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THE PEOPLE'S REPUBLIC OF BANGLADESH

FEASIBILITY STUDY
ON
MEGHNA, MEGHNA-GUMTI BRIDGES CONSTRUCTION PROJECT

FINAL REPORT

MAIN REPORT

MARCH, 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the People's Republic of Bangladesh, the Japanese Government decided to conduct a feasibility study on Meghna, Meghna-Gumti Bridges Construction Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Bangladesh a study team headed by Dr. Tadayoshi Okubo (Pacific Consultants International) from March 1984 to November 1984.

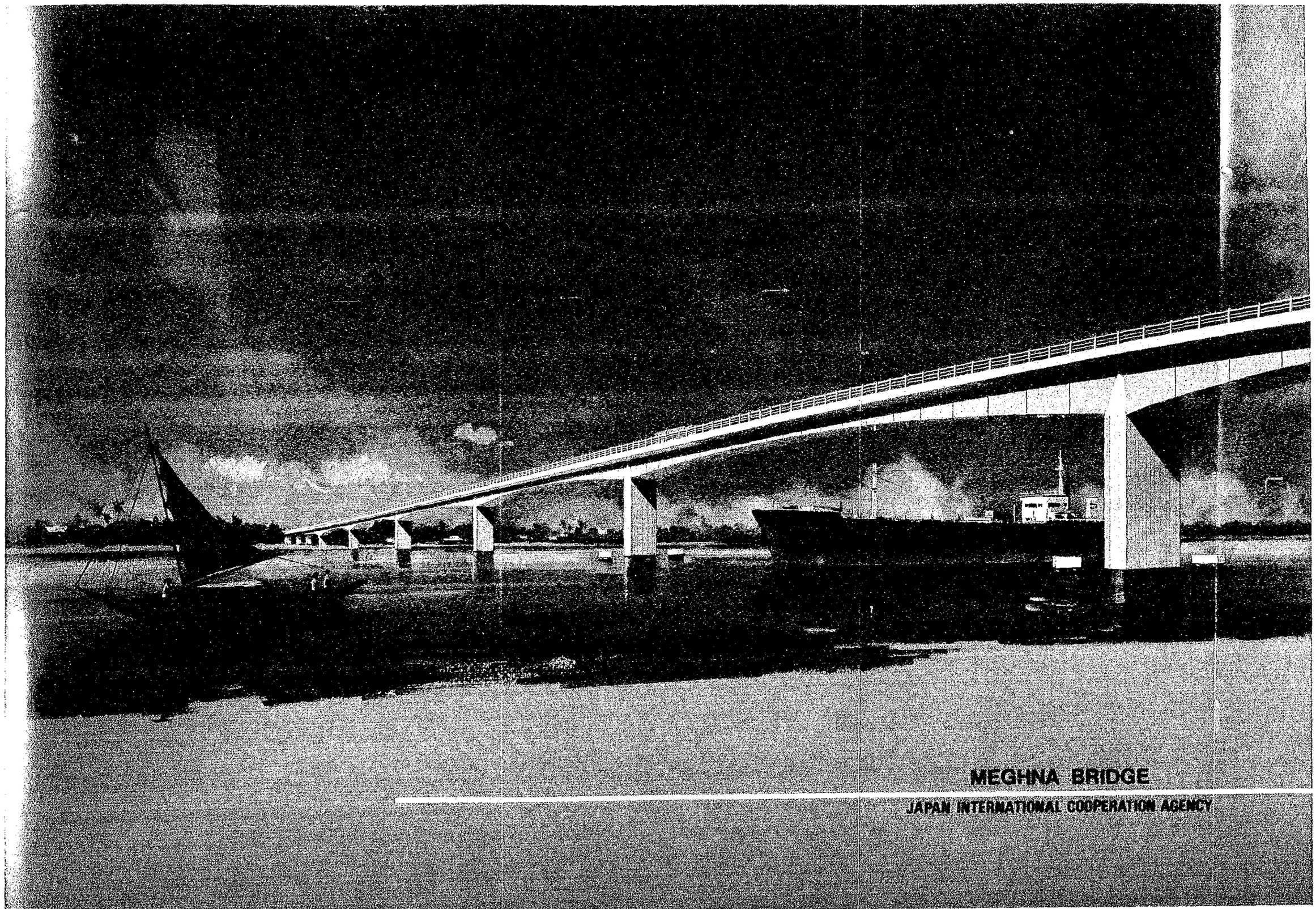
The team had discussions on the Project with the officials concerned of the Government of Bangladesh and conducted a field survey in Bangladesh. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the People's Republic of Bangladesh for their close cooperation extended to the team.

