MINISTRY OF WORKS
THE UNITED REPUBLIC OF TANZANIA

No. 1

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE BRIDGE IMPROVEMENT
ON
TRUNK ROADS
IN
THE UNITED REPUBLIC OF TANZANIA

JANUARY 1997

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)
ORIENTAL CONSULTANTS CO., LTD.
CONSTRUCTION PROJECT CONSULTANTS, INC.

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PREFACE

In response to a request from the Government of the United Republic of Tanzania, the Government of Japan decided to conduct a basic design study on the Project for the Bridge Improvement on Trunk Roads and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Tanzania a study team from August 8th, 1996 to September 7th, 1996.

The team held discussions with the officials concerned of the Government of the United Republic of Tanzania, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Tanzania 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 United Republic of Tanzania for their close cooperation extended to the teams.

January 1997

Kimio Fujita
President
Japan International Cooperation Agency

January 1997

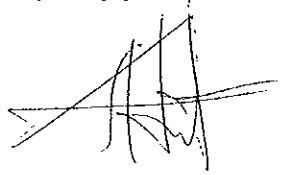
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Bridge Improvement on Trunk Roads in the United Republic of Tanzania.

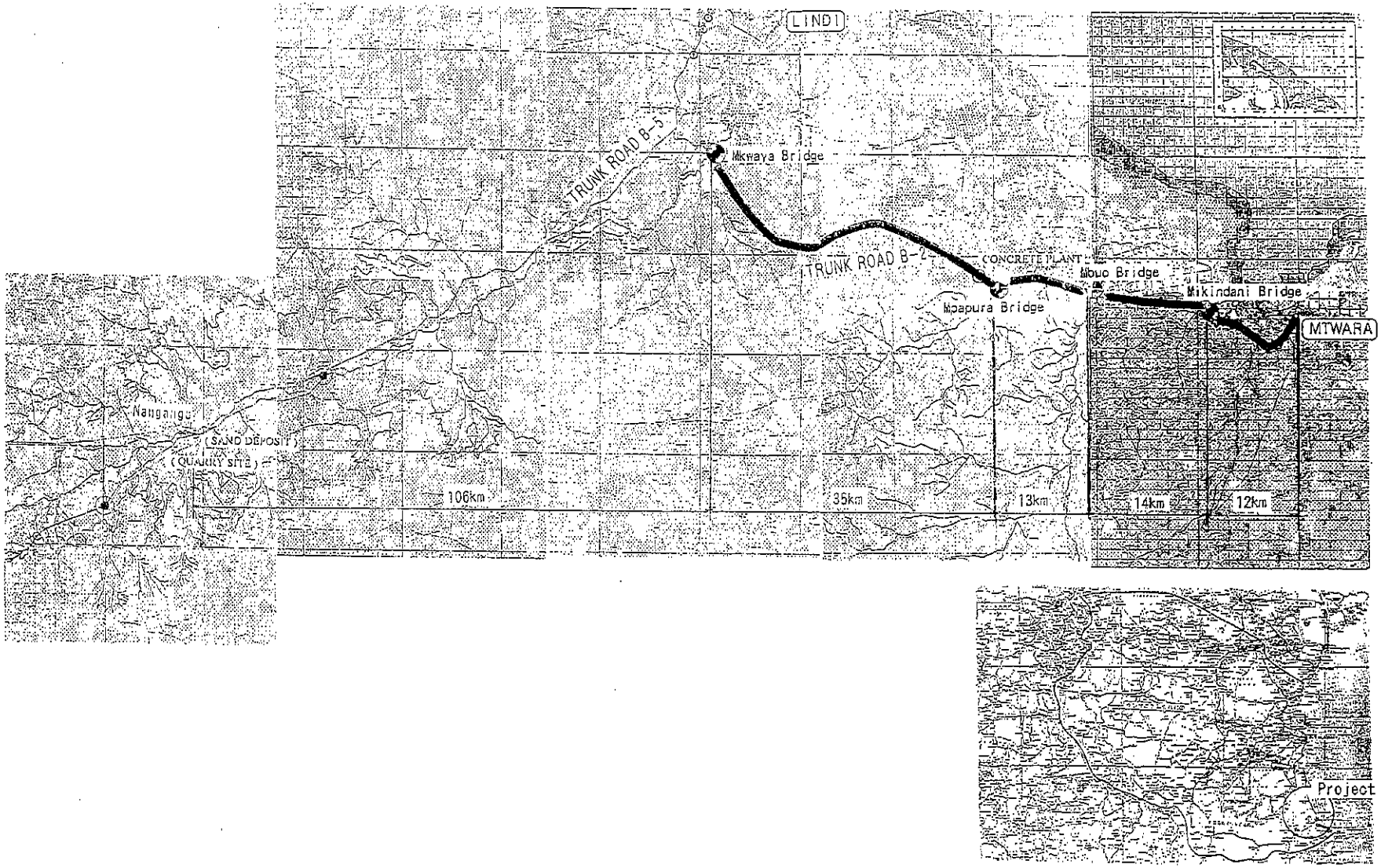
This study was conducted by Oriental Consultants Company Limited and Construction Project Consultants Incorporated, under a contract to JICA, during the period from August 2nd, 1996 to February 4th, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Tanzania 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.

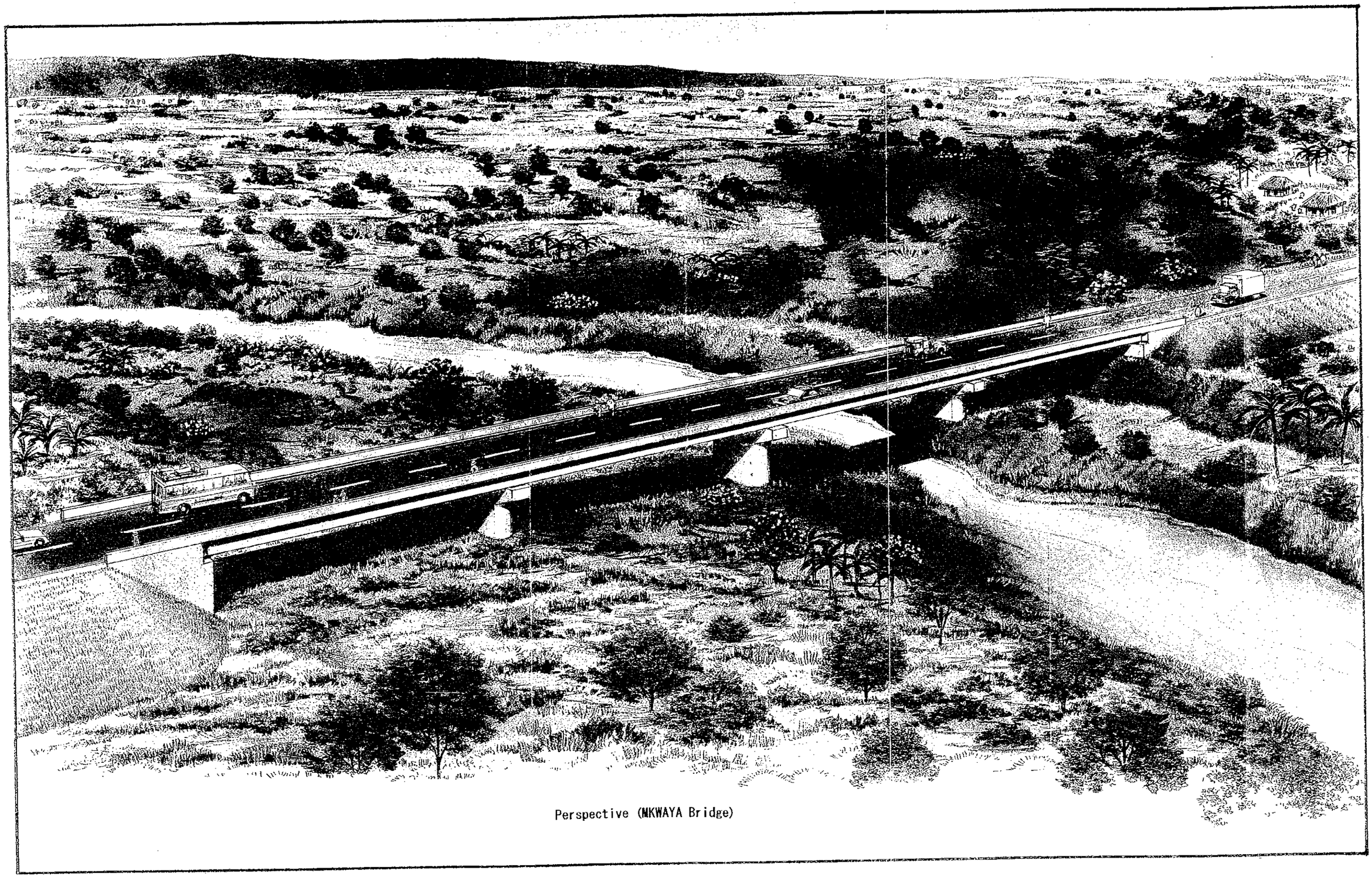
Very truly yours,



Akihiko Hirotani
Project manager,
Basic design study team on
the Project for the Bridge Improvement
on Trunk Roads
Oriental Consultants Company Limited



THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OR TRUNK ROAD	LOCATION MAP (1:200,000)	JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO.,LTD CONSTRUCTION PROJECT CONSULTANTS,INC
		DATE : September 1996 / DRAWING NO :	



Perspective (MKWAYA Bridge)

Abbreviation

A Authorities and Agencies

ADB	Asian Development Bank
JICA	Japan International Cooperation Agency
MOW	Ministry of Works
UNDP	United Nations Development Program
USA/US	United States of America

B Other Abbreviations

AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
@	At the rate
B/D	Basic Design
BR	Bridge
BL	Bridge length
BS	British Standard
BST	Bituminous Surface Treatment
CBR	California Bearing Ratio
℄	Center Line
cm	Centimeter
cm^2	Square centimeter
D/F	Draft Final Report
$	Dollar
Ec	Young's modules of cement
Es	Young's modules of steel
Esp	Modules of elasticity
El	Elevation
FWL	Flood Water Level
H	Height
i	Coefficient of impact
HWL	High water level
Kgf/cm^2	Kilogram force per square centimeter
Kgf/cm^3	Kilogram force per cubic meter
Kgf/mm^2	Kilogram force per square mirimetre
Kh	Horizontal seismic coefficient
Km	Kilometer
Km^2	Square kilometer
Km/h	Kilometer per hour
L	Length
l	Length
LWL	Low water level
m	Meter
M	Million
m^2	Square meter
m^3	Cubic meter

m^3/s	Cubic meter per second
Min.	Minimum
MSL	Mean sea level
N	N-value or Number of wheel load application
n	Number of Ratio of Es to Ec
%	Percent
Φ	Diameter
PC	Prestressed concrete
PCU	Passenger car unit
PSI	Present serviceability index
Q	Quantity
RC	Rainforced concrete
REO	Regional Engineer's Office
S	Scale
σ ck	Specified compressive strength of concrete
σ sa	Allowable stress of steel bar
Sta/St	Station
t	Ton or Thickness
T.Shs	Tanzania Shilling
W	Width
WID	Women In Development
W.L	Water level

Table of Contents

Chapter 1: Background of the Project

Chapter 1 Background of the Project

1.1 Background of the Project

The floods which swept through all parts of Tanzania in April 1990 left a large amount of damage in roads and bridges. Especially hard-hit were the southern states of Lindi and Mtwara, which suffered enormous damages. In both states there was more than 500mm daily rainfall for four consecutive days, causing breakage of dams, washing away of houses, immersion of fields, and severing of road networks. Even along the stretch of trunk route highway connecting Lindi, Mtwara, and Masasi were cited 15 locations of damage or washed-away portions. Although some emergency repairs were carried out, road conditions are still quite poor, creating obstacles for the living standards of local inhabitants and economic recovery.

The region including the states of Lindi and Mtwara has long been known for a number of agricultural products, including cashew nuts, coconuts and hemp, and is also promising in the fields of mining, forestry, and fishing. Mtwara's harbor is one of the best in the country, following Dar es Salaam and Tanga; and is significant as an export center for these important products of the southern regions. Furthermore, a coastline of 800km blessed with beautiful white sandy beaches with shoals and coral reefs has great potential as a tourist attraction hopefully to be developed in the future. Finally, the two states' major routes; National Roads B2 and B5; as part of the 2,040km southern "ring route" (connecting Dar es Salaam - Kibiti - Nangurukuru - Lindi -
Masasi - Songea - Makambako - Iringa - Morogoro - Dar es Salaam) play vital roles in the lives of the inhabitants as well as their economic activities.

In face of these conditions and the surrounding environment, the following are anticipated as results of securing a dependable and well-aligned transportation route:

1) Establishment of a base for fulfillment of basic human needs;
   - Schools, medical facilities, routes to ease religious and/or cultural activities. (In particular, routes which can be safely traversed even in rainy seasons)
   - Lightening of the woman's share of labor in such areas as housework and carrying water from wells. (75% of transport of goods is carried out by women with the loads on their heads)
2) Alleviation of proverty and establishment of a base for economic activities.
   - Provision of a transport route for agricultural and agro-industrial products, which are the main industries of the region. (Transport and collection of cargo during rainy season made possible; also transport of large-scale vehicles)
   - Diversification of employment for local inhabitants as a result of the above.
   - Creation of jobs as a direct result of the Project.
3) Rectification of developmental imbalance among states.

- Through completion of the "ring route", distribution and trade among areas, as well as with neighboring countries, will become more active.
- Economic activities, which are presently concentrated in the capital, will be decentralized and benefit other regions.

The government of Tanzania, aware of these conditions which are causing a burden to the residents of the affected areas; particularly the three further-deteriorating Mkwaya, Nyangu, and Nangu bridges along the main arteries National Roads B-2 and B-5 in Lindi and Mtwaya; requested the Japanese Government for non-remunerative financial aid in the following areas:

- Bridge reconstruction
- Construction of bank protection and riverbed protection in connection with the bridges
- Access roads

In order to maintain consistency with road projects heretofore conducted, Japan has positioned these three bridges as part of the regional road development covering the areas between Dar es Salaam and the cities of Mtwara and Lindi. This Basic Design Study has been conducted to verify the applicability of the project as a recipient of non-remunerative financial aid.

1.2 Alterations of Requested Contents

As a result of study, it has been verified that no alterations of the basic items of request have materialized, namely, those involving new construction of bridges or realignment of access roads west of the Nyangao Bridge.

However, with regards to the Nyangao and Nangoo Bridges, as the Tanzanian government has not established any natural disasters (flooding, rock slides) policy for the stretch of road between Mingoyo and Masasi and therefore effectiveness of reconstruction dubious, this section has been deleted from the study. Bridges in the remaining sections which meet with the standards of the Japanese non-remunerative aid system are therefore reviewed.

The four bridges selected for this study are indicated below, including one of the three (Mkwaya) originally requersted:

1) Mikindani Bridge MTW-1-10030
2) Mbuo Bridge MTW-1-10040
3) Mpapura Bridge MTW-1-10050
4) Mkwaya Bridge LIN-3-10010

These four bridges are located along the section of National Road B2 of the "southern corridor" beginning from Mtwara, Tanzania's third most important port, therefore vital to the livelihood, industries, and social stability of the areas involved.

Chapter 2 : Contents of the Project

CHAPTER 2 Contents of the Project

2.1 Objectives of the Project

National Highways B2 and B5, which are the central routes of the Southern Coastal Corridor and Southern Corridor which in turn compose the road network of southern Tanzania, are the most important transportation routes in the south of the country. Most settlements in the region are situated along these routes, and they are the only routes which connect the interior with the coast. Therefore, according to the three points mentioned below, these routes have a considerable influence not only on the development of Mtwara and Lindi Regions but also on that of southern Tanzania.

① Basic Human Needs / WID of local inhabitants
② Establishment of economic base, poverty alleviation
③ Amendment of economic disparity among regions; role as international highways

However, due to severe flooding which occurred in April 1990, most bridges along the route were heavily damaged or washed away. At present, these have been temporarily replaced with Bailey-type bridges. All bridges along the route have load limitations of 20 tons, and the passage of heavy trucks is regulated. The installation of bridges which can bear heavier loads is desired to facilitate the transport of the cashew from the southern regions to the market, and as a means for an efficient and economic transportation route. As a consequence, in order to establish transportation centers in the south, as well as to contribute to its economic growth, four temporary bridges will be replaced by permanent ones.

