DEPARTMENT OF FEEDER ROADS
MINISTRY OF ROADS AND TRANSPORT
THE REPUBLIC OF GHANA

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR CONSTRUCTION OF SMALL AND MEDIUM SCALE BRIDGES IN THE REPUBLIC OF GHANA

OCTOBER 2000

JAPAN INTERNATIONAL COOPERATION AGENCY
KATAHIRA & ENGINEERS INTERNATIONAL

PREFACE

In response to a request from the Government of the Republic of Ghana, the Government of Japan decided to conduct a basic design study on the Project for Construction of Small and Medium Scale Bridges and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Ghana a study team from January 11 to February 24, 2000 and from April 5 to June 3, 2000.

The team held discussions with the officials concerned of the Government of the Republic of Ghana, and conducted field studies at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Ghana from August 19 to August 30, 2000 in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Ghana for their close cooperation extended to the team.

October, 2000

Kunihiko Saito
President
Japan International Cooperation Agency

October, 2000

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Construction of Small and Medium Scale Bridges in the Republic of Ghana.

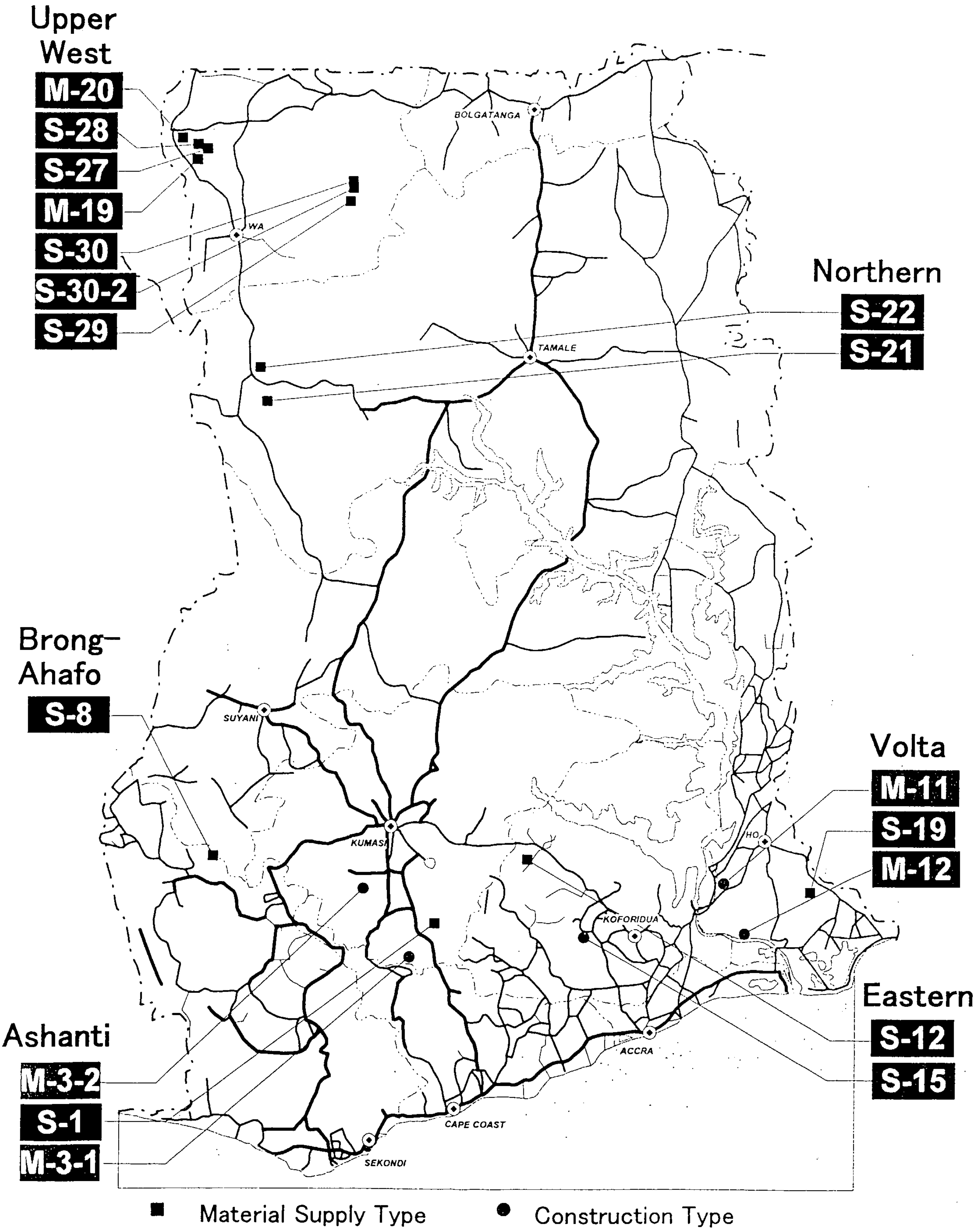
This study was conducted by Katahira & Engineers International, under a contract to JICA, during the period from January 7 to October 31, 2000. In conducting the study, we have examined the feasibility and rationale of the project, with due consideration to the present situation of Ghana, and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the Project.

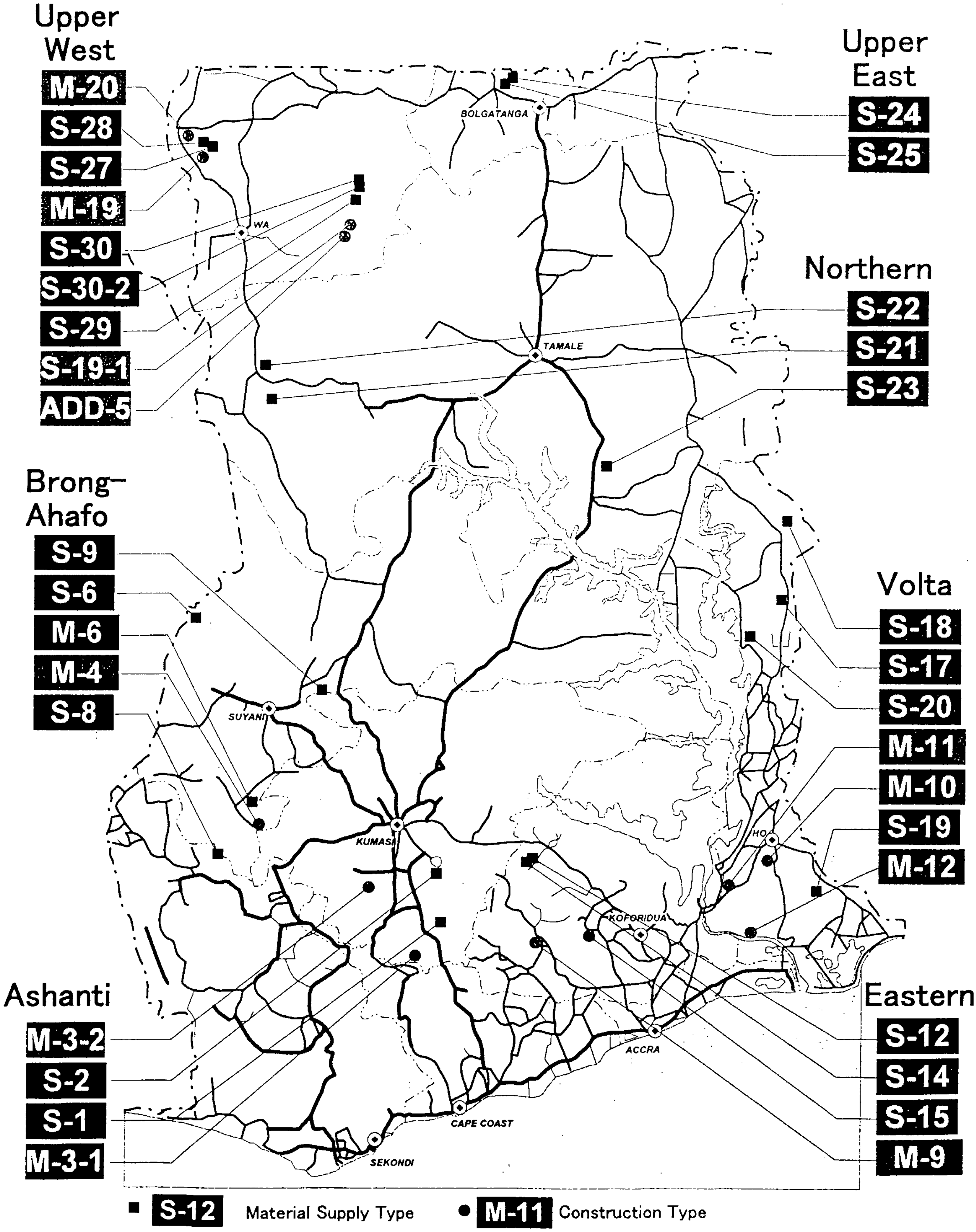
Very truly yours,

木内滿雄

Mitsuo Kiuchi
Project Manager,
Basic Design Study Team on the Project for
Construction of Small and Medium Scale Bridges
in the Republic of Ghana
Katahira & Engineers International



Location Map of Bridges for the Project



Location Map of Requested Bridges

BRIDGE S-27
(Material Supply Type)

PERSPECTIVE

PERSPECTIVE

BRIDGE M-3-2
(Construction Type)

Abbreviations

B.S.	:	British Standards
B H N	:	Basic Human Needs
D F I D	:	Department for International Development
D F R	:	Department of Feeder Roads
D U R	:	Department of Urban Roads
G D P	:	Gross Domestic Product
G H A	:	Ghana Highway Authority
G O J	:	Government of Japan
H.T.B.	:	High Tension Bolt
J I S	:	Japan Industrial Standards
M R T	:	Ministry of Roads and Transport
N D P C	:	National Development Planning Commission
P C	:	Prestressed Concrete
R C	:	Reinforced Concrete

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CHAPTER 1

BACKGROUND OF THE PROJECT

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1.1 Background of the Project

In Ghana, the road transport is the dominant transport mode, carring 94 % of goods and 97% of passengers. In view of importance of the road sector for the sound development of the country, the Government of Ghana formulated the Medium Term Road Development Plan (1995～2000) in 1995. Based on the Plan, the road sector development has been pursued and about 20% of the national budget have been allocated to the road network development. Due to the continuous efforts of the Government, development of urban roads in the large urban centers and trunk roads has been progressed in the recent years. However, development of feeder roads in the rural areas is left behind due to financial constraint and is one of the key issues of the road sector.

Along feeder roads in the rural areas, there are still many rivers which are not spanned by a bridge. There are also many temporary wooden bridges which can not allow vehicle passage and become impossible during rainy seasons. The agricultural system in Ghana is mostly small scale forming on individual basis. Farmers earn their income by selling their agricultural products at markets. They transport agricultural products to markets by themselves, however, traffic bottleneck at the bridge sites hampers the accessibility to markets, resulting in less opportunities to sell their products. Such transport condition is greatly discouraging farmers to produce more and causing low productivity of agricultural products.

Transport bottlenecks at bridge sites are not only hampering sound economic activities, but also affecting access to the social facilities such as schools, hospitals, etc., thus rural people can not satisfactorily receive the basic social services.

In order to improve daily life environment of rural people and to properly support socio-economic development of rural areas by removing such transport bottlenecks, the Government of Ghana made a request to the Government of Japan for grant aid for construction and procurement of superstructure material for small and medium scale bridges. The request of the Government of Ghana comprised 5 phases of bridge lists. It was confirmed through a diplomatic channel that the First and Second phases of bridges (33 bridges) shall be subjected to the basic design study. During the course of the Study, an additional bridge was requested by the Government of Ghana and a total of 34 bridges were studied.

CHAPTER 2

CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

The Project aims to promote the economic development of the rural areas and to improve the accessibility to commercial and social facilities such as markets, hospitals, schools, etc., by constructing bridges along the feeder roads.

The present condition of the 34 requested bridges are as follows: 21 sites have no bridge, 7 are temporary (log or bailey) bridges, 3 are foot bridges, 1 is a box culvert and 2 are permanent bridges. Most of temporary bridges can not allow the vehicle passage due to weak structure and even permanent bridges become impassable during the rainy season. Such poor conditions at the bridge sites causes the traffic bottlenecks for the movement of goods and people.

The objectives of the Project are as follows:

- To secure traffic and improve the movement of goods and people along the subject feeder roads.
- To contribute to the regional economic development and alleviation of poverty.
- To satisfy the basic human needs (BHN).

(1) To Secure Traffic and Improve the Movement of Goods and People Along the Subject Feeder Roads

By construction of bridges along the feeder roads, the traffic bottlenecks such as no bridge and traffic interruption during the rainy seasons will be eliminated in order to secure traffic. Bridges will also reduce detour distance which results in traffic cost savings and improves the movements of goods and people.

(2) To Contribute to the Regional Economic Development and Alleviation of Poverty

The agricultural system in Ghana is mostly small scale farming on individual basis. Farmers earn their income by selling their agricultural products at markets. They transport their products to markets by themselves, however, traffic bottleneck at the bridge site hampers the accessibility to markets, resulting in less opportunities to sell their products. Such transport condition is greatly discouraging farmers to produce more and causing low productivity of agricultural products. Construction of bridges along the subject feeder roads removes such transport constraints and contribute to enhance the regional economic development and increase farmers income, thus alleviating poverty.

(3) To Satisfy BHNs

Accessibility to hospitals, schools and other social/cultural facilities is greatly hampered due to low development level of bridge construction, therefore, BHNs are not satisfied yet. Hospitals are located only at Regional and District Capitals. Although Junior Secondary Schools (JSS) are established at major towns, Senior Secondary Schools (SSS) are located only at District Capitals. Construction of bridges will greatly improve accessibility to such facilities and contribute to improve the level of BHN satisfaction.

2.2 Basic Concept of the Project

Requested bridges were evaluated from the view points of engineering necessity / urgency and socio-economic effect to select bridges for the Project. Selected bridges were classified into the material supply type and the construction type. For the former type of bridges, necessity of procurement of materials and tools for superstructure assembly and erection as well as necessity of technical assistance were evaluated. Based on the above studies, the basic concept of the Project was established.

2.2.1 Selection of Bridges for the Project

(1) Selection Procedure

The procedure to select bridges for the Project is shown in Figure 2.2.1-1.

(2) Selection of Bridges for the Project

Engineering and socio-economic conditions of the requested 34 bridge sites are presented in Appendix-6. Selection criteria of bridges for the 2nd field survey and evaluation results are presented in Appendix-7. Based on the hydrological / hydraulic survey and analysis, the topographic survey and the geo-technical survey undertaken during the 2nd field survey, selected 22 bridges for the 2nd field survey were re-evaluated after determining the bridge location, bridge length, foundation type, etc. The following 4 bridges were excluded from the Project:

- A bridge is located in the huge flood plain and its approach road is submerged over one kilometer during the rainy seasons, therefore, not appropriate for bridge construction at present, and recommended to differ.
  → 3 bridges (M-4, S-24 and S-25)

- There is an other alternative road near a bridge and additional detour distance is less than 20 km, therefore, not urgently needed.
  → 1 bridge (M-9)

As a result, 18 bridges were recommended for the Project.

Engineering and socio-economic characteristics of 34 requested bridges and their appropriateness for the Project are shown in Table 2.2.1-1.

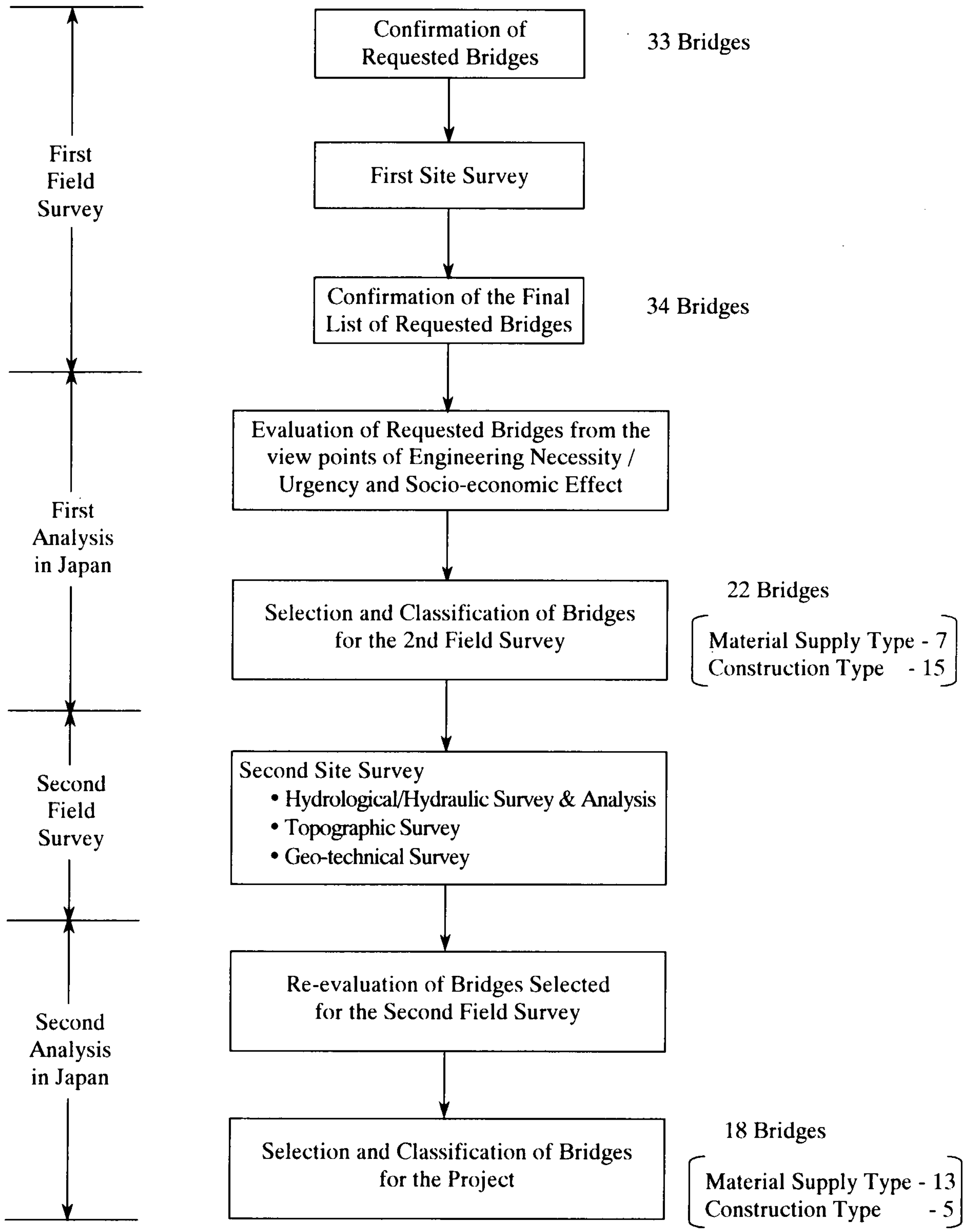


FIGURE 2.2.1-1 BRIDGE SELECTION PROCEDURE

TABLE 2.2.1-1 ENGINEERING AND SOCIO-ECONOMIC CHARACTERISTICS OF REQUESTED BRIDGES AND APPROPRIATENESS FOR THE PROJECT

Bridge No.	Region	Engineering Characteristics: Existing Bridge	Type	No. of Impassable Days/Year	Need of Re-Construction	Required Bridge Length (m)	Type of Bridge Needed	Alternative Route	Additional Distance (km)	Flood Plane	Socio-economic Characteristics: No. of Beneficiary	Influence Area (km2)	Vehicle (veh./day)	Potential (veh./day)	Pedestrian (person/day)	No. of Markets Accessible	Appropriateness for the Project
S-17	Volta	Exist	R C D G	4 (4)	No	-	-	Yes	21.0		4,700	56	28	0	140	1→1	• Not appropriate • Existing bridge is sound & usable.
S-18	Volta	None	(Ford Crossing)	4 (4)	Yes	-	River Bed Protection	None	∞		8,900	78	30	57	400	1→2	• Not appropriate • River bed protection rather than a bridge
S-19	Volta	None	(Ford Crossing)	60 (60)	Yes	15	1 span	Yes	25.5		8,100	39	8	30	450	1→2	• Appropriate
S-20	Volta	None	-	10 (365)	Yes	30	1 span	None	∞		3,800	10	0	12	350	0→1	• Not appropriate • Low social / economic effect
M-10	Volta	Exist	Log Bridge	15 (15)	Yes	15	1 span	None	∞		2,500	23	20	0	250	0→1	• Not appropriate • Low social / economic effect
M-11	Volta	None	-	150 (365)	Yes	27.65	1~4 spans	Yes	35.3		12,800	63	0	32	700	0→1	• Appropriate
M-12	Volta	None	-	365 (365)	Yes	51.92	2~3 spans	None	∞		24,100	92	0	168	500	1→2	• Appropriate
S-12	Eastern	Exist	(Foot Bridge)	35 (365)	Yes	20	1~3 spans	Yes	25.7		5,700	23	0	40	830	0→2	• Appropriate
S-14	Eastern	Exist	Log Bridge	22 (22)	Yes	25	1 span	Yes	31.6		3,250	18	0	26	315	0→2	• Not appropriate • Low social / economic effect
S-15	Eastern	Exist	(Foot Bridge)	21 (365)	Yes	20.74	1~3 spans	Yes	24.8		10,300	49	0	76	1,040	1→2	• Appropriate
M-9	Eastern	None	-	365 (365)	Yes	50	2~3 spans	Yes	12.3		23,100	63	0	148	1,500	4→4	• Not appropriate • Detour available, not urgent
S-1	Ashanti	Exist	Log Bridge	3 (3)	Yes	20	1 span	Yes	50.7		8,900	41	100	50	1,600	1→2	• Appropriate
S-2	Ashanti	Exist	Log Bridge	9 (9)	Yes	-	R C B C	Yes	40.9		29,300	35	150	45	1,050	1→3	• Not appropriate • Box culvert rather than a bridge
M-3-1	Ashanti	None	-	365 (365)	Yes	56.92	3 spans	None	∞		40,000	90	0	248	2,600	2→5	• Appropriate
M-3-2	Ashanti	None	-	365 (365)	Yes	35.70	1~2 spans	None	∞		24,900	78	0	166	600	1→3	• Appropriate
S-6	Brong-Ahafo	Exist	Log Bridge	18 (18)	Yes	25	1 span	None	∞		3,800	22	55	0	600	0→2	• Not appropriate • Low social / economic effect
S-8	Brong-Ahafo	Exist	Log Bridge	12 (12)	Yes	25	1 span	None	∞		16,400	197	65	33	1,100	1→2	• Appropriate
S-9	Brong-Ahafo	Exist	(Foot Bridge)	14 (365)	Yes	45	2 spans	Yes	33.0		7,300	42	0	74	470	1→2	• Not appropriate • Long bridge affect social / economic effect
M-4	Brong-Ahafo	None	-	365 (365)	Yes	40	1~2 spans	Yes	34.6	Very Wide	24,900	67	0	120	325	2→3	• Not appropriate • Approach road submerged over 1 km.
M-6	Brong-Ahafo	Exist	R C D G	16 (16)	No	-	-	Yes	35.8		22,800	64	140	0	700	2→2	• Not appropriate • Existing bridge is sound & usable.
S-21	Northern	None	(Ford Crossing)	8 (60)	Yes	20	1 span	Yes	49.6		6,800	198	15	80	130	2→4	• Appropriate
S-22	Northern	None	(Ford Crossing)	8 (60)	Yes	25	1 span	None	∞		7,500	65	0	28	500	0→1	• Appropriate
S-23	Northern	None	(Culverts)	6 (60)	Yes	100~200	4~6 spans	None	∞		13,500	218	11	71	2,000	0→1	• Not appropriate • Bridge is too long for the Project.
S-24	Upper East	None	-	20 (365)	Yes	45	1~2 spans	None	∞	Very Wide	9,000	61	0	38	1,500	0→1	• Not appropriate • Approach road submerged over 1 km.
S-25	Upper East	None	(Ford Crossing)	20 (90)	Yes	35	1~2 spans	None	∞	Very Wide	18,400/27,400	36/76	18	45 (88)	1,500	0→1	• Not appropriate • Approach road submerged over 1 km.
S-27	Upper West	None	(Culverts)	30 (60)	Yes	25	1 span	Yes	45.2		15,800/32,300	79/108	21	48 (131)	3,000	2→3	• Appropriate
S-28	Upper West	None	(Culverts)	15 (60)	Yes	50	2~3 spans	Yes	45.2		15,800/32,300	79/108	10	48 (131)	1,800	2→3	• Appropriate
S-29	Upper West	None	(Ford Crossing)	60 (60)	Yes	15	1 span	None	∞		6,000/12,000	36/117	0	16 (48)	480	0→2	• Appropriate
S-30	Upper West	None	(Ford Crossing)	60 (60)	Yes	25	1 span	None	∞		10,000	91	0	39	180	0→2	• Appropriate
S-30-2	Upper West	None	(Ford Crossing)	60 (60)	Yes	20	1 span	None	∞		10,000	91	0	39	180	0→2	• Appropriate
Add-5	Upper West	None	-	90 (365)	Yes	150	4~5 spans	None	∞		21,500	500	0	360	350	1→2	• Not appropriate • GHA road • Bridge is too long.
M-19-1	Upper West	None	(Ford Crossing)	15 (45)	Yes	-	River Bed Protection	None	∞		4,000/21,500	85/500	0	25/360	500	1→2	• Not appropriate • GHA road • River bed protection rather than bridge.
M-19	Upper West	Exist	Bailey	Unknown (60)	Yes	40	2 spans	Yes	46.8		23,600	67	105	0	1,500	1→2	• Appropriate
M-20	Upper West	Exist	(R C B C)	0 (60)	Yes	25	1 span	Yes	48.0		13,700/32,300	29/108	12	0/31	2,000	1→3	• Appropriate

(3) Classification of Bridges into Material Supply Type and Construction Type

Selected bridges were classified into a material supply type and a construction type based on the following criteria:

Bridges not appropriate for a material supply type

- Technically difficult for most Ghanaian contractors to construct sub-structure and foundation, specifically under the following site conditions:

  - a site where there is always water and a cofferdam is required for the sub-structure construction.
  - a site where pile foundation is required.

