PRELIMINARY REPORT

ON

THE GARAI RIVER BRIDGE CONSTRUCTION PROJECT

EAST PAKISTAN

NOVEMBER 1966

OVERSEAS TECHNICAL COOPERATION AGENCY

P R E F A C E

The Government of Pakistan requested in March 1966 the Government of Japan to render necessary technical cooperation with respect to the investigations on the Gurai River Bridge Construction Project, East Pakistan. In response to this request, the Government of Japan undertook to conduct the investigations, entrusting the Overseas Technical Cooperation Agency (hereinafter referred to as OTCA) with its execution.

The OTCA thereupon organized a Survey Mission comprising 8 members headed Mr. Nobutaka Katahira, Director of Japan Highway Public Corporation, which conducted the Preliminary Investigations required for the Project during the period between the end of March and the beginning of May.

The outcome of the Preliminary Investigations has been compiled into the present Preliminary Report, which is hereby presented to the Government of Pakistan through the Government of Japan.

The present Report contains chiefly the selection of the bridge site and its alternatives and the reason for their selection, as well as the results of the topographical and river sounding surveys.

It is to be noted that the present Report will serve as the Preliminary Design Report when it has been compiled with the results of the geological survey and the preliminary design work to be conducted in the near future.

On the occasion of presenting this Preliminary Report, I wish to express my heartfelt gratitude to the Government authorities of both Pakistan and Japan as well as private organizations concerned for their kind cooperation and assistance extended to the Survey Mission.

November 1966

S. Shibusawa

SHINICHI SHIBUSAWA
Director General
Overseas Technical Cooperation Agency

I-N-D-E-X

CHAPTER I. PURPOSE OF INVESTIGATION

The investigation included in this Report is the first stage of basic field investigation out of a series of investigations (refer to the attached investigation plan) for the construction of a bridge over the Garai river in East Pakistan. The main purposes of this investigation were the selection of the bridge site and topographic survey accompanying thereto.

The investigation for the Garai river bridge project includes, in addition to the above mentioned investigation, the observation of water level of the Garai river in flood season and soil investigation at the bridge site after the rainy season. Based on the results of these investigations, basic design of the bridge is to be prepared.

On the consequence, this is the interim report in half way to the final conclusion covering the results of the investigations of the first stage.

CHAPTER II. PROCESS OF INVESTIGATION

1. Member of Investigation Team and Period

Leader:	Mr. N. Katahira, Japan Road Corporation
Member:	Mr. T. Hayanari
"	Mr. H. Chiba, Pacific Consultants, K. K.
"	Mr. N. Aishima, "
"	Mr. S. Matsuda, "
"	Mr. S. Kamayachi, "
"	Mr. K. Tanaka, "
"	Mr. M. Kuwahara, OTCA

The investigation was carried out for the period of 36 days starting from 29th March till 3rd May, 1966.

The brief descriptions of the investigation team during the period are as follows:-

March 29: The investigation team (all members) arrived at Dacca and stayed at Shahbagh Hotel.

March 30: Called on the Waterways, Transport, Road and Highway Department and conferred with the Secretary, Mr. Nusrat Hassan, Chief Engineer, Mr. Hatem Ali Khan and his staff about the Project.

March 31. Group 1 (consisting of Messrs. Katahira, Chiba, Hayanari and Matsuda) made reconnaissance of the road, bridge and ferry transport existing between Dacca and Aricha under the guidance of Mr. Ali Khan.
Group 2 (consisting of Messrs. Aishima, Kamayachi, Tanaka and Kuwabara) worked on the preparation for survey works.

April 1: Group 1 made reconnaissance of the proposed bridge site of the Garai river and stayed overnight at Faridpur Bungalow.
Group 2 worked on the preparation for survey works.

April 2: Group 1 made reconnaissance of the road between Fariapur and Barisal and stayed at Fariapur.
Group 2 worked on the preparation for survey works.

April 3: Group 1 made re-investigation of the proposed bridge site with the Chief Engineer, Mr. Ali Khan, Designing Engineeer, Mr. Samad and resident engineer of Fariapur, Mr. Hakimuddin, and then had discussion all together at Fariapur Bungalow.

April 4: Group 1 returned to Dacca.
Group 2 worked on the preparation for survey works.

April 5: Group 1 (consisting of Messrs. Katahira, Chiba and Hayanari) flew to Sylhet in order to make reconnaissance of roads.
Group 2 completed preparation works of survey.

April 6: Group 1 made investigation of roads between Sylhet to Dacca passing through Shadipur, Srimanga, Sarail, Brahmanbaria with designing engineer, Mr. Samad.
Group 2 (consisting of Messrs. Aishima, Matsuda, Kamayachi and Tanaka) moved to Fariapur by 2 jeeps taking survey instruments.

April 7: Group 1 discussed the work plan of the investigation.
Group 2 carried out detailed investigation at the two points of the proposed bridge sites:

A. Sitaranpur - Komarpur

B. Chandpur - Datiadaha

April 8: Group 1 discussed with Mr. Zaman and Mr. K. E. Choudhury on the Project in respect to economical and technical points.
Group 2 moved the base for the surveying to Kamarkhali and checked the surveying instruments.

April 9: Group 1 (consisting of Katahira, Chiba and Kuwahara) flew from Dacca to Jessore and went to the surveying base at Kamarkhari.
Group 2 carried out triangulation survey to determine the centerline of the proposed site A.

April 10: Continued surveying works and had technical discussions.

April 11: Group 1 (consisting of Messrs. Katahira and Chiba) returned to Dacca by air bus and prepared a report to the central government and the Japanese Enbassy.
Group 2 conducted the sounding of the proposed bridge site.

April 12: Group 1 greeted, and reported the general circumstances of survey work to Mr. M. Zaki Azam, deputy secretary of Economic Affairs Division, Department of Investment

Promotion of Central Government, and to Japanese Embassy.
Group 2 continued the sounding work and surveyed the flow velocity of the river.

April 13: Group 1 greeted, and reported to Mr. Ijlal Hussain, deputy secretary, Ministry of Communication.
Group 2 carried out the plane-table surveying and set up the bench-mark (B.M.) at the proposed site A.

April 14: Group 1 returned to Dacca via Lahore.
Group 2 continued surveying.
Matsuda and Kuwahara joined Group 1 at Dacca.

April 15 ~ 17 Group 1 (consisting of Messrs. Katahira, Chiba, Matsuda and Kuwahara) made a draft interim report at Dacca.
Group 2, the surveying members came back to Dacca.

April 18: Made reconnaissance of Megna Dandkandi, Narayangandi District with Messrs. Ali Khan and Zaman.

April 19: Mr. Katahira, the chief of the team, left Dacca to Japan, and the rest of members left for the proposed bridge sites, and arrived at Kamarkhari.

April 20: Continued surveying: Plane-table surveying, sounding and setting up the bench-mark at the proposed site B (upper-stream)

April 21: Continued surveying: carried out the leveling, connecting with the bench-mark at Kamarkhari.

April 22: Finished surveying work.

April 23: Collection of data and its coordination work at Kamarkhari.

April 24: Moved to Faridpur.

April 25: Made preparations to move at Faridpur.

April 26: Returned to Dacca.