The four bridges in question are found along National Highway B2 between Mtwara and Mingoyo, situated in both the regions of Mtwara and Lindi. They are: Mikindani Bridge, Mbuo Bridge, Mpapura Bridge, and Mkwaya Bridge. The route begins in Mtwara, runs 41.2km in that region, 40.5km in Lindi, for a total of 81.7km.

2.2 Basic Concept of the Project

2.2.1 General design specifications

① Design speed : 100km / h
② Total width : 9m

③ Composition : 0.5m + 0.75m + 3.25m x 2 + 0.75m + 0.5m
(covering) (shoulder) (carriage way)

④ Type of pavement : BST pavement (asphalt/aggregates, alternating layers)

⑤ Bridges to be constructed to withstand greater vehicle loads. (HA + HB 45 load)

2.2.2 General scale of bridges

Bridge name	Mikindani Bridge	Mbuo Bridge	Mpapura Bridge	Mkwaya Bridge
Bridge no.	MTW-1-10030	MTW-1-10040	MTW-1-10050	LIN-3-10010
Present condition	Temporary bridge (Bailey, 37.7m)	Temporary bridge (Bailey, 42.7m)	Temporary bridge (Bailey, 30.5m)	Temporary bridge (Bailey, 48.8m)
Type of Improvement	Replacement (permanent)	Replacement (permanent)	Replacement (permanent)	Replacement (permanent)
New location	no change	no change	no change	Previous bridge point
New bridge length	42 m	42 m	30m	120m
New bridge width	8 m (effective width)	8 m (effective width)	8 m (effective width)	8 m (effective width)
New bridge span lengths	6m+30 m+6 m	6m+30m+6m	30m	4x30m
New bridge load	HA + HB 45 Unit (BS)	HA + HB 45 Unit (BS)	HA + HB 45 Unit (BS)	HA + HB 45 Unit (BS)
New bridge foundation	Steel pier (H-type)	Steel pier (H-type)	Steel pier (H-type)	Steel pier (H-type)
New bridge substructure	Cast-on-site reinforced	Cast-on-site reinforced	Cast-on-site reinforced	Cast-on-site reinforced
New bridge superstructure	Prefabricated PC	Prefabricated PC	Prefabricated PC	Prefabricated PC
New bridge pavement	DBST	DBST	DBST	DBST
Access road	Partially change of road form	no change	no change	Restoration of former road (washed out)

2.3 Basic Design

2.3.1 Design concept

(1) Basic Consideration on design

This basic design study was carried out along the scheme of the grant assistance program of the Japanese government in sufficient consideration of what would be most effective for the socio-economic conditions, natural environment, laws, and other conditions in terms of construction in Tanzania. The following are the points considered for this project:

1) Dry season / rainy season

The dry season generally lasts from the end of May to the beginning of November, while the rainy season extends from the latter part of November to the first part of May. The period between November and the beginning of January is known as the minor rainy season, when rain is relatively light. This is followed by a brief recess, after which comes the major rainy season from the end of March to the beginning of May, when rainfall is heavier. However, even throughout this part of the rainy season, there are not days upon end of torrential rains, but rather certain days with rainfall and others without.

2) Establishment of road / bridge standards in consideration of present and future road use

This route was improved in 1975 and completed to meet loads of 20 tons; installation of temporary bridges following the floods followed the same standards. However, along with the growth of Tanzania's economy, travel volume as well as load volume has rapidly increased, and damages have been observed at bridges with a 20-ton design load. Accordingly, the British Standard HA + HB45 load is adopted and applied to design of all roads and bridges along the main route west of Masasi, the route which is a continuation of this one has also had the same measures applied, so for sake of continuity this standard is important as well.

3) Effective use of local equipment and materials

Construction equipment useful for the project in Tanzania can be found in Dar es Salaam, and is leasable through contracts. Therefore, types of utilizable equipment were surveyed and made use of as much as possible.

4) Consideration of technical level of local engineers

Although there are many capable engineers in Tanzania, especially in the Ministry of Public Works, their experience do not cover all the engineering items. As far as the project at

hand is concerned, there should be little or no problem concerning foundations, substructure, or access roads, but Tanzania has had almost no experience with prestressed concrete superstructure. Consequently, it will be necessary to send Japanese engineers for this particular area of construction.

5) Adoption of easy-maintenance structure and type

Tanzania's road authorities are making the best efforts to preserve existing road facilities through their maintenance budget. However, as the country covers such a wide area, it is difficult to keep up roads as they should be. Accordingly, in order to keep future maintenance / management at a minimum, sufficient review of methods, structure, materials, and type should be conducted.

6) Reduction of construction cost and shortening of construction period

In order to meet the requirements of the Japanese government's grant assistance program, the contents of construction must be reviewed to keep cost low and construction time as short as possible.

(2) Applied standards and basic policy

1) Applied standards

At the commencement of this project, the Tanzanian government requested application of the British Standard (BS) for application of this bridge improvement project. To counter the demand, the study team carried out a detailed explanation of Japan's latest design standards (A-live load and B-live load) covering the following points:

(A) Japan's design standard is among the top class in the world, having accumulated a wide variety of expertise;

(B) Japan's bridge engineers have engineered some of the largest-scale bridge projects in the latter part of this century;

(C) Japan's present design load of 25 tons equals that of Great Britain, Germany and the United States in terms of safety;

(D) Bridges are designed to withstand the load not only of 60 to 90-ton class trailers, but also overload vehicles; and

(E) Furthermore, additional examination of BS5400 (HB-45 unit) live load will be carried out to ensure the most realistic design.

Therefore, applied standards are based on the following:

"Design Specification for Roads and Bridges" February 1994, Japanese Road Association.

In addition, due to reasons mentioned above, an additional live load (HB-load, 45 units) will be tested according to BS5400.

2) Basic policy

As part of the basic design study, the following basic policies are adopted in consideration of the above circumstances.

① Project plans are made in consideration of rainy and dry seasons. Work efficiency will decrease during the rainy season, although not to the point of postponing construction. For this project, no construction in the river area will take place in the rainy season.

② Japanese design standards are adopted. Bridge design will be conducted according to Japanese specifications, but live load will refer to British Standard (HA + HB 45 units)

③ Pavement will be asphalt type, in consideration of durability and ease of maintenance.

(3) DESIGN STANDARDS

The important subject on selecting design standards and establishing design criteria is to design bridge to satisfy the following conditions ;

- To have sufficient loading capacity for present vehicle loading due to heavy cargo truck/ tractor-trailor and also future cargo traffic,
- To have reasonable durability during it's life period as public facility,
- To be easy and less maintenance structure,
- To have reasonable feasibility as public investment.

In the past history of bridge design in the world, design standards of major countries which were established based on each design conception, policy, technology backed up by it's historical background and experiences, and have been periodically revised as to improve loading capacity responding to increasing weight of cargo truck and durability of structure.

It is reported that some serious damages were found at bridge on major trunk road and MOW is intending to improve loading capacity of bridges to be constructed in the country of Tanzania.

On the meeting between JICA Study Team and MOW , fruitful discussion were done as to find appropriate design methodology for the project, such as design standards, design criteria etc., and through those discussion it was understood that the British Standard of HA and HB(45 units) loading is one of the appropriate resolutions for getting sufficient loading capacity and durability of bridge.

On the other hand, it was understood by the both sides, JICA Study Team and MOW,

that the Japanese Design Standards based on it's much experiences and knowledgement on the largest public investment programme in the world on late 20th Century , is also appriate standard, and it is considered to be more appropriate and applicable for the project because of it's more feasibility in engineering and economics.
The methodology for design, established for the Basic Design, are as follows ;

- The Japanese Design Standards are applied for bridge design with B-live loadin conditions .
- In under to obtain reasonably sufficient loading capacity for present and future heavy cargo traffic ,the main girder and deck slab will be checked with BS live loading conditions of (HA + HB/45 units) under the conditions of BS, 25% overstress permissible.

(4) DESIGN CRITERIA

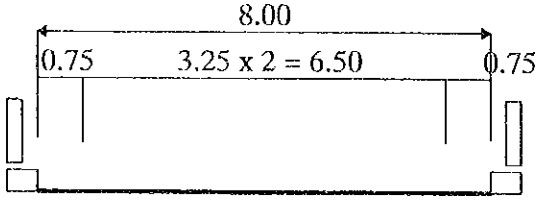
Characteristically domestic conditions, such as weather conditions, quality of local materials, such as cement, steel, aggregates and other, will be advantageously considered on establishing of Design Criteria.

1) TYPICAL CROSS SECTIONS

Considering the road classification, planned traffic volume, rate of heavy cargo vehicles etc., the following typical cross sections are proposed;

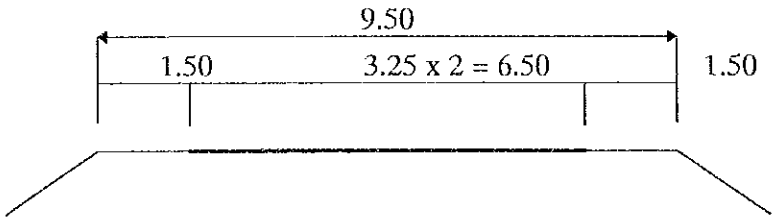
a) Bridge Section

Number of lanes	=	2
Lane width	=	3.25m
Width of shoulder	=	0.75m x 2
Effective width	=	8.00 m.



b) Connecting Road

Number of lanes	=	2
Lane width	=	3.25m x 2
Width of shoulder	=	1.50m.x 2
Total width		9.50m



2) LOADING CONDITIONS

a) DEAD LOADS

Concrete	2.5 tf / m3,
Steel	7.8 tf/ m3,
Earth Embankment	1.8 tf/ m3

b) LIVE LOAD

The live loads and loading conditions (effects of live loads) should be established based on measures, weights of vehicles, cargo truck etc., traffic volume, rate of heavy vehicles etc.

The proposed loading conditions of Live Load and structural analysis method to be adopted in the Basic Design Study are as follows;

- Design of Deck Slab and Main Girder

Deck slab will be designed by Japanese B-Loading (two wheels of 10 tones each) and be checked by BS HA/HB(45 units) loading with condition of overstress condition of 25% , specified in BS 5400.

- Seismic Design

The collected information and data show no record of earthquake in the project are and The Building Codes established by BRU, Building Research Unit, Ministry of Lands, Housing and Urban Development specifys the project area as Rare/Unknown area for earthquake, but Study Team considers it not to mean no possibility of earthquake in future or in the design life period of the projected bridges.

On this item, it is proposed to adopt basic figure for effect of earthquake considering low possibility of it;

Kh = 0.05 and,
Kv= 0.

- Others

-1 Wind Load

Effect of wind load is considered in design, however considering the local climate conditions, type of bridge, concrete bridge, and length of bridge and span, it is understood that wind load will have negligible effect on bridge design.
The above said Building Code gives guideline for wind velocity on 10m. height building,

V = 45 m./sec.

-2 Effect of Temperature Changing

The planned temperature changing range established based on informed climate data on temperature,

Changing range : ± 15 c. deg.

-3 Effect of Stream Current

In designs of sub-structure, effect of stream current is considered in design of pier

wall and foundation, but not combined with effect of earthquake.

-4 Protection against to Drift Wood

Considering difficulty of estimation of effect due to drift wood in the Project area because of lack of engineering data, the effect of collision of drift woods is not considered in structural analysis.

For more applicable consideration for protection to drift woods, halfy round shaped reinforced concrete will be allocated at both ends of pier wall.

3) MATERIAL STRENGTH

a) Concrete

The planned design strength of concrete to be used in the Design are as follows;

[Super structure]

Main girder	:	35 MPa.or 350 kg/cm2
Others		24 MPa.or 240 kg/cm2

[Sub-structure]

Pier,Pilecap,Abutment and other miscellaneous

RC member	24 MPa. or 240 kg/cm2

Cement of Type-1 is applicable for foundation, sub-structure, super structure and other miscellaneous concrete structures, and only unusual rushed construction schedule will require Type - 3 Cement (fast hardening type)only for precast prestressed concrete main girder.

b) Steel

The planned design strength of steel are as follows;

(Prestressing steel)

-PC Strands

Multiple Strands, like 12 T 12.7etc --- for Main Girder,

Mono Strands, like T 15.4 etc. ----for Deck Slab.

[Reinforcing Steel]

- Deformed bars will be used for PC and RC members

Yield strength; 300 Mpa or 3,000 kg/cm2

2.3.2 Basic Design

As a result of field survey of target bridges, it was judged that four bridges between Mtwara and Mingoyo need replacing. Results of field survey and basic policies for improvements are shown in Table 2.3.1

(1) Design Plan

1) Bridge location

① Mikindani Bridge

At this bridge site there are the original bridge and a temporary bridge; the vertical alignment of the latter is 1.1m higher. Location of project bridge was considered by comparing aspects of cost, alignment, constructability, schedule, detour routes for both seasons, etc., of bridge locations (including access road) according to the alternatives shown below.

Results of comparison are shown in Table 2.3.2.

Alternative 1: Replacement of bridge at original location

Alternative 2: Replacement of bridge at location of temporary one

As a result of comparison, from the aspects of road alignment, construction schedule, and constructability it was deemed that the new bridge would be built at the site of the present temporary bridge, placing the presently-used Bailey bridge on the original bridge for detour use.

② Mbuo Bridge

This bridge will be replaced at the same location as the original bridge for the following reasons: Present road alignment on the Mingoyo side is basically straight to the bridge, but the access road on the Mtwara side is somewhat curved. Judging from the circumstances of the course of the Mbuo River, as well as road alignment, locating the bridge upstream or downstream is not recommendable. Furthermore, since there is a settlement on the Mtwara side, changes in alignment would bring about issues of land acquisition and the displace of

population.

③ **Mpapura Bridge**

The project bridge will be built on the same location as the original bridge, as there is no apparent benefit to altering the present road alignment, which is nearly straight on both sides.

④ **Mkwaya Bridge**

At this site there are the original bridge and a temporary one. The original bridge was a steel I-girder bridge which had its abutment washed away in the floods of 1990. A Bailey bridge was installed as a temporary measure 20m downstream. The project bridge is to be replaced at the site of the original bridge for the following reasons: Road alignment of access to original bridge is gently curved; vertical alignment is 3.2m higher than present road surface; and part of original access road earthworks are remaining.