March, 1985

Keisuke Arita
President
The Japan International Cooperation Agency



MEGHNA BRIDGE

JAPAN INTERNATIONAL COOPERATION AGENCY

SUMMARY

SUMMARY

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SUMMARY

1. PROJECT BACKGROUND

The Dhaka-Chittagong Highway with a total length of about 257 km connects Dhaka City (about four million population), the capital of Bangladesh with Chittagong City (about 1.5 million population), the second largest city and an international port.

The Meghna River (about 830 m wide) and the Meghna-Gumti River (about 1,360 m wide) cross the Dhaka-Chittagong Highway about 25 km and 40 km east of Dhaka, respectively, where the Roads and Highways Department (RHD) provides mechanised ferry services. As the waiting time of vehicles for the ferries has increased, RHD has expanded the ferry arrangements to accommodate the increased traffic demand. However the necessity of ferry improvements will arrise with the continuously increasing traffic. It is urgent to construct two bridges across these rivers which will complete the 380 km long Aricha-Dhaka-Chittagong Highway, and avoid the inconvenient, time-consuming ferry system, and boost economic activities.

Under these circumstances, the Government of Bangladesh requested the Government of Japan for a feasibility study leading to the construction of Meghna and Meghna-Gumti Bridges. The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan, was appointed to conduct this Study.

2. STUDY

2.1 Study Objective

The objective of the Study is to carry out a feasibility study for the construction of Meghna Bridge and Meghna-Gumti Bridge including their approach roads, in order to facilitate transportation as well as remove traffic obstructions on the Dhaka-Chittagong Highway.

2.2 Contents of Study

The study area can be limited to the area covering the two bridge locations from the engineering aspects. In view of the necessity to meet the requirement of the traffic study associated with the Dhaka-Chittagong Highway, however, the area adjacent to the highway is considered as the study area in a broader perspective which includes parts of Dhaka, Comilla, Noakhali and Chittagong districts.

The Study was conducted in RHD, Dhaka, from March 13, 1984 to November 30, 1984 in close cooperation of the RHD counterpart staff.

From the characteristics of the Study the following work items, among others, were carried out to meet the Scope of Work:

- Topographic survey of the existing ferry approaches and alternative locations of the proposed Meghna Bridge and Meghna-Gumti Bridge;
- Hydrological and hydrographical investigations during dry and rainy seasons;
- Soils investigations at both bridge sites;
- Laboratory tests of soil samples taken from the Meghna and Meghna-Gumti Bridge sites;
- Review of existing design standards of roads and bridges and establishment of appropriate design criteria for this project;
- Review of the unit prices of major construction items used for the recent typical road and bridge construction projects;
- Conduct of the road traffic survey at the ferry crossings for analysis;
- Forecast of future traffic on the ferry crossings;
- Determination of the recommended locations of the Meghna Bridge and Meghna-Gumti Bridge and resulting centre-lines;
- Broad comparative study for the proposed bridges: location, type, length, spans, foundations, approaches, etc.;
- Preliminary design of the two bridges and approach roads;
- Design of ancillary facilities;
- Study for an improved ferry scheme (without-bridge-case);
- Project cost estimates for the two bridges and approach roads;

– Economic evaluation of the project; and

– Implementation programmes for the two bridges.