Multi-span bridges appropriate for a material supply type

- Multi-span bridges were judged appropriate for a material supply type under the following site conditions:

  - a site where there is no water during dry seasons and sub-structure can be constructed by the open-cut method.
  - Ghanaian contractors have experience of 1-span bridge erection by the launching method. Erection of multi-span bridges can be undertaken by the same method, therefore, Ghanaian contractors were judged to be able to erect multi-span bridges. Connecting member materials between spans, appropriate winches, etc. are needed to be supplied. It is also recommended to include the erection training in the technical assistance.

Construction Type Bridges

Bridges other than a material supply type were classified into a construction type.

Bridge classification of selected 18 bridges for the Project is summarized in Table 2.2.1-2.

TABLE 2.2.1-2 BRIDGE CLASSIFICATION OF SELECTED BRIDGES FOR THE PROJECT

Region	No. of Requested Bridges	Bridges for the Project		
		Material Supply Type	Construction Type	Total
Volta	7	S-19 (15 m)	M-11 (46.94 m) M-12 (52.04 m)	3 (113.98 m)
Eastern	4	S-12 (20 m)	S-15 (31.88 m)	2 (51.88 m)
Ashanti	4	S-1 (20 m)	M-3-1 (57.04 m) M-3-2 (35.70 m)	3 (112.74 m)
Brong-Ahafo	5	S-8 (25 m)	---	1 (25.00 m)
Upper East	2	---	---	---
Northern	3	S-21 (20 m) S-22 (25 m)	---	2 (45.00 m)
Upper West	9	S-27 (25 m) S-28 (50 m) S-29 (15 m) S-30 (25 m) S-30-2 (20 m) M-19 (40 m) M-20 (25 m)	---	7 (200.00 m)
Total	34	13 (325 m)	5 (223.60 m)	18 (548.60 m)

2.2.2 Necessity of Procurement of Superstructure Assembly and Erection Tools

Request made for the superstructure assembly and erection tools and vehicles was as follows:

REQUEST FOR ASSEMBLY AND ERECTION TOOLS

Vehicles for Construction Supervision and Material Transportation	No. of Vehicle
• Pick-up (including spare parts)	7
• 8t Cargo Truck(including spare parts)	2
• 8～10t Truck with Crane (including spare parts)	1
Assembly and Erection Tools	**No. of Set**
• Launching nose	2
• Assembly tools	2
• Erection and launching tools	2
Survey Equipment	**No. of Set**
• Total Station	2
• GPS	2

(1) Vehicles for Construction Supervision and Transportation of Materials

The following vehicles were procured under the Project for Small Stream Bridges Rehabilitation in 1996 and these are still in fair condition, therefore, can be utilized and number of vehicles are sufficient for the Project:

Vehicles Already Procured	No. of Vehicles
• Pick-up	6
• 4 WD Wagon	2
• 8t Truck	4
• 4t Truck	4
• Semi-trailer	1
• 16t Crane	2

With regard to a truck with crane, it is considered to be effective for transporting superstructure materials, however, 2 cranes and 1 trailer have already been procured which can be used for the same purpose. It is recommended that no additional vehicles are necessary for the Project.

(2) Assembly and Erection Tools

Three sets of assembly and erection tools for 1-span bridge erection have been procured under the Project for Small Stream Bridges Rehabilitation. The erection method adopted was the launching method on the staging. During the implementation of the similar project using the same erection method, DFR has the experience that the superstructure fell down to the river due to collapse of the staging work. Therefore, DFR strongly requested to adopt a launching nose erection method, of which advantages are as follows:

- The method can be applicable during rainy seasons.
- Erection period can be reduced and cost for the staging work can be eliminated.
- Safer method in Ghana.

The Project plans to erect 2 and 3-span bridges by a launching method, therefore, bigger capacity of winches, rollers, etc., are required.

The storage location of the procured assembly tools is shown in Table 2.2.2-1. Condition and quantity of tools stored in the DFR ACCRA workshop were confirmed by the Study Team. Those which are leased to the Contractors could not be confirmed their condition and quantities. Some of tools leased to the Contractors are said to be damaged. Whereabouts of many small tools such as hammers, wire clips, etc. are unknown.

In due consideration of above, the Project procures the following tools:

- Launching nose 1 set
- Assembly and erection tools 1 set

Table 2.2.2-1 Storage Situation of Assembly Tools

Item	Tool / Product	Supplied Number (for 3 sets)	Storage Situation		
			D F R Accra Storage	Out on Loan for Contractor	Total
Survey Tools	Level Gauge	3 pcs.	-	2	2
	Steel Measuring Tape	3 pcs.	1	1	2
Assembly Tools	Torque Wrench	12 pcs.	-	4	4
	Socket	18 pcs.	-	9	-
	Single Offset Wrench	30 pcs.	-	14	14
	Sledge Hammer, Double Face	6 pcs.	-	2	2
	Hand Hammer, Double Face	30 pcs.	-	1	1
	Lever Block	6 pcs.	-	-	-
	Bolt Clipper	3 pcs.	-	-	-
	Wire Clip	60 pcs.	-	-	-
	Craw Bar	3 pcs.	-	-	-
	Craw Bar	3 pcs.	-	-	-
	Erection Bolt	900 pcs.	-	-	-
	Drift Pin	450 pcs.	360	-	360
Lifting Equipment	Three Prong Lift	6 pcs.	2	-	2
	Pulley Block	12 pcs.	5	-	5
	Shackle	12 pcs.	-	12	12
	Pipe	18 pcs.	-	2	2
	Nylon Sling	24 pcs.	3	-	3
	Portable Winch	6 units	4	-	-
	Steel Wire Rope	6 rolls	-	-	-
	Stay Wire Rope	6 pcs.	-	-	-
	Base Beam	6 pcs.	-	-	-
Scaffolding	Scaffolding	12 sets	2	-	2
	Stage Plank	9 pcs.	3	-	3
	Jack Base	24 pcs.	3	-	3
	Ladder	3 pcs.	-	-	-
	Bracing	12 pcs.	6	-	6

(3) Survey Equipment

The detailed design and construction supervision works are contracted out to the local consulting firms and DFR does not undertake such works by force account, therefore, need of survey equipment is not so high. During the checking of survey works, DFR can utilize equipment owned by the local consulting firm, therefore, procurement of survey equipment under the Project is not required.

2.2.3 Technical Assistance for the Material Supply Type Bridges

Twenty one bridges procured under the Japan's Grant Aid in 1996 were constructed by DFR. The Study Team visited all the sites and found that there is no critical errors or mistakes, but there are some matters to be corrected. During the implementation of the previous project, the Government of Japan did not have the technical assistance scheme for the material supply projects. In due consideration of importance of technical assistance, the Government of Japan introduced the technical assistance scheme. In order to assure the technically sound construction, and to realize the effects of the project at the earliest possible time as well as to assure sustainable project effects, the Project plans to include the following technical assistance for the material supply type bridges:

<u>Detailed Design Stage</u>

- Preparation of standard design for sub-structure and related works
- Preparation of design guidelines
- Preparation of superstructure erection guidelines
- Preparation of material management and delivery guidelines

<u>Construction Supervision Stage</u>

- Training in superstructure assembly and erection
- Preparation of construction supervision guidelines

2.2.4 Basic Concept of the Project

The basic concept of the Project is summarized as follows:

- Procurement of superstructure materials for the 13 bridges (bridge length = 325 m)
- Construction of 5 bridges (bridge length = 223.60 m)
- Procurement of superstructure assembly and erection tools for the material supply type bridges ------ one set
- Technical assistance for the material supply type bridges

2.3 Basic Design

2.3.1 Design Concept

2.3.1.1 Principle Design Concept

All bridges will be constructed along the feeder roads, of which functions are as follows:

- A road for rural people's daily activities.
- A road to contribute agricultural production increase by connecting farms with markets and/or trunk roads.
- A road to secure access to basic social facilities such as schools, hospitals, markets, etc.

Traffic volume on feeder roads is basically not so heavy, therefore, appropriate bridge size shall be determined in consideration of traffic service level required by each bridge, and principle design concept is described below.

(1) Number of Lane of Bridges

Number of lane of a bridge is determined by traffic volume and bridge length. Maximum traffic volume of subject bridges at market days is less than 400 veh./day and bridge length is less than 60 m. Traffic volume which requires a 2-lane bridge is about 800 veh./day. All bridges of the Project shall be a 1-lane bridge.

(2) Sidewalk

It is ideal to provide a sidewalk for a bridge, in order to secure traffic safety of pedestrians. However, provision of a sidewalk may not be economically justifiable depending on traffic volume, number of pedestrians and bridge length. Such a provision to construct a hump before a bridge so that vehicles are forced to reduce running speed may be more practical solution for traffic safety.

In case of a bridge with length of 30 m, time required to cross a bridge is about 0.5 minute. During this period, possibility of number of pedestrians who cross a bridge would be 2 in case of pedestrian traffic of 1,000 persons/day and possibility of vehicles would be 0.3 vehicles in case of daily traffic volume of 200. Under such condition, one out of 6 pedestrians would encounter one vehicle.

A sidewalk should be provided when a bridge satisfies all of 3 conditions below:

- Bridge length is over 30 m
- Vehicular traffic volume on market days is over 200 veh./day.
- Number of pedestrians is over 1,000 people per day.

Traffic volume, number of pedestrians and bridge length of each bridge is shown in Table 2.3.1-1. Bridges which require a sidewalk are as follows:

Bridge with a sidewalk : 2 bridges (M-3-1, M-19)

For bridges without a sidewalk, following safety measures should be adopted:

- A hump shall be provided before a bridge.
- Necessary traffic signs, warning signs, etc., shall be provided.
- A bridge shall be so designed that a sidewalk can be provided in future as much as possible.

TABLE 2.3.1-1 NECESSITY OF SIDE WALK

Bridge No.	Traffic Flow Volume				Bridge Length (m)	Necessity of Side Walk
	Predicted Vehicle Volume (per day)		Motorcycle (per day)	Pedestrian		
	Ordinary Day	Market Day				
S-19	56	112	-	450	15m	Not necessary
M-11	74	148	-	700	28m	Not necessary
M-12	168	252	-	500	50m	Not necessary
S-12	42	84	-	830	20m	Not necessary
S-15	76	152	-	1,040	26m	Not necessary
S-1	150	225	10	1,600	20m	Not necessary
M-3-1	248	372	-	2,600	55m	Necessary
M-3-2	166	249	-	600	35m	Not necessary
S-8	98	196	10	1,100	25m	Not necessary
S-21	95	190	-	130	20m	Not necessary
S-22	47	94	-	500	25m	Not necessary
S-27	152	228	15	1,000	25m	Not necessary
S-28	141	212	10	800	50m	Not necessary
M-20	143	215	15	1,200	25m	Not necessary
S-29	69	138	-	480	15m	Not necessary
S-30	54	108	-	180	25m	Not necessary
M-30-2	54	108	-	180	20m	Not necessary
M-19	105	210	50	1,500	40m	Necessary

Note 1) On Market days, Vehicle Volume increases to 150%-200%.

Note 2) Pedestrian Volume is based on the result of the interview survey.

(3) Principle Concept for Determining River Conditions for Bridge Planning

Hydrological data such as rainfall, water levels, etc., in Ghana are not well-established. Rivers in the project area flow down repeating over-flow and storage, therefore, detailed topographic data are required for a detail hydrological and hydraulic analysis. Due to lack of detailed data, detailed analysis can not be expected. Under such situation, river conditions which are needed for bridge planning are established in accordance with the following considerations:

- Basic river conditions shall be determined based on data obtained by the interview survey as well as the engineering judgment of the Study team members.
- Results of the hydrological and hydraulic analysis shall be used to support the above interview results and the Study Team members' judgment.
- Rivers shall be classified into 3 types as follows:
  - Case-1 : River channel can be clearly defined and no overflow is observed.
  - Case-2 : River channel is narrow and flood water overflows a channel, but a flood plane is not so wide.
  - Case-3 : River channel is narrow and flood water overflows a channel and a flood plane is quite wide.
- Flood water level obtained by the interview survey shall be considered at the probability of 10 years.
- Free board shall be determined bridge by bridge based on possibility of water level to become higher than that of the interview result and floating logs. Free board shall be determined for a minimum of 0.5 meter.

Based on the above principles, a waterway width shall be determined as follows:

Case-1 : An existing channel width shall be adopted.
Case-2 : A waterway width which will not adversely affect present condition drastically (such as backwater and velocity increase) shall be selected.
Case-3 : A waterway width shall be determined based on an existing channel width and lateral movement of a channel course.

(4) Design Concept of Material Supply Type Bridges

Principle concept is as follows:

- Superstructure of a bridge can be assembled and erected by utilizing man-power and small scale equipment in due consideration of local contractors' capability. In order to realize this concept, maximum weight of one member shall be about 250 kg.

- A type of superstructure shall be the same as procured in 1996, for which Ghana has experiences of assembly and erection. Necessary improvement in design shall be made based on the previous experience.

(5) Design Concept of Construction Type Bridges

Taking into account Ghana's design standards, construction conditions, local materials available, required maintenance, etc., possible bridge type alternatives shall be established and compared. The optimum type of a bridge from the engineering and economic viewpoints shall be selected.

(6) Design Speed of Approach Road

Standard road width of feeder roads is 6 m which is operated as an 2-lane road. All bridges under the Project are a 1-lane bridge, therefore, a road width must be narrowed from 2-lane to1-lane. Therefore, design speed should be set low, so that vehicles have to reduce their traveling speed at bridge approach, which will reduce traffic accidents as well as to avoid vehicle collision with bridge members. With above considerations, the design speed of an approach road was selected to be 40 km/hr based on the Feeder Road Design Standard of DFR.

(7) River Bank Protection and River Bed Protection

River conditions such as, discharge, water velocity, floating logs, possibility of river course change and river bed elevation change, etc., shall be carefully studied to design river bank protection works and river bed protection works.

2.3.1.2 Bridge Design Standards and Criteria

1) Design Specifications

Bridge design of feeder road bridges generally follows GHA's guideline, i.e. 「Guide For Bridge Design, 1991」. The Project adopts the same guidelines for bridge design. As the GHA's guidelines follows the British Standards, some items which are not specified in the Guidelines, B.S. Standards shall be referred.

2) Design Loads

Live load	:	HA loading and to be checked against 30 units of HB loading (British Standard)
Temperature Change	:	+8℃ ~ +51℃
Wind force	:	27 m/sec
Earthquake	:	lateral earthquake coefficient = 0.08

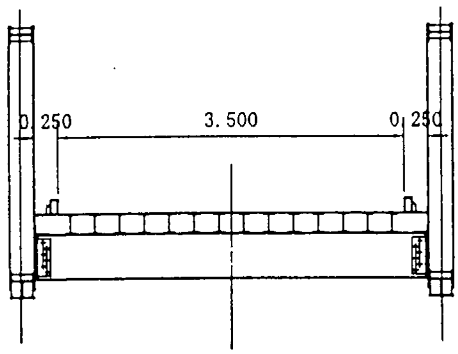
3) Standard Bridge Cross Section

Carriageway width	:	3.5 m
Sidewalk width	:	1.0 m
Lateral clearance	:	0.25 m

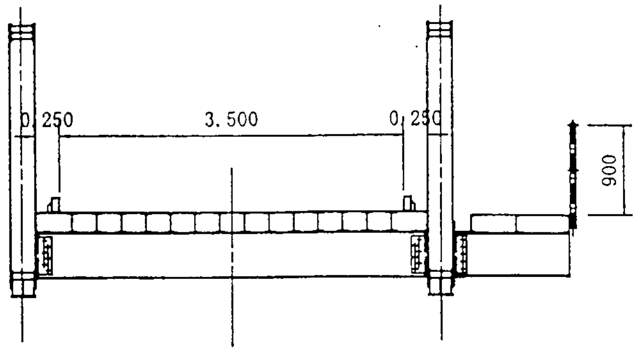
Standard bridge cross sections are shown in Figure 2.3.1-1.

4) Design Strength of Materials

Concrete	:	RC Girder/RC Slab Bridge	240 kgf/cm^2
		Slab	240 kgf/cm^2
		Abutment/Pier	240 kgf/cm^2
Reinforcing Bar	:	up to D 25 mm (local material) – BS 4449	
		D 29 – D 32 mm – JIS SD 295	
Steel Materials	:	JIS	
		SS 400 (BS Equivalent)	
		SS 490 (BS Equivalent)	
		SM 490 Y (BS Equivalent)	

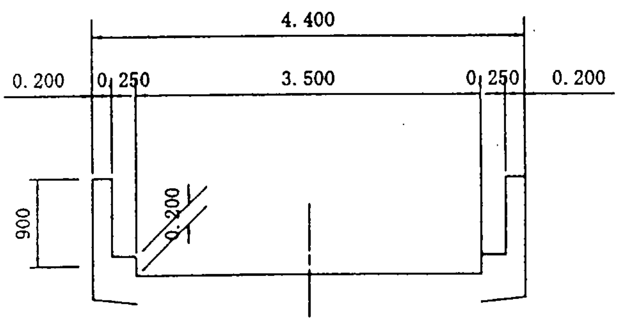


1 LANE PONY TRUSS BRIDGE
WITHOUT SIDE WALK

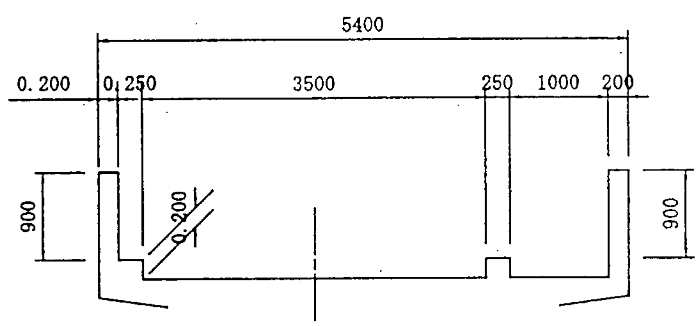


1 LANE PONY TRUSS BRIDGE
WITH SIDE WALK

PONY TRUSS BRIDGE TYPICAL SECTION



1 LANE DECK BRIDGE
WITHOUT SIDE WALK



1 LANE DECK BRIDGE
WITH SIDE WALK

DECK BRIDGE TYPICAL SECTION

FIGURE 2.3.1-1 TYPICAL SECTION OF BRIDGE

2.3.1.3 Approach Road Design Standards

DFR's Standards : 「Standard Details for Feeder Roads」 (March 1991) and GHA's standards : 「Road Design Guide」 (March 1991) shall be basically followed. Geometric design standards of approach roads are as follows:

GEOMETRIC DESIGN STANDARDS OF APPORACH ROADS

	Geometric Designs Standards
Design Speed	40 km/hr.
Road Width (Carriageway + Shoulder)	6.0 m
Minimum Horizontal Curve Radius	60 m
Maximum Vertical Grade	8 %
Minimum Vertical Curve Radius	450 m
Cross Fall (Gravel Surface)	4.0 %
Maximum Superelevation	10.0 %

Standard cross sections of approach roads are shown in Figure 2.3.1-2.