Table 2.3.1 Present Condition and Policies for Improvement of Bridges between Mtwara and Mingoyo

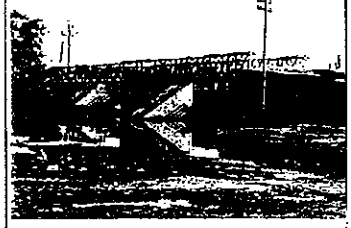
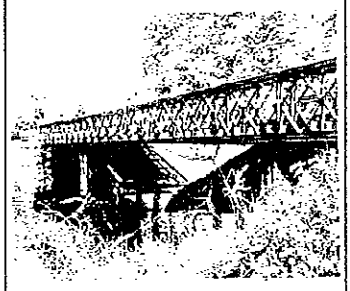
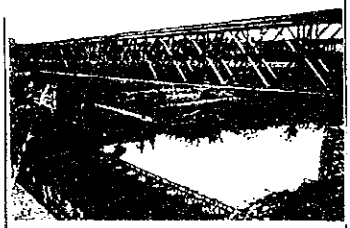
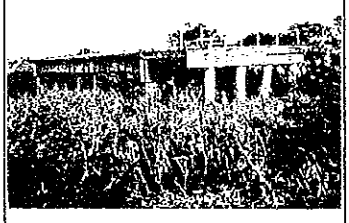
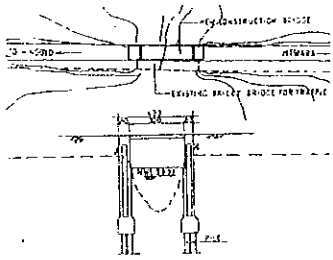
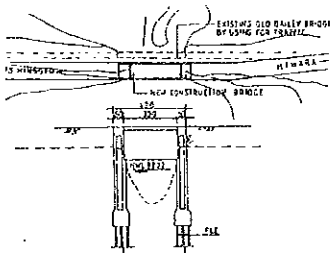
Bridge name	Present condition	Structural outline	Present state and characteristics	Improvement policies
Mikindani Bridge 13.3km		**Length:** 33.0m **No. of spans:** 2 (16.5m+16.5m) **Lane width:** 3.4m **Superstructure type:** Bailey bridge (temp.) **Substructure type:** wall-type piers **Superstructure load:** HA **Clearance:**4.3m	-Design load = HA load (20 tons) -Situated adjacent to Mikindani Bay, tidal difference of 2m -Distance between abutments 30m; sticking out somewhat and appear to interfere with tidal flow -An intermediate pier further contributes to tidal interference -Existing embankment protection is covered by concrete but cracking and flaking are noticeable	-Live load set at HA+HB45 -Location of new bridge will be at present bridge, with its favorable road alignment -In consideration of flooding, space allowance for underside of bridge will be 1.0m -In consideration of tidal flow, the new abutment will be box-type for improved passage of water -A Bailey bridge will be placed at the site of original bridge as detour. The necessary detour route will be secured and established upstream, where river width is less.
Mbuo Bridge 27.2km		**Length:** 42.0m **No. of spans:** 3 (12.0m+21.0m+9.0m) **Lane width:** 3.4m **Superstructure type:** Bailey bridge (temp.) **Substructure type:** Existing abutment used as piers **Superstructure load:** HA **Clearance:**4.3m	-Original bridge has been damaged from sinking; Bailey bridge has been placed over it. -Base of existing abutment has become unstable due to erosion -Existing embankment protection has been eroded by the 1990 floods -Little or no water flowing during dry season -In normal conditions, high water level is 1.6m over dry season -Allowance below bottom side of bridge is 4.3m	-Live load set at HA+HB45 -Location of new bridge will be at present bridge, with its favorable road alignment -In consideration of flooding, space allowance for underside of bridge will be 1.0m -New abutment will be in the same style as the Mikindani Bridge -The necessary detour route will be secured and established upstream, where river width is less.
Mpapura Bridge 39.8km		**Length:** 30.0m **No. of spans:** 1 **Lane width:** 4.8m **Superstructure type:** Bailey bridge (temp.) **Substructure type:** Installed directly onto earthwork **Superstructure load:** HA **Clearance:**3.0m	-Bailey bridge is placed on abutment of original bridge -Following 1990 floods, new embankment protection installed in the form of wire-encased rocks -Little or no water flowing during dry season -Surrounding embankment protection is in the form of wire-encased rocks or natural slopes -In normal conditions, high water level is 2.2m over dry season -Allowance below bottom side of bridge is 3.0m	-Live load set at HA+HB45 -Location of new bridge will be at present bridge, with its favorable road alignment -In consideration of flooding, space allowance for underside of bridge will be 1.0m -The necessary detour route will be secured and established upstream, where river width is less.
Mkwaya Bridge 75.0km		**Length:** 48.0m **No. of spans:** 3 (15.0m+18.0m+15.0m) **Lane width:** 4.0m **Superstructure type:** Bailey bridge (temp.) **Substructure type:** wall-type piers **Superstructure load:** HA **Clearance:**4.4m	-Except for a small portion, the original bridge was swept away by the 1990 floods -The slab of the present Bailey bridge is made of steel -The speed of flow in the river during the dry season is 0.3m/sec. Water depth in the rainy season is 2.5m above that of the dry season, under normal circumstances -Allowance below bottom side of bridge is 4.4m	-Live load set at HA+HB45 -Location of new bridge will be at present bridge, with its favorable road alignment -In consideration of flooding, space allowance for underside of bridge will be 1.0m -The presently-used bridge located downstream will be used as the detour route

Table 2.3.2 Comparison of Location Alternatives for Mikindani Bridge

Alternative 1: Replacement of Bridge at Original Location			
	Order of Construction Step	Dry season	1. Erection of temporary wharf, construction of access road 2. Removal of existing abutment and piers 3. Construction of pile foundations 4. Temporary binding, excavation, manufacture of piers
		Minor rainy season	5. Construction of footing and abutment 6. Manufacture of girders 7. Placement of girders
		Rainy season	8. Clear-up
	Merits, demerits		Merits: -Present bridge can be used as detour road Demerits: -Much time taken up by removal of original bridge (lengthening of schedule, high cost of removal)
	Evaluation		△
Alternative 2: Replacement of Bridge at Temporary Location			
	Order of Construction Step	Dry season	1. Erection of temporary wharf, construction of access road 2. Moving of present Bailey bridge to original bridge 3. Removal of existing abutment and piers 4. Construction of pile foundations 5. Temporary binding, excavation, manufacture of girders
		Minor rainy season	6. Construction of footing and abutment 7. Manufacture of girders 8. Placement of girders
		Rainy season	9. Clean-up
	Merits, demerits		Merits: -Utilization of original bridge and Bailey bridge as detour route -Period required for removal of original bridge is abbreviated, compared to Alternative 1 Total construction schedule is shortened Demerits: -None in particular
	Evaluation		◎

(2) Bridge length

In deciding bridge length, it is necessary to consider upstream and downstream river width, water passing capability, scouring of abutment area, location of original bridge, etc. Especially important in the case of Mkwaya Bridge, which crosses the Rukwenzi River, is that maximum water flow volume be properly calculated before deciding bridge length. In order to avoid bridge damage caused by blocking of flow by uprooted trees, etc., in floods, distance between piers must be greater. Piers will be constructed no closer together than the width of the river at its low dry season level.

The minimum span length (L) considering the projected maximum water flow volume (Q) is shown below (by Japanese River Regulating Lode where Q is discharge).

$$L = 20+0.005Q$$
$$= 20+0.005x1944$$
$$= 29.72m$$

Therefore, considering the area's topography and circumstances of the river, the standard span length is to be 30m.

Lengths of other bridges are based upon the standard girder length of 30m of Mkwaya Bridge. The lengths of each bridge result as follows:

-Mikindani Bridge:	L=6m+30m+6m (Bridge length 30m; rigid frame type abutment erected to ease the flow of tidal water)
-Mbuo Bridge:	L=6m+30m+6m (Bridge length 30m, remaining length rigid frame abutment for securing sufficient river course cross-section.)
-Mpapra Bridge	L=30m (same as present bridge)
-Mkwaya Bridge	L=30m+30m+30m+30m

(3) Spans

Learning from the lesson of the 1990 floods, erection of bridge piers inside the river was judged best to be avoided in order to prevent obstruction by piers during flooding. As a consquence, in consideration of economics, constructability, discharge volume, etc., number of spans was studied. Mikindani Bridge, in consideration of inflow and outflow of tides; and Mbuo Bridge, in consideration of discharge capacity, are adopting rigid frame type abutment (span length = 6.0m)

Discharge volume in regards to discharge capacity at the point of bridge locations is shown in Table 2.3.3.

Table 2.3.3 Discharge Capacity at Project Bridges

	Mikindani Bridge	Mbuo Bridge	Mpapra Bridge	Mkwaya Bridge
Span pitch (m)	6.0+30.0+6.0	6.0+30.0+6.0	30.0	4 x 30
River cross-section (m^2)	60	156	168	516
Discharge Volume (m3/sec.)	172	916	1,082	1,944
Discharge Capacity (m3/sec)	192	1,052	1,174	2,309
Remark	The span pitch will satisfy the demands of the discharge volume			

(4) Clearance from water level

According to survey and interviews, it is known that all four of the bridges involved in the study were under water in the 1990 floods and washed away by the same. The main cause of this was that trees and driftwood caught at the bridges blocked the flow of water under the bridge, causing the water to flow over the bridges, in turn washing away bridge superstructure or causing severe erosion which caused both abutment and superstructure to be carried off.

Consequently, according to Japan's river structure standards, Mbuo, Mpapra and Mkwaya Bridges will be designed with clearance from water level of 1.0m. The flood water level of Mkwaya Bridge, in particular, will be planned at the position of the original bridge deck. The Mikindani Bridge will have an allowance of 0.6m due to the relation with the design discharge capacity. This relationship is shown in Table 2.3.4.

Table 2.3.4 Discharge Capacity and Clearance from Water Level

Design discharge capacity Q (m3/s)	Q<200	200≦Q<500	500≦Q<2,000	2,000≦Q<5,000
Clearance from water level (m)	0.6	0.8	1.0	1.2

(5) Superstructure type

1) Selection of basic superstructure type of bridges

In this study, the decision of whether the superstructure bridge type be concrete type or steel type is made in consideration of the aspects below.

-Economy and constructability, regarding substructure and foundation costs as well.
-Ease of maintenance, type with less expense
-Ease of use for Tanzania, and transfer of technology

Considering that the basic span of the project bridges is 30m and supporting stratum is 20 - 30m, concrete bridges are more economical, and low cost of maintenance can be realized. Most bridges built in Tanzania have been concrete: steel bridges built by Italian, British, or German aid but with incomplete transfer of technology. Accordingly, these bridges have received almost no proper maintenance.

In consideration of the above, concrete bridges are chosen, as they are constructable locally; thereby easing transfer of technology.

2) Review of superstructure types

Basic span arrangement of the project bridges is set at 30m based on examination of bridge length and span arrangement. As demonstrated in Table 2.3.5, the ideal type of superstructure in terms of structure and economics is mainly determined by span arrangement. Applicable superstructure types are shown in Table 2.3.6.

Table 2.3.6 Applicable Bridge Types for this Study

Concrete bridge	-PC-T shaped girder bridge, PC-I shaped girder bridge -PC hollow slab bridge, RC-T shaped girder bridge
Steel bridge	-Simple I shaped girder steel bridge

The PC hollow slab bridge in the table is a cast in place type; superstructure work must wait until the completion of the substructure, greatly lengthening the construction process. Since the construction period for this project is only about one year, this type is deemed unfeasible and thereby not included as an alternative.

A comparison of bridge types not including PC hollow slab bridge is seen in Table 2.3.7. PC-T shaped girder bridge has been chosen as the superstructure type for this project.

(6) Substructure type

The following points are considered in selection of substructure type, particularly concerning abutment.

-The axis of the bridge is planned so as to be set perpendicular to the course of the river. Scouring-prevention measures and abutment protective works are also considered.

-The abutment is to be of a structure secure in the face of floodwater levels, placed at an appropriate depth in regards to flow speed, and the soil quality of the riverbed. Calculating scouring depth according to flow speed at floodwater level, a range of 1.85 to 2.50 meters in depth is attained. Therefore, the upper end of the footing should be at least at a depth of 2.0 meters below the riverbed surface.

-Since abutment type is closely related to structure height, an appropriate structure will be selected in this light (Table 2.3.8). With regard to Mikindami and Mbuo bridges, due to the stability of the river course, rigid frame type abutment is adopted.

Table 2.3.5 Standard Application Spans for Superstructure Type

Type		Span			Curvability		Ratio of girder height to span
		50m	100m	150m	Main structure	Bridge surface	
Steel Bridge	Simple composite girder				○	○	1/18
	Simple girder				○	○	1/17
	Continuous girder				○	○	1/18
	Simple box girder				○	○	1/22
PC Bridge	Hollow slab				○	○	1/22
	Simple T shaped girder				×	○	1/17.5
	Simple composite girder				×	○	1/15
	Continuous girder				×	○	1/15

(Note) (1) Girder height of arch type indicates span rise ratio

(2) Under main structure ○= Bridge structure can be applied to curving lines

×= Bridge structure cannot be applied to curving lines

Under bridge surface ○= Structure of road surface can be curved.

Table 2.3.7 Comparison of Superstructure Types

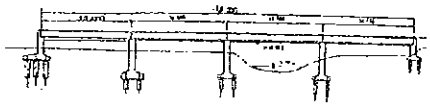
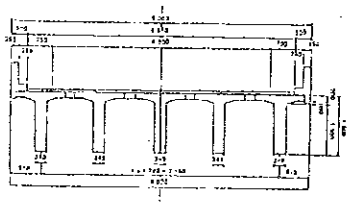
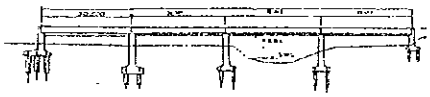
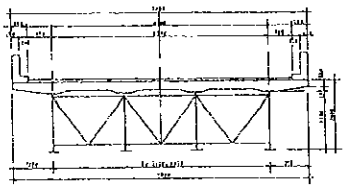
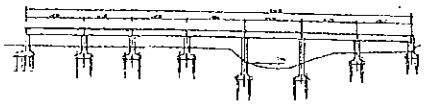
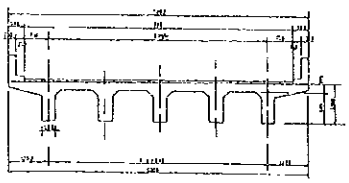
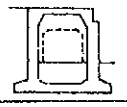
Alternative 1: Mkwaya Bridge PC 3 span articulated girder bridge		
 	Structure	-Great torsional stiffness of each girder, high degree of safety. -Durability due to use of PC steel wires for main girders and slab. -Greater comfort in driving due to use of articulated girder.
	Construction	-Both placement with truck crane or gate-type crane are possible. -Care must be taken when placing girder. -Short construction period.
	Maintenance	Concrete bridge; simple
	Economic	◎
	Evaluation	◎
Alternative 2: Mkwaya Bridge Steel 3-span continuous I-girder bridge		
 	Structure	-Overall structural stiffness is somewhat less than that of concrete. -Noise and vibration is greater than concrete. -Excels in driving comfort due to being a continuous structure.
	Construction	-Due to lightness of main girder, placement is made easy. -Main girder is not so flexible, so care to avoid warping must be taken during placement.
	Maintenance	Repainting required (5 - 10year)
	Economic	○
	Evaluation	○
Alternative 3: Mkwaya Bridge RC 3 span simple T-girder bridge		
 	Structure	-Overall structure highly stiffness. -As reinforced concrete structure, durability is somewhat less than PC structure. -Driving comfort is poor, as simple girder type.
	Construction	-Support works are required inside river area; construction inadvisable in rainy season. -Cast in place; longest construction period -Non-economical (high amount of substructures)
	Maintenance	Concrete bridge; simple
	Economic	△
	Evaluation	△

Table 2.3.8 Comparison of Abutment Structure Types

Abutment Type	Height (m) 10	20	Shape	Characteristics	Evaluation
Gravity Type	4			- Economical when abutment height is low.	○
Semi-gravity Type	6			- Gravity type with steel reinforcement; lighter in weight, economical.	○
Reverse T type	6	12		- More economical than gravitational type when abutment height is high.	○
Buttress Type				- More economical than reverse T type when abutment height is high.	△
Rigid frame type				- Economical when abutment height is high, as can be lightened by earth pressure.	○

(7) Foundation structure types

Results of soil quality survey at location of project bridges is shown in simplified version in Table 2.3.9.

Table 2.3.9 Outline of Results of Soil Quality Survey

	Depth (m)	Soil Type	N-value	Comments
Mikindani Bridge	~12 13~15	Silty sand Silty clay	10~13 10~16	Pile foundations
Mbuo Bridge	~9 10~15	Silty clay Sand	10~13 40~64	Pile foundations
Mpapra Bridge	~15	Silty clay Silty sand	~24	Pile foundations
Mkwaya Bridge	~15	Sandy soil	13~15	Pile foundations

The foundation type adopted for the project bridges is pile foundation, as the location of the supporting stratum is more than 25m from the surface.

As shown in Table 2.3.10, a variety of pile types, such as RC, PC, H-steel, steel pipe, cast-in-place, etc.; can be considered, but for the following reasons, H-steel pile type has been chosen for all bridge.

① Relative shortness of pile length, ease in construction, and economical

② Ease in driving of piles

③ Since seismic activity is practically nonexistent, the number of piles will not be large.

Pile size will be H section - 400mm x 400mm, with few causes of deformation.