April 27: Greeted to Japanese Consulate General.

April 28: Messrs. Ali Khan, Zaman and other staff joined the party of survey members, and exchanged the reports on the investigation process.

April 29: Collection of data at Dacca. Attended to the party in celebration for the Japanese Emperor's Birth Day that was held at the Japanese Consulate General.

April 30 ~ May 1: Collection of data.

May 2: Prepared for returning to Japan.

May 3: Left Dacca to Bangkok.

May 4: Contacted with ECAFE, and Mr. Takeda, chief of the resident office of OTCA at Bangkok.

May 5: Left Bangkok and arrived in Japan.

2. Method of Investigation

The investigation was generally divided into four steps to be taken in the course of investigation period.

The first step included the reconnaissance of the existing main roads, bridges and rivers in East Pakistan. Occaisional meetings were held with the governmental officials in order to have better understanding of the real circumstances. On the other hand, efforts were made to collect as much basic data as possible that are necessary for the Garai River Bridge Construction Project.

The second step was a geographical study on map to locate the

proposed site in relation to the river flow, and in connection with the approach roads and with the future possibility of making an alignment of the Asian Highway. After all, two sites were selected, being confirmed by the reconnaissance by speed boat.

The third step was to carry out the field investigation, i.e. topographical surveying at the two selected sites.

The fourth step was to made a study of the future investigation necessary for materialization of the project.

The further description for these investigations will be given in the following chapter.

CHAPTER III. FIELD INVESTIGATION

Due to the dry season, the investigation work made the full progress on schedule. Main objectives of investigation were given as follows:-

1. Factors for the Selection of the Bridge Construction Site

In selecting the site, consideration was taken for the circumstances peculiar to East Pakistan, and the following factors were taken up as requirements for the construction site.

a. General situation

The bridge construction site should be located so convenient as to connect with the existing road, and to be incorporated in the future into a new road network which would probably be planned accordingly as the economic status develops.

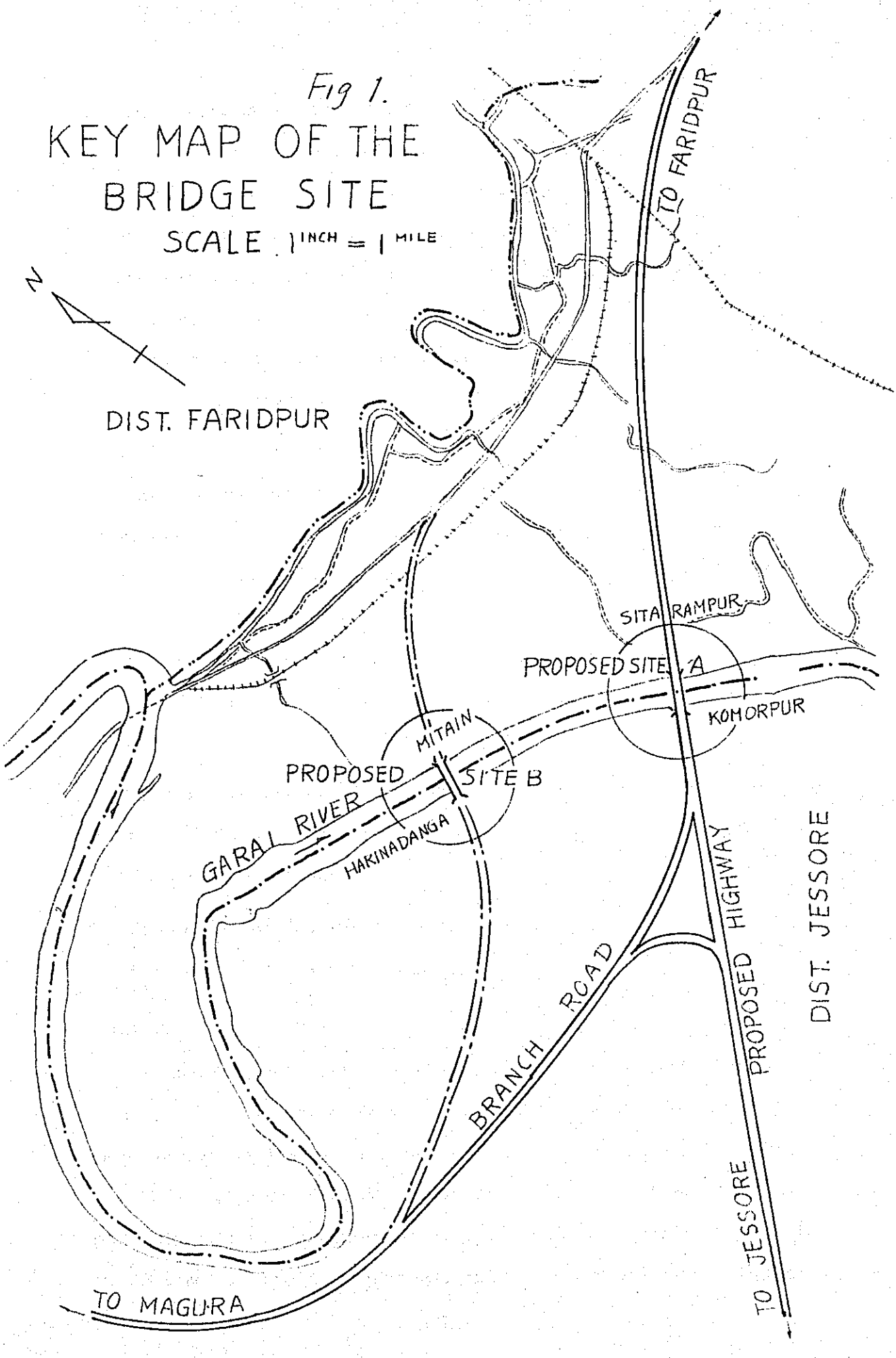
b. Study of construction site on map

A study was made on map for the construction site in the broader aspects in relation to the general situation of neighboring road network and rivers.

Fig 1.

KEY MAP OF THE BRIDGE SITE

SCALE 1 INCH = 1 MILE



c. Reconnaissance of construction site

The reconnaissance of construction site was carried out to confirm the conclusion obtained by the map study. Taking into consideration the common characteristics of the rivers in East Pakistan that the river beds and banks would have a treacherous tendency to move at times, the location of construction site was selected at the place where the least erosion against banks and most stable river bed were expected.

d. Furthermore, the site should be situated at the place where the river is less deep and narrow in width. The factor involved a contradicting nature to itself, but the narrowness of river width would shorten the bridge length; the less depth of river flow would help to facilitate the bridge construction work.

In addition, it will bring an easier maintenance of bridge. This factor should, anyway, be decided after the deliverate comparative study of various technical objectives in the survey.

e. The bridge construction site should be selected at such a configuration of place as the approach roads would costs as low as possible for the construction.

f. The geological feature of the site should be suitable for the foundation structure of bridge.

2. Selection of Bridge Site

In the past, the crossing of bridge over the Garai River should have been made in plan at Kamarkhari, terminal point of the road extended from Faridpur; which road was regarded as a part of future Asian Highway.