3 FINDINGS AND RECOMMENDATIONS

3.1 Engineering Study

Hydrological and hydrographical surveys were conducted; to provide the data to select the proposed bridge sites; to determine design flood discharge and high water level; to estimate scouring depth around the piers of the proposed bridges; and to find appropriate measures against river erosion. To supplement the data collected the JICA Study Team conducted velocity survey and sounding survey of the rivers on two occasions, the first during the dry season and the second during the rainy season. To find a relationship the same surveys were conducted in the same way around the existing Bhairab Bazar railway bridge which is located 60 km upstream of the Meghna ferry ghat.

Topographic survey was conducted around the proposed bridge sites and topographic maps were prepared to provide a basis for both the determination of the bridge centre-lines and the preliminary engineering design of the bridges and their approach roads.

Subsoil investigations were conducted along the proposed centre-lines of the bridges and soil samples taken therefrom were tested at the laboratory, to clarify the geotechnical problems and to provide the data for a best design selection. Below the riverbed of the Meghna the subsoils consist mainly of non-cohesive soils with fine sand, silty sand and silt, and the reliable bearing strata for the bridge pier foundation was found to exist around the depth of 52 to 55 metres below zero (0) datum PWD. Similarly below the riverbed of the Meghna-Gumti the subsoils consist mainly of non-cohesive soils with fine sand, sandy silt and silt down to the depth of 30 metres PWD below which there is sandy silt. The bearing strata for bridge pier foundation was estimated to exist at depths varying from 60 to 70 metres below the datum line.

Materials required for the construction of the bridges were surveyed to confirm their availability. Sand, stone, cement, asphalt, steel bar, some kinds of steel materials are available in Bangladesh. However, plasticiser, deformed bar, prestress-

ing cable and accessories, fabricated steel and cast iron, and shaped steels must be imported.

The existing RHD design standards for roads and bridges were reviewed and found applicable to the Project. The navigational clearances for the bridges were confirmed through the Bangladesh Inland Water Transport Authority (BIWTA).

Five alternative bridge centre-lines were selected for the location of the Meghna Bridge: one was upstream of the existing ferry course, second along the existing ferry course and the remaining three downstream of the ferry course about 150, 250 and 400 metres away, respectively. After examination the most suitable centre-line of the Meghna Bridge was determined to be downstream of the existing ferry course, 250 metres on the right bank and 320 metres on the left bank. The principal reasons for this decision are: minimal or no bank erosion could be anticipated; the existing ferry operation would not be hampered during the construction period; and no displacement of the existing ferry facilities would be required.

Similar to the Meghna Bridge five alternative bridge centre-lines were selected for the location of the Meghna-Gumti Bridge: two were upstream of the existing ferry ghats, third along a straight line connection between both ferry ghats and the remaining two were downstream of the existing ferry ghats. The centre-line located upstream of the existing ferry ghats was adopted: 50 metres on the right bank and 120 metres on the left bank, for the following major reasons: no displacement of the ferry facilities including existing approaches and other buildings would be required; the construction of the bridge would not hamper the existing ferry operation; and the reclaimed land owned by RHD on the left bank could be used for the land of the approach road.

Four types of bridge foundation were studied:

- reverse circulation drilled pile;
- steel pipe pile;
- interlocked steel pile well; and
- open caisson.

As the result of a comparative study, the reverse circulation drilled pile foundation was recommended because of shorter construction period, lower construction

cost; materials easily available from the domestic market, easy confirmation of bearing stratum, reliable supports and no corrosion problem.

For the determination of the superstructure of the bridges the following 8 types of structures were studied, taking into consideration respective construction methods and span lengths of 25, 30, 35, 45, 60, 90 and 120 metres:

- PC Box Girder (Cast-in-situ method);
- PC Box Girder (Segmental box method);
- PC Box Girder (Incremental launching method);
- PC T-beam Girder (Precast beam) for side span bridge;
- Steel Truss Girder;
- Steel Lohse Girder;
- Steel Box Girder; and
- Steel Composite Plate Girder for side span bridge.

As the result of a comparative study, the PC box girder (cast-in-situ) type superstructure was recommended, because of lower construction cost, and easy availability of materials from the local market.