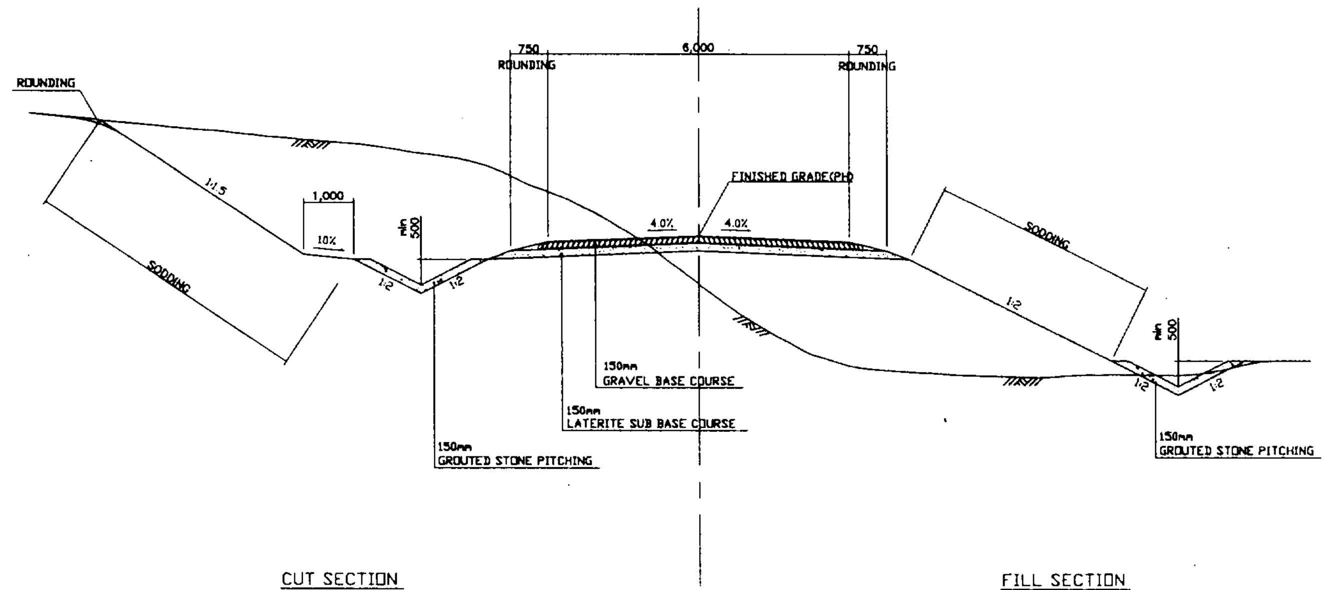


FIGURE 2.3.1-2 TYPICAL ROAD CROSS SECTION

2.3.2 Basic Design

2.3.2.1 Hydrological Requirements at Bridge Site

(1) General

The proposed bridge sites are distributed over seven (7) regions, except three regions in the southern part of Ghana. Outline of natural condition in the whole Ghana is described in this section.

Topography

Ghana is located in West Africa and covers 238,540 square kilometers (92,101 square miles). Ghana is bordered on the north and northwest by Burkina Faso, on the east by Togo, on the south by the Gulf of Guinea, and on the west by the Ivory Coast.

Ghana is a lowland country with gentle undulations, and mostly covered by the laterite. The country's highest point, in the eastern hills, is about 876 meters (about 2,900 feet) above sea level. The sandy coastline is backed by a coastal plain that is crossed by several rivers and streams, generally navigable only by canoe. In the west, the terrain is broken by heavily forested hills and many streams and rivers. To the north lies an undulating savanna country that is drained by the Black and White Volta rivers, which join to form the Volta. The Volta then flows south to the sea through a narrow gap in the hills. Lake Volta, formed by the Akosombo Dam on the Volta, is one of the largest artificial lakes in the world, with a reservoir area of about 8,400 square kilometers.

Climate

The climate of Ghana is tropical, but temperatures vary with season and elevation. Except in the north, two rainy seasons occur, from April to June and from September to November. In the north, the rainy season begins in March and lasts until September. Annual rainfall ranges from about 1,000 millimeters (about 40 inches) in the north to about 2,000 millimeters (about 80 inches) in the southeast.
The harmattan, a dry desert wind, blows from the northeast from December to March, lowering the humidity and creating hot days and cool nights in the north. In the south, the effects of the harmattan are felt in January. In most areas, the highest temperatures occur in March, the lowest in August. The average annual temperature is about 26 degrees centigrade (about 79 degrees Fahrenheit).
The monthly average rainfalls, rainfall days and temperatures in the last five years (1995 – 1999) at the major observation stations are shown in Figure 2.3.2-1 and locations of the major stations are listed below.

Location of observation station

Station	Latitude	Longitude	Elevation
Wa	10° 03' N	02° 30' W	323 m
Navrongo	10° 54' N	01° 06' W	201 m
Tamale	09° 30' N	00° 51' W	183 m
Yendi	09° 27' N	00° 01' W	195 m
Bole	09° 02' N	02° 29' W	299 m
Kete-Krachi	07° 49' N	00° 02' W	122 m
Wenchi	07° 45' N	02° 06' W	339 m
Sunyani	07° 20' N	02° 20' W	309 m
Kumasi	06° 43' N	01° 36' W	287 m
Abetifi	06° 40' N	00° 45' W	630 m
Ho	06° 36' N	00° 28' E	158 m
Akuse	06° 06' N	00° 07' E	19 m
Koforidua	06° 05' N	00° 15' W	167 m
Akim-Oda	05° 56' N	00° 59' W	139 m
Akatsi	06° 07' N	00° 48' E	46 m
Cape Coast	05° 06' N	01° 15' W	53 m

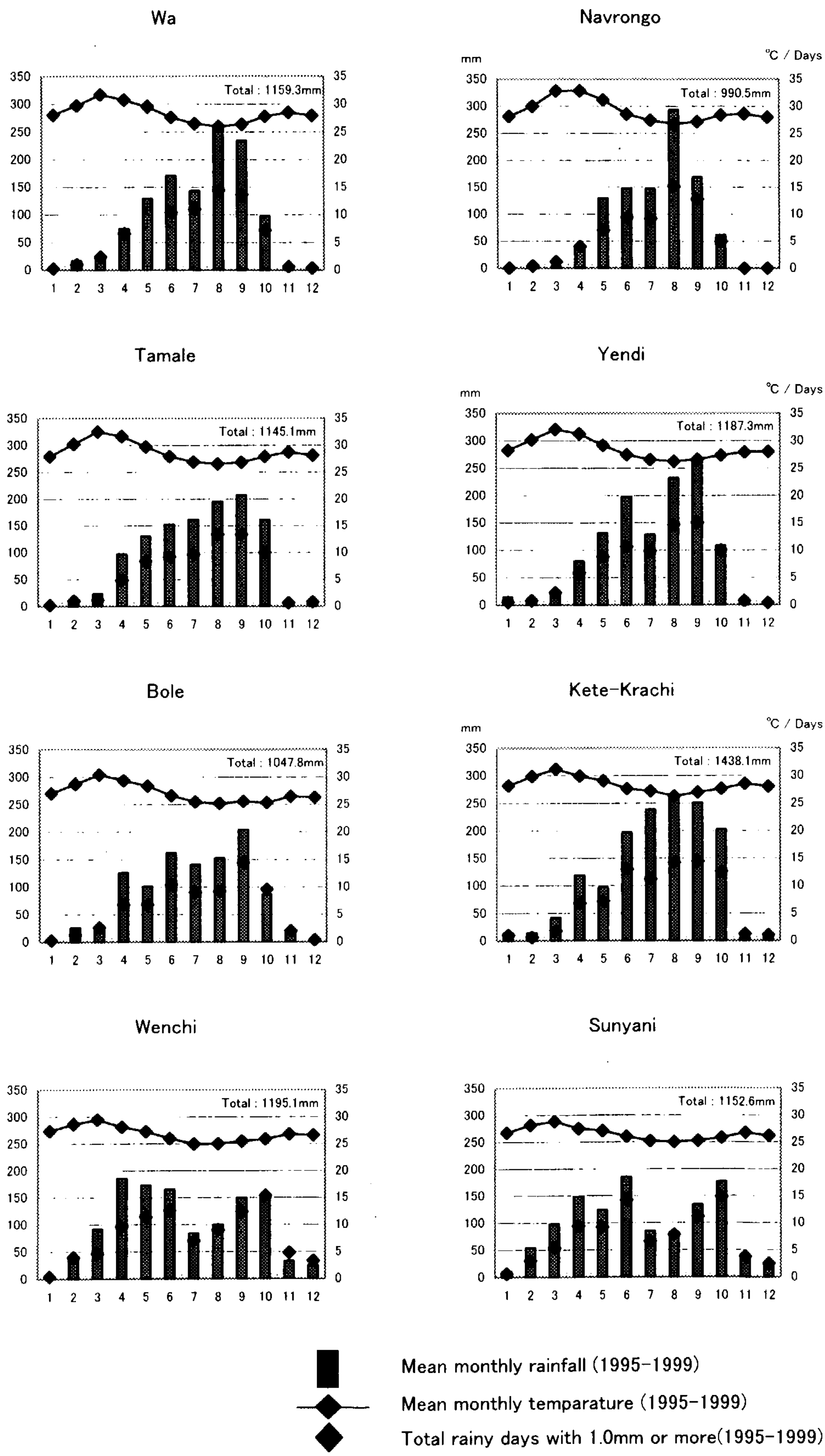


Fig. 2.3.2-1 Rainfall, Rainy Day, Temperature (1/2)

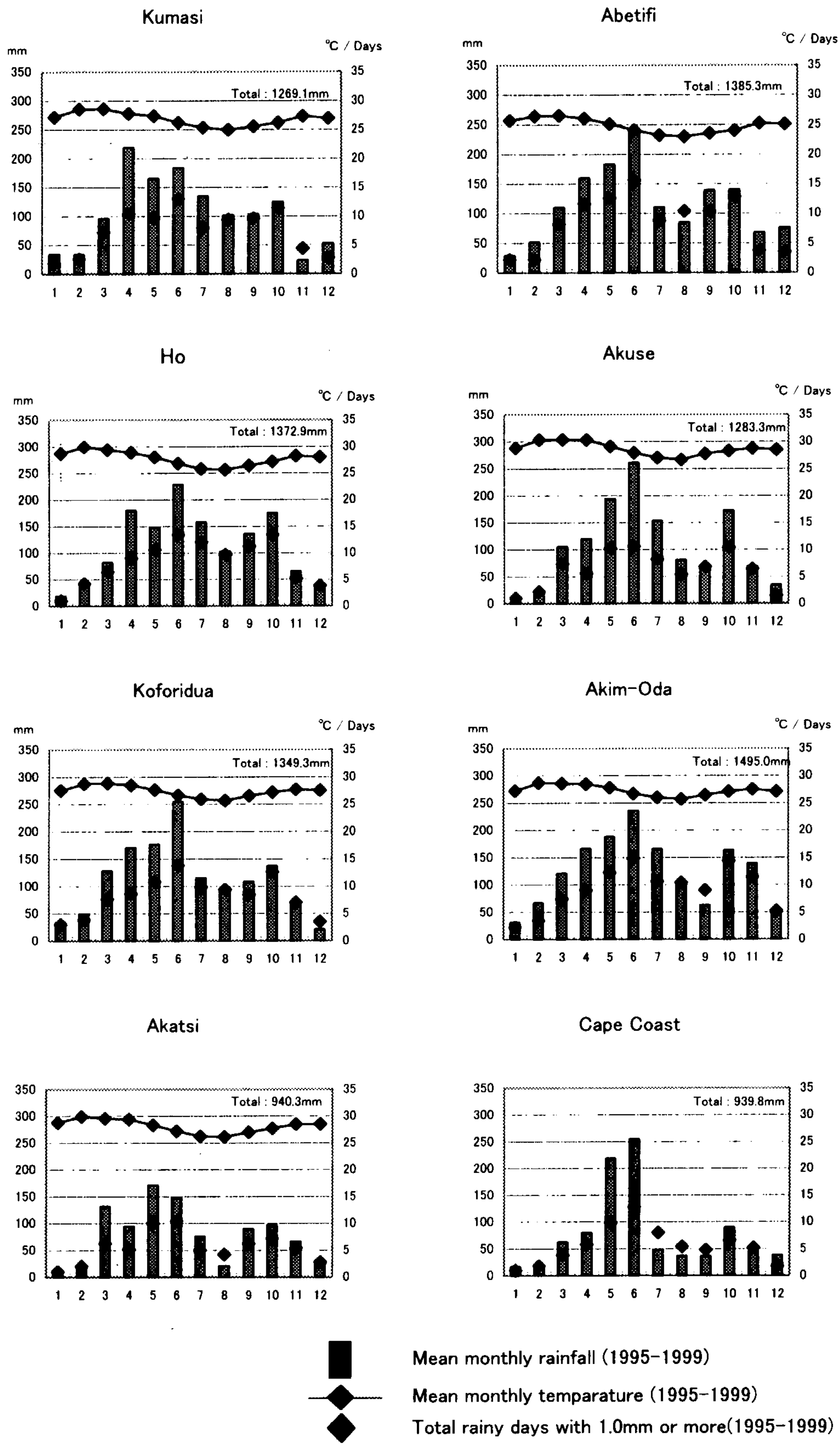


Fig. 2.3.2-1 Rainfall, Rainy Day, Temperature (2/2)

(2) River Management in Ghana

Organization for River Management

There is no organization in Ghana to administrate the rivers comprehensively, except the Volta River Authority for management of the Akosombo Dam and Lake Volta. The other concerned authorities related to the river management are as follows:

- Ministry of Works and Housing
- Ministry of Lands and Forestry
- Ministry of Environment, Science, and Technology

Availability of Basic Data

Availability of the basic data related to the rivers is as follows:

- Meteorological observation:
  Meteorological observations are managed by the Ghana Meteorological Services Department of the Ministry of Environment, Science, and Technology. The meteorological observation stations are divided into four (4), such as the synoptic stations, climatological stations, rainfall stations and agromet stations. In addition, the maximum rainfall intensity-duration frequencies at 14 major stations have been derived from the observed data.
- Hydrological observation
  Hydrological observations are managed by the Hydrological Survey Department of the Ministry of Works and Housing.
- Topographic and geological surveys
  Topographic and geological surveys are managed by the Geological Survey Department of the Ministry of Lands and Forestry.
  Topographic survey has been conducted all over the country and the topographic maps with a scale of 1/50,000 are published. In addition, aero photographs, which are the base of the topographic maps, can be examined at the Geological Survey Department.
- River survey
  River survey was not conducted with the proposed river in the past.
- Plan related to the river
  Plans related to the river, such as the river improvement plan, basin development plan and construction works plan, have not been prepared yet.

Design Criteria of Bridge

The Department of Feeder Roads does not have its own design criteria for the bridges. However, the design guide of the highway bridge, which is "GUIDE FOR

BRIDGE DESIGN, 1991 Edition" by the Ghana Highway Authority, has been applied similarly to the bridge design for the feeder roads.
According to the design guide of the highway bridges, the probability of the design flood and the freeboard are stipulated as follows:

Type of structure	Probability of design flood (Year)	Freeboard (m)	Remarks
Culvert	10	0.0	Span length < 4m
Short Bridge	25	0.5	Span length = 4 ~10m
Bridge	50	1.0	Span length = 10~25m
Major Bride	100	1.0	Span length >= 30m or Bridge length >= 50m

Hydrological and Hydraulic Problems of Existing Bridges

Based on the results of the field reconnaissance, the following problems of the existing bridges are pointed out from the hydrological and hydraulic points of view.

- Lack of the street drains: cause of gullies on the roads.
- Lack of the drainage facilities across the roads: cause of collapses of the roads at the crossing sites of the small undulations.
- Insufficient discharge capacity of the bridge and culvert
- Insufficient bridge length and road elevation

(3) Condition of Rivers at Proposed Bridge Sites

Outline

The proposed bridge sites are distributed over seven (7) regions. The conditions of river basins, river channel and present bridges are summarized as shown in Tables 2.3.2-1, -2 and –3, respectively.

Flood Characteristics

According to the results of the field reconnaissance and information from inhabitants, flood characteristics at the proposed bridge sites are as follows:

1) Within channel (Case-1)
The river channel is wide and deep, and has sufficient capacity for floods (3 bridges: S-19, M-12, M-3-2, S-25).

Table 2.3.2-1 Condition of River Basin

No.	Type	Bridge code	Region	River name	Topography	Vegitation	Catchment area (km2)	Upper most elevation (EL. m)	Ground elevation (EL. m)	Headspring elevation (EL. m)	Channel Length(L) (km)	Head (H) (m)	Bed Slope H/L (%)	Crosssectional Slope (%)	Remarks
1	M	S-19	Volta	Kplikpa	Rolling Plain	Dense	175.0	99	43	99.06	28.0	56.4	0.20	1.02	*2
2	C	M-11	Volta	Alabo	Hill	Dense	678.0	686	61	274.32	56.0	213.4	0.38	0.85	*2
3	C	M-12	Volta	Kolo	Plain	Dense	182.3	227	9	60.96	33.7	51.8	0.15	1.27	*1
4	C	S-12	Eastern	Nwin	Hill	Dense	100.0	312	201	243.84	18.4	42.7	0.23	2.34	*3
5	C	S-15	Eastern	Densu	Mountain	Dense	37.1	724	229	350.52	11.7	121.9	1.04	3.05	*1
6	C	M-9	Eastern	Birim	Hill	Dense	2510.0	457	114	457.2	100.0	342.9	0.34	2.77	*3
7	C	S-1	Ashanti	Fum	Mountain	Dense	19.9	617	162	320.04	6.3	158.5	2.52	3.05	*1
8	C	M-3-1	Ashanti	Fum	Hill	Dense	690.0	610	85	304.8	45.0	219.5	0.49	4.35	*3
9	C	M-3-2	Ashanti	Oda	Hill	Dense	1760.0	381	146	304.8	90.0	158.5	0.18	5.08	*3
10	M	S-8	Brong-Ahafo	Sui	Hill	Dense	157.7	328	183	274.32	19.5	91.4	0.47	4.06	*1
11	C	M-4	Brong-Ahafo	Tano	Hill	Dense	6160.0	533	155	457.2	150.0	301.8	0.20	1.69	*3
12	M	S-21	Northern	Kabawu	Hill	Thin	73.6	389	262	365.76	13.4	103.6	0.77	2.18	*1
13	M	S-22	Northern	Wiago	Hill	Thin	107.8	373	287	350.52	12.2	64.0	0.52	3.05	*1
14	C	S-24	Upper East	Tankara	Hill	Bare	388.0	381	174	304.8	26.0	131.1	0.50	1.08	*2
15	C	S-25	Upper East	Budunga	Hill	Bare	20.6	236	181	228.6	9.3	47.2	0.51	1.91	*1
16	C	S-27	Upper West	Nantarbo	Hill	Thin	19.0	328	253	304.8	8.1	51.8	0.64	1.17	*1
17	C	S-28	Upper West	Duaba	Hill	Thin	23.4	312	251	289.56	6.7	38.1	0.57	1.17	*1
18	M	S-29	Upper West	Hapulumbie	Hill	Thin	14.7	267	213	259.08	6.0	45.7	0.76	1.91	*1
19	M	S-30	Upper West	Bunchum	Hill	Thin	16.6	297	229	286.512	7.7	57.9	0.75	1.27	*1
20	M	S-30-2	Upper West	Vaang	Hill	Thin	10.3	312	229	274.32	5.2	45.7	0.88	2.54	*1
21	C	M-19	Upper West	Dobaa	Hill	Thin	7.0	312	280	304.8	3.2	24.4	0.76	3.05	*1
22	C	M-20	Upper West	Fulo	Hill	Thin	17.6	297	262	283.464	4.9	21.3	0.44	1.52	*1

Note
* : Channel-bed slope and ground elevation are measured by using the maps with a scale of 1/50,000.
*1: Catchment area and upper most elevation are measured by using the maps with a scale of 1/50,000.
*2: Catchment area and upper most elevation are measured by using the maps with a scale of 1/500,000.
*3: Catchment area and upper most elevation are measured by using the maps with a scale of 1/1,000,000.

DF-Table2.3.2-1~4(Rev).xls/RiverBasin/2000/10/18

Table 2.3.2-2 Condition of River Channel

No.	Type	Bridge Code	Channel Condition: LWL Width (m)	LWL Depth (m)	Width during Flood (m) Left	Width during Flood (m) Channel	Width during Flood (m) Right	Depth during Flood (m) Left	Depth during Flood (m) Channel	Depth during Flood (m) Right	Channel bed Slope (1/?)	Vegitation	River Course	Bed Material 60% (mm)	Riverbed Variation	Quantity of driftwood	Characteristics (Condition during Floods)
1	M	S-19	-	-	-	14.2	-	-	2.25	-	610	Dense	Meander	0.5-1.0	Stable	Large	within Channel
2	C	M-11	10.00	0.50	37.5	30.1	-	2.73	5.18	-	938	Dense	Meander	Rock	Stable	Large	Overflow
3	C	M-12	25.70	1.80	8.1	47.2	-	0.60	4.80	-	3,170	Dense	Meander	< 0.1	Stable	None	within Channel
4	C	S-12	11.00	0.60	40.0	18.3	7.2	0.20	3.19	0.36	787	Dense	Meander	3.0-4.0	Stable	Small	Overflow
5	C	S-15	3.20	0.30	30.0	9.4	30.0	1.50	3.29	1.67	282	Dense	Meander	10	Stable	Small	Flooding
6	C	M-9	21.20	2.00	-	38.1	12.9	-	5.83	0.44	1,860	Dense	Meander	Rock	Stable	Large	Overflow
7	C	S-1	-	-	10.6	18.6	20.2	0.15	2.88	0.78	374	Dense	Meander	0.5	Stable	Large	Flooding
8	C	M-3-1	27.30	0.30	17.1	39.0	-	0.47	3.29	-	1,235	Dense	Meander	20 Rock	Stable	Large	Overflow
9	C	M-3-2	12.80	0.40	0.0	22.4	-	-	3.63	-	1,969	Dense	Meander	30 - 40	Stable	Small	within Channel
10	M	S-8	1.80	0.10	7.9	20.0	10.0	0.32	3.69	0.66	617	Dense	Meander	5 - 10	Stable	Large	Overflow
11	C	M-4	14.80	0.90	50.0	20.7	約3,000	0.55	5.37	2.70	4,199	Dense	Meander	0.1-0.15 Rock	Stable	Small	Storage
12	M	S-21	-	-	7.4	11.0	16.0	0.59	3.07	1.82	249	Thin	Meander	0.2	Stable	Small	Overflow
13	M	S-22	-	-	36.1	9.8	11.8	0.26	2.19	0.17	440	Thin	Meander	8	Stable	Small	Overflow
14	C	S-24	-	-	83.8	37.4	> 180m	2.12	3.90	1.72	814	Bare	Meander	0.5	Aggradation	Small	Storage
15	C	S-25	-	-	-	22.9	-	-	2.57	-	407	Bare	Meander	3.0-4.0	Stable	Small	within Channel
16	C	S-27	-	-	-	15.1	7.5	-	2.54	0.88	289	Thin	Meander	< 0.2	Stable	None	Flooding
17	C	S-28	-	-	19.4	6.3	19.8	1.70	3.76	1.70	302	Thin	Meander	3.0	Stable	None	Flooding
18	M	S-29	-	-	7.1	11.5	-	0.21	1.64	-	138	Thin	strait	1.0	Aggradation	None	Overflow
19	M	S-30	-	-	32.0	11.4	21.3	0.70	2.82	0.85	295	Thin	strait	2.0	Aggradation	None	Overflow
20	M	S-30-2	-	-	32.7	12.5	17.4	0.63	1.59	0.51	256	Thin	strait	1.0	Aggradation	Small	Overflow
21	C	M-19	-	-	不明	37.4	不明	1.42	2.93	1.20	171	Thin	Meander	4.0-5.0	Aggradation	Small	Overflow
22	C	M-20	5.80	0.30	17.6	22.6	不明	0.62	3.69	1.06	322	Thin	Meander	4.0	Degradation	None	Overflow

Table 2.3.2-3 Condition of Existing Bridge

No.	Type	Bridge code	Catchment area (km2)	Width (m): Bank Shoulder	Dimension of Existing Bridge			Road closure term(day)	
					Type	Length(m)	Width (m)	Pedestrian	Vehicle
1	M	S-19	175.0	14.9	None(channel-bed=road)		-	60	60
2	C	M-11	678.0	30.1	None	-	-	150	365
3	C	M-12	182.3	48.0	None	-	-	365	365
4	C	S-12	100.0	18.4	Footpath	-	-	35	365
5	C	S-15	37.1	9.4	Footpath	-	-	21	365
6	C	M-9	2510.0	38.6	None	-	-	365	365
7	C	S-1	19.9	12.3	Wooden	14.5	4.2	3	3
8	C	M-3-1	690.0	42.0	None	-	-	365	365
9	C	M-3-2	1760.0	31.7	None	-	-	365	365
10	M	S-8	157.7	20.0	Wooden	11.6	3.6	12	12
11	C	M-4	6160.0	20.7	None	-	-	365	365
12	M	S-21	73.6	11.0	None	-	-	8	60
13	M	S-22	107.8	9.8	None(channel-bed=	-	-	8	60
14	C	S-24	388.0	37.4	None	-	-	20	365
15	C	S-25	20.6	23.3	None(channel-bed=road)		-	20	90
16	C	S-27	19.0	23.8	None(channel-bed=road)		-	30	60
17	C	S-28	23.4	44.5	None(channel-bed=road)		-	15	60
18	M	S-29	14.7	11.5	None(channel-bed=road)		-	60	60
19	M	S-30	16.6	11.4	None(channel-bed=road)		-	60	60
20	M	S-30-2	10.3	12.5	None(channel-bed=road)		-	60	60
21	C	M-19	7.0	37.4	Bailey	40	6	?	?
22	C	M-20	17.6	22.9	Culvert	8.4	9.5	0	0

DF-Table2.3.2-1~4(Rev).xls/ExistingBridge/2000/10/18

2) Overflow (Case-2 (a))
   The river channel is comparatively wide and deep, but the river sometimes overflows its banks (12 bridges: M-11, S-12, M-9, M-3-1, S-8, S-21, S-22, S-29, S-30, S30-2, M-19 and M-20).
3) Flooding (Case-2 (b))
   Discharge capacity of the channel is small compared with the flood discharge, and floodwater always over flow the riverbanks and flow on the flood plain (4 bridges: S-15, S-1, S-27 and S-28).
4) Storage (Case-3)
   Discharge capacity of the downstream channel is small, and floodwater stands around the proposed bridge site during flood (2 bridges: M-4 and S-24).