As anticipated beforehand, however, it was recognized after the reconnaissance that the place of Kamarkhari was situated in the middle of the bend of river for both upper and lower streams. What is worse,

the outer banks of the bend had been eroded away gradually by the past floods. Contrarily, the shoals at the inside of the bend were protruding toward the river center. The general aspect at present only suggested that the curving flow of river would grow larger, and that the tendency would apparently continue still in future. Consequently, it should be said that the place could not be stable for the bridge construction.

At Kamarkhari, the present trunk road connecting Jossore and Dacca, capital of East Pakistan, is crossing the Garai River by ferry boat service and extending through Faridpur toward the Ganges. Therefore, if Kamarkhari were selected to be the bridge site, no problem would take place as to its connecting roads. On the other hand, a careful study would reveal that the route were not the shortest cut to tie the cities: Jossore - Faridpur - Dacca, but a roundabout way Jhenida from Jessore. It might not be eligible for a route suitable as the modern highway requirment for rapid transit.

For these two reasons, it was concluded that Kamarkhari should be taken out from the proposed sites.

A new proposed site was put under discussion by the survey team members and the road authority officials of East Pakistan Government. Further, the reconnaissance for this purpose were carried out by foot or speed boat for several days in search of the suitable location, going along the downstream of Kamarkhari.

In the result, three points were found to be suitable for the sites about 8 km, 10 km and 13 km down from Kamarkhari. In view of such features that the river flow, conditions of both banks, and easy linking of approach road construction, they seemed qualified for the sites.

Afterwards it was turned out, however, that 8-km point was located so close to the bend of Kamarkhari that would be easily exposed to the erosion upon the banks by flood and the changes in the river bed and flow.

So, this point was excluded from the studying subject.

The remaining two points satisfied the required conditions; either to one could be no better than the other. These points were taken up in this survey to determine the center line of proposed bridge, to measure the water depth and flow velocity, and to carry out the topographic surveying.

The road officials of East Pakistan agreed to the choice of these two points for the bridge site. (see Fig.1)

3. Surveying Works at Proposed Bridge Construction Site

The surveying works at the proposed bridge construction sites were as follows:-

a. The selection of bridge construction site and the determination of the center line of bridge.

b. Triangulation surveying to measure the present river width, etc.

c. Topographical surveying in the neighbourhood of the proposed sites by means of plane-table and stadia surveying methods.

d. Setting up the site bench marks (the site bench marks were set to refer to B. M. No.101 of WAPDA's at Kamarkhari.)

e. Measurement of water depth along the center line of proposed bridge. (used the water-depth measuring instrument Type P-612, manufactured by Japan Supersonic Research Co.)

f. Measurement of flow velocity

The measurement was conducted by means of a bamboo buoys, of 8 cm in diameter and 80 - 100 cm in length, filled with a proper amount of sand in it. Three bamboo buoys were floated in the river about 200 m between upper and lower streams from the center line of bridge.

4. Result of Surveying

Table of Sounding

Downstream Site A

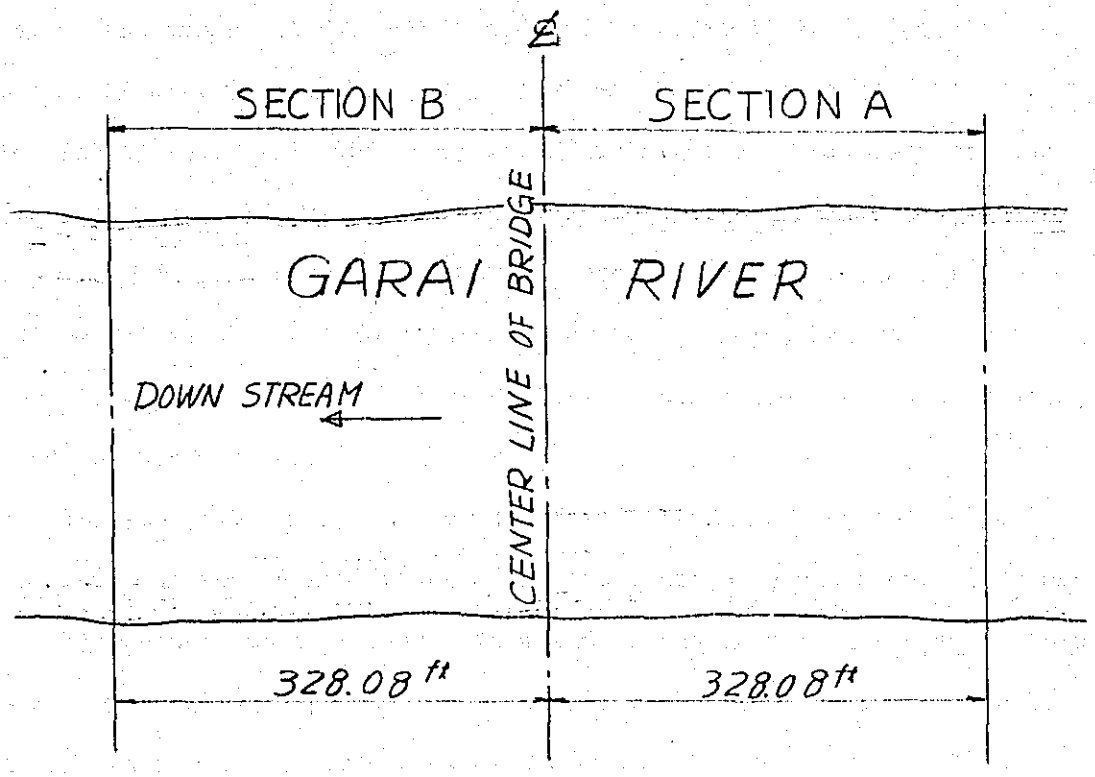
Distance	1st	2nd	3rd	Average
902.22ft				0ft
928.47	5.03	5.03	5.03	5.03
951.43	4.92	5.25	4.92	5.03
984.24	5.41	5.35	5.32	5.36
1.017.05	5.83	5.77	5.95	5.85
1.049.86	5.95	6.01	6.10	6.02
1.082.66	6.35	6.22	5.97	6.18
1.115.47	6.40	5.59	6.07	6.02
1.148.28	6.43	6.40	6.19	6.34
1.181.09	7.57	7.29	7.61	7.49
1.213.90	8.03	8.37	8.53	8.31
1.246.70	8.35	9.19	8.86	8.80
1.279.51	9.19	9.02	8.70	8.97
1.312.32	9.35	9.52	9.51	9.46
1.345.13	9.34	9.84	9.68	9.62
1.377.94	9.84	10.00	10.01	9.95
1.410.74	10.67	11.48	11.15	11.10
1.443.55	12.47	11.66	12.14	12.09
1.476.36	13.12	12.65	12.96	12.91
1.509.17	14.27	14.44	14.43	14.38
1.541.98	13.78	14.01	13.88	13.89
1.574.78	14.43	13.45	12.80	13.56
1.607.59	13.29	12.96	13.44	13.23
1.640.40	14.29	14.76	14.60	14.55
1.673.21	16.24	15.93	16.40	16.19
1.706.02	15.75	15.92	15.91	15.86
1.738.82	13.29	13.94	14.44	13.89
1.771.63	13.12	14.11	13.45	13.56
1.804.44	14.76	15.09	14.76	14.86
1.837.25	13.61	14.44	15.09	14.38
1.870.56	15.26	15.91	16.41	15.86
1.902.86	16.08	14.93	16.56	15.86
1.932.39	9.51	8.85	9.54	9.30
1.964.71				0