Span arrangements were studied based on the study results of structural requirements, construction requirements, economy, aesthetics, effective river width, locations of abutments and end piers of the side span bridges, etc. At the same time, the overall bridge length was determined based on mainly vertical navigation clearance, effective river width plus allowance against future probable erosion of the river bank, maximum possible road embankment height, etc.: 930 metres for the Meghna Bridge and 1,480 metres for the Meghna-Gumti Bridge.

Through the preliminary structural calculation, the dimensions of foundation, substructures and superstructures were determined to meet the established design requirements. Preliminary design of the approach roads was made based on the established design criteria and design high flood water level. Ancillary facilities were also studied; the protection of the bridge piers against the collision by ships was designed and the protection methods against the river bank erosion near the bridge abutments were recommended.

Construction schedules of the bridges were prepared taking into consideration the location of the bridges; since the project sites are in inundated areas in the

flood season, the contractor should prepare the working yards, temporary quays, temporary stagings, cofferdams of double-skin sheet piling, etc. The construction periods of Meghna Bridge and Meghna-Gumti Bridge were estimated at 48 months and 58 months, respectively.

The costs for construction and maintenance used by the recent RHD road and bridge projects were reviewed. The basic unit prices were established and broken down into foreign and local currency portions. The project costs for both bridges were estimated based on the result of the preliminary engineering design and the respective construction methods and the proposed implementation schedules. The project costs estimated are shown in Table 1.

Overall implementation schedules of the two bridges were examined and are shown in Fig. 1. For the Meghna-Gumti Bridge three alternative plans were assumed.

Table 1 Summary of Project Costs

1. Meghna Bridge (Unit: 1,000 Taka, June 1984 prices)

Items	Foreign Currency	Local Currency	Total
1) Construction Cost	359,035	527,597	886,632
2) Engineering Service Cost	74,923	11,208	86,131
3) Land Acquisition Cost	-	11,561	11,561
Total	433,958	550,366	984,324

2. Meghna-Gumti Bridge (Unit: 1,000 Taka, June 1984 prices)

Items	Foreign Currency	Local Currency	Total
1) Construction Cost	518,159	669,825	1,187,984
2) Engineering Service Cost	57,262	12,762	70,024
3) Land Acquisition Cost	-	5,833	5,833
Total	575,421	688,420	1,263,841