<u>Stability of River Channel</u>

Stability of the river channel is evaluated based on the present conditions of the proposed bridge sites by the field reconnaissance.

- Changes Fluctuation of Watercourse of River
  Watercourses of the rivers shown in the topographical map (1/50,000) which was prepared based on 1974 aerial photographs, have been checked and confirmed by the field reconnaissance. It is considered that the positions of watercourse of the rivers did not change at the proposed bridge sites in the past 26 years.
- Stabilization of River Bank
  Except S-24 and S-25, all the riverbanks around the proposed bridge sites are in stable condition. At S-24 site, erosion of the upstream right bank and of the downstream left bank is being developed. At S-25 site, left bank erosion is being developed.
- Riverbed Variation
  It is expected that extreme riverbed variation will not occur in the future because deforestation for the development is not planned in the foreseeable future. On the other hand, tendencies of a slight aggradations of the riverbed at M-20 and slight degradation of the riverbed at S-24, S-29, S-30, S-30-2 and M-19 were observed during the field reconnaissance. Those tendencies will be taken into consideration during the bridge design.

(4) Waterway Design

<u>Basic Concept</u>

Flood routine in Ghana is complicated due to the characteristics of rainfall and topography. It is difficult to expect the precise analyses due to the insufficient hydrological data and topographic data. In this study, the waterway design was undertaken based on the following concepts:

- The waterway is designed based on the information from the inhabitants about the river condition during flood, the river survey results and the engineer's judgments.
- Peak flood water levels informed from the inhabitants are basically adopted as the design high water level of the bridge design.
- Design freeboards of the bridges are determined based on the quantity of the driftwood and the channel condition.

Waterway Design

Based on the basic concepts mentioned above, waterway width for the bridge planning were studied, and summarized in Table 2.3.2-4.

2.3.2.2 Basic Design of Material Supply Type Bridges

(1) Bridge Planning

In accordance with the design concept and the hydrological requirements at the bridge site discussed in Section 2.3.2.1, bridge location, bridge length, span composition and bridge elevation were planned.

Bridge Location

Topographic condition, geological condition, river condition and construction methods were considered to determine the bridge location. Particularly, the following were taken into considerations:

- Location which makes a bridge shortest.
- Location which avoids relocation of houses, electric poles, water lines, etc., as much as possible.
- Location where land acquisition is not required or does not cause problems.
- Location which achieves the most economical construction
- Location where a skew bridge can be avoided as much as possible.

Bridge Length and Span composition

Bridge length was designed in accordance with the following:

- Bridge length shall be longer than waterway width planned in Section 2.3.2.1.
- Bridge length shall be minimized to achieve economical design.

Table 2.3.2-4 Summary of Waterway Design

No.	Bridge code	Region	Catchment area (km2)	Existing Bridge: Type	Existing Bridge: Road closure term(day) Pedestrian	Existing Bridge: Road closure term(day) Vehicle	Width (m): Bank Shoulder	Quantity of driftwood	WL of Past flood (EL m)	Condition during Floods	Waterway Design Dimension: Width (m)	Waterway Design Dimension: DHWL (EL m)	Waterway Design Dimension: Freeboard (EL m)
1	S-19	Volta	175.0	None(bed=road)	60	60	14.9	Large	44.17	within Channel	14.9	44.17	1.00
2	M-11	Volta	678.0	None	150	365	30.1	Large	58.90	Overflow	45.0	58.90	1.00
3	M-12	Volta	182.3	None	365	365	48.0	None	15.51	within Channel	48.0	15.51	0.50
4	S-12	Eastern	100.0	Footpath	35	365	18.4	Small	213.50	Overflow	18.4	213.54	1.00
5	S-15	Eastern	37.1	Footpath	21	365	18.0	Small	243.30	Flooding	30.0	242.50	1.00
6	M-9	Eastern	2510.0	None	365	365	38.6	Large	117.05	Overflow	38.6	117.06	1.00
7	S-1	Ashanti	19.9	Wooden	3	3	12.3	Large	181.00	Flooding	20.0	181.05	1.00
8	M-3-1	Ashanti	690.0	None	365	365	42.0	Large	97.30	Overflow	56.1	97.30	1.00
9	M-3-2	Ashanti	1760.0	None	365	365	31.7	Small	142.10	within Channel	31.7	142.10	1.00
10	S-8	Brong-Ahafo	157.7	Wooden	12	12	20.0	Large	198.00	Overflow	25.0	198.01	1.00
11	M-4	Brong-Ahafo	6160.0	None	365	365	20.7	Small	200.60	Storage	40.0	200.64	0.50
12	S-21	Northern	73.6	None	8	60	11.0	Small	258.16	Overflow	20.0	258.16	0.50
13	S-22	Northern	107.8	None(bed=road)	8	60	9.8	Small	289.72	Overflow	25.0	289.76	0.50
14	S-24	Upper East	388.0	None	20	365	37.4	Small	180.80	Storage	45.0	180.84	0.50
15	S-25	Upper East	20.6	None(bed=road)	20	90	23.3	Small	179.90	within Channel	35.0	179.90	0.50
16	S-27	Upper West	19.0	None(bed=road)	30	60	23.8	None	252.28	Flooding	23.8	252.28	0.50
17	S-28	Upper West	23.4	None(bed=road)	15	60	44.5	None	254.40	Flooding	50.0	254.75	0.50
18	S-29	Upper West	14.7	None(bed=road)	60	60	11.5	None	199.02	Overflow	15.0	199.03	0.50
19	S-30	Upper West	16.6	None(bed=road)	60	60	11.4	None	228.81	Overflow	25.0	228.82	0.50
20	S-30-2	Upper West	10.3	None(bed=road)	60	60	12.5	Small	228.27	Overflow	20.0	228.31	0.50
21	M-19	Upper West	7.0	Bailey	?	?	37.4	Small	291.00	Overflow	37.4	290.50	0.50
22	M-20	Upper West	17.6	Culvert	0	0	22.9	None	267.30	Overflow	22.9	266.80	0.50

Note:

*1: Culvert=3.0m(B)*2.0m(H)*3Barrels

*2: Culvert=3.0m(B)*2.5m(H)*3Barrels

DF-Table2.3.2-1~4(Rev).xls/Summary/2000/10/18

- Bridge length shall be so designed that washout of abutments or excessive scouring at substructure shall not occur.

Span Composition

Bridge length varies from 15 m to 50 m. Span composition shall be made of combination of 15 m, 20 m and 25 m. Bridge length and span composition are as follows:

Bridge Length	No. of Spans	No. and Bridge Name
15 m	1	2 (S-19, S-24)
20 m	1	4 (S-12, S-1, S-2, S-30-2)
25 m	1	5 (S-8, S-22, S-27, S-30, M-20)
40 m (with sidewalk)	2 (20^{m} x 2 spans)	1 (M-19)
50 m	3 (15^{m} + 20^{m} + 15^{m})	1 (S-28)
Total		13 bridges

Number of spans by standard span length is as follows:

Standard Span Length	No. of Spans
15 m	4
20 m	5
25 m	5
20 m (with sidewalk)	2
Total	16 spans

(2) Bridge Roadway Elevation

Bridge roadway elevation is determined by adding high water level, freeboard and structural depth. Bridge roadway elevation is shown in Table 2.3.2-5.

TABLE 2.3.2-5 BRIDGE ROADWAY ELEVATION

Bridge Number	High Water Level Elevation (m)	Freeboard (m)	Structural Depth (m)	Bridge Roadway Elevation (m)
S-19	44.17	1.00	0.80	45.97
S-12	213.54	1.00	0.80	215.34
S-1	181.05	1.00	0.80	182.85
S-8	198.01	1.00	0.80	199.81
S-21	258.16	0.50	0.80	259.46
S-22	289.76	0.50	0.80	291.06
S-27	252.28	0.50	0.80	253.58
S-28	254.88	0.50	0.80	256.18
S-29	199.03	0.50	0.80	200.33
S-30	228.82	0.50	0.80	230.12
S-30-2	228.31	0.50	0.80	229.61
M-19	290.50	0.50	0.80	291.80
M-20	266.80	0.50	0.80	268.10

Note : • Freeboard of 0.5 m was adopted for the bridge site where no floating logs are expected.

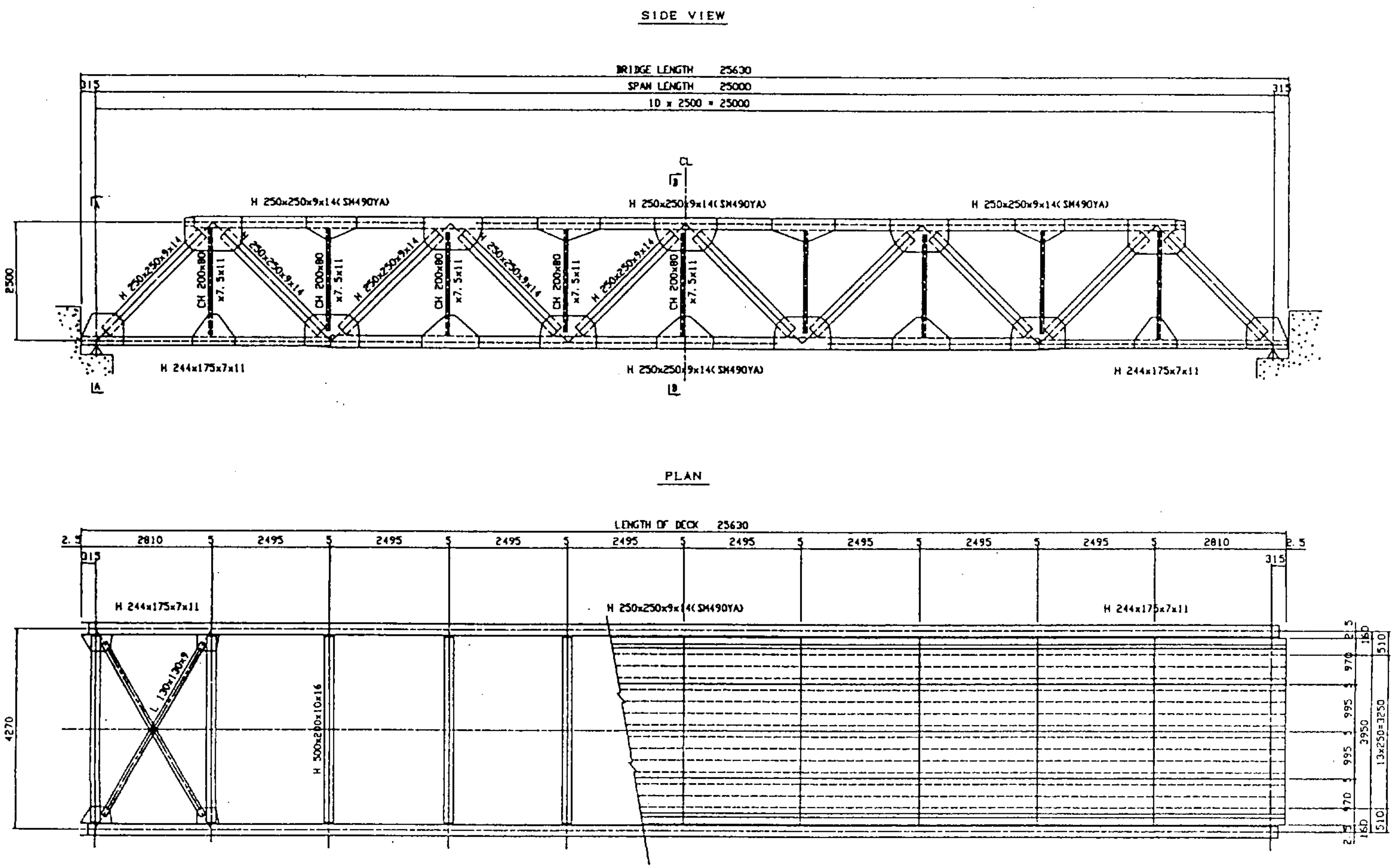
(3) Basic Design of Superstructure

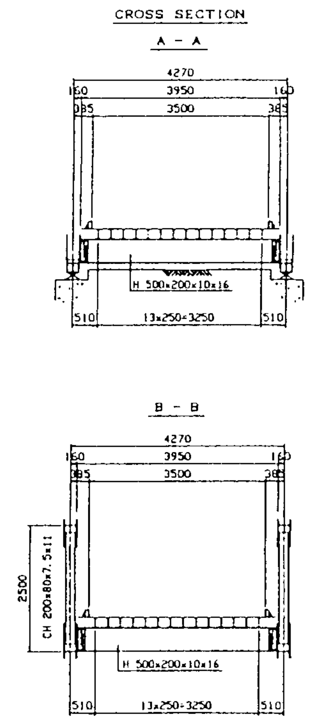
The same type of superstructure, i.e. a pony truss type procured under the Japan's Grant Aid in 1996 was selected, for which Ghana has already experience in assembly and erection. Necessary improvement for the items observed to be corrected during the field survey by the Study Team was made, which are as follows:

- Separation of sidewalk from carriageway for a bridge with sidewalk.
- Distance between steel deck slab and back wall of abutment
- High tension bolt length
- Bigger bolt holes within allowable limit for easier assembly
- Weep-hole to upper and bottom chord members
- Camber to be eliminated for easier assembly

General view of superstructure is shown in Figure 2.3.2-2.

GENERAL ARRANGEMENT
SCALE 1 : 50





ST. HEIGHT OF SUPPORT

1. DECK PL	6.0 mm	Ch PL
2. DECK BEAM	200.0 mm	H 200x100
3. CROSS BEAM	500.0 mm	H 500
4. GUSSET PL	5.0 mm	t = 10/2 = 5.0mm
5. SUPPORT	159.5 mm	
6. L. FLG	10.0 mm	
7. U. SHOE	25.0 mm	
8. L. SHOE	75.0 mm	
TOTAL	980.5 mm	

PORTABLE BRIDGE
SUPERSTRUCTURE
25m PONY TRUSS

FIGURE 2.3.2-2 SUPERSTRUCTURE OF PONY TRUSS BRIDGE

(4) Substructure Design

Substructures were planned based on the bridge planning (bridge length and span composition) and the geo-technical survey results. All substructures were planned to be the spread footing type, as the bridge site which requires pile foundation are not included in the material supply type bridges. The detail design of substructure must be undertaken by the Government of Ghana.

Abutment : Reversed T type of abutment was recommended. Wing Wall length was planned to properly hold shoulder and embankment materials. Approach slab was planned to be provided to eliminate the gap between superstructure deck slab and approach embankment.

Pier : Circular column type of piers was planned for smooth flow of flood water so as to reduce scouring at a pier.

(5) Quantities of Material Supply Type Bridges

Table 2.3.2-6 shows the summary of bridges. Table 2.3.2-7 shows the detailed quantity of superstructure materials to be procured. Table 2.3.2-8 shows overall work volumes of the material supply type of bridges.

Table 2.3.2-6 Summary of Material Supply Type Bridges (1/2)

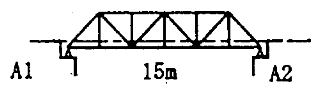
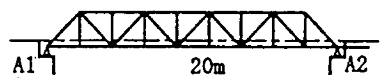
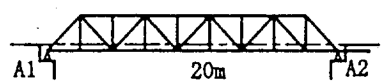
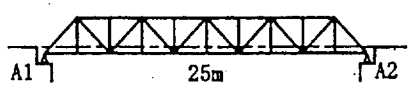
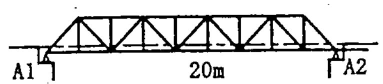
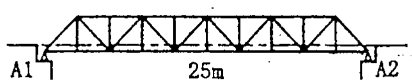
No.	Region	Bridge No.	Sketch	Superstructure	Substructure		Approach Road (m)	Revetment (m^2)	Remarks
					Abutment/Pier	Foundation			
1	VOLTA	S-19		L=15.67m W=19.579ton	A1: H=6.5m A2: H=6.5m	Al: Spread Footing A2: Spread Footing	R: 34.9 L: 27.3	R: 105 L: 67	No Boring undertaken, DFR to undertake to be boring.
2	EASTERN	S-12		L=20.67m W=28.055ton	A1: H=7.0m A2: H=7.0m	Al: 3.0m Replacement with concrete A2: 1.5m Replacement with concrete	R: 14.9 L: 47.7	R: 45 L: 143	
3	ASHANTI	S-1		L=20.67m W=28.055ton	A1: H=5.0m A2: H=5.0m	Al: 2.0m Replacement with concrete A2: 2.0m Replacement with concrete	R: 11.8 L: 30.4	R: 35 L: 91	
4	BRONG AHAFO	S-8		L=25.67m W=37.459ton	A1: H=7.0m A2: H=7.0m	Al: Spread Footing A2: Spread Footing	R: 16.5 L: 13.6	R: 50 L: 41	No Boring undertaken, DFR to undertake to be boring.
5	NORTHERN	S-21		L=20.67m W=28.055ton	A1: H=7.0m A2: H=7.0m	Al: Spread Footing A2: Spread Footing	R: 13.7 L: 15.5	R: 41 L: 47	No Boring undertaken, DFR to undertake to be boring.
6	NORTHERN	S-22		L=25.67m W=37.459ton	A1: H=7.0m A2: H=7.0m	Al: 2.0m Replacement with concrete A2: 2.0m Replacement with concrete	R: 13.7 L: 48.9	R: 41 L: 147	
7	UPPER WEST	S-27		L=25.67m W=37.459ton	A1: H=6.0m A2: H=6.0m	Al: 2.0m Replacement with concrete A2: 2.0m Replacement with concrete	R: 19.1 L: 28.7	R: 57 L: 86	

Table 2.3.2-6 Summary of Material Supply Type Bridges (2/2)

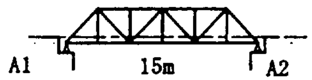
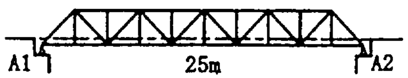
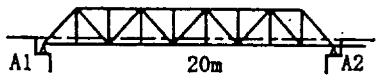
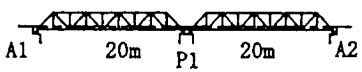
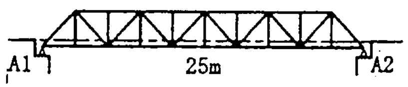
No.	Region	Bridge No.	Sketch	Superstructure	Substructure		Approach Road (m)	Revetment (m^2)	Remarks
					Abutment/Pier	Foundation			
8	UPPER WEST	S-28		L=51.97m W=67.213ton	A1: H=8.0m P1: H=6.0m P2: H=6.0m A2: H=7.0m	Al: 2.0m Replacement with concrete P1: Spread Footing P2: Spread Footing A2: 2.0m Replacement with concrete	R: 40.6 L: 30.7	R: 122 L: 92	
9	UPPER WEST	S-29		L=15.67m W=19.579ton	A1: H=5.0m A2: H=5.0m	Al: Spread Footing A2: Spread Footing	R: 39.1 L: 27.5	R: 117 L: 96	
10	UPPER WEST	S-30-1		L=25.67m W=37.459ton	A1: H=6.0m A2: H=6.0m	Al: Spread Footing A2: Spread Footing	R: 31.7 L: 31.7	R: 95 L: 95	No Boring undertaken, DFR to undertake to be boring.
11	UPPER WEST	S-30-2		L=20.67m W=28.055ton	A1: H=5.0m A2: H=5.0m	Al: Spread Footing A2: Spread Footing	R: 27.2 L: 26.8	R: 82 L: 80	No Boring undertaken, DFR to undertake to be boring.
12	UPPER WEST	M-19		L=41.32m W=61.936ton	A1: H=6.0m P1: H=6.0m A2: H=6.0m	Al: Spread Footing P1: Spread Footing A2: Spread Footing	R: 17.3 L: 6.1	R: 52 L: 18	with Sidewalk
13	UPPER WEST	M-20		L=25.67m W=37.459ton	A1: H=6.5m A2: H=6.5m	Al: Spread Footing A2: Spread Footing	R: 52.5 L: 29.1	R: 158 L: 87	
				(L=335.66m) (W=467.822ton)					