Upperstream Site B

Distance	1st	2nd	3rd	Average
699.79ft				0ft
721.78				2.46
754.58				4.92
787.39				7.55
803.80				9.84
836.60				6.56
853.01				6.56
885.82				6.56
918.62				9.19
951.43				9.84
984.24				9.84
1.000.64				9.84
1.033.45				6.56
1.049.86				2.62
1.088.90				0
1.172.89				0
1.181.09	0.66	0.66	0.66	0.66
1.213.90	2.62	3.28	2.95	2.95
1.246.70	3.56	3.41	3.38	3.45
1.279.51	4.92	5.25	5.10	5.09
1.312.32	4.61	5.08	5.58	5.09
1.345.13	3.94	4.26	4.10	4.10
1.377.94	4.10	3.60	4.27	3.77
1.410.74	3.96	4.59	4.74	4.43
1.443.55	4.76	4.10	4.43	4.43
1.476.36	6.40	6.06	5.75	6.07
1.509.17	7.71	7.89	7.05	7.55
1.541.98	8.69	9.02	8.36	8.69
1.574.78	9.35	8.69	9.02	9.02
1.607.59	9.02	9.67	9.36	9.35
1.640.40	9.69	9.68	10.66	10.01
1.673.21	10.50	10.33	11.15	10.66
1.706.02	11.81	12.14	11.48	11.81
1.738.82	14.93	13.61	15.26	14.60

Distance	1st	2nd	3rd	Average
1.755.23^{ft}	14.77	14.27	14.76	14.60^{ft}
1.771.63	11.15	12.80	11.48	11.81
1.804.44	10.82	11.82	10.33	10.99
1.837.25	11.15	10.17	11.17	10.83
1.870.56	11.00	11.81	11.15	11.32
1.902.86	10.88	10.82	9.80	10.50
1.935.67	7.71	8.37	8.04	8.04
1.960.27	5.74	5.09	4.41	5.08
1.976.35				0 W.L.

VELOCITY MEASUREMENT



SECTION	Frequency of Measurment & Time spent	Floating Length.	Measured Velocity
SECTION A	1. 286.6 sec. 2 296.2	328.08 ft	$V = \frac{L}{T}$ $= \frac{329.08}{291.4}$ $= 1.13$ ft/sec.
SECTION B	1 297.0 sec 2 285.8	328.08 ft	
Mean Value	$T = 291.4$ sec	$L = 328.08$ ft	

CHAPTER IV. STUDY OF APPROACH ROADS

One of the important factors to select the Garai River Bridge site, as stated precedingly, is to take up the alignment of the approach roads and of a whole highway route. In this respect, it is considered to construct new route as a main road in future connecting Jessore with Faridpur in the shortest distance. It should be further taken into consideration, if the Garai River Bridge were set to construction and completed before this main road, how the problem should be treated for the connection with the existing roads and the traffic flow.

Judging from the present situation of industiral development and of traffic growth in East Pakistan, supposing the traffic volume should increase about double as much as at present, it would be enough to relieve a possible congestion by constructing a branch road from Magra, located at the middle of existing main route of Jessore-Jhenida-Faridpur, down to the south-east to reach the bridge site, where a route is to be built to the north-east to connect with the main road of the future plan.

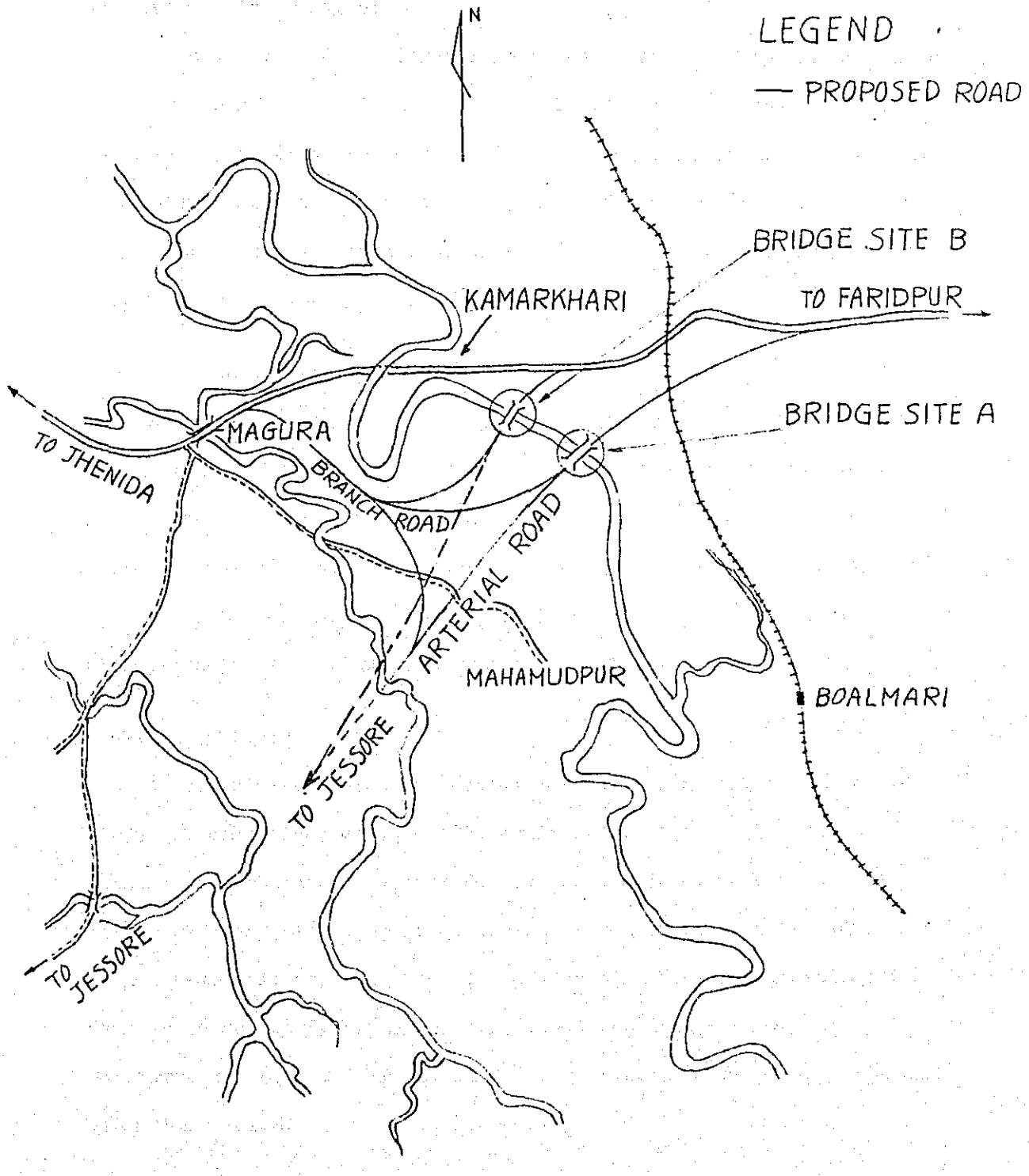
This branch road will have a contribution to development of Jhenida district after the main road is completed, and also this road would be easily extended toward Jessore, diverting from the road to bridge at a certain point in the south of Magra.