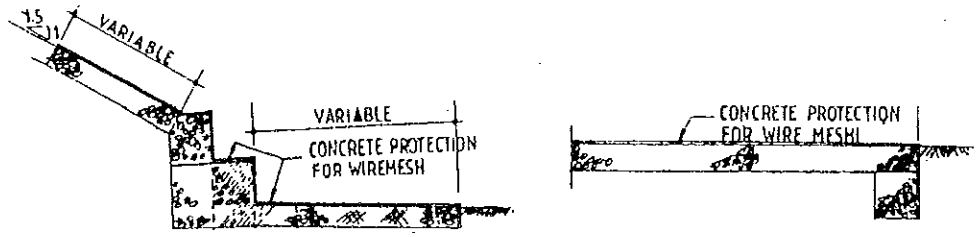
Table 2.3.10 Characteristics of Applicable Pile Types

Pile type	Applicable range of pile length	Procurement	Characteristics
RC pile	Approx. 20m	Manufacturable in Tanzania	-Probable to be driven into place, as upper stratum is soft, and generally applied to supporting stratum of about 20m. -Applicable in cases where vertical and horizontal load is small. -Economically most preferable
PC pile	Approx. 30m	Import South Africa, Singapore, Japan)	-Probable to be driven into place, as upper stratum is soft, and generally applied to supporting stratum of about 30m. -Applicable in cases where vertical and horizontal load is small. -Stronger than RC pile in terms of concrete strength. Little problem in cracking, etc., when poured. -Economically preferable.
H-steel pile	Approx. 30m	Import (South Africa, Singapore, Japan)	-Since there is little problem with welded joints, applicable in cases where pile length is long. -Applicable in cases where vertical and horizontal load is small. -Economically preferable.
Steel pipe pile	15~60m	Import (South Africa, Singapore, Japan)	-Since there is little problem with welded joints, also applicable in cases where pile length is long. -Preferred in cases where vertical and horizontal load is great. -Economically, somewhat inferior
Cast-in-place	15~60m	Procurable in Tanzania (possible if drilling machinery is available)	-Since there are no problems with welded joints, also applicable in cases where pile length is long. -Preferred in cases where vertical and horizontal load is great. -Economically, somewhat inferior

(8) Types of embankment/riverbed protection

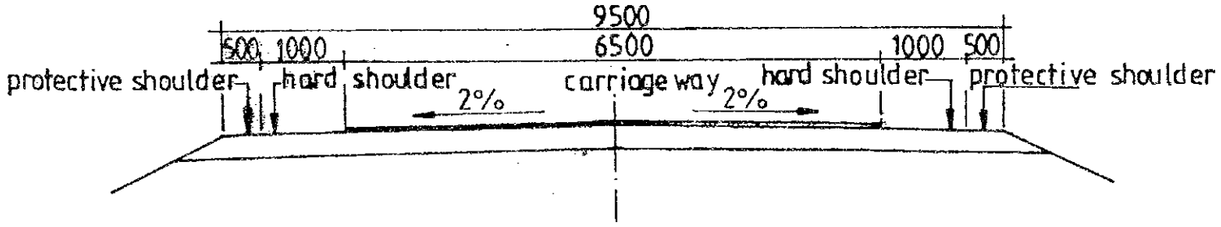
The course of the river is greatly influenced by embankment or riverbed protection. The basic concept for such facilities which are to be installed for the stability of the river course and bridge safety is shown in Figure 2.3.1. As seen in the figure, wiremesh and stone will be placed in needed areas for the protection of river banks and riverbed.

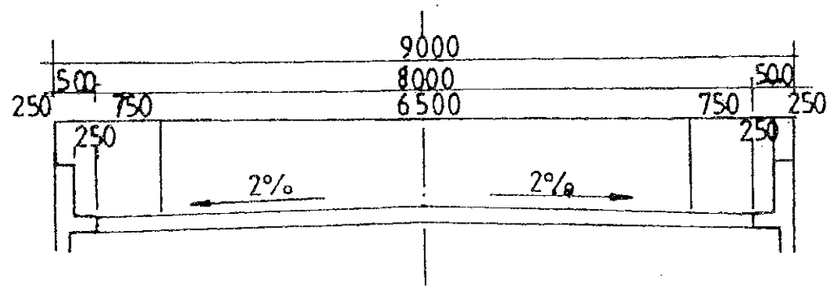
Figure 2.3.1 Form of Embankment/Riverbed Protection



(9) Basic Design Drawing

The Basic Design Drawings for Mikindani, Mbuo, Mpapura and Mkwaya are attached herewith.





STANDARD CROSS SECTION

THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : TYPICAL CROSS SECTION		JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO.,LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996	DRAWING NO :	

No. 1 Mikindani (MTW-1-10030)

PLAN
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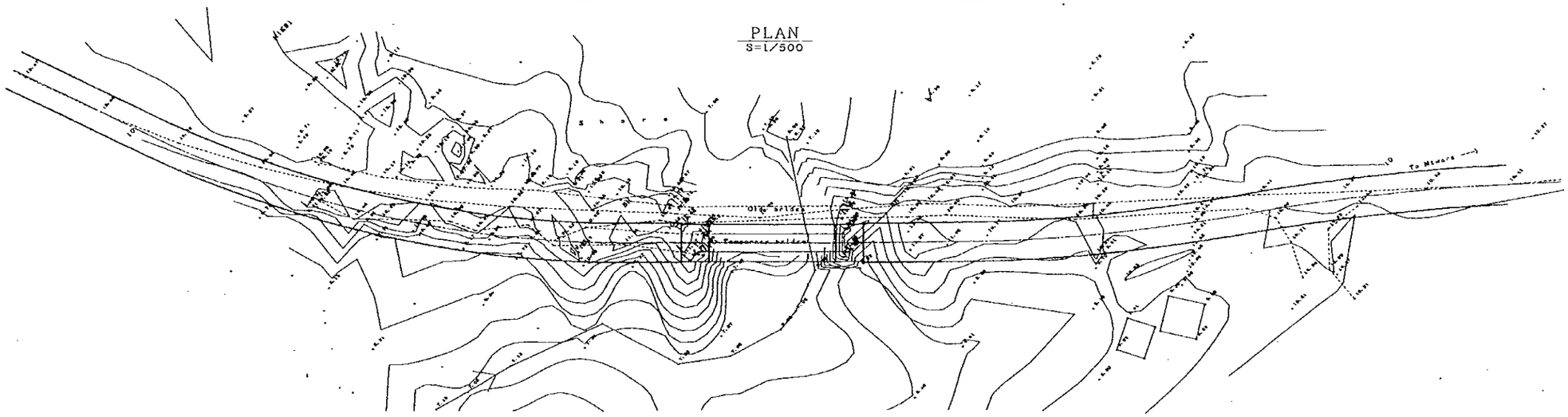

PROFILE
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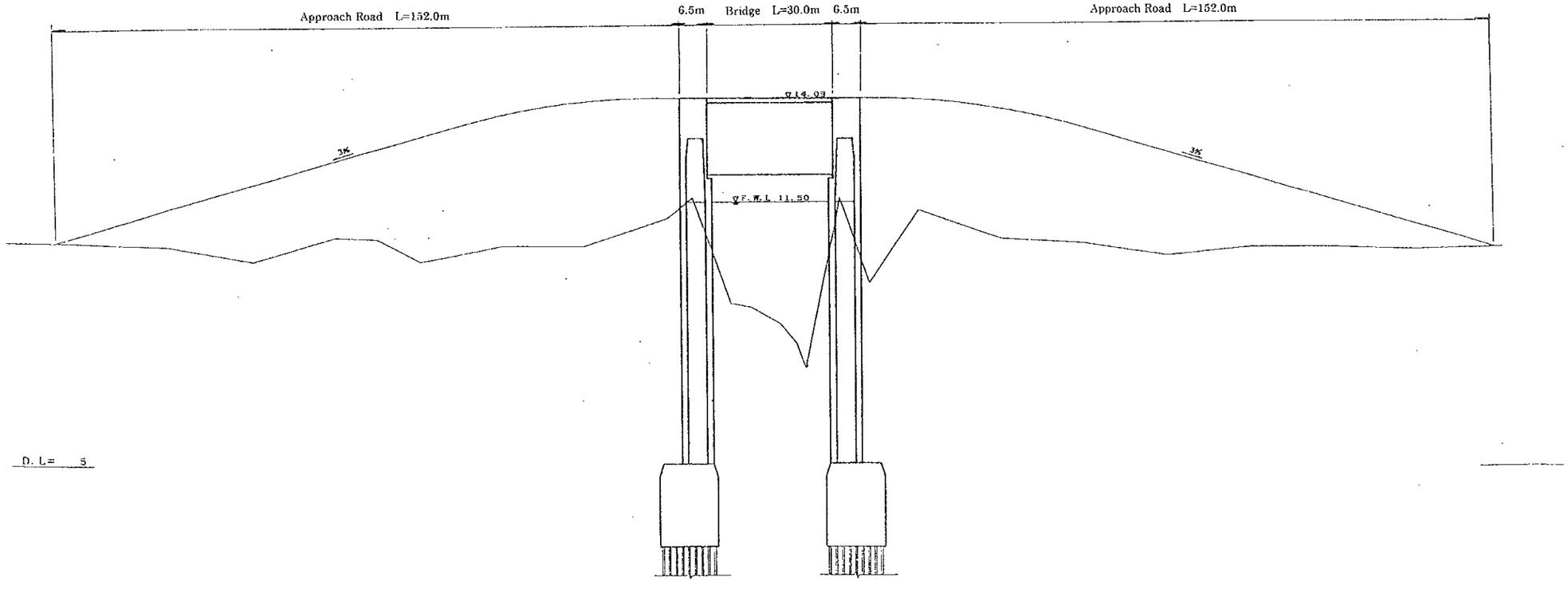
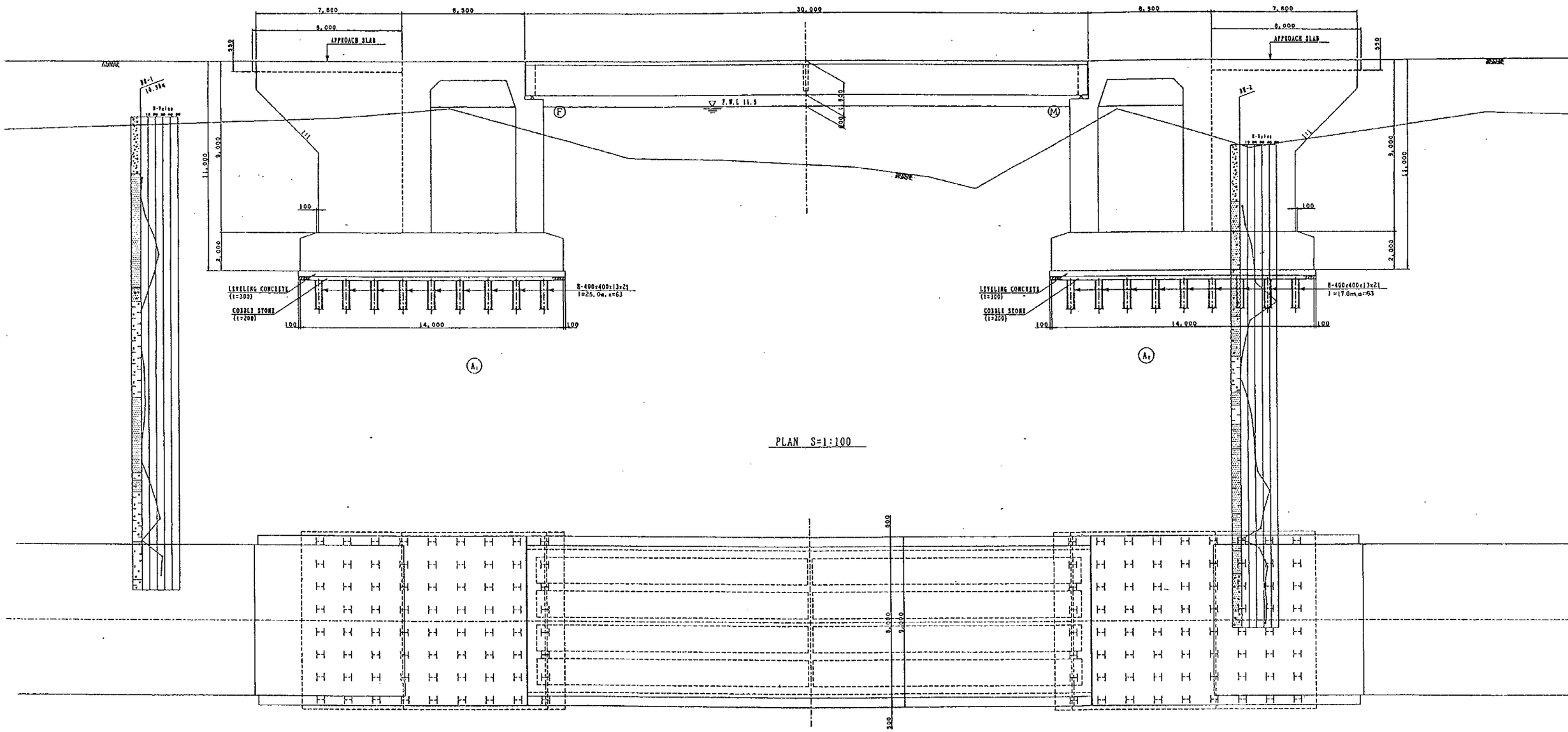
V=1/50



THE UNITED REPUBLIC OF TANZANIA	THE POJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO. 1 BRIDGE(Mikindani) (1/2)	JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996 / DRAWING NO :	

No. 1 Mikindani (NTW-1-10030)

ELEVATION S=1:100

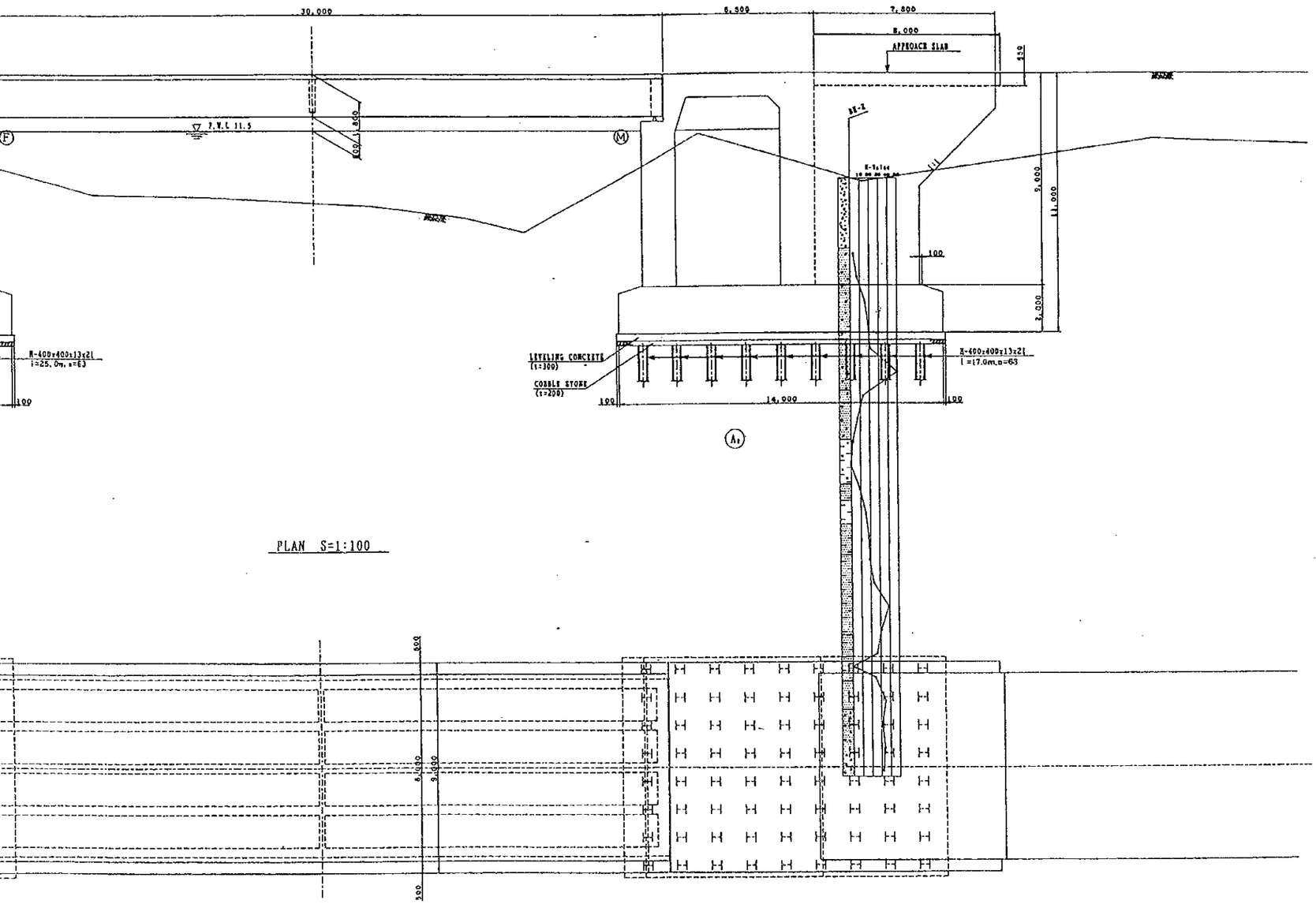


PLAN S=1:100

THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO.1 BRIDGE(Mikindani)	
		DATE : September 1996	DRAW