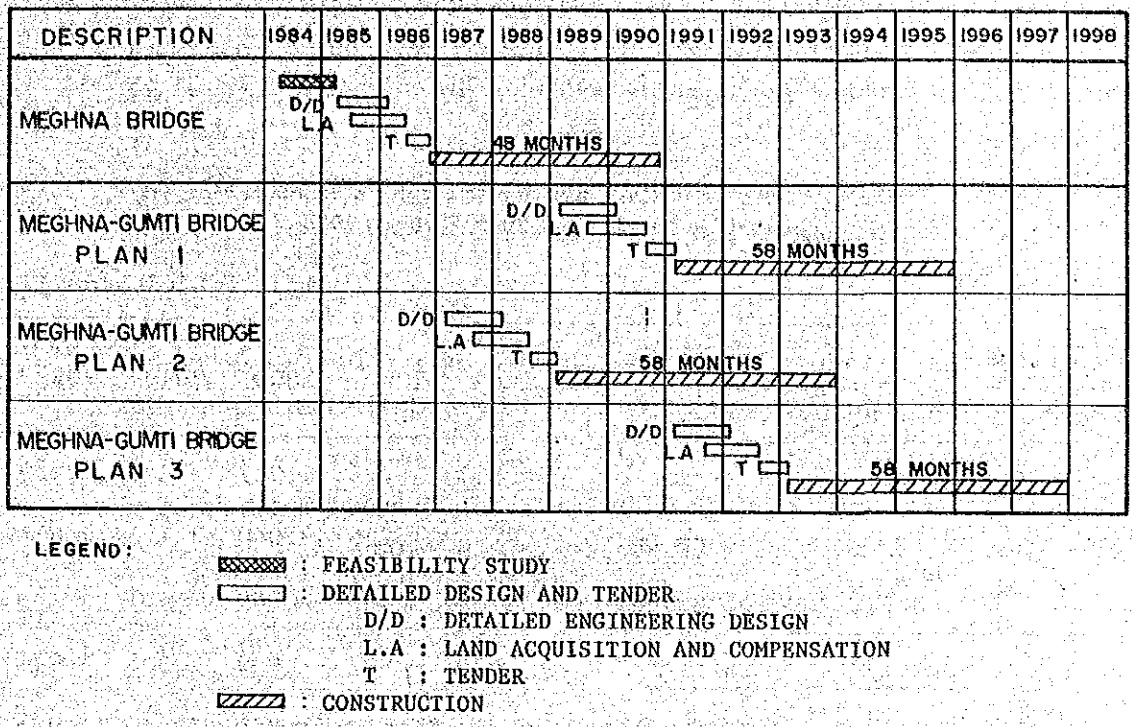

Fig. 1 Overall Implementation Schedule of Meghna, Meghna-Gumti Bridges Construction

3.2 Crossing Traffic and Economic Evaluation

In June 1984 the JICA Study Team conducted traffic count survey, origin-destination (O-D) interview survey and crossing time survey for the waiting vehicles to find the characteristics of the present traffic flows crossing the ferry ghats of Meghna and Meghna-Gumti on the Dhaka-Chittagong Highway.

The total traffic flow in one day was 1,468 vehicles on the average, out of which the truck traffic occupied 55% of the total vehicle traffic. The truck traffic which ran during nighttime from 10:00 p.m. through 6:00 a.m. occupied about 50% of the daily total truck traffic. More than half of the total tonnage of commodities carried by trucks was for movement between Dhaka and Chittagong. Among commodities, the movement of machinery and metal products from east to west occupied the largest share, while agricultural products had a large share in the opposite movement. The longest crossing time delay was observed in the case of trucks waiting for crossing during early morning hours at the eastern side of the Meghna-Gumti River; the trucks at this point were found to wait for a maximum of 238 minutes during 2:00 to 3:00 a.m.

The future traffic crossing the ferries (normal traffic) was forecast, taking into account projection of population and economic conditions of Bangladesh. The

traffic induced from the construction of the two bridges was separately estimated. Table 2 shows the kinds of traffic estimated. The total traffic crossing the rivers in 2020 would be about eight times that in 1984.

Table 2 Future Traffic Crossing Two Rivers With and Without Induced Traffic : in 1990, 2000, 2010 and 2020

(Unit: Vehicles/day)

Traffic By Vehicle Type, By Case \ Year			1984	1990	2000	2010	2020
Truck	Normal	Traffic	811	1,195	1,927	2,943	4,366
	Normal and Induced	Meghna Only	-	1,265	2,040	3,116	4,611
		Two Bridges	-	1,408	2,269	3,467	5,153
Bus	Normal	Traffic	439	597	909	1,308	1,831
	Normal and Induced	Meghna Only	-	650	990	1,424	1,993
		Two Bridges	-	776	1,183	1,702	2,388
Minibus	Normal	Traffic	85	116	176	254	355
	Normal and Induced	Meghna Only	-	126	192	277	386
		Two Bridges	-	151	229	331	463
Car	Normal	Traffic	104	291	689	1,358	2,431
	Normal and Induced	Meghna Only	-	332	786	1,547	2,769
		Two Bridges	-	418	984	1,932	3,455
Others	Normal	Traffic	29	40	64	98	145
	Normal and Induced	Meghna Only	-	46	73	112	165
		Two Bridges	-	58	92	140	207
Total	Normal	Traffic	1,468	2,239	3,765	5,961	9,128
	Normal and Induced	Meghna Only	-	2,419	4,081	6,476	9,924
		Two Bridges	-	2,811	4,757	7,572	11,666

By using these traffic volumes a plan to continue the ferry facilities (with required investment for minimum expansion) for carrying the vehicles across the rivers was studied, to estimate the extent of expansion required, and the maintenance and transport costs associated with the ferry system. Based on the improved ferry scheme, 7 and 10 sets of terminal facilities are required around the years 2010 and 2020 respectively, to accommodate the increasing traffic.