Table 2.3.2-7 Summary of Quantities of Steel Bridge Material

Material			Quantity (kg)					
Material Shape	Material Designaiton	Material Size (mm)	Span 15m (4 spans)	Span 20m (5 spans)	Span 20m (Sidewalk) (2 spans)	Span 25m (5 spans)	Total (16 spans)	Member
H-Beam	SM490Y	250x250x9x14	-	-	-	25,640	25,640	Truss
	SS400	250x250x9x14	-	22,680	9,072	20,600	52,352	Truss
		244x275x7x11	15,440	12,140	4,856	4,500	36,936	Truss
		200x100x5.5x8	18,224	30,060	12,024	37,340	97,648	Stringer
		500x200x10x16	9,744	15,660	6,264	19,140	50,808	Cross Beam
		450x200x9x14	-	-	1,536	-	1,536	Sidewalk
	Sub total		43,408	80,540	33,752	107,220	264,920	
L-Beam	SS400	150x90x9	376	610	244	740	1,970	Truss
		130x130x9	1,204	1,505	602	1,505	4,816	Cross Beam
	Sub total		1,580	2,115	846	2,245	6,786	
Flat Bar	SS400	75x6	1,056	1,760	704	2,200	5,720	Deck Slab
	Sub total		1,056	1,760	704	2,200	5,720	
Plate	SS400	t = 6	11,952	19,720	7,888	24,500	64,060	Deck Slab
		t = 3.2	-	-	1,080	-	1,080	Sidewalk
	Sub total		11,952	19,720	8,968	24,500	65,140	
C-Beam	SS400	200x80x7.5	2,192	3,770	1,508	4,750	12,220	Truss
		180x75x7	-	-	2,652	-	2,652	Sidewalk
	Sub total		2,192	3,770	4,160	4,750	14,872	
Checkered Plate	SM490YA	t = 10	-	-	-	14,490	14,490	Truss
	SS400	t = 25	-	1,260	504	1,690	3,454	Truss
		t = 22	840	250	100	250	1,440	Truss
		t = 10	7,724	14,745	5,898	8,005	36,372	Truss, Cross Beam
		t = 6	1,384	2,270	928	2,810	7,392	Cross Beam, Deck Slab
		t = 4.5	48	80	32	100	260	Deck Slab
		t = 3.2	-	600	240	260	1,100	Truss
	Sub total		9,996	19,205	7,702	27,605	64,508	
Square Pipe	STKR400	150x80x4.5	1,904	3,140	1,256	3,900	10,200	Deck Slab
	Sub total		1,904	3,140	1,256	3,900	10,200	
HTB	F8T	M22	3,896	7,000	2,884	11,740	25,520	Truss, Cross Beam
		M16	-	-	-	-	-	
	Sub total		3,896	7,000	2,884	11,740	25,520	
Bolt	SS400	M-20	48	80	32	100	260	Deck Slab
		M-16	-	-	22	-	22	Cross Beam, Deck Slab
		M-12	188	305	122	375	990	Cross Beam, Deck Slab
		M-10	-	-	28	-	28	Sidewalk
	Sub total		236	385	204	475	1,300	
Bolt	SS400	M22	40	70	28	90	228	Truss
	Sub total		40	70	28	90	228	
Bearing	SC450	MOV-S-56	1,004	1,255	502	1,255	4,016	
		FIX-S-56	1,052	1,315	526	1,315	4,208	
	Sub total		2,056	2,570	1,028	2,570	8,224	
Pipe	SGP	50A	-	-	6	-	6	Sidewalk
		40A	-	-	292	-	292	Sidewalk
		32A	-	-	6	-	6	Sidewalk
		25A	-	-	100	-	100	Sidewalk
	Sub total		-	-	404	-	404	
Total (kg)			78,316	140,275	61,936	187,295	467,822	

TABLE 2.3.2-8 SUMMARY OF BRIDGE CONSTRUCTION QUANTITY

Item			Unit	Quantity
Number of Bridges			Bridge	13
Super-structure	15 m Span Portable Bridge		Span	4 (60 m)
	20 m Span Portable Bridge		Span	5 (100 m)
	20 m Span Portable Bridge (with Side Walk)		Span	2 (40 m)
	25 m Span Portable Bridge		Span	5 (125 m)
	Total		Span	16 (325 m)
	Steel Transportation Weight		t	477.451
	Erection Weight		t	467.822
Sub-structure	Abutment Reversed T-type Spread Foundation	H ≦ 4.5 m	No.	1
		4.6 m ≦ H ≦ 6.0 m	No.	22
		H ≧ 6.1 m	No.	3
		Total	No.	26
	Pier Column-Type, Spread Footing	5.0 m ≦ H ≦ 7.5 m	No.	2
		7.5 m ≦ H ≦ 9.5 m	No.	1
		Total	No.	3
Appurt-enant Work	Approach Road		m	692
	Revetment		m^2	2,077

2.3.2.3 Basic Design of Construction Type Bridges

1) Bridge Planning

Bridges were planned based on the same concept and considerations discussed in Section 2.3.2.2.

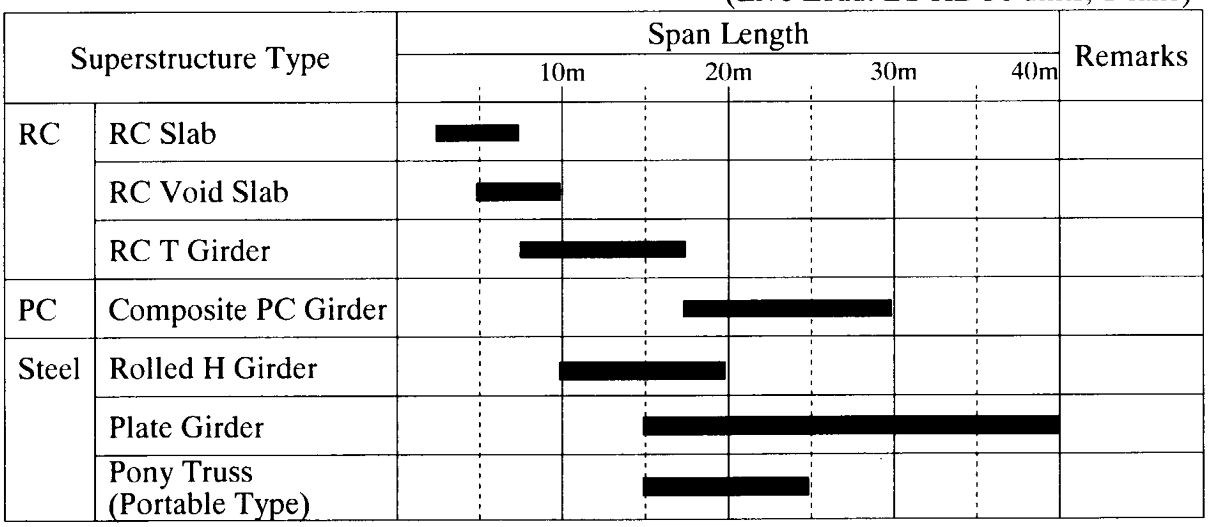
2) Selection of Bridge Type

In order to select the most appropriate type of bridge, several alternatives were prepared and compared. First of all, inappropriate types of bridge were identified, which were not considered for the alternative study.

Various superstructure types and their economically applicable span length are as shown below.

Superstructure Types and Their Applicable Span Length

(Live Load: BS HB 30 units, 1-lane)



Judging from the bridge length of the construction type bridges of the Project, 3 kinds of the span length which are 15 m , 20 m and 25 m are most commonly required.

Applicable superstructure types for these span length are as follows:

Span = 15 m	Span = 20 m	Span = 25 m
RC T Girder	PC Composite Girder	PC Composite Girder
Rolled H Girder	Rolled H Girder	Plate Girder
Plate Girder	Plate Girder	Pony Truss
Pony Truss	Pony Truss	

Among above superstructure types, PC Composite Girder has the following problems:

- High strength concrete is required, therefore, a concrete batching plant is required.
- Due to high temperature of Ghana, concrete pouring must be done early in the morning or during night time, thus a lighting facility is required and longer construction period is required.
- Careful quality control is needed and Japanese engineers are required to station at the job site.
- Girder weight is heavy. Weight of one 20 m girder and 25 m girder is about 33 tons and 47 tons, respectively. For erection of such heavy girder, two 120-ton capacity cranes are required.
- In comparison with plants and equipment requirements, number of girders per bridge is at most 6 only, therefore, construction cost becomes quite high.

In view of above, PC composite girder is not appropriate for the Project, therefore, excluded from further study.

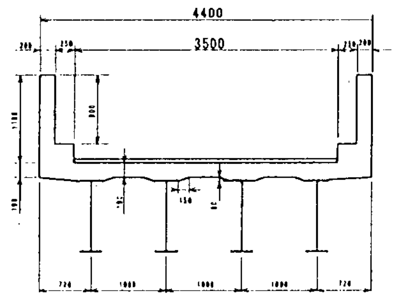
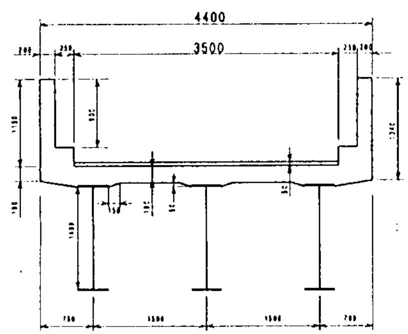
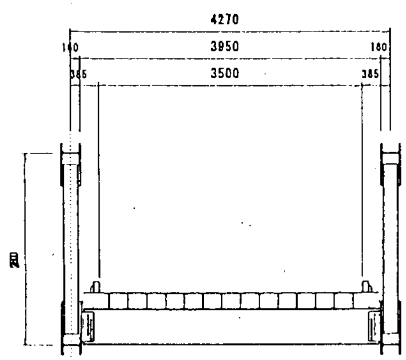
Comparison of three types of superstructure, i.e. a rolled H girder, a plate girder and a pony truss, is shown in Table 2.3.2-9.

- A rolled H girder is quite expensive, therefore, excluded from the further study.
- A pony truss is slightly expensive than a plate girder, however, the former requires lower structural depth between a bottom of a girder and a bridge roadway surface, therefore, both types are considered for the further comparative study.

3) Bridge Type of M-11

Waterway width	:	45.0 m
High water level elevation	:	58.9 m
Freeboard	:	1.0 m
Floating logs	:	many (ϕ = 0.15 m, ℓ = 5 m)
Ordinary water depth	:	0.4 m
Geological condition		
Right bank side	:	Quartzite and phyllite at 6 m from the ground surface.
Left bank side	:	Quartzite and phyllite at 4 m from the ground surface.

Table 2.3.2-9 Comparison of Structure Types for 20 m Span

STRUCTURE TYPE	CROSS SECTION	STEEL WEIGHT	COST COMPARISON	STRUCTURAL DEPTH	CONSTRUCTION PERIOD
H STEEL GIRDER		27.0 ton	1.18	1,232 mm	Longer than pony truss by deck slab construction period
STEEL PLATE GIRDER		20.2 ton	1.00	1,720 mm	Ditto
PONY TURSS		27.8 ton	1.10	803 mm	Shortest

Bridge Planning

- The river runs through the rolling terrain. The bridge site is located at the down stream side of the meandered channel. The main channel is located at the right bank side. The left bank side is partially low land where no water flow is expected (or dead water area).
- Abutments are planned to be located outside of the proposed waterway.
- Pier No.2 is planned to be located at the left side of the main channel.
- In order to span over the waterway width, the bridge length is planned to be 46.94 m, composing of three spans (12.5 m + 12.5 m + 20.0 m).
- Based on the results of cost comparison of M-12, M-3-1 and M-3-2, the most economical superstructure type is selected for each span as follows:

12.5 m	+	12.5 m	+	20.0 m
RC T Girder		RC T Girder		Steel Plate Girder

- As the rock layer can be expected at a shallow depth, the spread footing is selected for the type of foundation of substructures.
- Right bank is protected by the revetment made of the grouted stone pitching. As the left bank side is the dead water area, only the abutment is protected by the grouted stone pitching.

The general view of the bridge is shown in Appendix 8.

4) Bridge Type of M-12

Waterway width : 48.0 m
High water level elevation : 15.51 m
Freeboard : 0.5 m
Floating logs : None
Ordinary water depth : 1.8 m
Geological condition :

Left bank side—Granitoid exists 7 m below the ground surface. 4 m from the ground surface is clayey silt and from 4 m to 7 m is clayey sandy gravel.
Right bank side within the channel—Granitoid is found at 13 m below the ground surface, and in between layers are clayey silt and clayey silt with gravelly sand.
Right bank side—Sandy clay with N-value over 50 at 13 m from the ground surface. In-between layers are clayey silt, silty clay and silty fine sand with low N-value.

Span Composition and Superstructure Alternatives

Considering the waterway width of 48.0 m, ordinary water depth of 1.8 m, and pile foundation required, number of spans is 2 or 3 spans. Alternatives are shown below:

Alternative-1 (3 spans) : 15 m + 20 m + 15 m
(Pony Truss) (Pony Truss) (Pony Truss)
⇨ Bridge Length = 51.95 m

Alternative-2 (2 spans) : 25 m + 25 m
(Pony Truss) (Pony Truss)
⇨ Bridge Length = 51.95 m

Alternative-3 (3 spans) : 12.5 m + 25 m + 12.5 m
(RC T Girder) (Pony Truss) (RC T Girder)
⇨ Bridge Length = 51.84 m

Alternative-4 (3 spans) : 12.5 m + 25 m + 12.5 m
(RC T Girder) (Plate Girder) (RC T Girder)
⇨ Bridge Length = 51.92 m

Comparison of 4 alternatives is shown in Table 2.3.2-10. Alternative-4 was economically most advantageous and engineeringly sound, therefore, was selected for this project. The general view of the bridge is shown in Appendix-8.

5) Bridge Type of S-15

- The bridge site is located at the flood plain, of which width is about 160 m.
- The main channel is narrow at 9.4 m in width.
  During a flood, flood water overflows the main channel and runs within the flood plain. According to the near-by residents, water velocity is quite slow (almost zero) except the main channel.
- The safest way to construct a bridge at this kind of a site is to span over the flood plain, however, construction cost will be extremely high and not practical.
- For this bridge site, the bridge is planned to achieve the minimum cost and, at the same time, safe against excessive flood as follows:
  - Traffic will not be interrupted at least for a flood of 10-year probability.
  - Bridge structure is designed to withstand the force of flowing water during excessive flood.
  - Approach embankment slopes are protected by a grouted stone pitching.
  - Approach embankment is planned to be low as much as possible, so that approach embankment can be easily repaired, even if it is damaged by excessive flood.
- Bridge Planning
  - Water way width : 30 m
  - High water level elevation : 242.50 m (annual high water)
  - Freeboard : 0.5 m
  - Ordinary water depth : 0.4 m
  - Geological condition
    Right bank side : Sand and gravel layer with N-value over 50 at 6 m from the ground surface.
    Left bank side : Sand and gravel layer with N-value over 40 at 5 m from the ground surface.
  - Bridge length, span composition and superstructure type
    Bridge length : 31.88 m
    Span composition : 3@ 10 m
    Superstructure type : 3 x RC T Girder

The general view is shown in Appendix-8.

TABLE 2.3.2-10 COMPARISON OF STRUCTURE TYPE FOR M-12 BRIDGE

Scheme	Substructure/ Foundation Execution	Erection Ease	Quality Control	Construction Period	Maintenance	Local Product Use	Cost Comparison	Structural Depth & Fill Height	Evaluation
Scheme-1 : 3 spans 15m + 20m + 15m Pony Pony Pony Truss Truss Truss Bridge Length 51.95 m	2 Cofferdams required for 2 Piers	Easy	Easy	Shortest (13.0 months)	No problem (Galvanized Steel Members)	Less than Scheme-3	1.02	Structural 0.80 m Fill Left Bank: 1.6 m Right Bank: 1.0 m	
Scheme-2 : 2 spans 25m + 25 m Pony Pony Truss Truss Bridge Length 51.60 m	1 Cofferdam (with Larger Drainage close to River Center)	Easy	Easy	Moderate (14.0 months)	No problem (Galvanized Steel Members)	Least	1.16	Structural 0.80 m Fill Left Bank: 1.6 m Right Bank: 1.0 m	
Scheme-3 : 3 spans 12.5m + 25m + 12.5m RC T- Pony RC T- Girder Truss Girder Bridge Length 51.84 m	2 Cofferdams Required	Staging Required for RC T-Girder After Completion of Substructure	Careful Q/C for Concreting of RC T-Girders Main Reinforcing Steel Bar to be Imported	Longest (15.5 months)	No problem (Galvanized Steel Members)	Less than Scheme-4	1.04	Structural 1.43 m Fill Left Bank: 2.23 m Right Bank: 1.63 m	
Scheme-4 : 3 spans 12.5m + 25m + 12.5m RC T- Steel RC T- Girder Plate Girder Girder Bridge Length 51.92 m	2 Cofferdams Required	Staging Required for RC T-Girder After Completion of Substructure	Careful Q/C for Concreting of RC T-Girders Main Reinforcing Steel Bar to be Imported	Longest (15.5 months)	No problem (Atmospheric Corrosion Resisting Steel Plate)	Most	1.00	Structural 1.83 m Fill Left Bank: 2.63 m Right Bank: 2.03 m	Recommended

6) Bridge Type of M-3-1

Planning Level : 1
Waterway width : 56.1 m
High water level elevation : 97.30 m
Freeboard : 1.0 m
Floating logs : many (ϕ = 0.5 m, ℓ = 8 m, many branches)
Ordinary water depth : 0.5 m
Geological condition :
Left bank side—gneiss is found at 6 m below the ground surface.
Right bank side —gneiss is found at 6.2 m below the ground surface.

Span Composition and Superstructure Alternatives

Considering the waterway width of 56.1 m and expected floating logs, a pier should not be placed at the center of channel. Embankment height should be low as much as possible. Foundation type is the spread footing. The bridge should be composed of 3 spans. Alternatives are shown below:

Alternative-1 : 15 m + 20 m + 15 m → Bridge Length = 56.94 m
(Pony Truss) (Pony Truss) (Pony Truss)
Alternative-2 : 15 m + 20 m + 15 m → Bridge Length = 56.84 m
(RC T Girder) (Pony Truss) (RC T Girader)
Alternative-3 : 15 m + 20 m + 15 m → Bridge Length = 56.92 m
(RC T Girder) (Plate Girder) (RC T Girader)

Comparison of 3 alternatives is shown in Table 2.3.2-11. Alternative-3 was economically most advantageous and engineeringly sound, therefore, was selected for this bridge. The general view of the bridge is shown in Appendix-8.

7) Bridge Type of M-3-2

Waterway width : 31.7 m
High water level elevation : 142.10 m
Freeboard : 1.0 m
Floating logs : not so many (ϕ = 0.3 ~ 0.5 m, ℓ = 5 ~ 8 m)
Ordinary water depth : 0.4 m
Geological condition :
Left bank side—stiff silty clay with N-value over 50 is found at 13 m below the ground surface. In-between layer is silty clay with N-value ranging from 6 to 10.

TABLE 2.3.2-11 COMPARISON OF STRUCTURE TYPE FOR M-3-1

Scheme	Substructure/ Foundation Execution	Erection Ease	Quality Control	Construction Period	Maintenance	Local Product Use	Cost Comparison	Structural Depth & Fill Height	Evaluation
Scheme-1 : 3 spans 15m + 25m + 15m Pony Pony Pony Truss Truss Truss Bridge Length 56.94 m	Little Difference among 3 schemes	Easy	Easy	Shortest (15.5 months)	No problem (Galvanized Steel Members)	Least	1.12	Structural 0.80 m Fill Left Bank: 2.0 m Right Bank: 1.2 m	
Scheme-2 : 3 spans 15m + 25m + 15m RC T-Girder Pony Truss RC T-Girder Bridge Length 56.84 m	Little Difference among 3 schemes (Higher Abutment by 0.9 m & Height Difference at Pier Coping)	Staging Required for RC T-Girder After Completion of Substructure	Careful Q/C for Concreting of RC T-Girders Main Reinforcing Steel Bar to be Imported	Longest (16.0 months)	No problem (Galvanized Steel Members)	Less than Scheme-3	1.03	Structural 1.70 m Fill Left Bank: 2.9 m Right Bank: 2.1 m	
Scheme-4 : 3 spans 15m + 25m + 15m RC T-Girder Steel Plate Girder RC T-Girder Bridge Length 51.92 m	Little Difference among 3 schemes (Higher Abutment by 0.9 m & Height Difference at Pier Coping)	Staging Required for RC T-Girder After Completion of Substructure	Careful Q/C for Concreting of RC T-Girders Main Reinforcing Steel Bar to be Imported	Longest (16.0 months)	No problem (Atmospheric Corrosion Resisting Steel Plate)	Most	1.00	Structural 1.80 m Fill Left Bank: 3.0 m Right Bank: 2.2 m	Recommended

Right bank side —stiff sandy clay with N-value over 50 is found at 9 m below the ground surface. In-between layer is sand with N-value ranging from 8 to 18.

Span Composition and Superstructure Alternatives

Judging from the waterway width of 31.7 m, floating log sizes and the fact that the valley is quite deep, 1 or 2 spans of the bridge is appropriate. Alternatives are shown below:

Alternative-1 (1 span):	35 m (Plate Girder)			→	Bridge Length = 35.70 m
Alternative-2 (2 spans):	10 m (RC T Girder)	+	25 m (Plate Girder)	→	Bridge Length = 36.13 m
Alternative-3 (2 spans):	15 m (Pony Truss)	+	20 m (Pony Truss)	→	Bridge Length = 36.90 m

Comparison of 3 alternatives is shown in Table 2.3.2-12. Alternative-1 was economically most advantageous and engineeringly sound, therefore, selected for this bridge. The general view of the bridge is shown in Appendix-8.

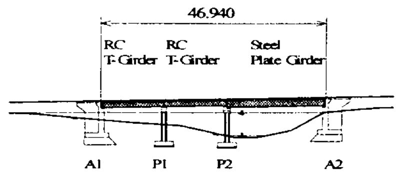
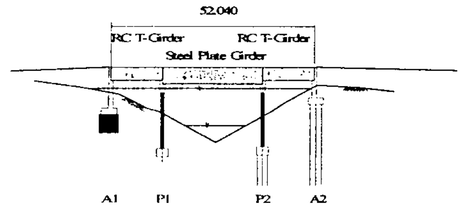
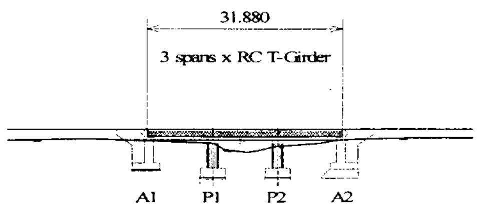
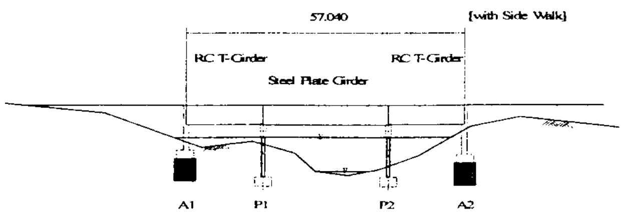
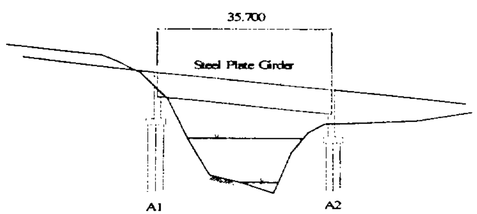
8) Summary of Construction Type Bridges

Summary of construction type bridges is shown in Table 2.3.2-13.