No.1 Mikindani (NTW-1-10030)

ELEVATION S=1:100



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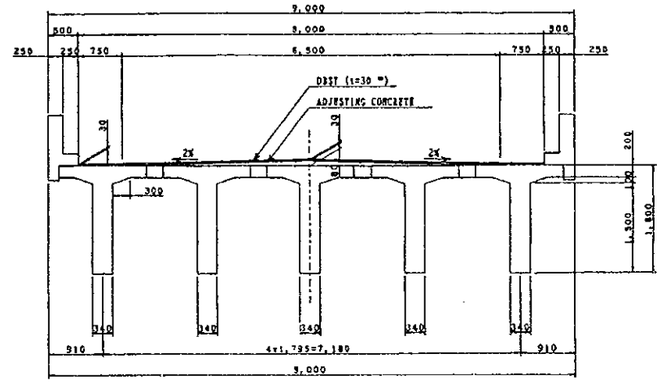
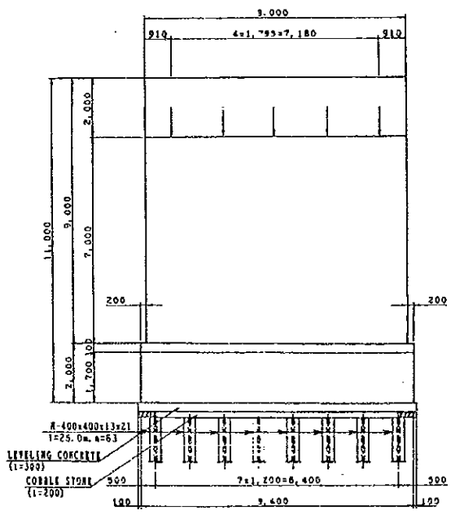


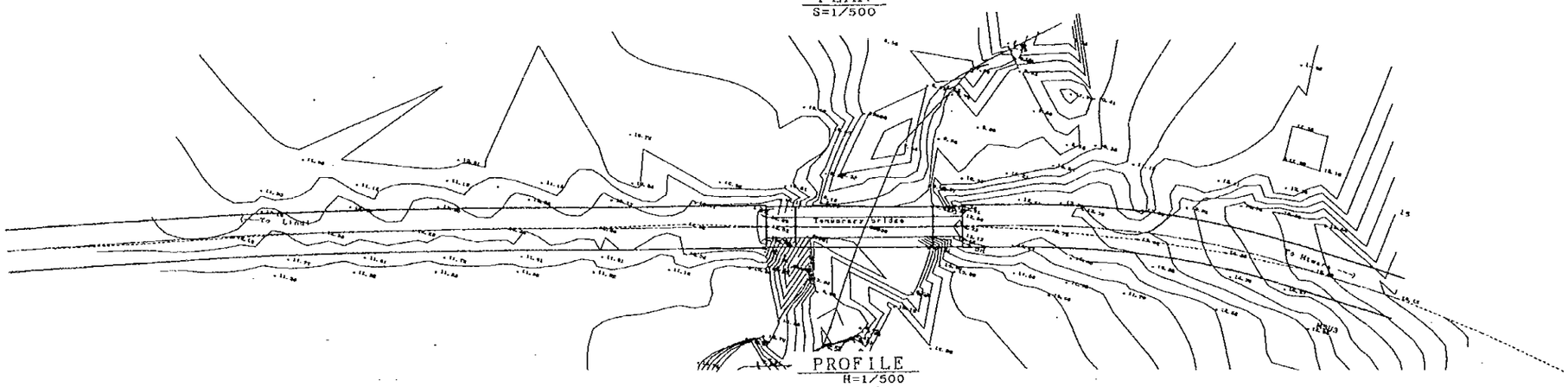
FRONT VIEW S=1:100



THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO.1 BRIDGE(Mikindani) (2/2)		JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO.,LTD CONSTRUCTION PROJECT CONSULTANTS.INC
		DATE : September 1996	DRAWING NO :	

No. 2 Mbuo (MTW-1-10040)

PLAN
S=1/500



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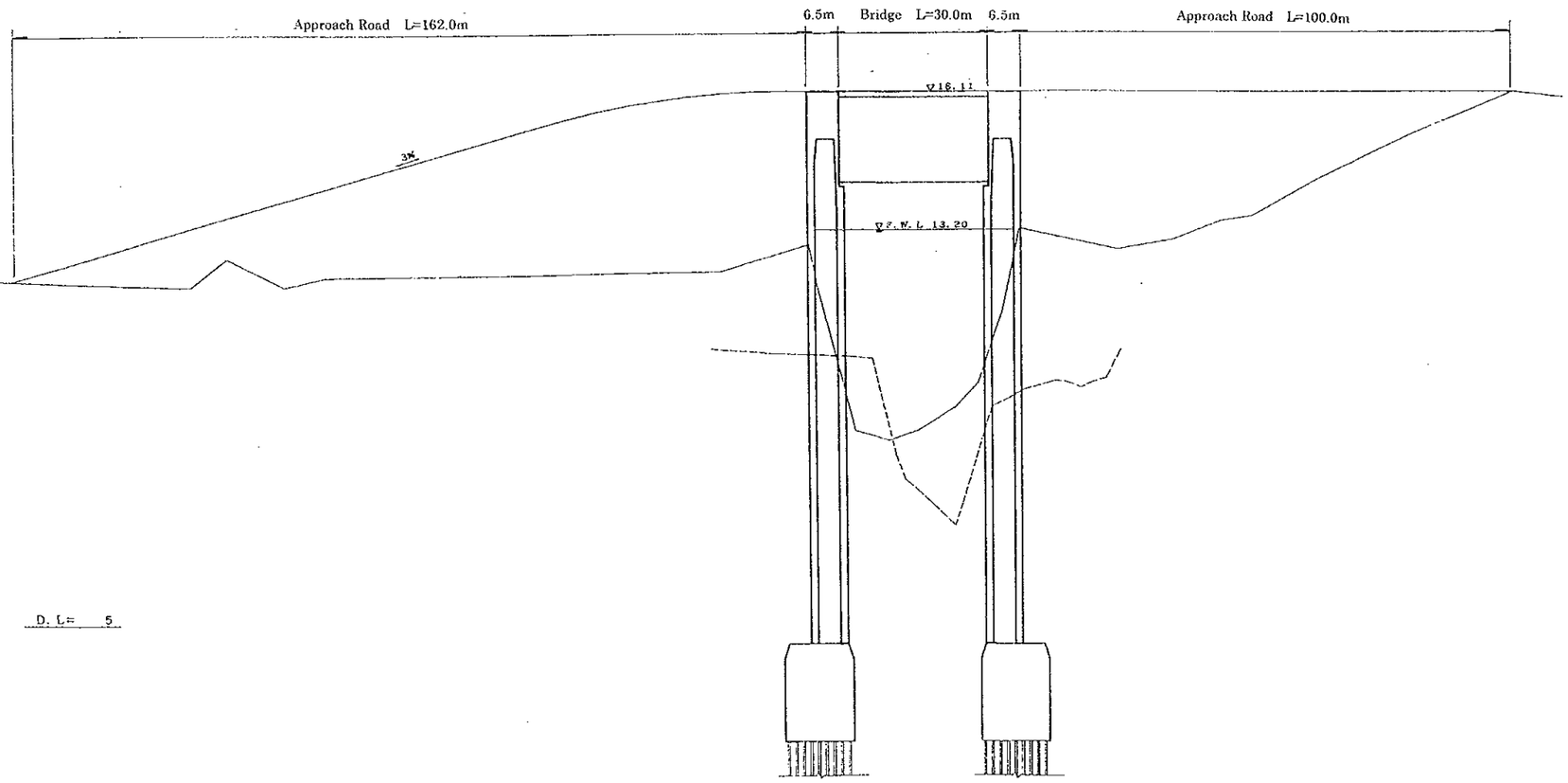

THE UNITED REPUBLIC OF TANZANIA	THE POJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO. 2 BRIDGE(Mbuo) (1/2)		JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996	DRAWING NO :	

No. 2 Mbuo (MTW-1-10040)

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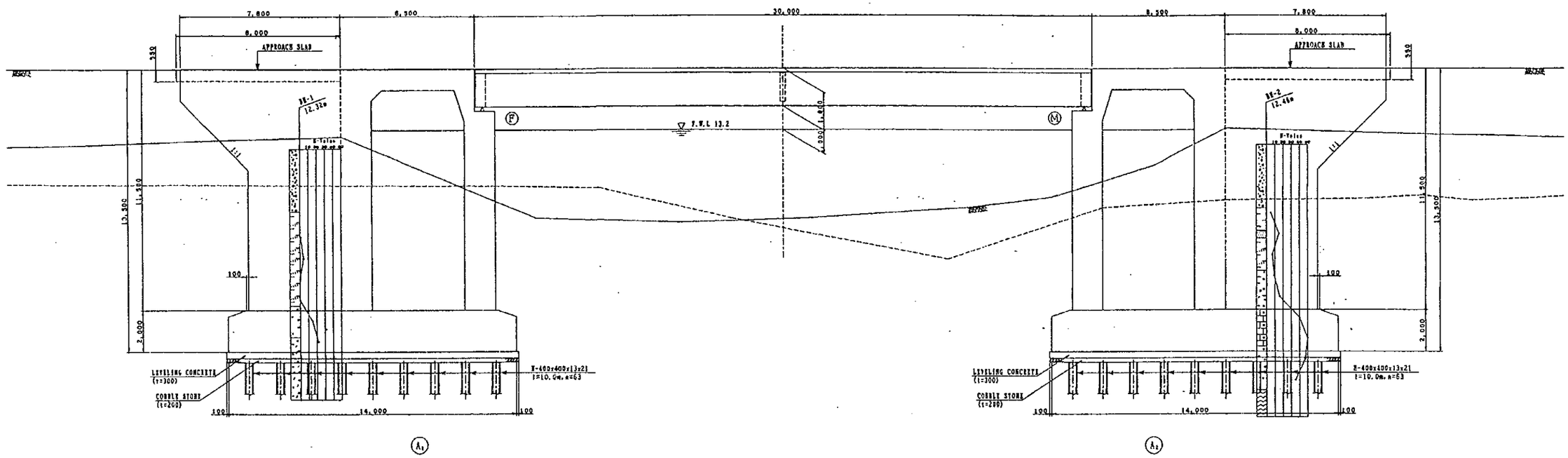

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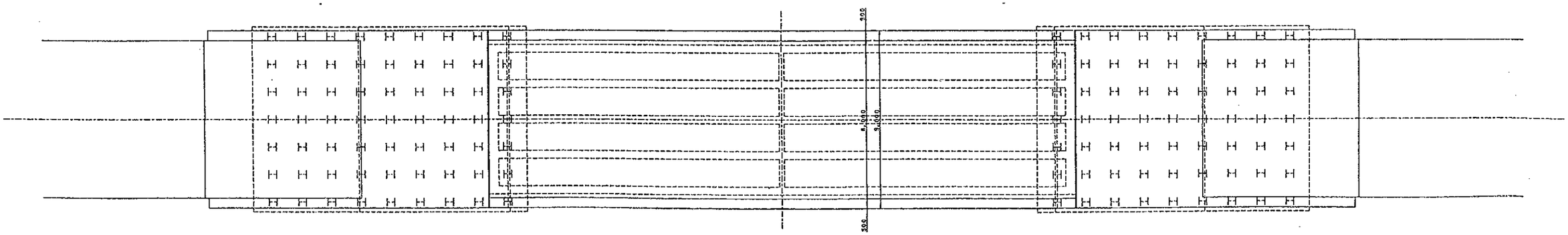

THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO.2 BRIDGE(Mbuo) (2/2)
		DATE : September 1996 | DRAWI

No. 2 Mbuo (MTW-1-10040)

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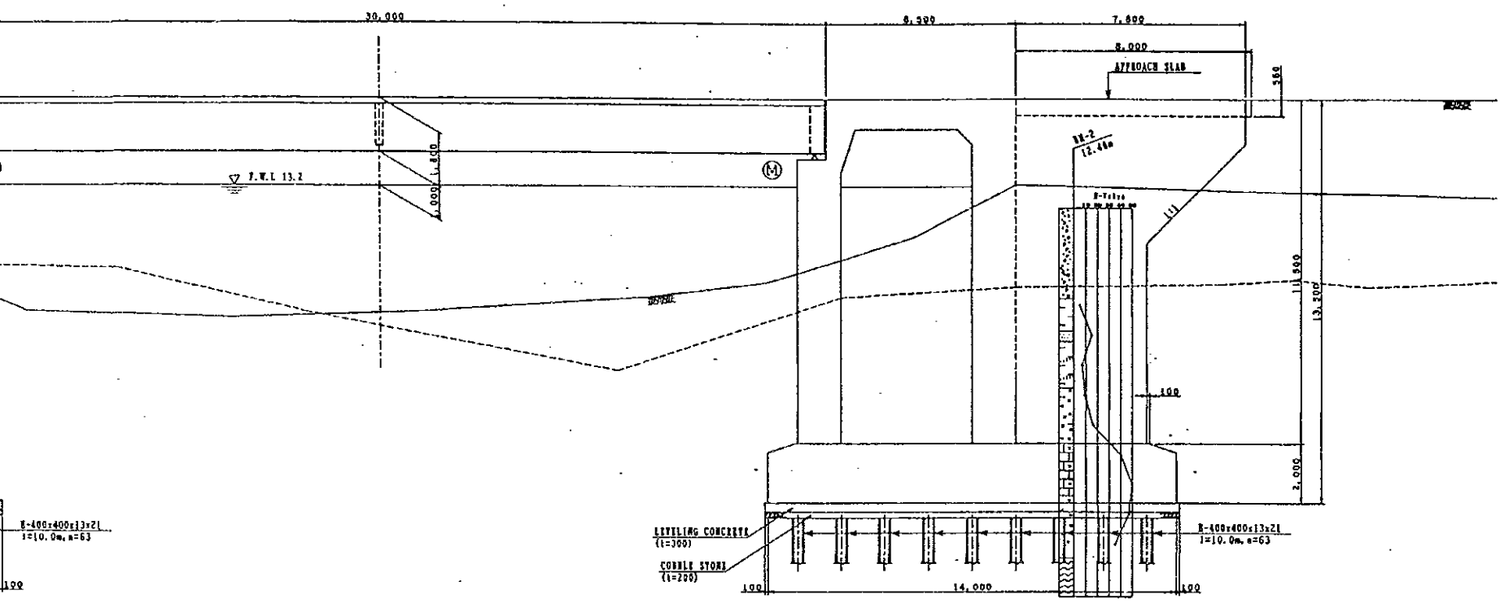