The economic evaluation for this project was made by comparing economic costs and benefits in order to examine the feasibility of the project. The total project cost composed of the land acquisition cost, engineering service cost, direct construction cost, overhead cost and cost for physical contingency was divided into the local and foreign currency components, and the tax elements for the respective components were subtracted. Using the shadow pricing rates the construction cost and maintenance cost of the project at net of taxes market prices were converted to the economic costs.

The benefits attributed to the traffic can be measured from the difference in cost and time between using the bridges and crossing the rivers by ferry. The project benefits were estimated from the saving in investment cost for ferry boats, landing facilities and other terminal facilities, the saving in ferry operating cost, vehicle operating cost and time cost which are all related to the future increased traffic. In the same manner as the economic costs these benefits were converted into economic benefits.

The future traffic projection considerably varies between the case that both Meghna and Meghna-Gumti Bridges are constructed and the case that only Meghna Bridge is constructed. For the economic evaluation the following alternative cases were examined:

Meghna Case I : Construction of Meghna Bridge with no construction of Meghna-Gumti Bridge afterwards.

Meghna Case II : Construction of Meghna Bridge in expectation of subsequent construction of Meghna-Gumti Bridge. In this case both costs of, and benefits from, the construction of Meghna-Gumti Bridge were excluded, but the traffic induced from the construction of Meghna-Gumti Bridge was considered.

Meghna-Gumti : Construction of Meghna-Gumti Bridge following the completion of Meghna Bridge. In this case costs of, and benefits from, the construction of Meghna Bridge were neglected.

Combined Meghna/ Meghna-Gumti : Joint successive construction of Meghna and Meghna-Gumti Bridges was evaluated as one single project.

The economic feasibility of the project was tested based on the conventional criteria of EIRR (Economic Internal Rate of Return) and B – C (Net Present Value: Benefit minus Cost) and B/C (Benefit Cost Ratio) at two discount rates of 10% and 15%. The result is summarised as shown in Table 3.

Table 3 Summary of Economic Evaluation

Case	Economic IRR (%)	Discounted at 10%		Discounted at 15%	
		B-C (Tk.million)	B/C (Ratio)	B-C (Tk.million)	B/C (Ratio)
Meghna - Case I	10.2	17.2	1.03	-207.2	0.57
Meghna - Case II	10.7	52.2	1.09	-193.0	0.60
Meghna-Gumti	14.8	310.0	1.73	-5.3	0.98
Combined Meghna/ Meghna-Gumti	12.4	362.2	1.37	-198.2	0.74

The construction projects of the proposed Meghna and Meghna-Gumti Bridges are both economically feasible with EIRR of more than 10%. And the construction of the Meghna Bridge with a joint project of Meghna-Gumti Bridge construction will produce a higher economic feasibility.

Sensitivity tests were conducted under the different assumptions for economic benefit (reduced passenger time value), economic cost (increased construction cost) and construction schedule of Meghna-Gumti Bridge. The result revealed that the economic feasibility of the proposed project is not adversely affected.

3.3 Conclusion and Recommendations

In Bangladesh the importance of the road transport has increased in recent years; the performance of road transport in respect of carriage of freight traffic is generally more than three times the role played jointly by both railway and water transport and the road freight transport recorded the highest rate of increase among the three modes of transport.

The Dhaka-Chittagong Highway carries the heaviest traffic among the arterial roads in the country. The Meghna and Meghna-Gumti ferry ghats have been the only bottlenecks in transportation on the road. Unless the two bridges would replace the existing Meghna and Meghna-Gumti ferry ghats, the future traffic across the rivers would necessitate the increase in ferry facilities which will result in higher investment cost in the long run. It is anticipated that the future operation and management of the ferry services would be extremely difficult and impracticable with many facilities.

With the two bridges vehicles could make one round trip in the daytime between Dhaka and Chittagong, and trucks can haul more quickly important commodities for economic development, thus saving the national resources.

The construction of the bridges will not involve any serious technical problems; subsoil conditions were found to be fairly good, and most construction materials are locally available.

