start.

7-1-5 Caisson Work.

(1) At the pier $P_8$ and $P_9$ the execution work should be carried out at the same time for the total 4 caisons, 2 each for a pier.

(2) The equipments and materials shall be transported by boat from the riverside to the site.

(3) The blower equipment consists of 2 sets of 100 HP low-pressure compressor. 4 stem-pipes shall be fitted from the main pipe. The hospital lock of one set is to be used.

(4) The excavation shall be done in use of a 5 ton derrick crane. 2 stages of derricks scaffolding shall be set between the piers $P_8$ and $P_9$, and one set of derrick shall be provided for 2 caissons.

(5) One working block is made to be 4 m deep, and the average settling volume per day shall be 50 cm.

(6) The metal-form mould shall be used, and the timbering shall be light-weight steel. 4 sets of circle type mould of 6 m diameter and 4.5 m height shall be prepared.

(7) For one caisson, 5 foreign workmen will engage in work, the excavation shall be carried out by the domestic workmen.

7-1-6 Works of Abutment and Pier.

(1) The excavation in the high water channel shall be successively carried out by a back hoe.

(2) Execution of concrete works: two parties are allocated and each party shall be in charge of 12

(3) One party consists of one each of foreign reinforcing workman, scaffold man and carpenter, totaling 3 persons, and 10 domestic labourers, making the grand total 13 persons.

(4) The mould is metal-formed; and the staging is in the pipe type; two sets each of them should be prepared.

(5) The concrete depositing shall be conducted in use of the concrete pump.

7-2 P.C. Girder Work.

(1) The post-tensioning method is to be decided, dependent upon the conditions of the site.

(2) The built-up shall be carried out near the site, and the erection work shall be carried out from both abutments.

(3) The P.C. girder shall be executed by 2 parties; one for the girder producing and erection; the other for the cross-beam work.

7-3 Steel Superstructure.

After completion of abutments and bridgepiers, the materials will be transported by ropeway from the bank to the construction site.

In case of Type A, the erection method is stated in 3-2-1-3.

In case of Type B, the erection method is stated in 3-2-2-3.

" Type C, " 3-2-3-3.

In case of Simple Box Girder, " 3-2-1-2.

7-4 Temporary Work (Site Temporary Work).

7-4-1 Batcher Plant.

2 units, Hand-controlling, mixer 21 with cutting and mixing, and gauge.

2 units, Dozer Shovel for transportation of aggregate.

7-4-2 Ropeway.

2 simple ropeways (3-ton capacity) will be extended for the total distance of 350 m from the Pier $P_7$ to $P_{11}$.

Tower: 50 m high (sag about 35 m)

Winch: 40 HP

Main Cable: 32 m/m, Running Cable 14 m/m

Hoisting Cable 16 m/m

Interval of Brief Ropeway: 14 m

The anchor block on Dacca side is the Pier $P_7$ to be used.

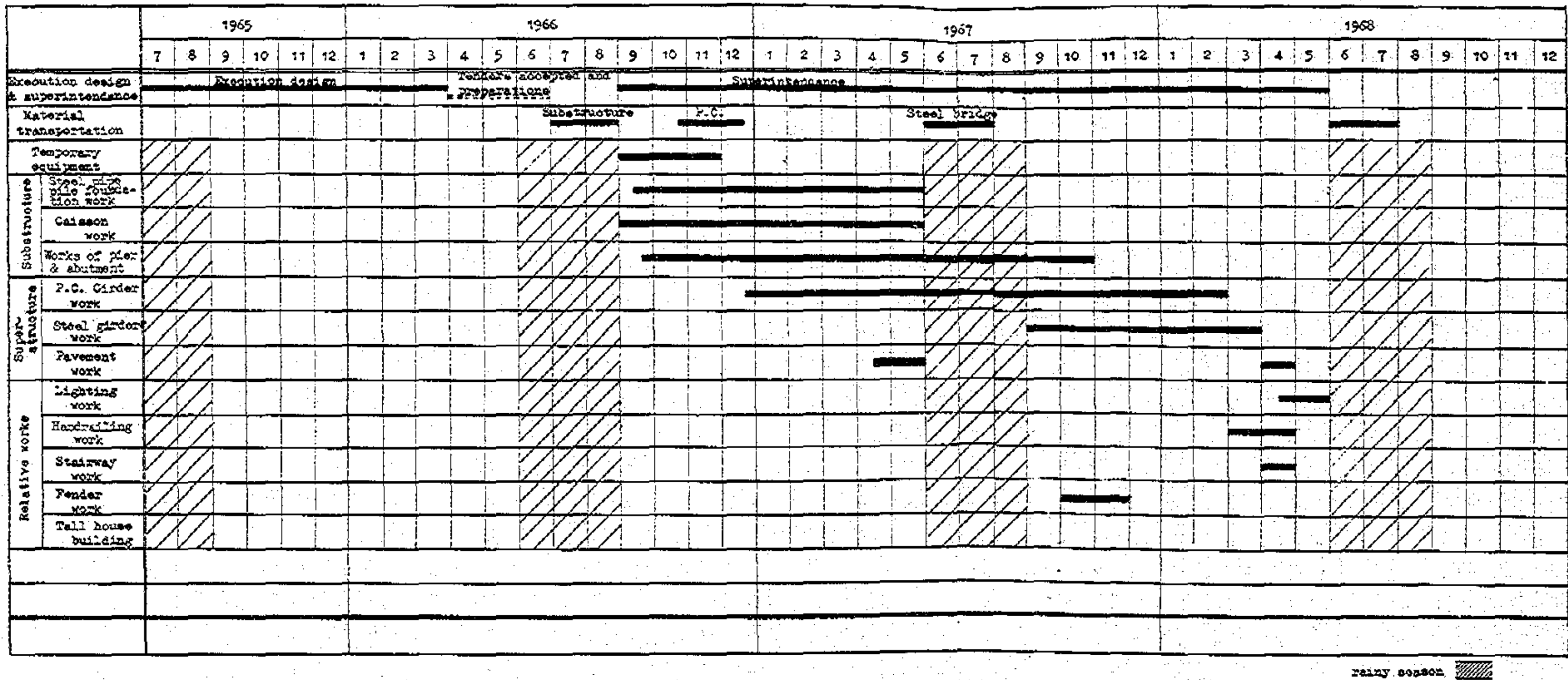
7-4-3 Electricity and Water Supply.