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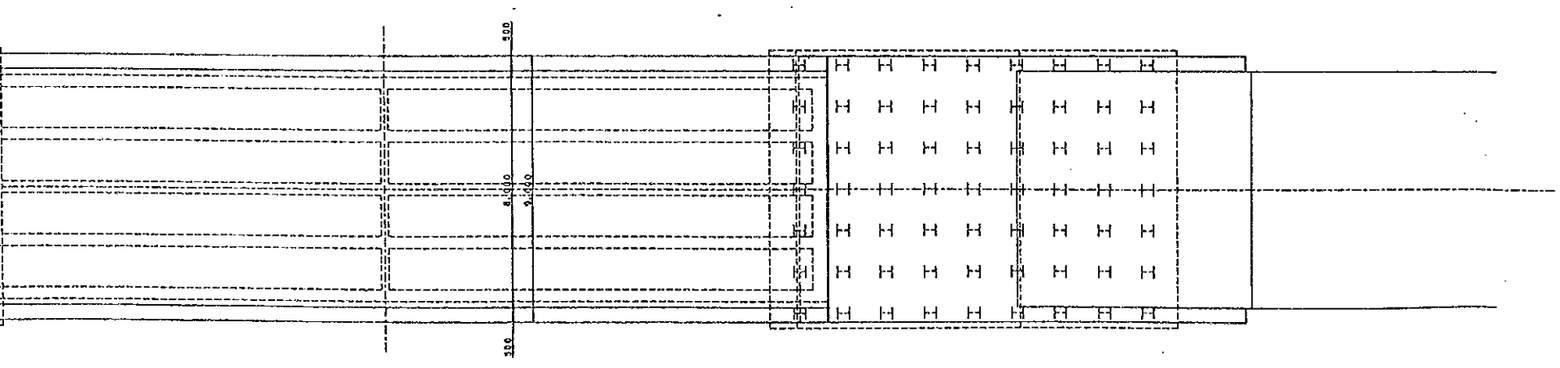

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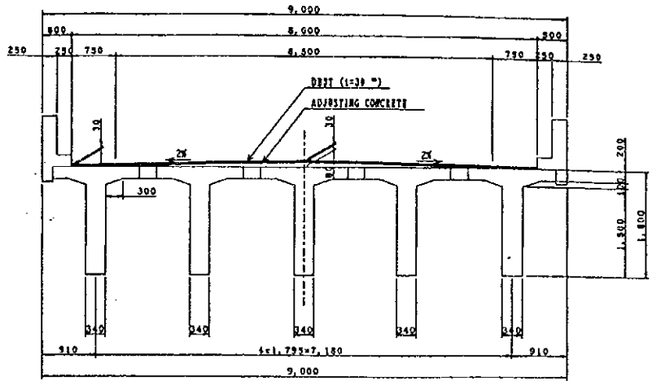

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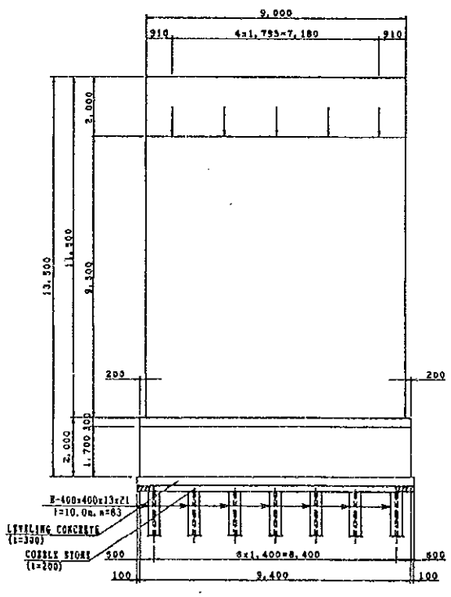
(A1) (A2)



THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO.2 BRIDGE(Mbuo) (2/2)	JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996 / DRAWING NO :	

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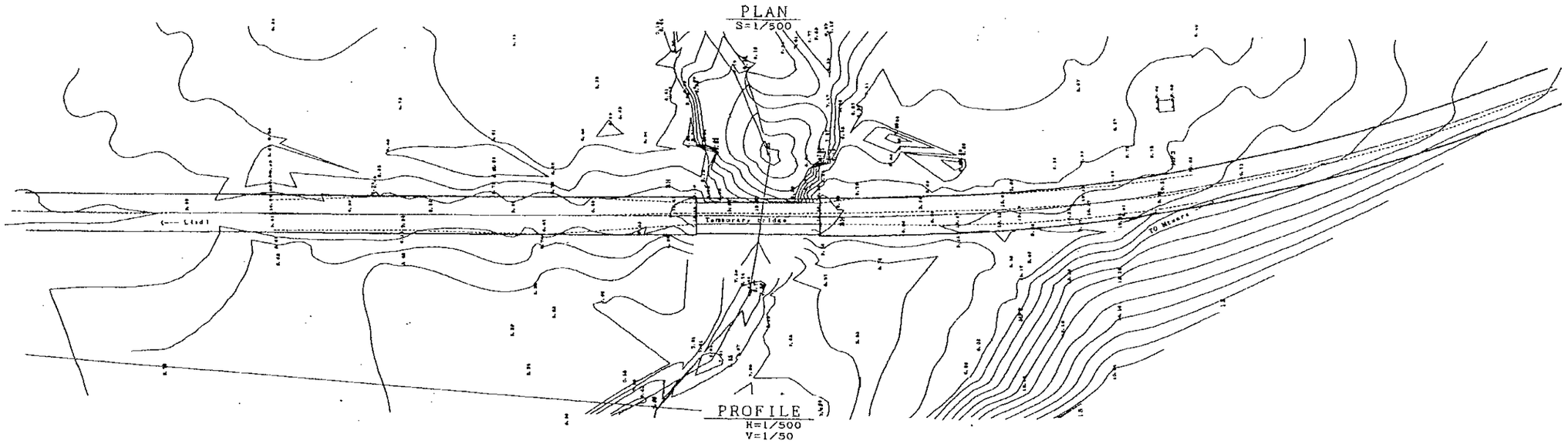

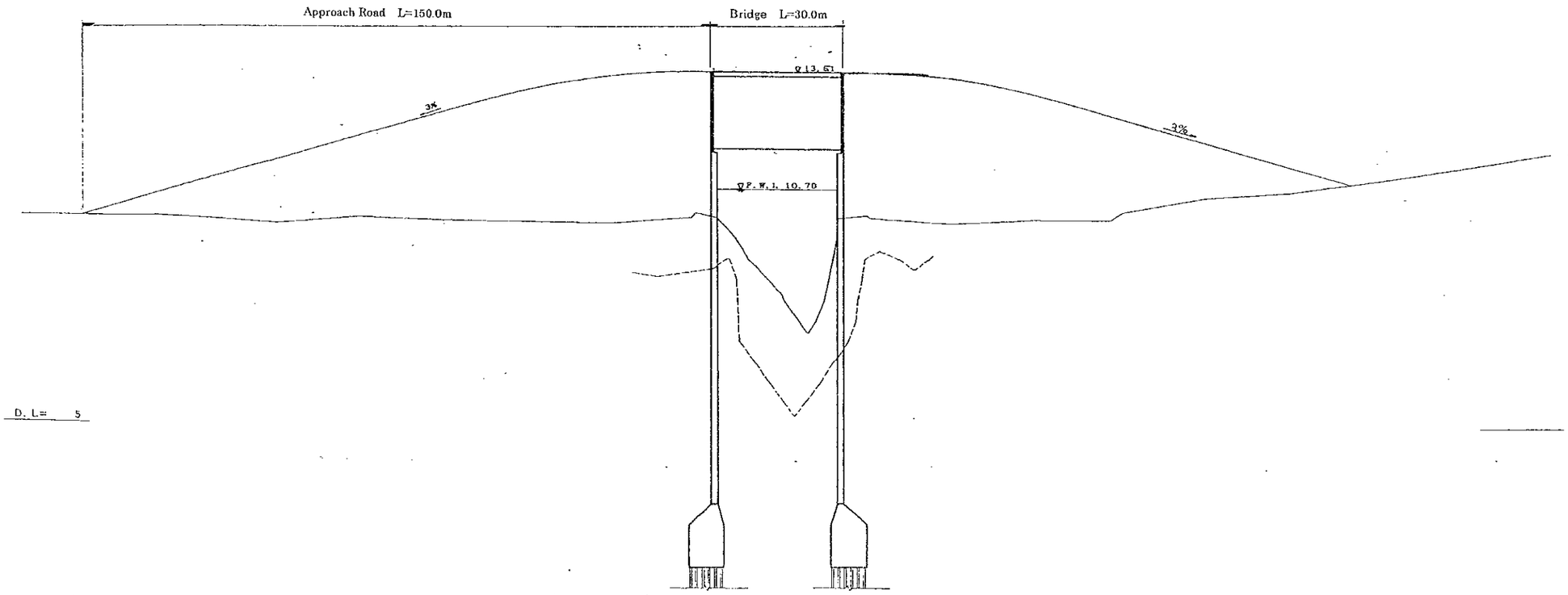

THE UNITED REPUBLIC OF TANZANIA	THE POJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO. 3 BRIDGE(Mpapura) (1/2)	JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996 / DRAWING NO :	

No. 3 Mpapura (MTW-1-10050)

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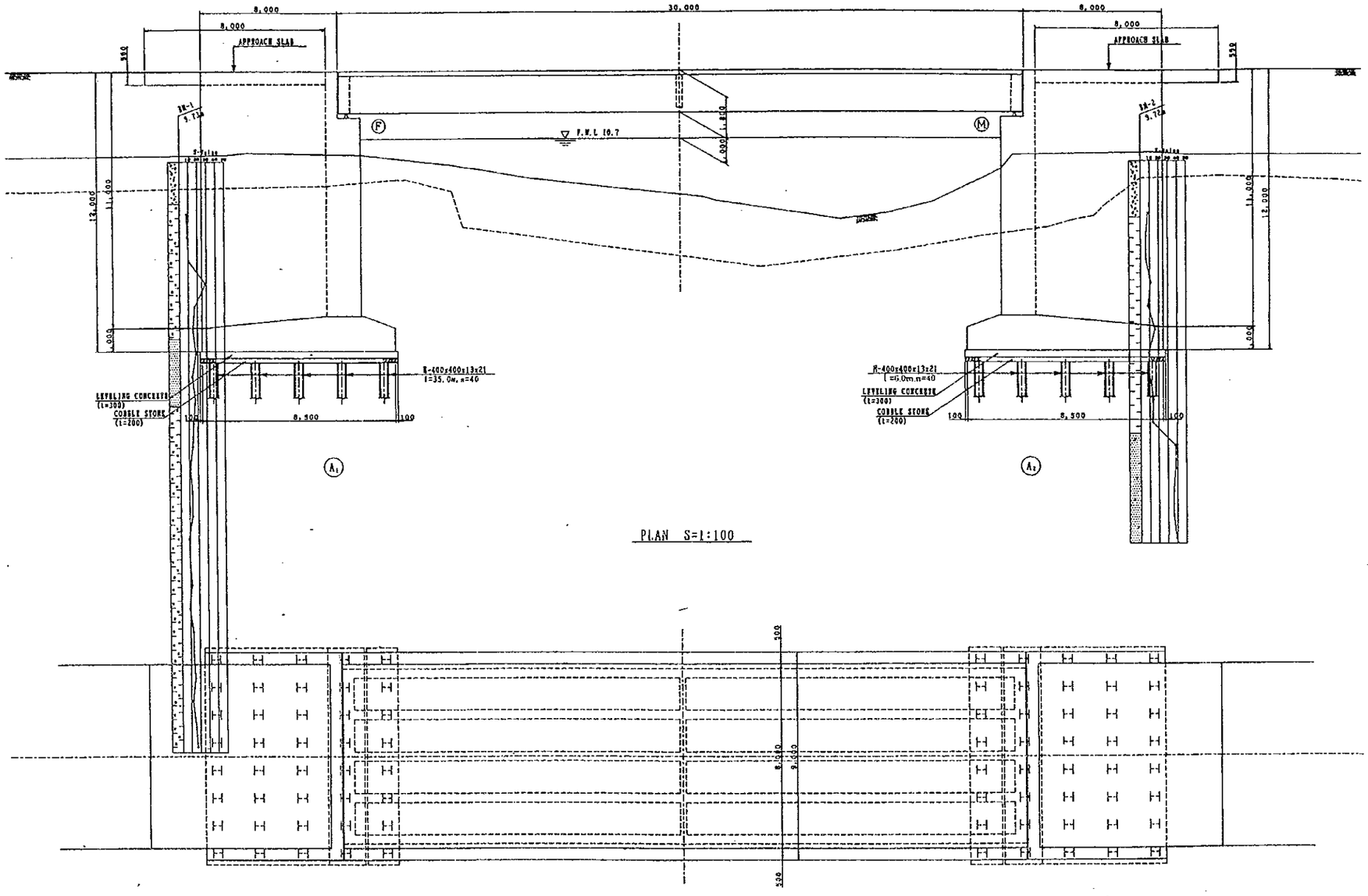

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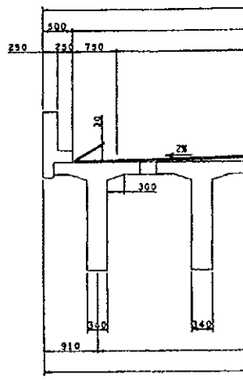

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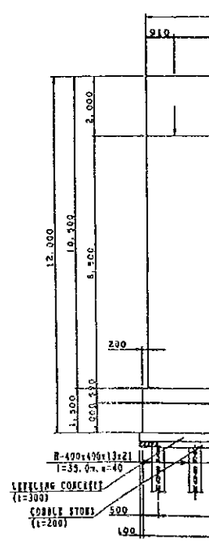
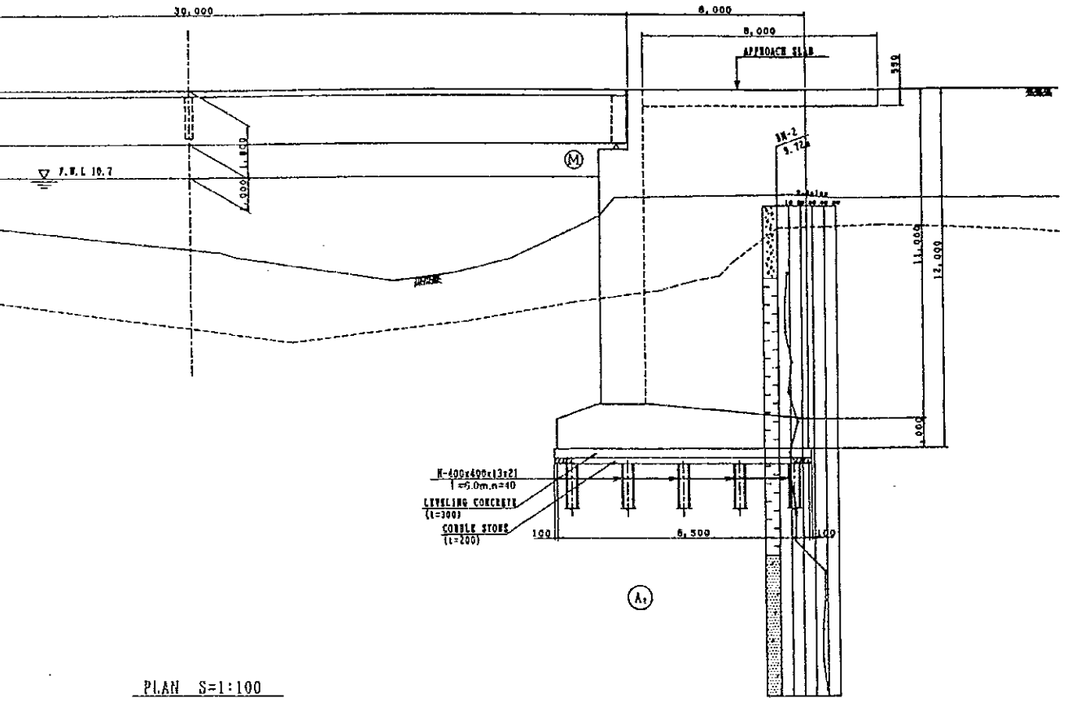


THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO. 3 BRIDGE (Mpapura) (2 DATE : September 1996 DRAWI

No. 3 Mpapura (MTW-1-10050)