TABLE 2.3.2-12 COMPARISON OF STRUCTURE TYPE FOR M-3-2

Scheme	Substructure/ Foundation Execution	Erection Ease	Quality Control	Construction Period	Maintenance	Local Product Use	Cost Comparison	Structural Depth & Fill Height	Evaluation
Scheme-1 : 1 span 35m Steel Plate Girder Bridge Length 35.70 m	Construction in River is not Required	Easy	Easy	Shortest (15.5 months)	No problem (Atmospheric Corrosion Resisting Steel Plate)	Less than Scheme-2	1.00	Fill Left Bank: 1.8 m Right Bank: 3.0 m	Recommended
Scheme-2 : 2 spans 10m + 25 m RC T-Girder Steel Plate Girder Bridge Length 36.13 m	Depth of Bearing Stratum is 4m (2.5m at minimum form River Bed) Deep Excavation Cofferdam is Required	Staging required for RC T-Girder Avoid Rainy Season After completion of Substructure	Careful Q/C for Concreting of RC T-Girders Main Reinforcing Steel Bar to be Imported	Longest (17.5 months)	No problem (Atmospheric Corrosion Resisting Steel Plate)	Most	1.07	Fill Left Bank: 1.8 m Right Bank: 3.0 m	
Scheme-2 : 2 spans 10m + 25 m Pony Truss Pony Truss Bridge Length 36.90 m	Depth of Bearing Stratum is 4m (2.5m at minimum form River Bed) Deep Excavation Cofferdam is Required	Easy	Easy	Moderate (16.5 months)	No problem (Galvanized Steel Members)	Least	1.12	Fill Left Bank: 2.0 m (1.0 m) Right Bank: 5.0 m (4.0 m) (Bridge Surface to be Level; High Embankment at Right Bank)	

Table 2.3.2-13 Summary of Construction Type Bridges

No.	Bridge No.	Region	Sketch	Superstructure	Substructure/Foundation	Revetment	Approach Road	Remarks
1	M - 11	VOLTA		RC T-Girder : 2 Spans Steel Plate Girder : 1 span Bridge Length =46.940 m W = 4.400m	A1 : H = 7.5m (Spread Footing) P1 : H = 7.8m (Spread Footing) P2 : H = 7.8m (Spread Footing) A2 : H = 7.5m (Spread Footing)	Left Bank: 325 m^2 Right Bank: 688 m^2	Left Bank: L = 95.10 m Gravel Pavement 529 m^2 Cut: 108m^3, Fill: 702m^3 Right Bank: L = 57.96 m Gravel Pavement 305 m^2 Cut: 181m^3, Fill: 554m^3	
2	M - 12	VOLTA		RC T-Girder : 2 Spans Steel Plate Girder : 1 span Bridge Length =52.040m W = 4.400m Steel Weight = 26.998t	A1 : H = 5.2m (Spread Footing) P1 : H = 8.0m (Spread Footing) P2 : H = 7.8m (Steel H Pile) ℓ = 6 m n = 12 A2 : H = 4.1m (Steel H Pile) ℓ = 12 m n = 12	Abutment Protection Left Bank: 201 m^2 Right Bank: 139 m^2	Left Bank: L = 68.40 m Gravel Pavement 368 m^2 Cut: 118m^3, Fill: 454m^3 Right Bank: L = 149.68 m Gravel Pavement 856 m^2 Cut: 266m^3, Fill: 2,350m^3	
3	S - 15	EASTERN		RC T-Girder : 3 spans Bridge Length : 31.88m W = 4.400m	A1 : H = 6.5m (Spread Footing) P1 : H = 6.5m (Spread Footing) P2 : H = 6.5m (Spread Footing) A2 : H = 6.5m (Spread Footing)	Abutment Protection Left Bank: 735 m^2 Right Bank: 696 m^2 River Bed Protection: 265 m^2	Left Bank: L = 128.99 m Gravel Pavement 731 m^2 Cut: 1,032m^3, Fill: 289m^3 Right Bank: L = 110.44 m Gravel Pavement 608 m^2 Cut: 743m^3, Fill: 179m^3	
4	M - 3 -1	ASHANTI		RC T-Girder : 2 Spans Steel Plate Girder : 1 span Bridge Length =57.040m W = 5.400m Steel Weight = 31.235t	A1 : H = 4.6m (Spread Footing) P1 : H = 5.5m (Spread Footing) P2 : H = 5.5m (Spread Footing) A2 : H = 5.0m (Spread Footing)	Abutment Protection Left Bank: 239 m^2 Right Bank: 143 m^2	Left Bank: L = 136.70 m Gravel Pavement 778 m^2 Cut: 1,019m^3, Fill: 240m^3 Right Bank: L = 131.38 m Gravel Pavement 746 m^2 Cut: 484m^3, Fill: 826m^3	
5	M - 3 -2	ASHANTI		Steel Plate Girder : 1 span Bridge Length=35.700m W = 4.400m Steel Weight = 48.776t	A1 : H = 4.8m (Steel H Pile) ℓ = 9 m n = 12 A2 : H = 4.8m (Steel H Pile) ℓ = 8 m n = 12	Steel Sheet Pile & Coping Concrete Revetment Left Bank: 24.4 m Right Bank: 24.4 m	Left Bank: L = 150.50 m Gravel Pavement 861 m^2 Cut: 2,710m^3, Fill: 9m^3 Right Bank: L = 89.30 m Gravel Pavement 493 m^2 Cut: 81m^3, Fill: 496m^3	

2.3.2.4 Design of Assembly and Erection Tools and Materials

1) Study of Erection Methods

The erection method recommended by the project procured in 1996 was the launching method on the staging. DFR has the experience that the superstructure fell down to the river due to collapse of the staging work under the similar bridge project. Therefore, DFR requested to adopt a launching nose method. Comparison of both methods is as follows:

Comparison of Erection Methods (1 Span Bridge)

Item	a) Launching Method on the Staging	b) Launching Nose Method
Erection period	. Longer than b) due to time required for the staging work.	. Shorter than a) . Time for a launching nose assembly is required, but shorter than time required for the staging work
Erection during rainy season	. Difficult due to possibility of wash out of the staging work.	. Possible
Technical requirement for local contractors	. Some local contractors are not accustomed to construct rigid staging work	. No problem
Erection cost	. Advantageous for the Ghana Government, as the staging work cost can be saved.	. Launching nose is not so expensive.
Safety during erection	. If rigid staging work can be prepared, no problem	. No problem

Based on the above discussion, the launching nose method was selected.

<u>1-Span Bridge Erection</u>

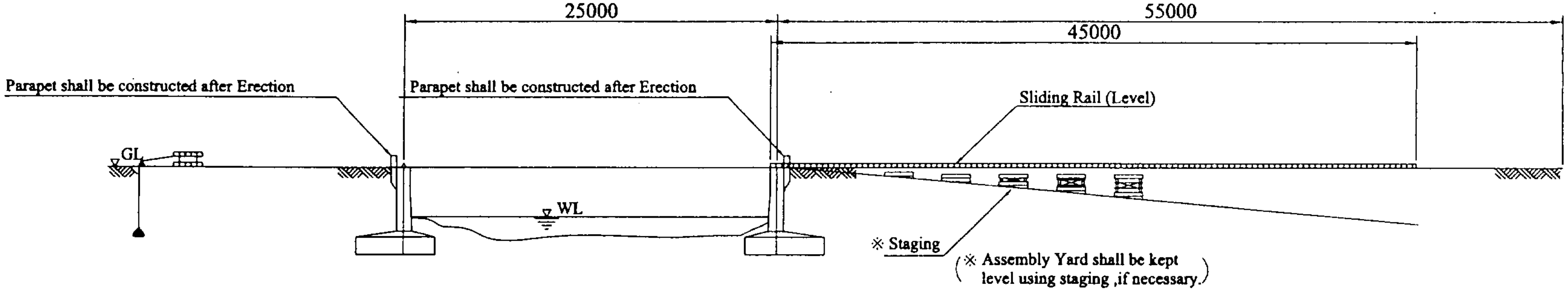
Procedure of 1-span bridge erection by the launching nose method is shown in Figure 2.3.2-3.

<u>Multi-Span Bridge Erection</u>

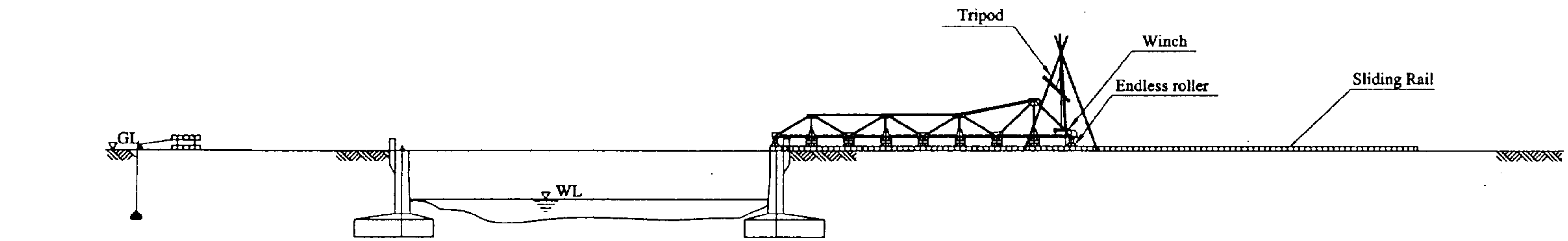
The Project includes a 3-span bridge (S-28) and a 2-span bridge (M-19) erection. Although the Ghanaian side has no experience in the erection of multi-span bridges, the principle erection procedure and method is the same as that of 1-span

Erection Sequence for Launching Method (L=25m)

STEP-1 ☆ Set up Assembly Yard
☆ Sliding Rail installation



STEP-2 ☆ Launching Nose assembly



STEP-3 ☆ Main structure assembly
☆ Installation of Deck for Main structure

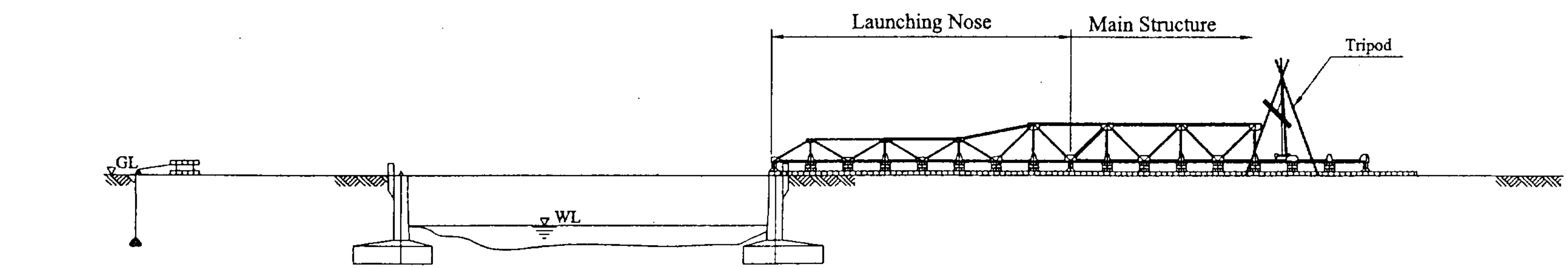
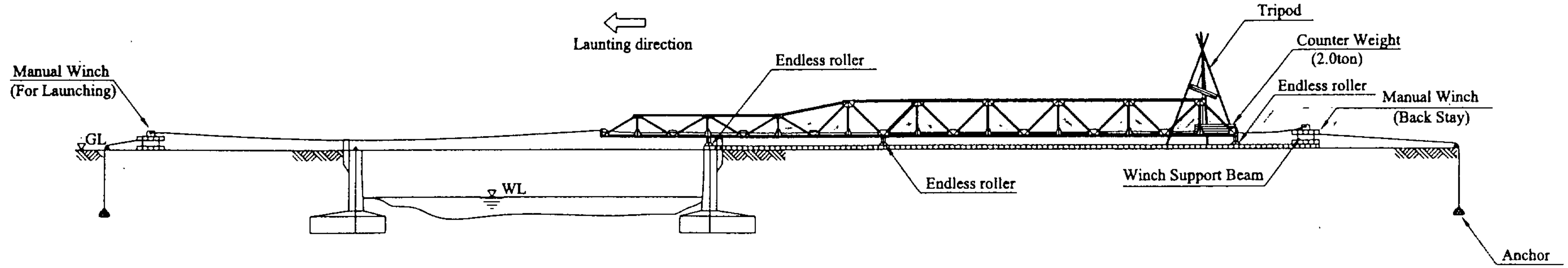


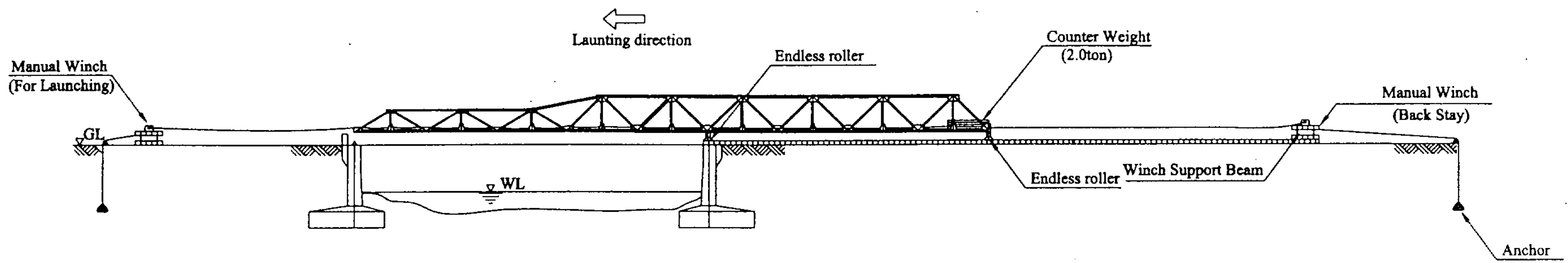
Figure 2.3.2-3 (1/3) PROCEDURE OF 1-SPAN LAUNCHING NOSE METHOD

Erection Sequence for Launching Method (L=25m)

STEP-4
- ✡ Main Structure assembly
- ✡ Launting
- ✡ Installation of Counter Weight



STEP-5 ✡ Launting



STEP-6 ✡ Launting

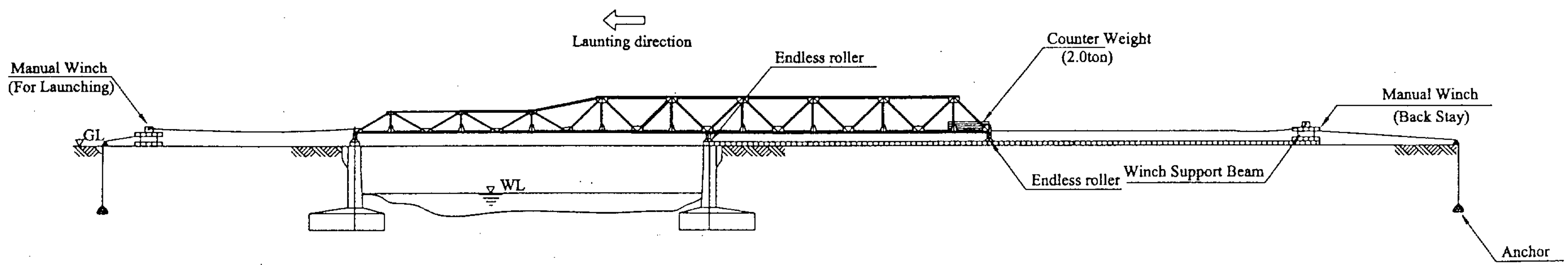
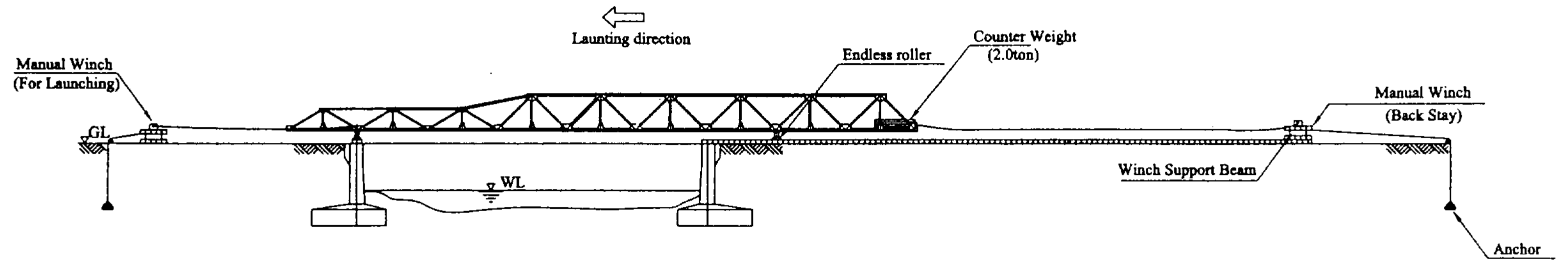


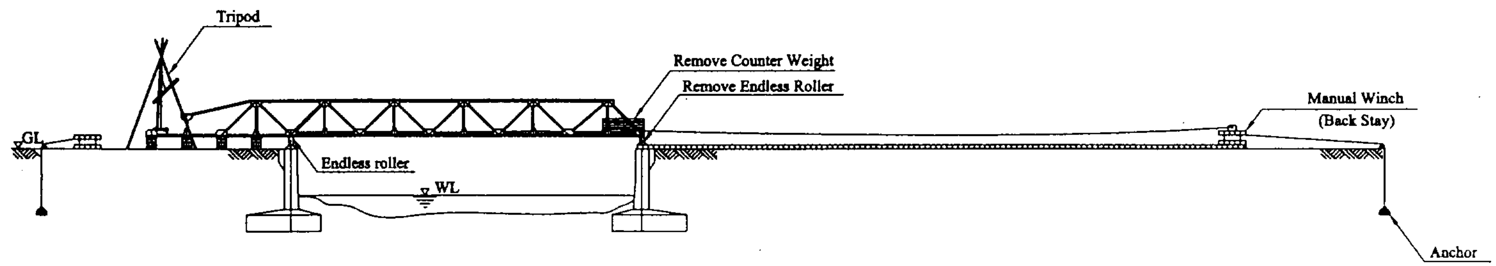
Figure 2.3.2-3 (2/3) PROCEDURE OF 1-SPAN LAUNCHING NOSE METHOD

Erection Sequence for Launching Method (L=25m)

STEP-7 ☆ Launting
☆ Remove Endless Roller



STEP-8 ☆ Dismantle of Launching Nose
☆ Remove Counter Weight



STEP-9 ☆ Remove Erection Tool
☆ Jacking Down. Erection Completed

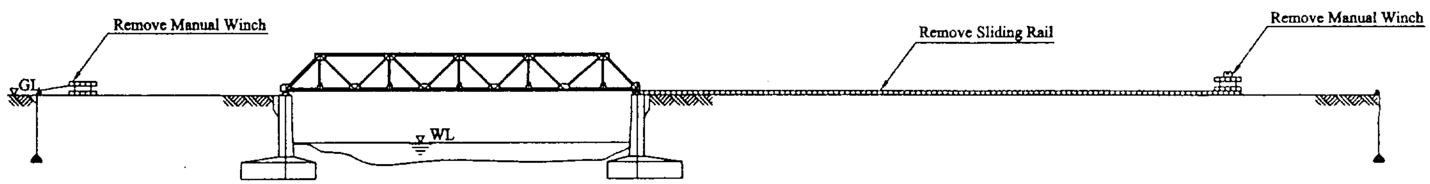


Figure 2.3.2-3 (3/3) PROCEDURE OF 1-SPAN LAUNCHING NOSE METHOD

bridge, it was judged that the Ghanaian side can execute the multi-span bridge erection. It is also recommended that preparation of the superstructure erection manual and erection training at the job site should be included in the technical assistance by the Government of Japan.

Procedure of multi-span bridge erection by the launching nose is shown in Figure 2.3.2-4. Details of the launching nose is shown in Figure 2.3.2-5.

2) Assembly and Erection Tools and Materials to be Procured

Three sets of assembly and erection tools for 21 bridges have been procured under the project in 1996. These were examined by the Study Team and found that most consumable items have already been consumed, many of tools have been damaged and only tools and materials stored in the DFR ACCRA workshop are usable for the Project. The Project requires tools and materials for erection of a 3-span bridge, therefore, bigger size or capacity of tools/materials than these procured previously are needed. Thus, new assembly and erection tools/materials are needed.

Number of Set Required

Number of days required for erection is estimated as follows:

Type of Bridge	Number of days required for erection per bridge	No. of bridge	Number of days required
1-span Bridge	46 days	11	506
2-span Bridge	65 days	1	65
3-span Bridge	81 days	1	81
Total		13	652 days (About 22 month)

One of the conditions agreed between two Governments is that all bridges shall be completed within 2 years after the delivery of superstructure materials to Ghana. When one set of assembly and erection tools/materials is procured, 13 bridges can be erected in 22 months. It was concluded that one set of assembly and erection tools/materials shall be procured for the Project.

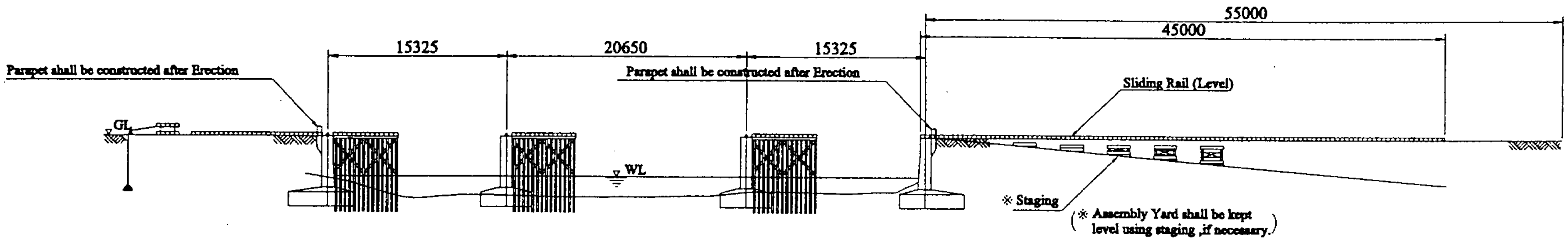
Quantity To Be Procured

Quantities to be procured for the Project is these required for a 3-span bridge from which those stored in DFR ACCRA workshop are deducted.