A day's consumption: 360 KWH

7-4-4 Lodge and Warehouse Building.

30 staff members and 70 foreign workmen to be housed.

CONSTRUCTION SCHEDULE



7-4-5 Construction Office. --90 $m^2$

Laison Car 1

6-ton Dump Truck 2

## 8. STUDY ON ECONOMICAL FEASIBILITY

### 8-1 Estimation of Total Project Cost.

In making the fund plan, not only the estimate of construction cost but all the necessary expenses involved in the project shall be taken into deliberation beforehand.

#### 8-1-1 Estimate for Construction Cost.

Bridge construction, including the construction cost for tollhouse.. . . . . . . . . . . . . . . . . . . Total: $4,941,000.-

The total amount excludes the cost for the relative construction works which should be carried out at the same time as the bridge building.

#### 8-1-2 Fee for Detailed Design.

The Report is just the preliminary design, and the execution of the construction works should additionally demand the all-out detailed design, the squaring of work costs and charges, the construction specification, and the various papers and drawings necessary for bidding, all of which must be drawn up by a consultant.

The fee amount is estimated 3.5% on the construction cost, making the sum of $173,000.-, which covers the expenses for the consultation on the execution design problems with the East Pakistani authorities concerned.

8-1-3 Expenses for Construction Superintendent and Testing Works.

The expenses will be appropriated for the superintendent and testing works of the consultant to be conducted at the request of the Government of East Pakistan. The fees should be in fact on the squaring system (for the actual cost plus some amount), but the approximate amount is estimated 4.0% on the construction cost, making the sum of $198,000.-.

8-1-4 Insurance Premium During Construction Work.

The premium for casualty insurance against the objectives of work during the construction period is estimated about 1.0% of the construction cost, making $50,000.-.

8-1-5 Net Interest during Construction Period.

The difference between the payable interest for the loan and the interest income from the deposit of the loan would be estimated 2.0% annually. The difference of interests for three years is taken into account, totaling $442,000.00.

8-1-6 Reserve Fund.

The amount of $692,000.- is estimated as the reserve fund for the payable net interest and miscellaneous expenditures in the total project.

In addition to the abovementioned costs and charges, the expenses, as shown in the following articles, should be included in the total project cost. However, the conditions of the project site are not so clearly available, and it is hard to estimate the proper cost amount.

The temporary calculations, therefore, are made just on the assumption, as follows:-

8-1-7 Procurement cost for Land Required for Bridge, and Compensation for Surface Rights .................. $50,000.-

(excluded the expenses involved in the relative works)

All the necessary costs summing up the abovementioned are shown in the following table.

TABLE 10

| | | |
|---|---|---|
| Construction Cost: | $4,941,000.- (including Tax $300,000.-) | |
| Execution Design Fee: | 173,000.- | |
| Superintendent & Testing: | 198,000.- | |
| Insurance Premium: | 50,000.- | |
| Net Interest: | 442,000.- | |
| Reserve: | 692,000.- | |
| Land Procurement & Compensation: | 500,000.- | |
| Total: | 6,996,000.- | (Type A) |
| | 7,455,000.- | (Type B) |
| | 7,095,000.- | (Type C) |

8-2 Balance on Earnings and Expenses in Case of Toll Bridge.