Bearing in mind the possible construction of this branch road, the reconnaissance was made all around the proposed sites, and it was found that the construction of new road would not be so difficult and that there existed roads nearby the site will be easily expanded if necessary.

The relations of these connecting road networks are illustrated in the Fig.2.

Fig 2.

KEY MAP OF PROPOSED BRIDGE SITE OF GARAI RIVER



SCALE 1 INCH = 4 MILES

CHAPTER V. FUTURE INVESTIGATION NECESSARY FOR THE DESIGN

1. Investigation in the Flood Season

Various surveys should be carried out for the high-water level of the river in the rainy season.

The monthly records of water-level at Kamarkhari were collected in the survey period, but this place is a little far from the bridge site where the Garai River would possibly show a difference in its cross and longitudinal section. Consequently, a new field survey must be undertaken for the purpose which to decide the bridge clearance, the positions of abutments and piers.

2. Foundation Survey and Soil Test

The type of bridge depends upon a combination of superstructure and substructure. Therefore, to make out a certain type, the foundation survey and soil test at the bridge site should necessarily be carried out. Boring, standard penetrating test, physical and dynamical test should be done so as to determine the suitable type of structures for the actual circumstancial conditions from the technical and economical standpoints.

3. Preliminary Design.

A preliminary design is devided into two categories; preliminary study and comparison design. The preliminary study is to decide the general requirements necessary for the future detailed design. In the latter category, the comparison design is concerned with the determination of most suitable type of bridge, based on the furnished investigation data (such as survey of high-water level, foundation survey and other measurements, etc.). The detailed design should be only made depending upon these works.

CHPTER VI. BASIC STUDY FOR DESIGN OF GARAI RIVER BRIDGE

1. General

The selection of the bridge type and its design will be done after the completion of the geological survey and further investigation. However, we wish to described some ideas on the bridge design in this country and to have the comment from the engineers of this country who have more experiences for the local situations of this country than us.

a. Approach viaduct

Most of the rivers in this country are used as the important water transportation channel, so the clearance of the bridge above the high-water level is extremely high. Consequently, the high approach is necessary. If we construct the high embankment as the approach, the scouring might be inevitable at the backside of the abutment. Besides this, most of the rivers are not yet so stable, so some erosion of the river bank is inevitable. The viaduct for some length of the approach may help to avoid such scouring and erosion problems.

b. Type of superstructure

Concerning the type of superstructure, the choice should be made, first of all, as to whether the bridge would be of a steel structure or a concrete one. For both structures there are advantageous points to their own, and the determination should depend upon the itemized comparison study of economical features, durability, difficulty in construction work, utilization of local materials, construction period, maintenance and administration, good appearance, construction cost, etc. Apart from these factors and in view of the suitability for the proposed site, the feasibility study would be worked out.

1) Steel bridge

Diagonal tension bridge

Archi bridge

Truss bridge

2) Concrete bridge

Post tension P. C. bridge

Among the above listed types of bridge, the most economical one might be chosed, reflected in relation to the substructure which should have been decided on the results from the following geological survey. It is necessary, especially for East Pakistan, to take into account the problem of procurement of steel materials, future prospect over traffic, maintenance and finance.

c. Substructure and type of foundation

The type of substructure and type of foundation are inseparably related to the conditions of base ground, weight or shape and function of superstructure. However, such structure should be eventually selected by the minimum cost of the foundation work and it will be in good balance with the cost of superstructure. To be added to these, the study must be made for the peculiality of the river flow and its influence. The strength of bridge is required so as to stand against the change of the river at the time of flood season.

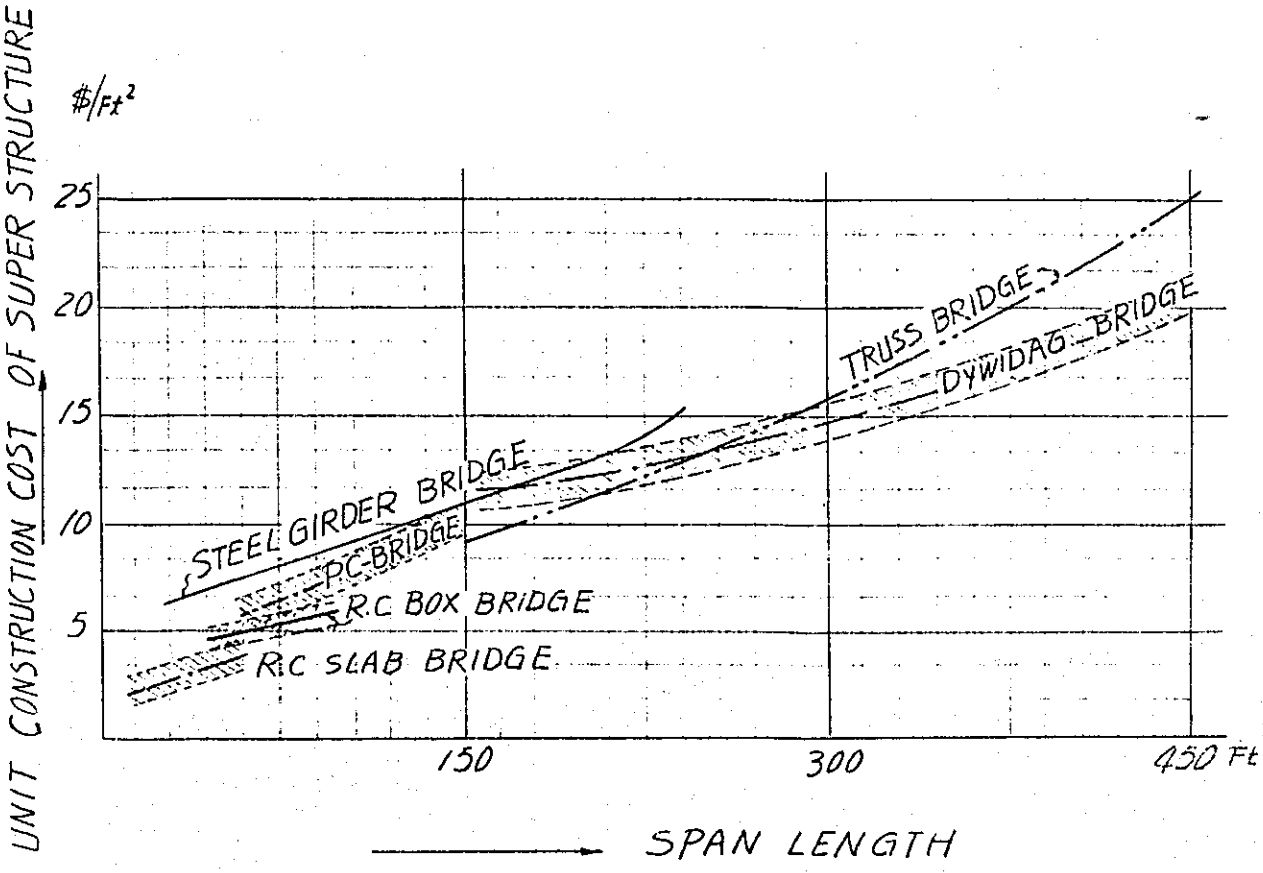
d. Decision of span

With a comprehensive study for the type of structures together with other requirements, an most economical span should be taken to fit the actual situation.