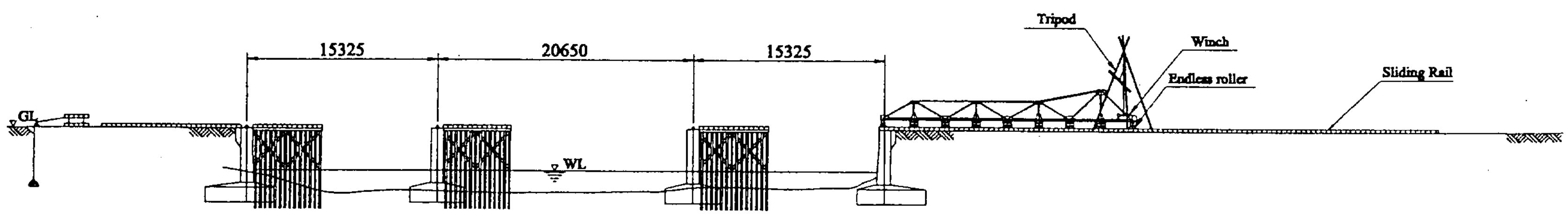
Quantities of assembly and erection tools/materials to be procured for the Project are shown in Table 2.3.2-14.

Erection Sequence for Launching Method (L=15m+20m+15m)

STEP-1
- ✡ Set up Assembly Yard
- ✡ Sliding Rail installation
- ✡ Staging installation



STEP-2
- ✡ Launching Nose assembly



STEP-3
- ✡ Main structure assembly
- ✡ Installation of Deck for Main structure

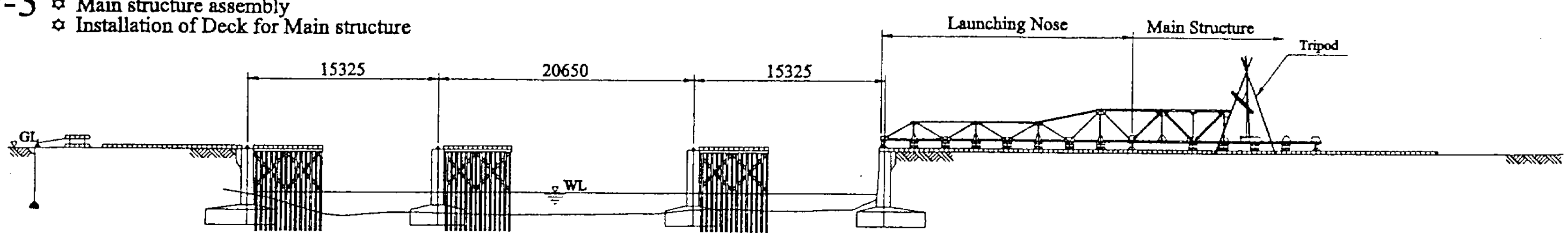
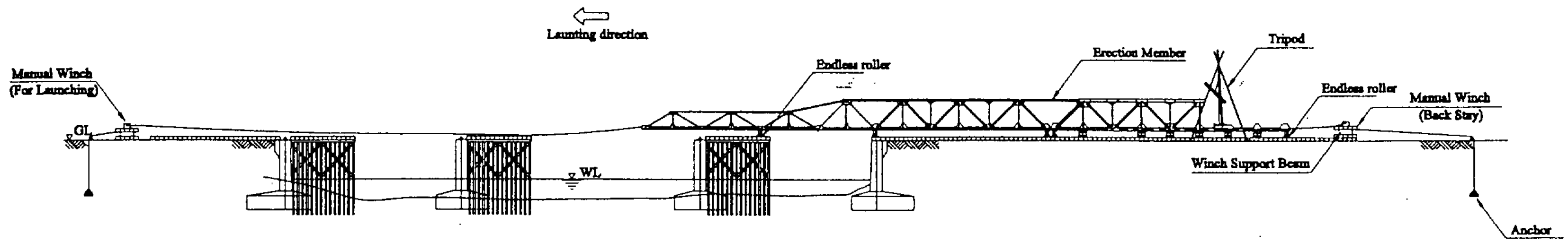


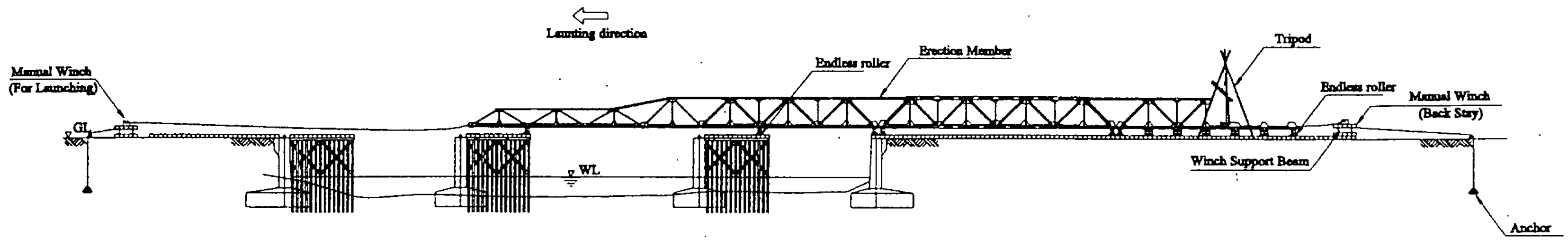
Figure 2.3.2-4 (1/3) PROCEDURE OF 3-SPAN LAUNCHING NOSE METHOD

Erection Sequence for Launching Method (L=15m+20m+15m)

STEP-4 ☼ Main Structure assembly ☼ Launting



STEP-5 ☼ Launting ☼ Main Structure assembly



STEP-6 ☼ Launting

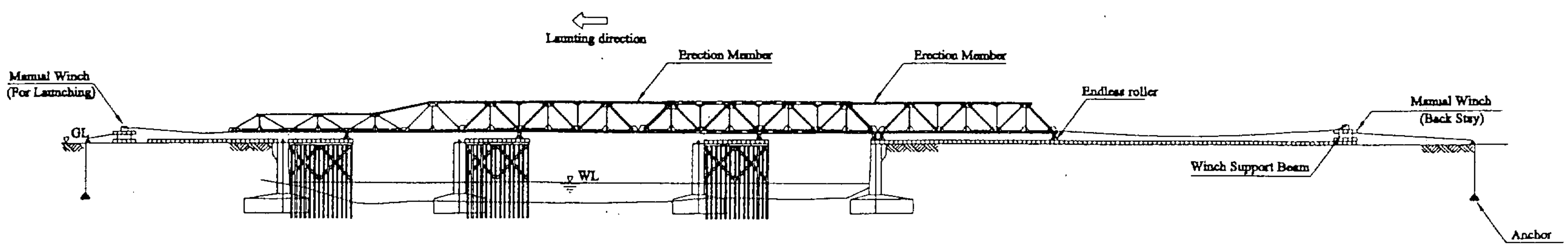
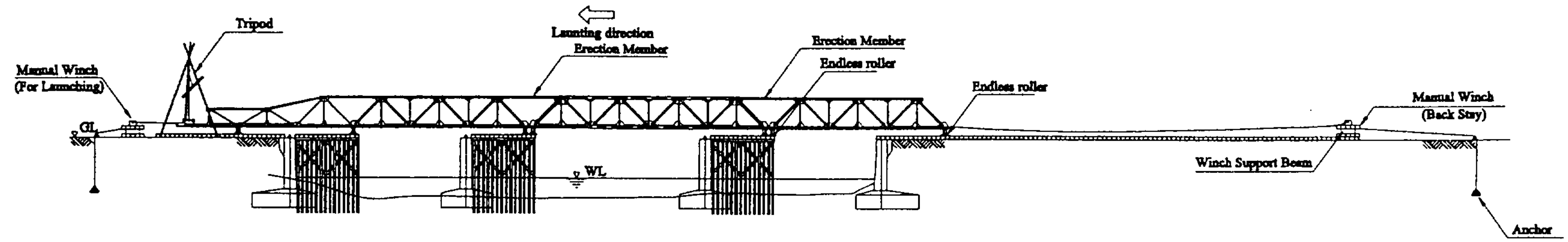


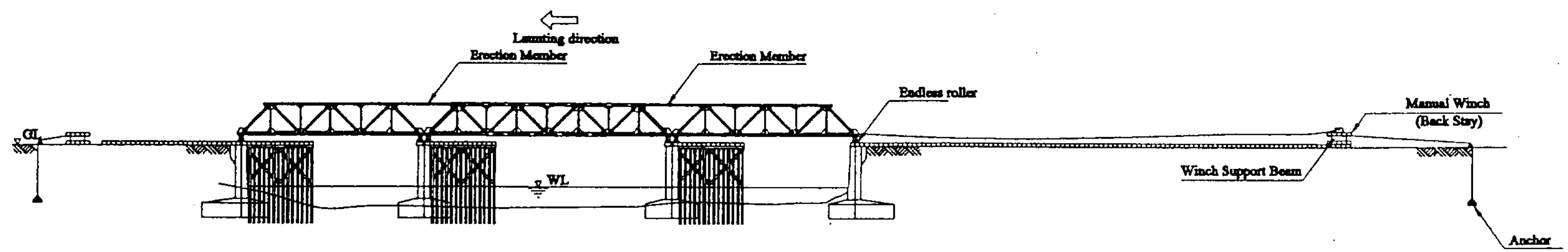
Figure 2.3.2-4 (2/3) PROCEDURE OF 3-SPAN LAUNCHING NOSE METHOD

Erection Sequence for Launching Method (L=15m+20m+15m)

STEP-7
- ✡ Launting
- ✡ Remove Endless Roller
- ✡ Dismantle of Launching Nose



STEP-8
- ✡ Dismantle of Launching Nose
- ✡ Dismantle of Erection member



STEP-9
- ✡ Remove Erection Tool
- ✡ Jacking Down. Erection Completed

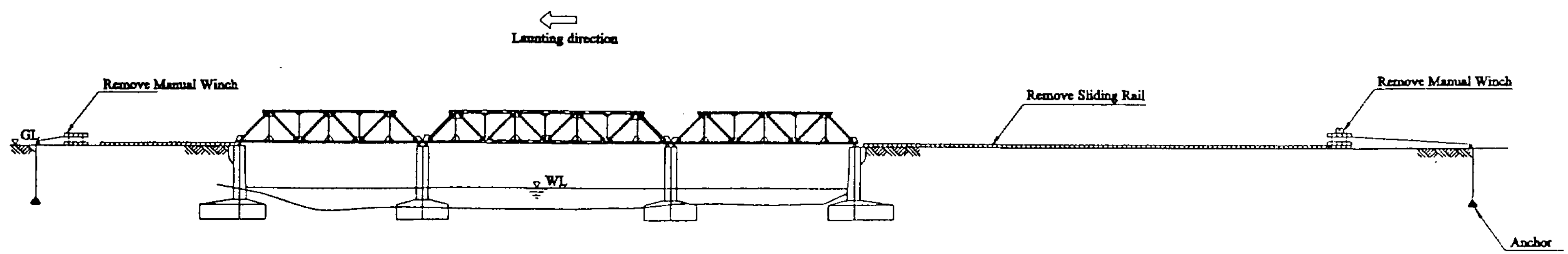
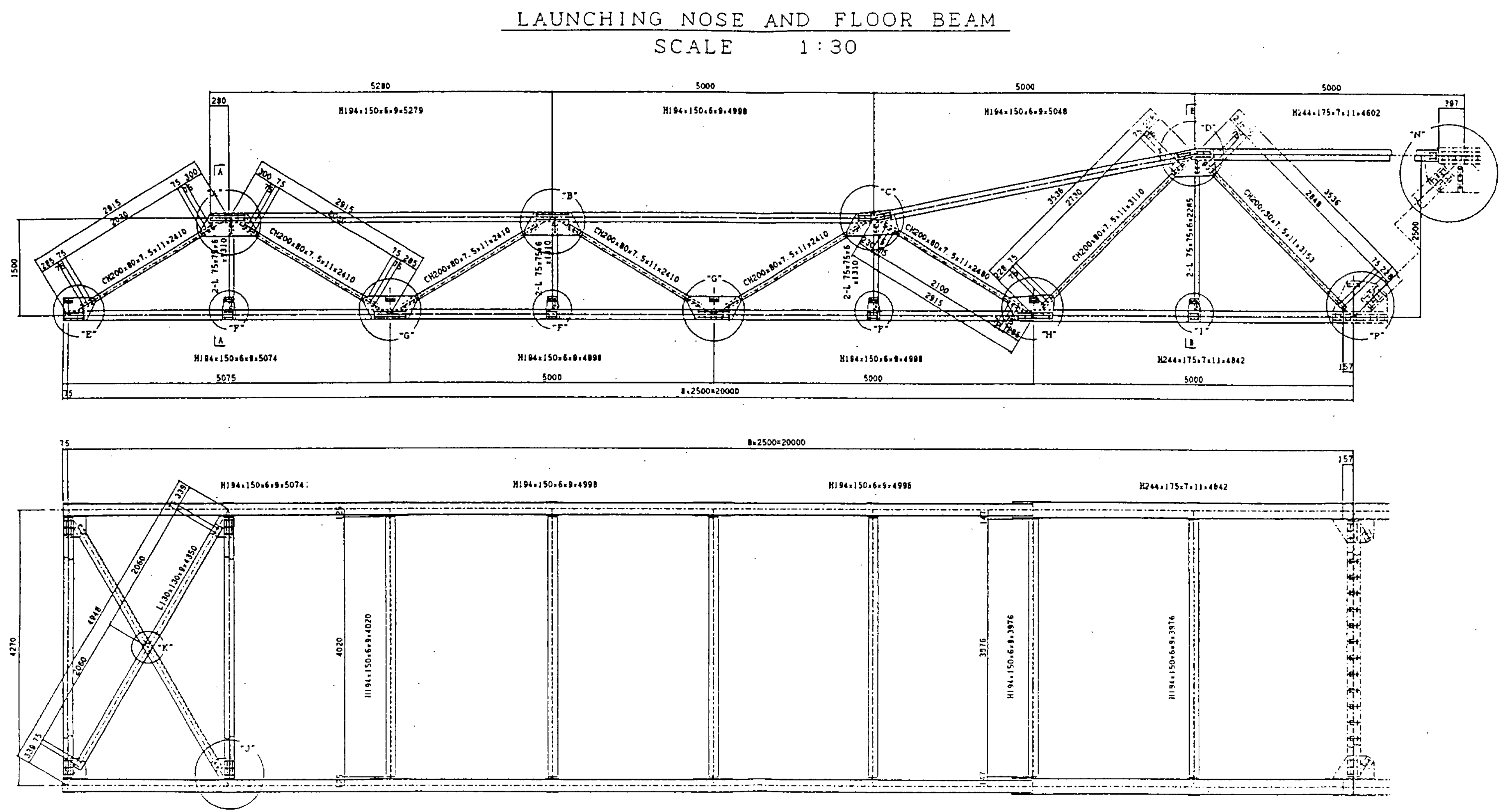


Figure 2.3.2-4 (3/3) PROCEDURE OF 3-SPAN LAUNCHING NOSE METHOD



NOTE

1. MATERIAL STANDARD NOT DESCRIBED IS JIS G3101 SS400 OR EQUIVALENT.
2. ALL MEMBERS SHALL BE HOT DIP GALVANIZED TO JIS H8641 GRADEHDZ55 OR EQUIVALENT.
3. ALL HIGH STRENGTH BOLTS ARE JIS B1186 F8T(M22) AND HOT DIP GALVANIZED TO JIS H8641.
4. HOLES FOR HIGH STRENGTH BOLTS:25.0ϕ

Figure 2.3.2-5 DETAILS OF LAUNCHING NOSE

Table 2.3.2-14 Assembly/Launching Tool List

1. Assembly

Item			Designation	Unit	Quantity for 3 Spans Erection	Quantity Stored by DFR	Supply Quantity
1) Survey Tools							
	(1)	Level Gauge	Steel 90cm	pcs.	3	-	3
	(2)	Plumb	Weight 800g	pcs.	8	-	8
	(3)	Steel Measuring Tape	50m	pcs.	2	1	1
2) Erection Tools							
	(1)	Torque Wrench	7,500 QLE	pcs.	6	-	6
	(2)	Socket	60° x 36mm	pcs.	26	-	26
	(3)	Single Offset Wrench	60° x 36mm	pcs.	8	-	8
	(4)	Sledge Hammer	#8 (3.5kg)	pcs.	4	-	4
	(5)	Hand Hammer	#3 (1.3kg)	pcs.	8	-	8
	(6)	Monkey Wrench	L=300mm	pcs.	4	-	4
	(7)	Lever Block	1.5 ton	pcs.	5	-	5
	(8)	Cutter	ϕ20 wire rope	pcs.	1	-	1
	(9)	Wire Clip	ϕ10	pcs.	35	-	35
	(10)	Craw Bar	L=1.0mm	pcs.	1	-	1
	(11)		L=1.5mm	pcs.	1	-	1
	(12)	Erection Bolt	M22 x 50	pcs.	1,000	-	1,000
	(13)	Drift Pin	ϕ24.5	pcs.	500	360	140
	(14)	Tapered Pin	ϕ24.6-ϕ22.0	pcs.	20	-	20
3) Lifting Equipment							
	(1)	Three Prong Lift	2 ton	pcs.	3	2	1
	(2)	Pulley Block	2S-Hock	pcs.	4	5	0
	(3)	Clamp	0.5 ton	pcs.	4	-	4
	(4)	Shackle	5/8"	pcs.	10	-	10
	(5)	Turnbuckle	2 screw	pcs.	4	-	4
	(6)	Pipe	ϕ60.5 x 7m	pcs.	8	-	8
	(7)	Nylon Sling	1.5 ton x 5m	pcs.	8	3	5
	(8)	Portable Winch	3 tons	unit	2	(4 : 2 ton)	2
	(9)	Steel Wire Rope	ϕ12 x 45m	roll	2	-	2
	(10)	Stay Wire Rope	ϕ12 x 3m	pcs.	2	-	2
	(11)	Base Beam	H150 x 1.5m	pcs.	4	-	4
4) Scaffolding							
	(1)	Scaffolding	KA3055A	set	24	2	22
	(2)	Stage Plank	KPS5183	pcs.	44	3	41
	(3)	Jack Base	KA752	pcs.	48	3	45
	(4)	Ladder	KA3055S	pcs.	4	-	4
	(5)	Bracing	KA14	pcs.	44	6	38

2. Launching

Item			Designation	Unit	Quantity for 3 Spans Erection	Quantity Stored by DFR	Supply Quantity
1) Launching Rail							
	(1)	Rail	73.8 kg/m	ton	10.322	-	10.322
	(2)	Base Plate	T = 25mm	ton	0.5	-	0.5
2) Launching Equipment							
	(1)	Roller	50 ton	pcs.	16	-	16
	(2)	Screw Clamp	T-100	pcs.	24	3	21
	(3)	Screw Clamp	T-100	pcs.	100	-	100
	(4)	Portable Winch	3 ton	pcs.	2	(4 : 2 ton)	2
	(5)	Chain Block	4 ton	pcs.	4	-	4
	(6)	Pulley Block	Double Pulley 2S-Hook	pcs.	4	-	4
	(7)		Single Pulley 1S-Hook	pcs.	8	2	6
	(8)	Stay Wire Rope	ϕ 12 x 2m	pcs.	6	-	6
	(9)	Steel Wire Rope	ϕ 12 x 200m	roll	2	2 (150m)	1
	(10)	Shackle	5/8"	pcs.	10	-	10
	(11)	Light Weight Shackle	RS5	pcs.	4	-	4
	(12)	Turnbuckle	2 screw	pcs.	4	-	4
	(13)	Roller Staging Beam	H150 x 4m	pcs.	6	-	6
	(14)	Filler Plate	6 x 200 x 200	pcs.	50	-	50
	(15)		25 x 200 x 200	pcs.	30	-	30
	(16)		10 x 200 x 200	pcs.	50	-	50
	(17)	Winch Staging Beam	H150 x 1.5m	pcs.	100	-	100
3) Erection Truss							
	(1)	Erection Truss/Tie Beam	Steel Structure	ton	6.941	-	6.941
	(2)	H.T. Bolt	F10T - M22	kg	1,802	-	1,802
4) Jack Up/Down Equipment							
	(1)	Mechanical Jack	25 ton Sliding-Type	unit	6	1	5
	(2)		50 ton Sliding-Type	unit	6	-	6
	(3)		25 ton	unit	0	-	0
	(4)	Saddle	H150 x 0.5m	pcs.	72	-	72
	(5)	Teflon Sheet	50cm x 50cm	pcs.	12	-	12

CHAPTER 3

IMPLEMENTATION PLAN

CHAPTER 3 IMPLEMENTATION PLAN

3.1 Implementation Plan

3.1.1 Implementation Concept

The following are the basic conditions for implementing this Project:

- This Project, if approved, will be implemented in accordance with the provisions of Japan's Grant Aid Program after the signing of the Exchange of Notes between the Governments of Japan (GOJ) and the Government of Ghana.
- The Department of Feeder Roads of the Ministry of Roads and Transport is the responsible agency for implementing the Project.
- The detailed design of Construction Type Bridges and Superstructure of Material Supply Type Bridges, tenders and construction supervision of Construction Type Bridges of the Project will be undertaken by a Japanese consulting firm in accordance with a contract between the Ministry of Roads and Transport and the consultant.
- The procurement of superstructure materials and assembly and erection tools/materials of the Material Supply Type Bridges will be undertaken by the successful Japanese tenderer in awarding the contract with the Ministry of Roads and Transport.
- The construction of the Construction Type of Bridges will be undertaken by the successful Japanese tenderer in awarding the contract with the Ministry of Roads and Transport.

The following are the main concepts in the implementation plan of the Construction Type Bridges:

- The construction will be undertaken by the Japanese contractor under its direct management, employing labors and leasing available equipment from local subcontractors.
- Materials and equipment necessary for the Project will be procured in Ghana as far as available. Items unavailable locally will be procured from Japan or third countries. Third countries will be selected on the basis of cost, with the conditions that the quality and supplying capacity meet the requirements.
- The construction method and schedule of the Project will be planned reflecting local conditions of climate, topography, geology, and so on.
- Easy and commonly used methods of construction, not needing special equipment or technology, will be adopted for the project as much as possible.
- Organization for construction management by the contractor and construction supervision by the consultant will be proposed meeting the standardized construction management methods.

- At least one lane shall be opened to traffic during construction and necessary measures for safety shall be taken.
- Full attention shall be paid to the environmental preservation, especially prevention of outflow of mud water and water pollution during execution of earth works.

3.1.2 Considerations on Implementation

Major considerations to be paid during implementation are (1) cofferdam construction method for substructure and river bank protection work construction, (2) steel girder erection method, and (3) detour road plan.

(1) Cofferdam Construction Method for Substructure Construction and River Bank Protection Work.

Construction of substructures and river bank protection works is scheduled to be implemented in dry seasons. Temporary Cofferdams are required during construction of structures located below ordinary water level. Where water depth is about 1 m and excavation depth is less than 2 m, a sand bag fill cofferdam is planned. A steel sheet pile cofferdam is planned where water depth is over 1 m and excavation depth is over 2 m. Cofferdam construction method for the Construction Type Bridge are as follows:

Bridge No.	Bridge Type	Ordinary Water Depth (m)	Cofferdam Method	Remarks
M-11	RC + RC + Plate Girder	0.6	Sand Bag Fill	-
M-12	RC + Plate Girder + RC	1.8	Steel Sheet Pile	-
S-15	RC + RC + RC	0.6	Channel Diversion	-
M-3-1	RC + Plate Girder + RC	0.8	Sand Bag Fill	-
M-3-2	Plate Girder	0.8	No need	No water at abutment

(2) Steel Girder Erection Method

The following methods are commonly used for erection of steel girders:

- Direct erection method using truck cranes and bents
- Launching method using launching nose
- Cable hanging erection method

Among the above, a direct erection method using truck cranes and bents is simple and easy and special technique is not required, thus selected for the Project.