8-2-1 Toll Rate.

Under the circumstances of the present economic standing and status in East Pakistan, there is an opinion that this sort of bridge should be made a public road bridge without tollage, and that the maintenance, repair and refundment should be made in Government pay at all as part of the public work expenditure.

On the other hand, a considerable amount of traffic is expected, and the study should be made on the case of being a toll bridge and the balance on earning and expenses, so that the bridge might be opened free from tollage after the refundment of the invested costs.

Judging from the paying capacity of those potential users of the bridge, the unit amount of tollage will be set as follows:-

(1) Rapid-Vehicle:

20 - 15 ฿/car (=0.9 - 0.675 Rs/car on the average)

(In practise, the classified rate should be applied for the kind of vehicle such as car, truck, auto-bycicle and three-wheel vehicle, etc.)

(2) Slow-Vehicle:

10 - 8 ฿/car (=0.45 - 0.36 Rs/car)

(In practise, to be classied oxcart, horse-carriage, ricksaw, bycicle)

(3) Pedestrian:

5 - 2 ฿/head (=0.023 - 0.009 Rs/head)

8-2-2 Administrative and Maintenance Charges.

Annual $40,000.- on the average would be taken in the estimate for the expenses of tollage collection, periodical inspection of bridge, paint coating and some amount of the base-up of employees' wages.

8-2-3 Interest.

In case that the construction fund might be raised either by the issurance of bonds or the finance given, the project is in nature a public investment work. The interest of the loan depends on the financing organization and the period of reimbursement. The study on the interest is hereby made on the case of the annual rate of 6%, being assumed that the bridge should be opened at the beginning of 1968. In the calculation it is also assumed that the interest be yielded on the unamortized balance amount of the end of year, and that the payment should be made at the beginning of the next year.

8-2-4 Loan and Reimbursement.

The loan should not be confined to the construction cost, but the total project cost of $6,996,000.- (in case of Type A) should be raised on loan.

The fund plan is examined on the assumption that the refundment should begin in 1970 and that in the last year of 1977 - 1980 the outstanding account should be cleared up altogether.

8-2-5 Estimate for Incomings and Outgoing, and Fund Plan.

In Table 11 - 12, as explained before, the estimation on the tollage income per sepcific year is made at the aforementioned toll rate for the expected traffic volume.

The construction scheme is presumed that the bidding should be made in April or May 1966, the transportation of equipments and materials in July, the start of construction work in September, and the completion in May 1968.

Further, the loan is presumably given at the beginning of 1966, and the reimbursement should commence in 1970 and end in 1977. The interest 6% on the loaned money before the reimbursement commences, should be added to the amount of the loan, and the distribution of the reimbursement money per year should be deliberated to make a proportion of 1.30 between the outgoings and incomings, and:

In case of the tollage of 15 ¢/car for rapid-vehicle, 8¢/car for slow-vehicle and 2¢/head for pedestrian, the total refundment should be finished in 1980, leaving the profit balance of $5,357,848.-.

In case of the toll rate of 20 ¢/car for rapid-vehicle, 10¢/car for slow-vehicle, 5 ¢/head for pedestrian, the refundment should be completed in 1977 with the saving of $2,240,130.

TABLE 11: TRAFFIC VOLUME ON BRIDGE AND EXPECTED TOLLAGE INCOME (1)