The design and construction of the bridges with longer spans, which have never been experienced in Bangladesh, will contribute to the technology transfer to the local engineers and technicians concerned, raising the level of construction technology in Bangladesh.

The construction of the two bridges has indirect benefits which are not measurable; it will reduce the congestion of the highway, providing the vehicles easier passage, and producing secondary effects such as accelerating development of agricultural areas along the highway and expediting investments to already established areas.

The result of the Study has shown the importance of the two bridges, and the Project is economically and technically feasible, and its implementation will no doubt act as a great social and development impetus.

It is concluded that the Meghna and Meghna-Gumti Bridges construction is an indispensable project and indeed a realistic solution for the development of economy as well as road transportation of the country.

The following points are recommended:

- The Project should be implemented at the earliest possible time from the view point of national economy. Prior to the commencement of the construction, the detailed engineering design and the practical implementation schedule of the Project should be prepared.
- The acquisition of the land for bridge and approach road right-of-way should be prepared before the construction starts.
- Close cooperation with other authorities concerned should be maintained.

4. GENERAL FEATURES OF MEGHNA AND MEGHNA-GUMTI BRIDGES

4.1 Meghna Bridge

a) Location : Downstream of the existing Meghna ferry ghats, 250 metres on the west bank and 320 metres on the east bank.

b) Bridge Length : 930 metres (including a 50 m long approach span bridge on Comilla side)

c) Bridge Type : Cast-in-situ Prestressed Concrete Box Girder (maximum span length = 87 metres)

d) Bridge Sections : Width = 9.2 metres
Carriageway width = 7.2 metres
Side walk width = 1.0 metre on both sides

e) Approach Road Length :

Dhaka side	:	937 metres
Comilla side	:	1,028 metres
Total	:	1,965 metres

f) Major Materials Required	:	Cement	:	7,700 tons
		Sand	:	4,560 cub. metres
		Shingle	:	7,750 cub. metres
		Pit sand	:	4,560 cub. metres
		Crushed stone	:	7,750 cub. metres
		Plasticiser	:	20.4 tons
		TORSTEEL	:	2,040 tons
		Deformed bar	:	840 tons
		High tensile bar & accessories	:	420 tons
		High tensile wire & accessories	:	9 tons
		Fabricated steel & cast iron	:	106 tons
		Shaped steels	:	6,910 tons
g) Construction Cost: (June 1984 prices)		Foreign currency	:	Tk.359 million
		Local currency	:	Tk.528 million
		Total	:	Tk.887 million
h) Land Acquisition Cost	:	Tk.12 million		
i) Construction Period	:	48 months		

4.2 Meghna-Gumti Bridge

a) Location : Upstream of the existing Meghna-Gumti ferry ghats, 50 metres on the west bank and 120 metres on the east bank.

b) Bridge Length : 1,480 metres.

c) Bridge Type : Cast-in-situ Prestressed Concrete Box Girder (maximum span length = 90 metres)

d) Bridge Sections : Width = 9.2 metres
Carriageway width = 7.2 metres
Side walk width = 1.0 metre on both sides

e)	Approach Road Length	: Dhaka side	:	900 metres
		Comilla side	:	440 metres
		Total	:	1,340 metres
f)	Major Materials Required	: Cement	:	16,540 tons
		Sand	:	9,660 cub. metres
		Shingle	:	15,740 cub. metres
		Pit sand	:	9,660 cub. metres
		Crushed stone	:	15,740 cub. metres
		Plasticiser	:	42.7 tons
		TORSTEEL	:	3,680 tons
		Deformed bar	:	1,480 tons
		High tensile bar & accessories	:	760 tons
		Fabricated steel & cast iron	:	100 tons
		Shaped steels	:	10,810 tons
g)	Construction Cost: (June 1984 prices)	Foreign currency	:	Tk. 518 million
		Local currency	:	Tk. 670 million
		Total	:	Tk.1,188 million
h)	Land Acquisition: Cost	Tk.6 million		
i)	Construction Period	: 58 months		

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