ELEVATION S=1:100



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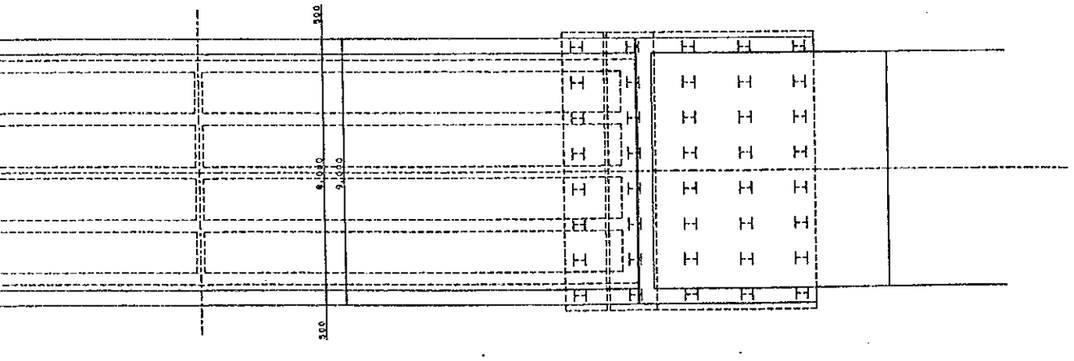

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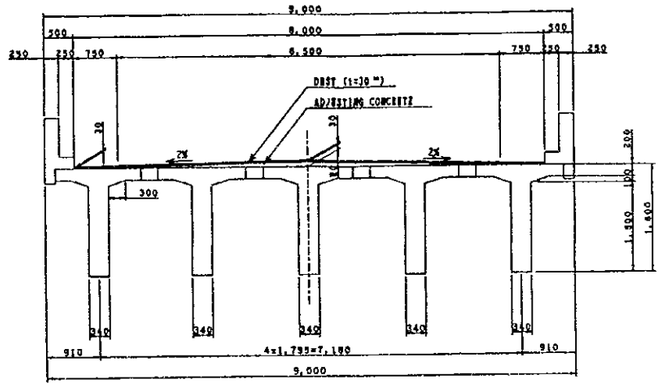

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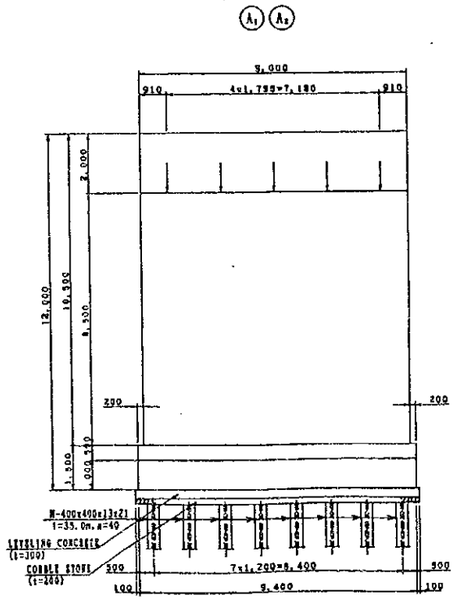

THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO.3 BRIDGE(Mpapura) (2/2)	JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO.,LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996 / DRAWING NO :	

No. 4 Mkwaya (LIN-3~10010)

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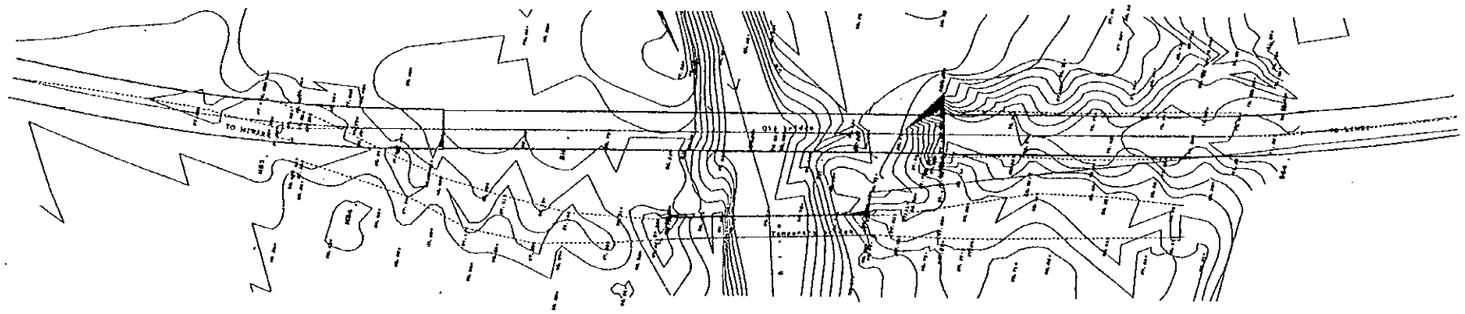
S=1/500



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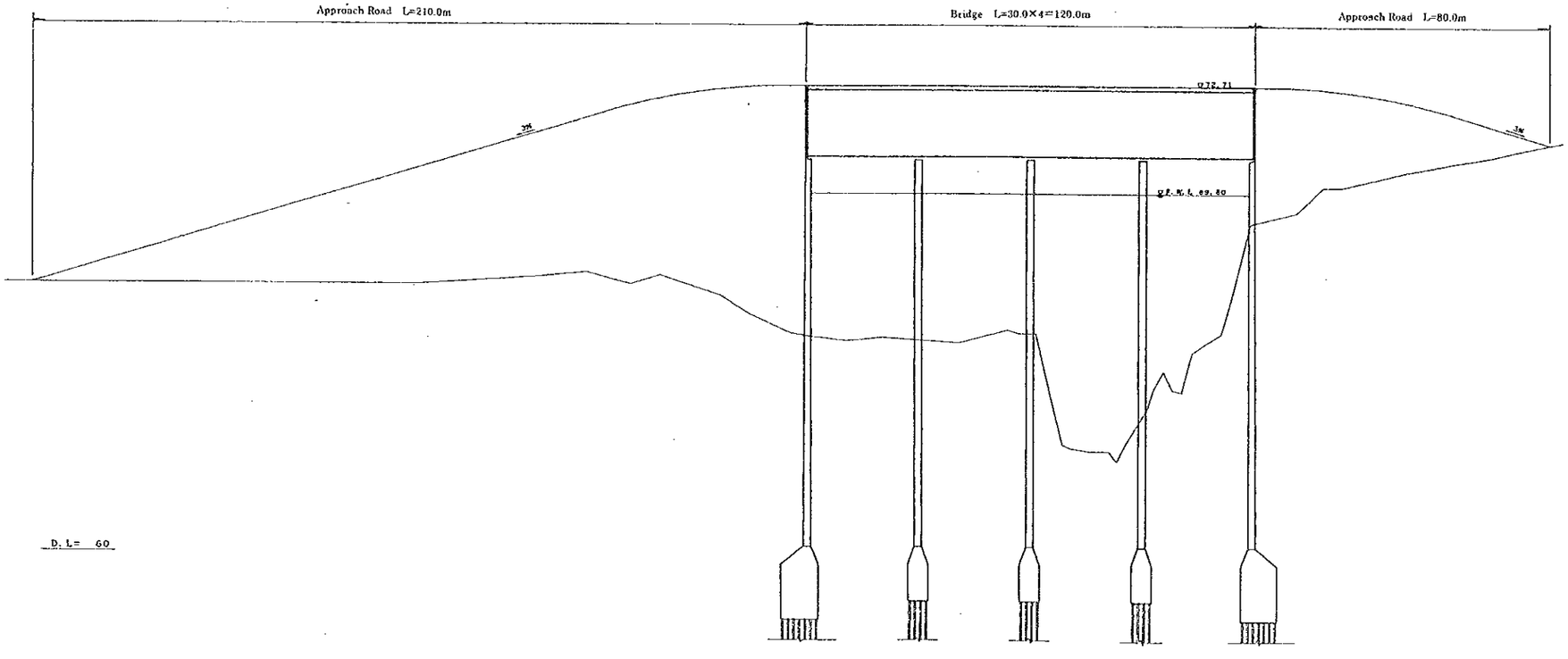
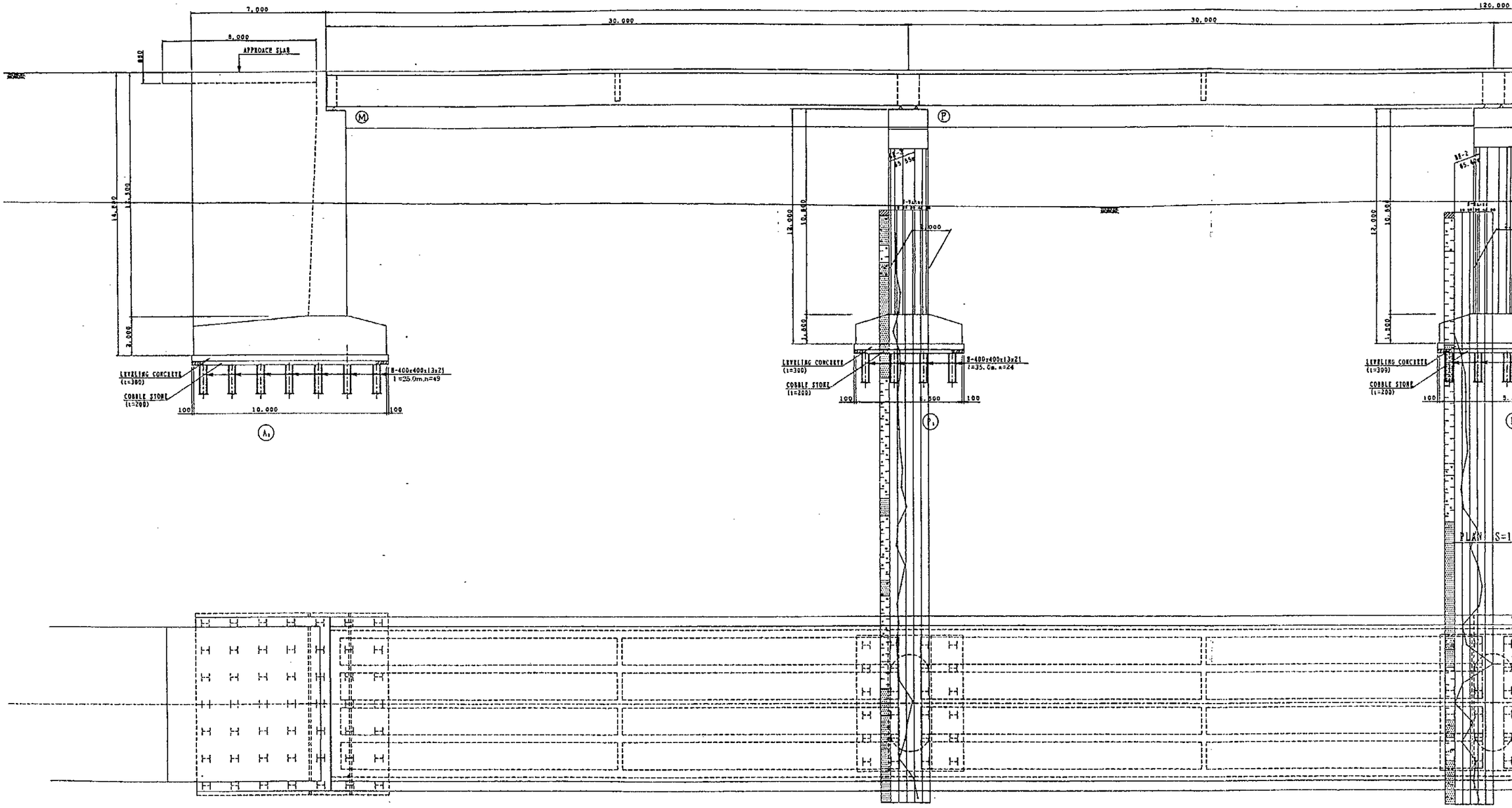


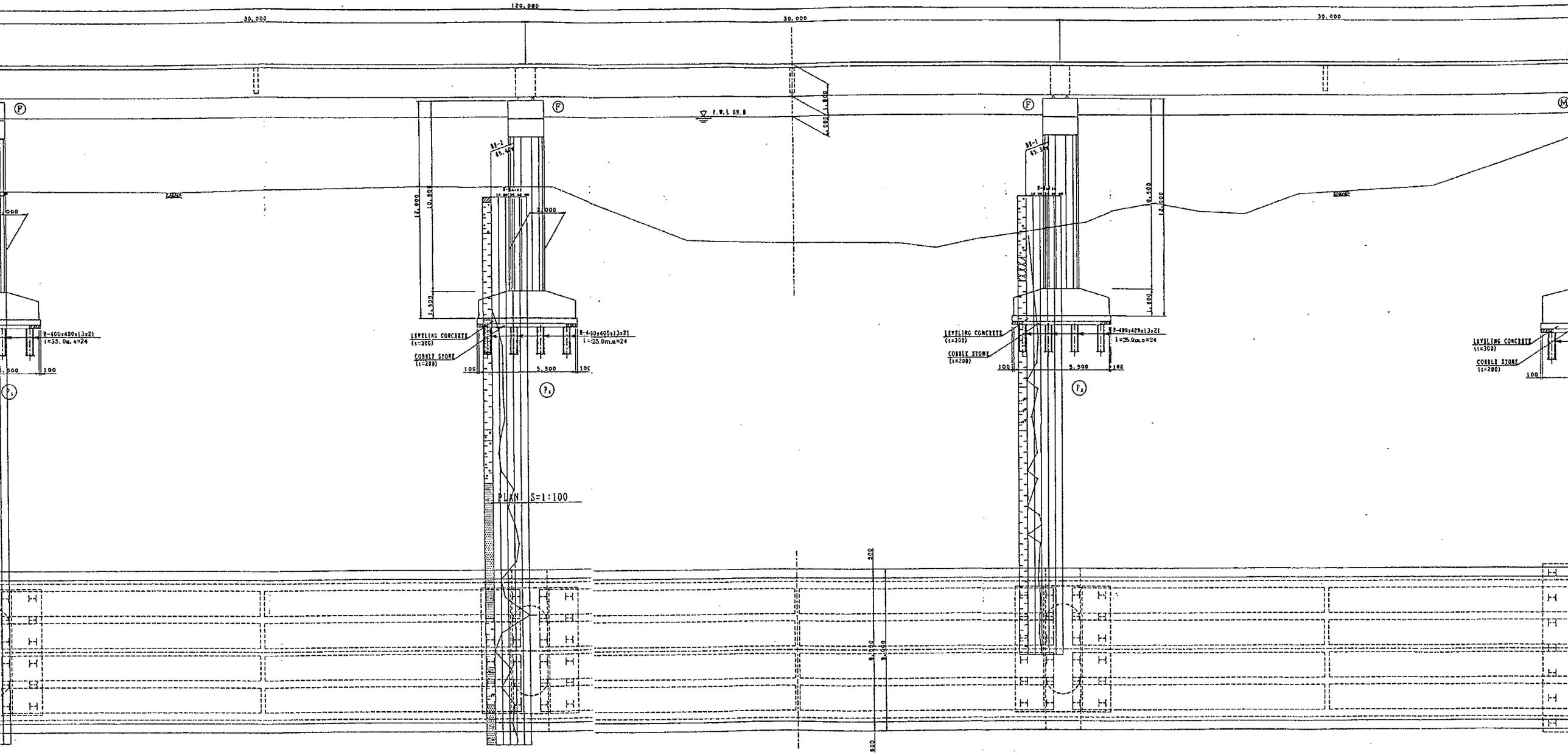
THE UNITED REPUBLIC OF TANZANIA	THE POJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO. 4 BRIGDE(Mkuwaya) (1/2)	JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996 / DRAWING NO :	

ELEVATION S


7,000
8,000
APPROACH SLAB
820
30,000
30,000
120,000
Ⓜ
Ⓟ
14,800
13,300
3,000
LEVELING CONCRETE
(t=300)
COBBLE STONE
(t=200)
B-400x400x13x21
l =25.0m,n=49
100
10,000
100
A1
12,000
10,800
1,800
5,000
LEVELING CONCRETE
(t=300)
COBBLE STONE
(t=200)
B-400x400x13x21
l=35.0m,n=24
100
5,500
100
P1
12,000
10,800
1,800
LEVELING CONCRETE
(t=300)
COBBLE STONE
(t=200)
100
PLAN S=1