| Year | Daily Traffic Volume | | | Daily Income | | | | Yearly Income |
|---|---|---|---|---|---|---|---|---|
| | Rapid-Vehicle | Slow-Vehicle | Pedestrian | Rapid-Vehicle @15¢/car | Slow-Vehicle @8¢/car | Pedestrian @2¢/head | Total | |
| 1968 | 600 | 1,000 | 15,000 | 90 | 80 | 350 | 520 | 166,400 |
| 1969 | 1,600 | 2,560 | 38,400 | 240 | 205 | 768 | 1,213 | 388,160 |
| 1970 | 2,600 | 4,000 | 59,800 | 390 | 320 | 1,196 | 1,906 | 627,200 |
| 1971 | 3,600 | 5,330 | 79,200 | 540 | 426 | 1,584 | 2,550 | 816,000 |
| 1972 | 4,600 | 6,950 | 96,600 | 690 | 556 | 1,932 | 3,178 | 1,016,960 |
| 1973 | 5,600 | 7,600 | 112,000 | 840 | 609 | 2,240 | 3,689 | 1,180,480 |
| 1974 | 6,600 | 8,580 | 125,400 | 990 | 686 | 2,508 | 4,184 | 1,329,250 |
| 1975 | 7,600 | 9,420 | 136,800 | 1,140 | 754 | 2,735 | 4,630 | 1,481,600 |
| 1976 | 8,470 | 9,570 | 144,000 | 1,270 | 765 | 2,880 | 4,915 | 1,572,800 |
| 1977 | 9,340 | 10,460 | 149,400 | 1,401 | 837 | 2,988 | 5,226 | 1,672,320 |
| 1978 | 10,210 | 10,820 | 153,200 | 1,532 | 865 | 3,064 | 5,461 | 1,747,520 |
| 1979 | 11,080 | 11,080 | 155,100 | 1,662 | 886 | 3,102 | 5,650 | 1,808,000 |
| 1980 | 11,950 | 11,230 | 155,400 | 1,792 | 898 | 3,108 | 5,798 | 1,855,360 |
| 1981 | 12,820 | 11,290 | 153,800 | 1,923 | 903 | 3,076 | 5,902 | 1,888,640 |
| 1982 | 13,700 | 10,960 | 150,700 | 2,055 | 877 | 3,014 | 5,946 | 1,902,720 |
| 1983 | 14,570 | 10,780 | 145,700 | 2,185 | 862 | 2,914 | 5,961 | 1,907,520 |
| 1984 | 15,440 | 10,780 | 138,900 | 2,316 | 862 | 2,778 | 5,956 | 1,905,920 |
| 1985 | 16,310 | 10,760 | 130,500 | 2,447 | 861 | 2,610 | 5,918 | 1,893,760 |

Note: The yearly income based on 320 working days a year.

TABLE 12: TRAFFIC VOLUME ON BRIDGE AND EXPECTED TOLLAGE INCOME (II)

| Year | Daily Traffic Volume | | | Daily Income | | | | Yearly Income |
|---|---|---|---|---|---|---|---|---|
| | Rapid-Vehicle | Slow-Vehicle | Pedestrian | Rapid-Vehicle @20¢/car | Slow-Vehicle @10¢/car | Pedestrian @5¢/head | Total | |
| 1968 | 600 | 1,000 | 15,000 | 120 | 100 | 750 | 970 | 310,400 |
| 1969 | 1,600 | 2,560 | 38,400 | 320 | 256 | 1,920 | 2,496 | 798,720 |
| 1970 | 2,600 | 4,000 | 59,800 | 520 | 400 | 2,990 | 3,910 | 1,251,200 |
| 1971 | 3,600 | 5,330 | 79,200 | 720 | 533 | 3,960 | 5,213 | 1,668,160 |
| 1972 | 4,600 | 6,950 | 96,600 | 920 | 695 | 4,830 | 6,445 | 2,062,400 |
| 1973 | 5,600 | 7,610 | 112,000 | 1,120 | 761 | 5,600 | 7,481 | 2,393,920 |
| 1974 | 6,600 | 8,580 | 125,400 | 1,320 | 858 | 6,270 | 8,448 | 2,703,360 |
| 1975 | 7,600 | 9,420 | 136,800 | 1,520 | 942 | 6,840 | 9,302 | 2,976,640 |
| 1976 | 8,470 | 9,570 | 144,000 | 1,694 | 957 | 7,200 | 9,851 | 3,152,320 |
| 1977 | 9,340 | 10,460 | 149,400 | 1,868 | 1,046 | 7,470 | 10,384 | 3,322,880 |
| 1978 | 10,210 | 10,820 | 153,200 | 2,042 | 1,082 | 7,660 | 10,784 | 3,450,880 |
| 1979 | 11,080 | 11,080 | 155,100 | 2,216 | 1,108 | 7,755 | 11,079 | 3,545,280 |
| 1980 | 11,950 | 11,230 | 155,400 | 2,390 | 1,123 | 7,770 | 11,283 | 3,610,560 |
| 1981 | 12,820 | 11,290 | 155,800 | 2,564 | 1,129 | 7,790 | 11,483 | 3,674,560 |
| 1982 | 13,700 | 11,280 | 155,000 | 2,740 | 1,128 | 7,750 | 11,618 | 3,717,760 |
| 1983 | 14,570 | 11,200 | 151,000 | 2,914 | 1,120 | 7,550 | 11,584 | 3,706,880 |
| 1984 | 15,440 | 11,000 | 145,000 | 3,088 | 1,100 | 7,250 | 11,438 | 3,660,160 |
| 1985 | 16,310 | 10,760 | 130,500 | 3,262 | 1,076 | 6,525 | 10,863 | 3,476,160 |

Note: The yearly income based on 320 working days a year.