In order to prepare for the abovementioned study, the fundamental subject which can be studied with the given conditions at present, are taken up as follows:-

Fig 3.

SPAN & COST OF SUPER STRUCTURE



1) Relation between the span and the construction cost of superstructure.

2) Study for the type of foundation of Garai River Bridge.

2. Specific Study

a. Relation between the span and the construction cost of superstructure

From the general experiences in the past, it is apparent that the cost of superstructure is predominant in the whole construction cost, unless the geological conditions are exceptionally inferior. In short, the construction cost per unit of pier or abutment would hardly be affected by any kind of span division of superstructure. Almost nothing of influence upon the unit cost of substructure would be brought from the change in span as long as it remains not to alter the type of foundation.

Therefore, important for the economical estimation of cost is to note how far the cost of superstructure should vary with the change in span. The interrelation of them is shown in the Fig.3, in which the values are picked up from the Japanese statistics but amended to fit the given conditions of East Pakistan, so that it may help a general estimation.

b. Study for structure of foundation

As for the structure of foundation, there are many kinds of type dependent upon the topographic and geological features and given design conditions.

In the instances of East Pakistan, such type, with few exceptions, has been prevailing that concrete pier were placed upon brick well.

For the reason why the water flow will increase in the rainy season, there is many obstacles anticipated. One fact is that in the past a well structure under construction was swept away owing to the scouring caused by the increased flow velocity in the rainy season. Therefore, it is essential to shorten the working period so as not to suspend the actual construction work.

To meet with these requirements, two kinds of foundation were taken up in the design; one is a brick well which costs low, the other a pile foundation requiring a short construction period. The alternative choice may be made for a final conclusion. The basic examination about brick well and pile foundation are referred to in the following.

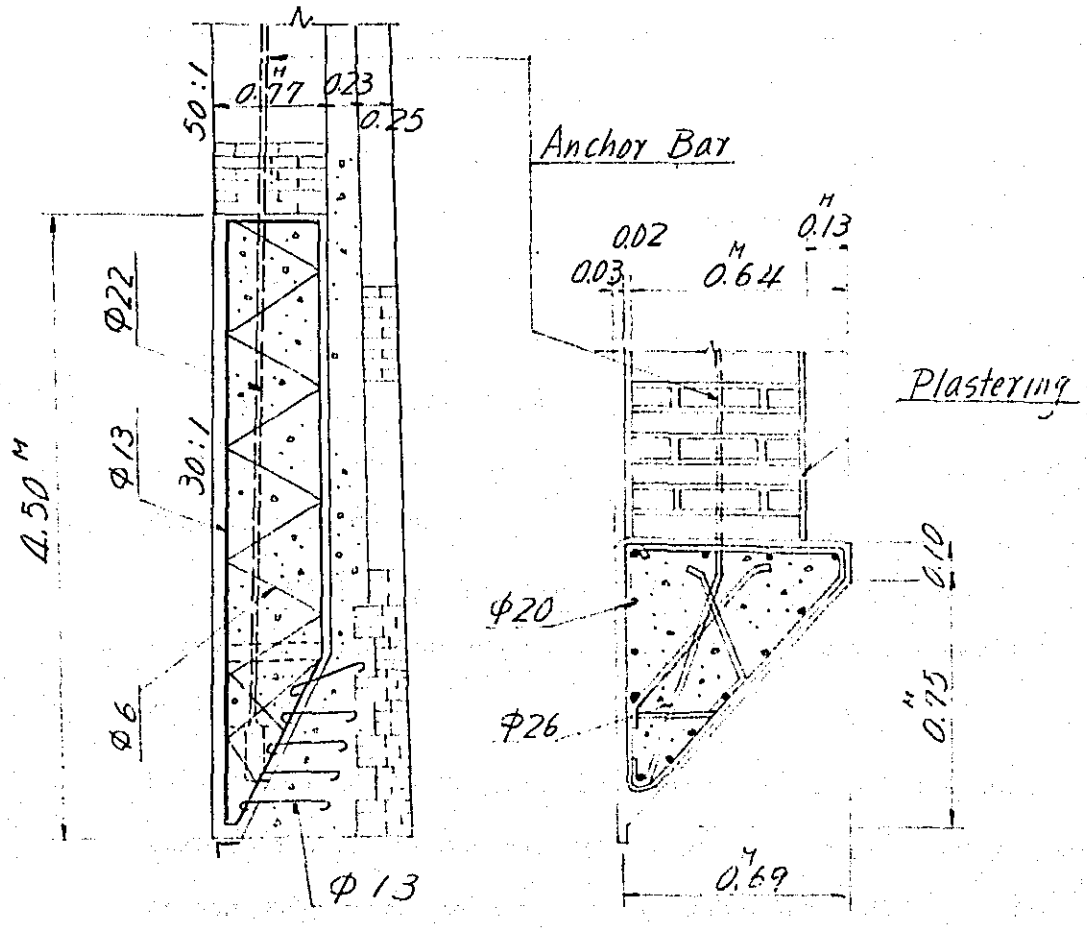
b-1) Brick well

The shapes of well in use are those round, oval, oblong, square or rectangular. Among them a round well has the least resistance in the ground in principle of having the minimum volume for a certain base area. Furthermore, one of the advantageous features are:- Since all the points on well edges are so in the same distance from the center that the settlement can be carried out uniformly and promptly by excavating the ground under water.

Of a sunk well structure is important its well edge, one of which sample used in Japan is given in the Fig.4.

Fig 4.

EXAMPLE OF BRICK WELL EDGE



The well foundation in Japan is given the consideration of the earthquake force, but in applying it to the construction in East Pakistan, it will become simpler than that in the Fig.4, however, no difference exists in principle.

Some drawbacks to the brick well structure will be pointed out as follows:- Since the outside of well is made of brick, all the joint parts should be packed thoroughly with mortar, or coated all over the outside. This causes an increase of friction resistance against the ground, but it makes difficulty in its settlement. Consequently, the balance of settlement should be taken into consideration accordingly to the geological nature of the bridge construction site, so that the area of over-coating might be adjusted.

In case of settling the well into the different layers, it is necessary to tightly tie the edge part and well body together by means of anchor bar so as not to let apart to each other by the different friction forces worked upon them.

In the district, which earthquakes seldom take place, the brick well structure seems somewhat satisfying the requirements for all substructures.

In comparison with other types of foundation, the main advantages or disadvantages of brick well might be numerated as follows:-

b-1-1) Taking the vertical load alone, it is assumed that the compressive force upon the well would be 35 kg/cm^2 being given an adequate safety factor. On the other hand, the safety bearing value of a rather solid ground would be even 80 t/m^2 (= 8 kg/cm^2) or no more than that, except very special instances.

Consequently, the compressive force of well generally comes to be 4 or 5 times as large as the bearing power of ground. In case of pile being used, even if all the bearing power of ground should be worked effectively, the pile iteself would not bring no more than one-fifth of it in effect.