In order to provide a working stage for truck cranes, platforms are planned for the site where water depth is deep. The required capacity of truck cranes is about 40 tons.

(3) Detour Road Plan

All the sites have no bridge at present, therefore, a detour road is not required.

3.1.3 Scope of Works

The undertakings of both governments, Japan and Ghana, are listed in Table 3.1.3-1.

TABLE 3.1.3-1 UNDERTAKING OF BOTH GOVERNMENT

Type of Bridge	Item	Contents		Undertaken by Japan	Undertaken by Ghana	Remarks
Material Supply Type	Detailed Design	Superstructure Design		○		
		Substructure Design		●	○	
		Foundation Design		●	○	
		Related Work Design		●	○	Approach Road, Revetment
		Steel Girder Erection Plan		●	○	
	Procurement of Material and Equipment and Construction	Steel Superstructure Members		○		Steel Girder, Steel Deck Plate
		Assembly/Erection Tools		○		Launching Nose and Others
		Transportation to Ghana		○		
		Unloading		○		
		Custom Clearance			○	
		Material Storage			○	
		Transportation in Ghana			○	
		Assembly/Erection		●	○	
		Substructure Construction			○	Inclusive of Foundation
		Related Works Construction			○	Approach road, Revetment
	Maintenance				○	
Const-ruction type	Detailed Design	Super- and Sub-structure		○		
		Approach road	Bridge Approach	○		
			Other than Above		○	
		Related Work Design		○		
	Procurement of Material	Procurement/Transportation		○		
		Custom Clearance			○	
		Repair of Transport Road			○	
	Preparation Work	Acquisition of Lots for Construction			○	Site Office, Storage Yard, Plant Yard and Work Shops
		Other Works than Above		○		
	Removal/Relocation of Existing Facilities				○	House, Store, Power Poles, Telephone Cable, Water Pipes
	Acquisition of Right-of-way				○	
	Bridge Construction Work			○		
	Maintenance				○	

Note: ● Items for Technical Assistance by the Government of Japan.

3.1.4 Consultant Supervision

A Japanese consulting firm will supervise the implementation of the Project on behalf of the Government of Ghana. The works to be undertaken by the consultant are as follows:

(1) Material Supply Type Bridges

<u>Detailed Design</u>

The major works in the detailed design to be curried out by the consultant are as follows:

- Detailed design of superstructure
- Detailed design of assembly and erection tools and materials
- Preparation of drawings and specifications
- Superstructure erection planning and cost estimate
- Preparation of tender documents

The necessary time for the detailed design is 2.5 months.

<u>Assistance in Tendering</u>

This task includes the following items:

- Tender publication
- Tendering
- Tender evaluation
- Contract facilitation

The necessary time for assistance in tendering is 2.5 months.

<u>Technical Assistance</u>

The major works for the technical assistance are as follows:

- Detailed design stage of the Government of Ghana
  - Preparation of standard design of substructure and ancillary works
  - Preparation of design guidelines
  - Superstructure erection guidelines
  - Material management guidelines

- Construction supervision stage of the Government of Ghana
  - Training of superstructure assembly and erection
  - Preparation of construction supervision guidelines

The necessary time for the detailed design is 7 months.

(2) Construction Type Bridges

Detailed Design

The major works in the detailed design to be curried out by the consultant are as follows:

- Supplementary site survey
- Detailed design of bridges, approach roads and related structures
- Preparation of drawings and specifications
- Construction planning and cost estimation
- Preparation of tender documents

The necessary time for the detailed design is 3 months.

Assistance in Tendering

This task includes the following items:

- Tender publication
- Pre-qualification
- Tendering
- Tender evaluation
- Contract facilitation

The necessary time for assistance in tendering is 3 months.

Construction Supervision

The main work items to be executed by the consultant are as follows:

- Inspection and approval of site surveys
- Inspection and approval of construction plan
- Quality control
- Progress control
- Measurement of work
- Inspection of safety aspects

- Final inspection and turnover

The construction period is 19.5 month. To successfully carry out the supervision, a resident engineer of the consultant is required to be stationed on the site during the entire construction period. Additionally, a bridge engineer is required for 3.5 month during the erection of superstructure.

3.1.5 Procurement Plan

(1) Material Supply Type Bridges

After the cost comparison, it was decided that superstructure materials and assembly and erection tools/materials will be procured in Japan.

(2) Construction Type Bridges

<u>Procurement of Steel Superstructure Materials</u>

After the cost comparison, it was decided that steel superstructure materials will be procured in Japan or in a third country (England, Spain, Italy, German, the Republic of South Africa, etc.).

<u>Construction Materials</u>

Principle considerations for construction materials procurement are as follows:

- Locally available materials will be used as far as their quality and quantity are acceptable.
- Imported materials which are constantly available in the local market and their quality, quantity and cost are acceptable will be procured regarded as local items.
- Materials which are not available in the local market will be procured from Japan or third countries. Countries of material source will be decided comparing quality, price and other points of materials.

Procurement plan of the major materials is shown in Table 3.1.5-1.

<u>Equipment</u>

Equipment procurement conditions in Ghana are as follows:

- There is no equipment lease firm in Ghana.

TABLE 3.1.5-1 MATERIAL PROCUREMENT PLAN

Item	Procured from			Remarks
	Ghana	Japan	Third Country	
Material of Permanent Structure				
Crush Stones (Foundation, Base Course)	○			Kumasi, Cape Coast Tarkwa, Bolgatanga
Cement	○			Tema (Local product: Imported Clinker)
Sand	○			
Cores Aggregate	○			the same as Crush Stones
Reinforcing Steel Bar: 6D~D25	○			Mild steel: (Local Product) Tema
Deformed Bar: D29~D32			○	High Yield Steel: Europe
Bar Connector: D32			○	Ditto
Steel H Pile: H-400		○		
Steel Plate Girder			○	England, Germany, Spain, Italy, South Africa
Bearing			○	Ditto
Paint			○	Ditto
Non-Shrink Mortar			○	Ditto
Expansion Joint			○	Ditto
Steel Truss girder		○		
Grass	○			
Rubble	○			
PVC Pipe: D = 100	○			ACCRA (Imported)
PC Pipe: D = 600	○			(Local Product)
Guard Rail for Approach Road			○	Italy, South Africa
Steel Sheet Pile			○	Europe, South Africa
Gabion			○	Ditto
Temporary Material				
RC Pipe: D = 600	○			(Local Product)
Wood Form Work	○			Kumasi (Local Product)
Plywood Form Work without Watertight	○			Ditto
Plywood formwork with Watertight			○	Europe, South Africa
Nail	○			Local Product
Scaffolding Pole	○			Kumasi (Local Product)
Steel Sheet Piles for Cofferdam		○	○	Europe, South Africa
Bracing		○	○	Ditto
Bracing Tools		○		
Bracing Bolt		○		
Bracing Drift Pin		○		
Sandbag	○			Kumasi (Local Product)
Welding Electrode			○	Europe, South Africa
Fuel/Oil	○			Tema (Imported: Stock Tank for exemption from taxation)
Oxygen, Acetylene Gas	○			Local Product
Gas Cutter	○			ACCRA (Imported)

- Equipment being used for other projects can not be leased to other project because these are brought in the country only for the use of the respective project..
- Local contractors are basically for labourers supply and do not own enough equipment for major construction works.
- Light equipment (concrete mixer, etc.) is imported and can be purchased locally.
- Heavy equipment is to be procured from Japan or third countries.

Procurement plan of the major equipment is shown in Table 3.1.5-2.

TABLE 3.1.5-2 EQUIPMENT PROCUREMENT PLAN

Equipment	Capacity	Procured from			Remarks
		Ghana	Japan	Third Country	
Backhoe Excavator	0.6 m^3			○	
Bulldozer	15 t			○	
Motor Grader	3.1 m			○	
Road Roller	8 t			○	
Concrete Mixer	0.3 m^3	○			Imported Product
Truck Mixer	3.0 m^3			○	
Dump Truck	10 t			○	
Truck Crane	15 t			○	
Truck Crane	30 t			○	
Diesel Hammer	2.5 t			○	
Vibro-Hammer	40 KW			○	
Generator	200 KVA			○	
Generator	35 KVA			○	
Submersible Pump	150 mm			○	
Truck	8 t			○	

3.1.6 Technical Assistance Plan

For material supply type bridges, the Ghanaian side is responsible for the detailed design (excluding superstructure), construction of substructure, assembly and erection of superstructure and construction supervision.

Through the experience of "the Project for Small Stream Bridges Rehabilitation" in 1996, the technical assistance by the Government of Japan was assessed to be needed for the smooth implementation of the project. DFR requested to include the technical assistance for the Project. At the initial stage of the implementation, the following should be considered:

1) To ensure the technical soundness of the detailed design to be undertaken by the Government of Ghana.

2) To ensure harmony of the design between the superstructure design which is made by the Government of Japan and the substructure and other design which is made by the Government of Ghana.

3) To ensure the accuracy and technical soundness of construction as well as to assure the completion of the project within the specified period of time so as to achieve timely socio-economic effects of the project.

In view of above, the following technical assistance by the Government of Japan is included in the Project:

Detailed Design Stage	Output
• Standard Design of substructure and related works (2 bridges)	• Standard Drawings
• Preparation of Design Guidelines	• Design manual
• Preparation of Superstructure Erection Guideline	• Assembly and Erection Manual
• Material Management Guideline	• Material list for each bridge
Construction Supervision Stage	
• Superstructure assembly and Erection Guideline	• Workshop • Jobsite assembly and erection demonstration at the S-28 site
• Preparation of construction Supervision Guideline	• Construction Supervision Manual

Both Governments' undertakings and their relation with the technical assistance are shown in Table 3.1.6-1.

3.1.7 Implementation Schedule

The implementation schedule is proposed as shown in Table 3.1.7-1.

Table 3.1.6-1 Flowchart of Technical Relations between Undertaking of Both Governments and Technical Assistance

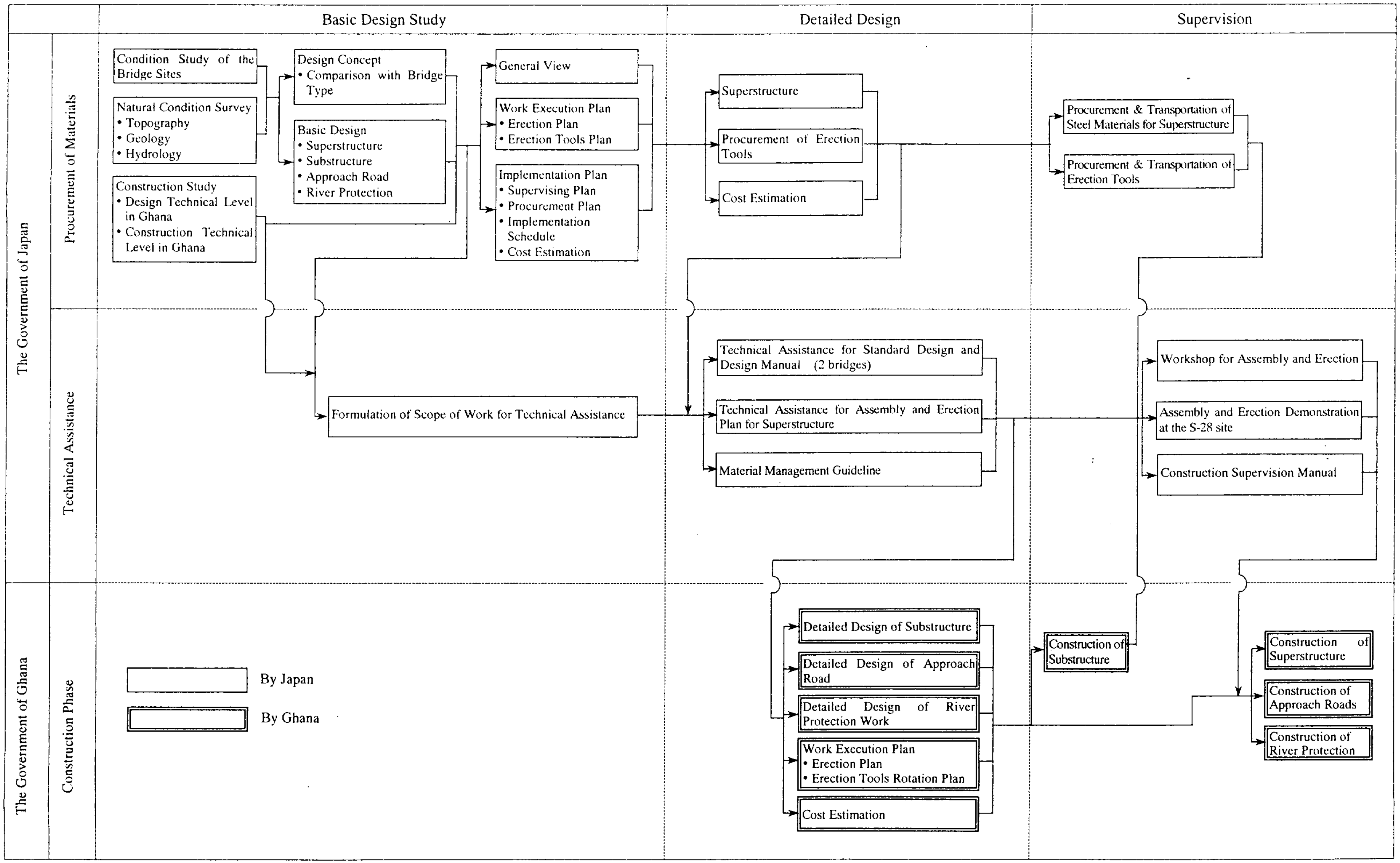
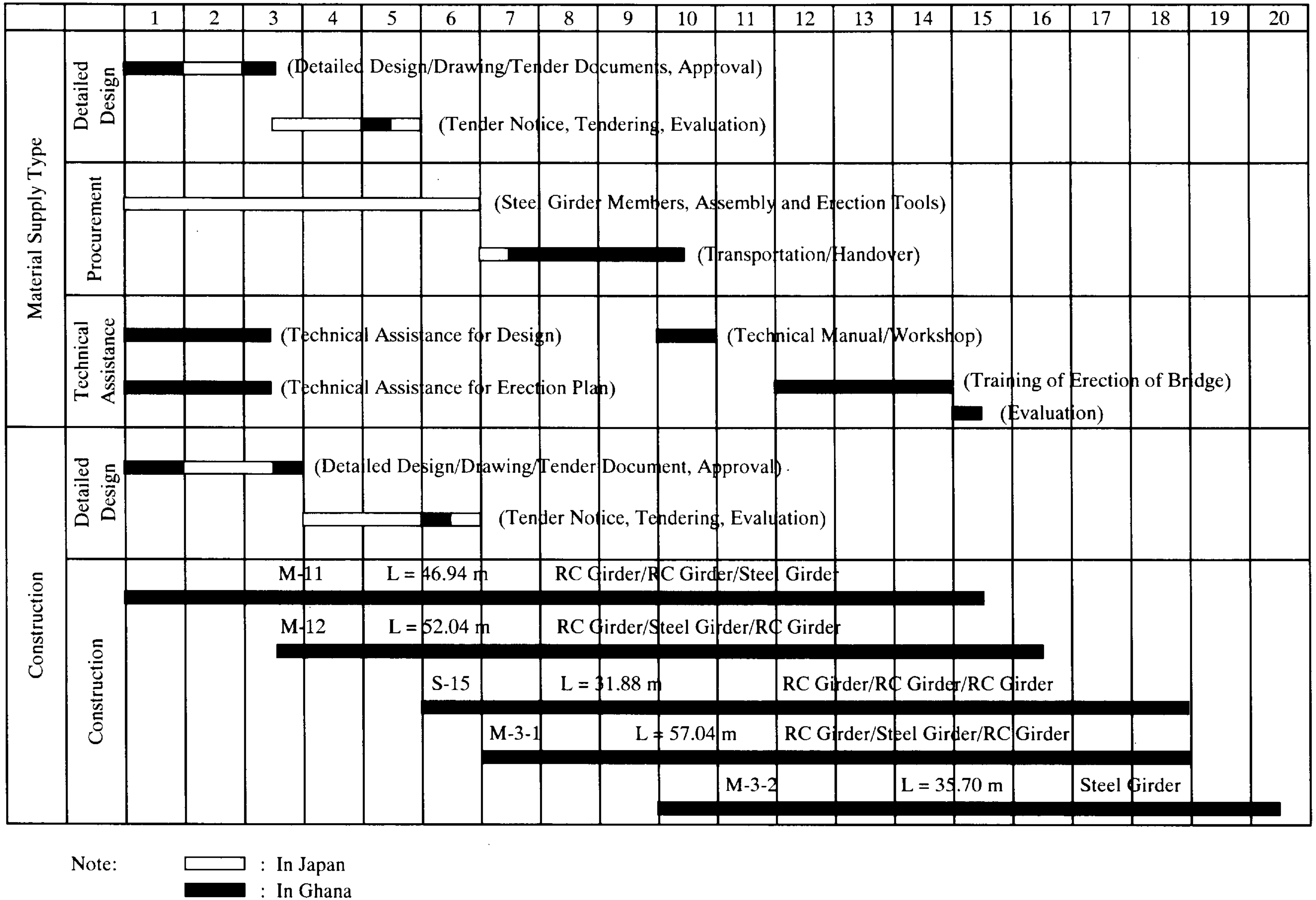


TABLE 3.1.7-1 IMPLEMENTATION SCHEDULE



3.1.8 Obligations of the Government of Ghana

The following necessary measures should be taken by the Government of Ghana on condition that the grant aid by the Government of Japan is extended to the Project:

- To provide data and information necessary for the Project.
- To secure the land necessary for the execution of the Project, such as the land for bridges, temporary offices, working areas, storage yards and others.
- To remove existing obstacles such as houses, stores, etc., within the right-of-way.
- To clear the sites prior to the commencement of the construction.
- To relocate existing utilities such as power poles, power cable, water pipes, etc. outside the Project site.
- To make passable all roads and bridges leading to the Project sites before the commencement of inland transportation of materials and equipment.
- To demolish existing bridges according to the construction schedule which will be provided in the later stage.
- To bear commissions to the Japanese foreign exchange bank for its banking services based upon the Banking Arrangement, namely the advising commission of the "Authorization to Pay" and payment commission.
- To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation in the Republic of Ghana and prompt internal transportation therein of the materials and equipment for the Project purchased under the Grant Aid.
- To exempt Japanese juridical and physical nationals engaged in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in the Republic of Ghana with respect to the supply of the products and services under the verified contracts.
- To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into the Republic of Ghana and stay therein for the performance of their work.
- To provide necessary permissions, licenses and other authorizations for implementing the Project, if necessary.
- To bear all the expenses, other than those covered by the Japanese grant aid, necessary for the Project.
- To maintain and use properly and effectively the facilities constructed under the Project.
- To coordinate and solve any issues related to the project which may be raised from third parties or inhabitants in the Project area during implementation of the Project.

3.2 Project Cost Estimation

Project cost born by the Government of Ghana is estimated at US$ 8.677 million (refer to Appendix-5) as follows:

Bridge construction cost	:	US$ 3.200 million
Improvement/rehabilitation cost of subject roads	:	US$ 5.300 million
Custom clearance fee	:	US$ 0.012 million
ROW and compensation cost	:	US$ 0.165 million

3.3 Operation and Maintenance Cost

Maintenance of bridges to be constructed under this Project will be carried out by the Department of Feeder Roads of the Ministry of Roads and Transport.

Maintenance works consist of the periodical inspection required at least for the first 10 years. The periodical inspection is done by DFR and cleaning of bridges is contracted out to local contractors.

Maintenance cost is estimated at US$ 20,000 per year.

CHAPTER 4

PROJECT EVALUATION
AND
RECOMMENDATION

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATION

4.1 Project Effect

The Project aims to eliminate traffic bottlenecks by constructing bridges along the feeder roads and to provide transport service throughout a year to the residents in the project influence areas. The Project will contribute to the rural area socio-economic development, alleviation of poverty and improvement of the level of BHN satisfaction.

The project roads connect rural communities, markets and agricultural farms each other and are important and basic infrastructure for transportation of agricultural products and socio-economic activities in the rural areas.

The Project includes 18 bridges with high priority from the viewpoints of engineering necessity/urgency and socio-economic effect. Thirteen bridges out of 18 are classified as the material supply type bridge and 5 are as the construction type bridge.

The implementation of the Project will benefit 233,400 people residing within the project influence areas.

The direct effects and extent of improving the present situation by implementing the project are summarized below:

Direct Effect	Expected Extent of Effect by the Project
• Transport service by vehicles can be provided.	• At 14 bridge sites, there is no bridge or vehicle passage is not possible due to structurally weak bridges. By constructing a bridge, transport service by vehicles can be provided, thus goods and passengers can be transported easier than the present. Socio-economic activity areas of the residents can be expanded.
• Traffic interruption during rainy seasons can be eliminated.	• At present, traffic interruption even by on foot occurs at 10 bridge sites for more than 30 days and at 6 bridge sites for less than 30 days. Construction of a bridge eliminates such condition and all-year-around access to schools, hospitals and markets can be provided.

• Detour distance can be reduced.	• At 8 bridge sites, there is no alternative route. At 7 bridge sites, over 30 km detour is required and 25 km detour at 3 bridge sites. Construction of a bridge eliminates such detour, resulting in transport cost and travel time savings and improvement of accessibility to social facilities.
• More markets can be accessible.	• Rural people earn their income by selling agricultural products at markets by themselves. Accessible markets increase by 1.5 times at 2 bridge sites, 2 times at 7 bridge sites and more than 2 times at 9 bridge sites, resulting in increased opportunities to sell their products at markets. It is expected that income of rural people will increase by about 1.5 to 2 times.

In addition to above direct effects, the Project will have indirect effects such as activation of socio-economic activities in the rural areas and the country as a whole, contribution to improvement of services for BHN and contribution to alleviation of poverty. Thus, the Project will contribute to the development of rural areas in Ghana.

4.2 Recommendation

The Project will contribute to improvement of living standard of rural people and development of rural areas of Ghana as well as it will have many direct effects. It is therefore concluded to be appropriate that the Project be implemented under Japan's Grant Aid.

The implementation system, institutional organization and personnel and budget of the Government of Ghana for implementation of the Project and its maintenance after completion are considered to be well arranged and no problem is expected.

To realize and sustain the effects of the Project, specific matters to be undertaken by the Government of Ghana are as follows:

- To carry out routine inspection/maintenance of the bridges and repair works as necessary.
- To carry out construction/improvement/rehabilitation of the project roads and maintain them in proper condition.
- To secure the budget for the above.