With the well structure which is void inside, and being designed to make such a wall thickness as the sectional area of well may become about one-fifth of total base section area, the full effectiveness of well-composing materials could be produced.

b-1-2) On the other hand, if such an most economical well were designed, there would be in fact difficulty in setting it. It happened very often that to be used two or three times as much materials in order to facilitate the work, resulting in an increase of settling cost of well. In so doing, no merit of well structure was utilized. Should the method of settlement be revised, an useless increase of sectional area would be cut off to make the best of well structure at the lower cost by saving materials and cost.

b-1-3) In case of pile foundation, the bearing power per unit pile is comperatively small, and several piles, or ten times as many of it at one time, should have to be used for sustaining a structure. But, the well structure only requires one or small number of unit for the same purpose.

In other works, the well makes its circumferential area to be equal to that necessitated in relation to the bearing power of ground. The main body of the well which are to connect structures and base ground, are set in the loop shape on edge,

void inside, the section modulus becomes larger for the common case. Contrarily, in case of pile, a sectional area equivalent to one well should be divided into several or far more number of unit, and that the section is bar form and filled inside, the section modulus becomes very smaller.

b-1-4) From a standpoint of construction period, the pile work can be completed in very much shorter time than the well work.

b-1-5) As was stated, there are some relative merits proper to each of pipe work and well one. However, when the ground is shallow and the load is small, the pile foundation is generally more advantageous in every repsect. In case of deeper bearing ground and large load, the well foundation is more economical. When the depth is far larger, the excavation work becomes difficult; in case of the penetration depth into the ground of the foundation excessing 40 m, the foundation is generally carried out by a long size joint pile work.

The boundary depth is quite dependent upon the geological nature of construction site, easiness of work, procurement of materials, and other economical viewpoints.

Into the hand of the survey team did come an example of blue print of the brick well (10' x 18' x 40', Wall thickness: 2'-1") currently used in East Pakistan, and the bearing power of the well is calculated assumedly as follows:-
(a certain geological nature is supposedly given in the culculation.)

W : Unit weight of soil 1.7 t/m^3 (assumed)

φ : Internal friction angle of soil 25^o (assumed)

h : Foundation depth of well in the ground 12 m (assumed)

B : Shorter side of well 3 m

a. Rankine's formula for bearing power (q):

$$q = Wh \left(\frac{1+\sin\varphi}{1-\sin\varphi}\right)^2$$

$$= 124.1 \text{ t/m}^2$$

b. Reissner's formula for bearing power:

$$q = Whk_1$$

$$k_1 = \tan^2\left(\frac{\pi}{4} + \frac{\pi}{2}\right) e^{\pi \tan\varphi}$$

$$= 12$$

$$q = 1.7 \times 12 \times 12 = 244.8 \text{ t/m}^2$$

c. Terzaghi's formula for bearing power:

$$g = 0.4\, B\gamma_B \cdot N_\gamma + \gamma_D \cdot h \cdot Ng$$

$$= 418.7 \text{ t/m}^2$$

N 25 assumed
N_γ 15
Nq 19

Taking the minimum value of the abovementioned; that from Rankine's formula:-

$$q = 124.1 \text{ t/m}^2$$

When the safety factor is made equal to 3:-

$$qn = \frac{124.1}{3} = 41 \text{ t/m}^2$$

Meanwhile, the friction between soil and well is estimated:-

On the assumption that the ground is made of considerably dense sand, the value at some 12 m below ground surface is: $f = 1.0 \text{ t/m}^2$. Therefore, the check-up for the stability of settling well is given as follows:-

Base area of well: $A = 14.75 \text{ m}^2$

Circumferential length of well: $P = 14.50 \text{ m}$

Resistance power: $\theta = A\, qn + P \cdot f$

$$= 14.75 \times 41 + 14.5 \times 1.0 = 619.25 \text{ t}$$

With this θ is to bear; the reaction force of bridge upper part, plus the weight of pier and abutment of foundation, plus weight of well. Compared with the filled pile, to bear the vertical load with a void well is to save about one-fifth of materials.

b-2) Pile foundation

A general comparative study has been made of pile foundation and well, but the pile foundation is further divided into two: concrete pile and steel pile, each of which has its own merits and demerits.

In case of large load and long size pile to be used, the concrete pile would be inconvenient for handling because of its large dead weight; a big hammer may be needed to drive the pile into the ground, often causing a crash the head of concrete or crack in the concrete pile with strong strokes. Further, there is difficulty in a joint work to be undertaken.

To make up with these drawbacks in addition to cover the disadvantages of the inside-filled pile, the steel pile would be quite available.

b-2-1) Characteristics of steel pile

a. Steel pile can stand against a strong stroke when driven into the ground. Due to the reason, a stable foundation capable of having a large bearing power can be constructed, which is deep in the bearing base ground. By constructing a foundation with a large bearing power, the required number of piles can be decreased, making the working period shorter and cost lower.

Examples have been reported that, compared with well or caisson work, the period of steel pipe work was shortened to about one-fifth and the cost of that to about one-third.

b. Easy work for long size steel pile

It is quite easy to handle and drive long-size steel piles into the ground. Large stiffness together with light weight would enable the pile to have a large stroke effect into the soil, and be driven deep with ease. When used in the soft ground, the steel pile will make such a deep foundation as cannot be carried out by any other materials.

c. Easy adjustment and change in steel pile length

Since the joint pile work is easy, the adjustment and change in pile can be effected very easy accordingly. It is especially advantageous to the case of under-pinning. Also, it will be distinctly suitable to use for the base ground of which depth is varying some places where the deep bearing layers come slant or bent.

d. Light weight, and easy handling and carrying

Compared with concrete piles which are filled inside, an ordinary steel pile of the same diameter has only not more than one tenth of sectional area; the weight per unit length less than one-third. This may eventually entail the lower equipment cost and higher working efficiency.

e. The sectional area of pile is small, so that the removal of soil can be accordingly small when driven in the ground. It is of great use to prevent the bad influence caused by the side displacement of soil.

f. Strong against bending, and large in resistance against horizontal force.

g. Due to the controlled manufacture at factory, uniform quality is obtainable at all times.

b-2-2) Kind of steel pile, and its advantageous use

Of steel pile there are two kinds, steel pipe pile and H-section pile. Each has its own advantageous use. For the purpose of using for bridge foundation, the steel pipe pile is generally preferred, for it is more advantageous to make as large bearing force per unit as possible in view of vertical and horizontal bearing power.

As was related, the steel pile has many promonent merits for bridge foundation. However, todays East Pakistan would have to import it, so the finance would be taken up in the project to make it possible.

The comparative study should be made between the brick well work prevailing in Pakistan and the steel pile work. Concerning this matter, an elaborate examination should be made afterwards at the stage of "designing of structures" following the geological survey being effected.

c. Study of the protection work against scouring on piers and abutments

Among the methods for the foot protection works of pier and abutment against the scouring caused by the water flow, the followings are most common at present:-

1. Wire cylinder
2. Mattress
3. Cribwork
4. Concrete block work

Each of the above listed has its own characteristic use, but the confronting problem to select one type of them should first treat the suitability for the circumstances of the construction site. The suitable type of work would be confined to itself.

The wire cylinder work requires a large quantity of pebbles and gravels which is hardly obtainable in East Pakistan. The substitute with bricks may be considered, but it is not so practical under the present circumstances.

Of the remaining cribwork and mattress work, the latter can be more feasible to be carried out at the given bridge site, for the required materials would be obtainable with comparative ease, and that the quantity of pebble and gravel (or alternatively brick) would be far smaller than in the wire cylinder work. Therefore, the mattress work is taken up to be suitable for the purpose.

There are also many kinds of mattress work, but the possible work in East Pakistan would be confined to two kinds, fascine mattress and fascine single mattress. The method of these works by means of fascine, spreaded fascine and gravels to cover the sandy river bed is to prevent the disturbance of river bed by river flow. Due to the materials' nature, a rich flexibility can be expected and the river bed soil will readily take to it. But, in the torrential flow, when the settled pebbles and gravels become useless, some other means would have to be considered.

In the Garai River, however, the ordinary flow velocity is less than 40 ~ 60 cm/sec, and even at the time of flood presumedly 2 ~ 3 m/sec more or less. The fascine mattress work, it seemed, would be most suitable for the slowly flowing river like this.

In the attached Appendix an outline of fascine mattress is given for reference, which one is now employed in Japan.

The fascine work would not be so difficult to carry out, making the use of rich woods in East Pakistan, and quite worthy of studying as an useful method for consolidation of foundation. Epsecially, this work would probably bring a great effect if applied to the foot area of pier and to the shore around abutment. For piers it is necessary to have the minimum circumferential area for 7 ~ 10 m (DWG No.7 to be referred to).

A P P E N D I X

An Outline of Fascine Mattress Work in Japan

1. Fascine Mattress

The elements of the work are composed of fascine, spreaded fascine, hurdle and pebbles. The fascine is made from those straight and plenty of twigs, which can be chosen from a fascine bundle. Stacking up the fascines in such a way the roots and twig ends come atop to each other, to be tightened up by rope or wire, and these fascines are tied up with zinced wire (#12) at an interval of 15 cm into a bundle of 15 cm diameter.

The fascine mattress is made in shape of grill having 1 m intervals by arrangement of the twig end putting in the direction of river width and downstream, and then the crossed parts are fastened tightly. This is called an under fascine grill, upon which spreaded fascine in 15 cm thick are to be laid in three layers in the direction of river width and downstream.

Further, an upper fascine grill of the same composition on the under fascine grill would be placed upon the spreaded fascine, and tightened up to it at the crossing parts by the same wire tied for the under fascine grill.

On the fascine of upper fascine grill, small stakes are driven at 50 cm intervals to go through the under fascines for 2 rows on the side parts and one each raw on the inside. Hurdles are constructed 15 cm high and among them filled with stones and pebbles of 20 ~ 40 kg weight. Further filled up with gravels and pebbles in it.

The thickness of whole mattress is about 90 ~ 120 cm. All the mattress are placed below the low-water level in order to prevent from decaying.

The fascine mattress is illustrated for its structure as shown in the DWG. No.6.

2. Fascine Single Mattress

The fascine single mattress is one of the simplified structure of fascine mattress, and used for the case where the water depth is shallow, or used under the fascine mattress. The work method is to do placing one layer of spreaded fascine on the under fascine grill. Omitting the upper fascine mattress, the hurdles are directly made to be about 60 cm thick.

GARAI RIVER BRIDGE CONSTRUCTION PROJECT

EAST PAKISTAN

Investigation Plan

A. Introduction

B. Outline of the Investigation

C. Scope of the Investigation Work

D. Formation of the Investigation Team

E. Schedule of the Field Investigation

F. Completion of the Investigation

G. Facilities to be rendered to the Team

February 1966

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO, JAPAN

A. INTRODUCTION

In response to the request of the Government of East Pakistan, the Government of Japan has decided to despatch a preliminary investigation team of 7 members with the view of cooperating in both the Garai River Bridge Construction Project, East Pakistan, and the Asian Highway Project. Accordingly, a preliminary investigation report is to be presented to both the Provisional Government of East Pakistan and the Central Government of Pakistan after the compilation of the investigation results.

B. OUTLINE OF THE INVESTIGATION

The investigation aims at the selection of the bridge construction site around the crossing point of the proposed Asian Highway Route A-1 and the Garai River running from north to south through the East Pakistan Province, and preparation of the preliminary design of the proposed bridge. At the same time, the investigation will serve for the road up-grading programme of East Pakistan (the sections Jessor - Faridpur and Jhenida - Faridpur are included in the Programme). The proposed construction site is situated about 90 km south-west of Dacca and about 90 km north-east of Jessor.

C. SCOPE OF THE INVESTIGATION WORK

The investigation will consists of two stages, i.e., a preliminary investigation and a preliminary design. The work of the preliminary investigation to be presently carried out is described as follows:

Field Investigation

1. Collection of data necessary for the project planning.
2. Selection of both the construction site and the type of the proposed bridge.
3. Topographical and sounding survey of the proposed construction site.

Home Office Work

4. Preparation of a preliminary report.

After this investigation, further field investigation for the preparation of a preliminary design report will have to be carried out in earliest possible time.

D. FORMATION OF THE INVESTIGATION TEAM

The Team will be organized by the following 7 members. However, this formation is subject to change in the future.

Assignment	No. of member
Leader	1
Road Engineer	1
Bridge Engineer	2
Surveyor	2
Liaison & Accountant	1
Total	7

E. SCHEDULE OF THE FIELD INVESTIGATION

The arrival of the Team to Dacca is expected to be in the end of March 1966. The Leader's group including the bridge and road engineers will leave for the proposed bridge site after careful discussions with the officials of the Provincial Government of East Pakistan at Dacca. Prior to this, the rest of members will immediately leave Dacca for the preparation for surveying and the reconnaissance at the proposed site, and proceed the work under the direction of the Leader's group on its arrival to the site. The field investigation will cover a period of 45 days.

F. COMPLETION OF THE INVESTIGATION

The period required for the completion of the present Investigation (first stage) is estimated at 5 months, as mentioned hereunder, from the commencement of its field work. This will, however, be affected to a certain extent by the progress of data analysis.

The proposed second stage investigation for the preliminary design may take 10 months after the commencement of its field work.

G. FACILITIES TO BE RENDERED TO THE TEAM

For the fully efficient execution of the field investigation, the Provincial of East Pakistan shall take such necessary steps for the Team as mentioned hereunder.

1. Despatch of one Liaison officer to the project area for the Liaison between the Provincial Government and the Team.

2. Tax exemption on any investigation equipment, materials and supplies brought into East Pakistan by the Team or which may be subsequently withdrawn therefrom..

3. Arrangement of the followings. However, the expenses shall be disbursed by the Team.

a.	Rent of Jeep	at Jessor	2 behicles	app. 40 days
b.	Employment of Driver	"	2 persons	"
c.	Employment of Interpreter	"	2 persons	"
d.	Rent of a house for living and office accommodation	"		"
e.	Rent of Motor boat (30 feet long) for sounding survey		1 boat	10 days

4. To provide with basic information materials including aerial photo's topographical maps and hydrological data.