No. 4 Mkwaya (LIN-3-10010)

ELEVATION S=1:100



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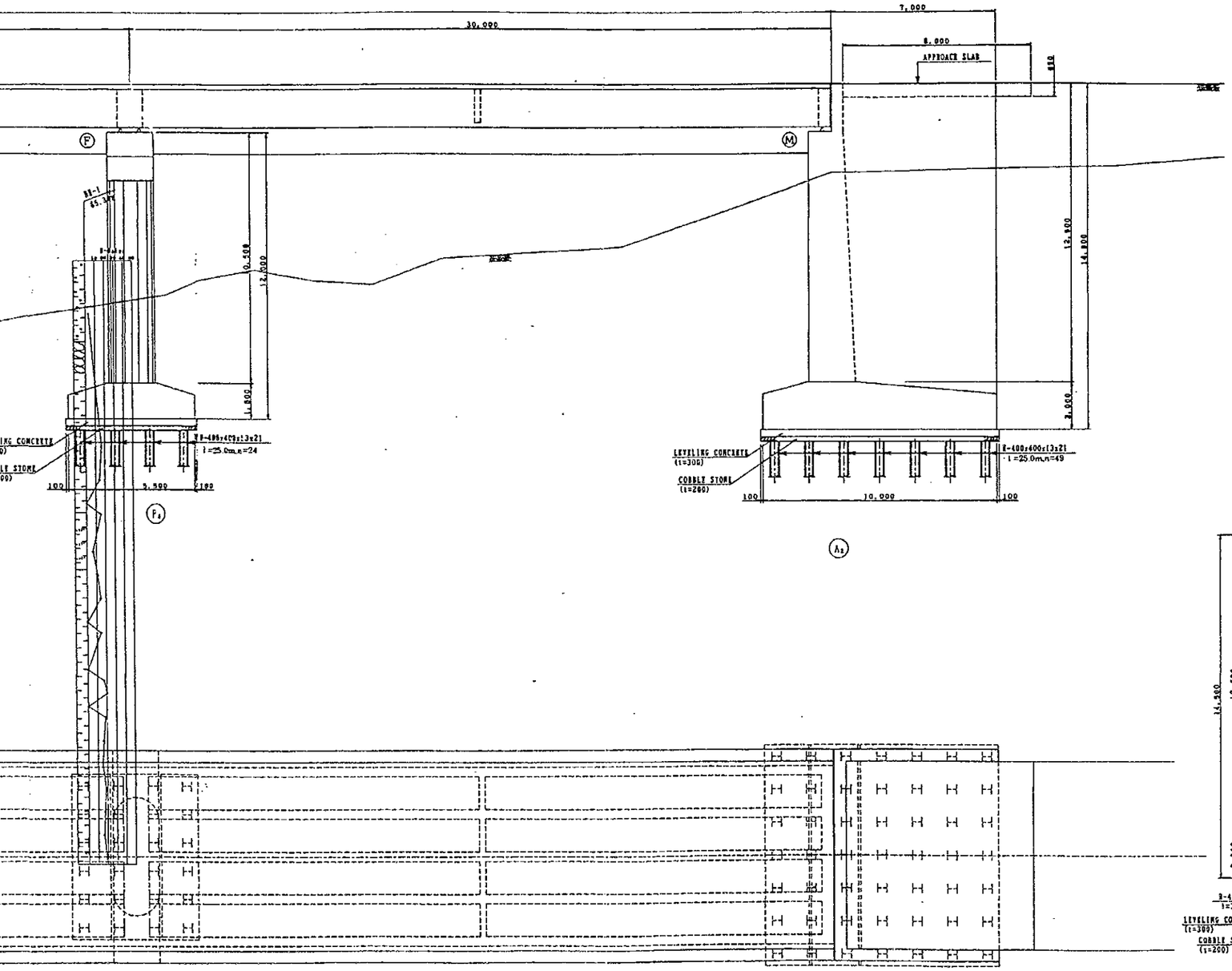
THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS



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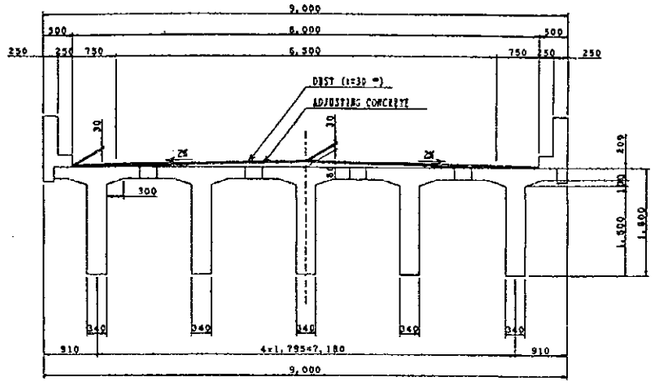

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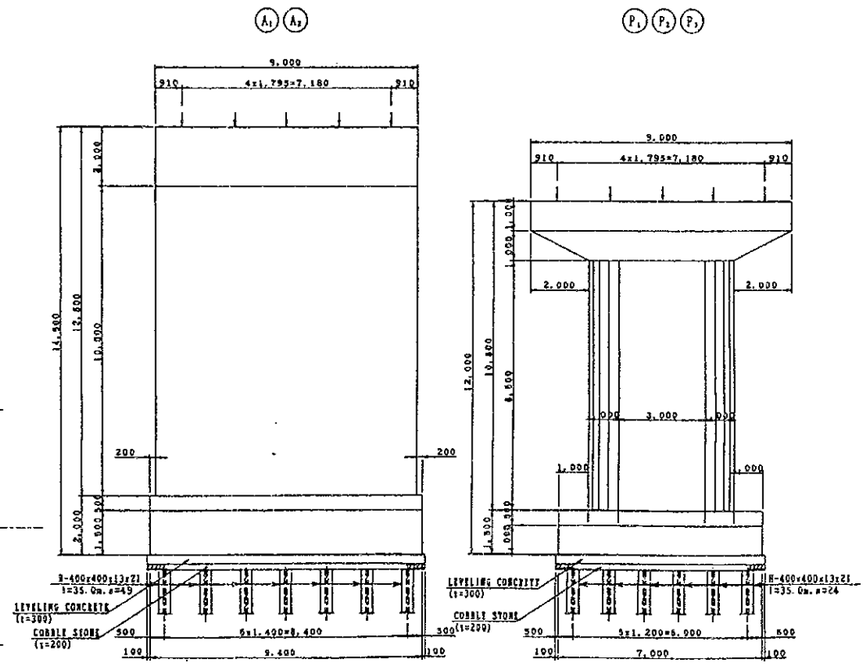


THE UNITED REPUBLIC OF TANZANIA	THE PROJECT FOR THE BRIDGE IMPROVEMENT OF TRUNK ROADS	TITLE : GENERAL VIEW OF NO.4 BRIGDE(Mkuwaya) (2/2)	JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO.,LTD CONSTRUCTION PROJECT CONSULTANTS, INC
		DATE : September 1996 / DRAWING NO :	

Chapter 3 : Implementation Plan

CHAPTER 3 Implementation Plan

3.1 Implementation Plan

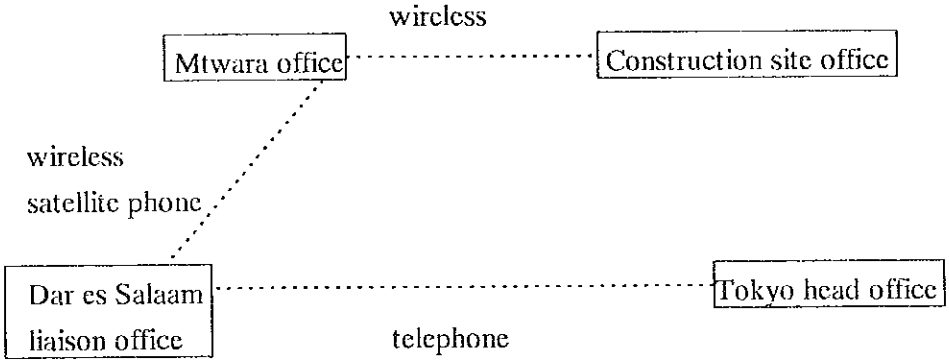
3.1.1 Implementation Plan

Tanzania's construction companies are ranked by the Ministry of Public Works according to the type of construction machinery owned. The engineering capacity of companies in the top rank is up to RC, T shaped or H shaped steel slab bridges of 15 meters. They have no experience in engineering PC bridges with 30 meter spans as are called for in this project.

The PC T-girder type as called for in this project requires the greatest care in manufacture and placement; therefore commissioned construction companies will be directly responsible for management of bridge construction.

There are no electricity or telephone facilities on site, so accommodations as well as the local office will be set up in the nearby town of Mtwara. A site office and consultant's office will be set up at Mpapra Bridge site as it is in a central location in relation to the four bridges.

In order to ease close communication between Japan and the local office, another liaison office will be set up in the city Dar es Salaam. The line of communication among the various offices is shown below.



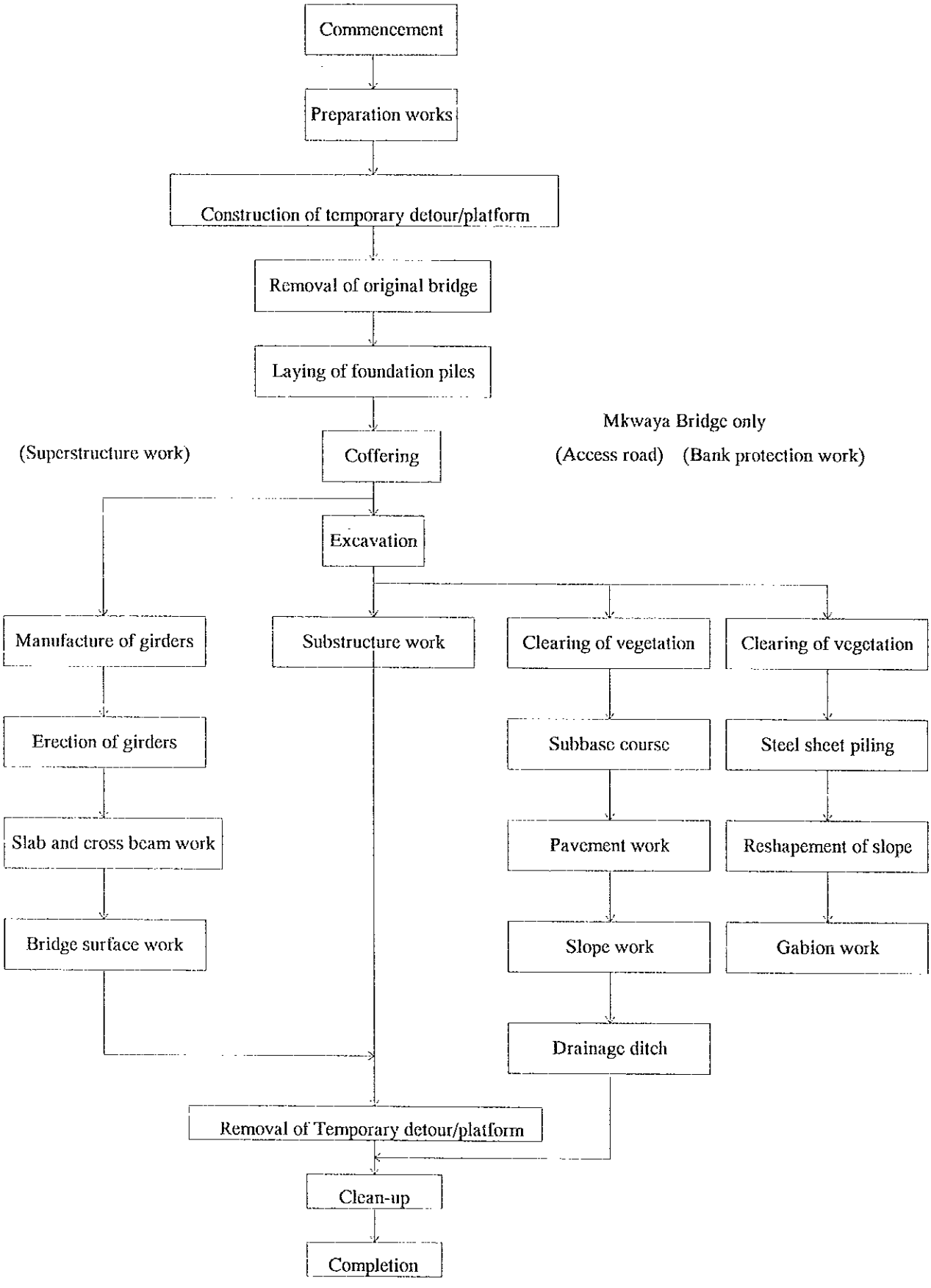


Figure 3.1.1 Flow chart

3.1.2 Implementation Concept

In consideration of results of survey mentioned above, the implementation plan below is recommended for this project.

(1) Establishment of Construction Period

Contents of construction include: preparation works, access road improvement, detour route work, removal of original bridges, replacement of bridges, and other miscellaneous works. The planned construction period is from May 1997 to completion in March 1999, approximately twenty-three (23) months. For five months during the rainy season (December to April), bridge and earth works will be suspended except at sites with relatively small water flow. Roadbed construction of access roads is possible in the rainy season.

(2) Implementation methods

1) Foundation

For this project, H shaped piles will be utilized and driven to a depth of 10 to 30 meters. Piles will be driven with a diesel pile driver on a 25-35 ton crane. Since the period of construction is limited, pile driving will be conducted from the present ground level and will be driven to the proper depth by a dolly.

Pile materials and driving machinery will be procured in Dar es Salaam or be import and brought to site. In case overland transport proves to be difficult in some cases, the pile driver will be brought to the bridge by special boat on water.

In the case of all bridges involved, any original structure which interferes with pile-driving work will be removed before commencement. If there is no such interference, removal of such structures will take place simultaneous to pile-driving works.

2) Construction of Substructure

Reversed "T" shaped abutment, rigid frame abutment, and wall-type piers are being considered as substructure types (see above). All of these types would be constructed within the river, therefore following common methodology will be employed:

① After piles are completely driven, a steel sheet pile which will secure the position of the substructure will be driven with a vibro-hammer.

② Excavation inside the coffering will be conducted with a back hoe. Digging is done

with great care, while wale, strut placement according to depth.

③ After attaining the predetermined depth, the bottom surface of the excavation is evened out, laid with cobblestone and flooring concrete is poured.

④ After pile head is treated with reinforcing bars, footing reinforcing bar is assembled, mold placed, footing concrete poured, and substructure is constructed from the bottom up.

⑤ Substructure is built up while removing the strut and wale.

⑥ After attaining predetermined height, surrounding base ground is returned to original form, and securing the steel sheet pile is removed.

Since construction in river is susceptible to natural accidents caused by flooding, construction during the rainy season is to be avoided, especially during the main rainy season.

3) Construction of Superstructure

The following methods can be considered as construction methods of the superstructure.

① Placement by crane
② Placement by fixed-position gate-type crane
③ Placement by placing a temporary girder
④ Placement by all-staging

All-staging placement was not included in the comparison of methods as the longer construction period required does not meet with the requirements of this study.

The superstructure is a PC girder-bridge with a 30m span, adopting the following construction method:

① Girder manufacturing yard and stockyard are to be made near the site while the substructure is under construction.

② Number of girders required for each bridge are to be manufactured. Concrete is to be supplied by a portable concrete plant set up nearby.

③ Materials required for girder construction (reinforcing bar, molding material, PC steel, cement, etc.) will be procured in Dar es Salaam or imported and brought to site by water via Mtwara port. Gravel will be quarried from nearby mountains.

④ Following completion of substructure, girders will be brought to temporary wharf and brought into place by gate-type crane to predetermined height to girder placement

position.

⑤ After the girder has been put into place, will be conducted the pouring of joint concrete and horizontal beam, horizontal tensing, etc.. Following this, bridge surface work will be conducted.

⑥ Bridge surface pavement will be alternating layers of gravel and asphalt emulsion.

⑦ Mkwaya Bridge is scheduled to be a four-spans bridge. To improve comfort in driving as well as simplify maintenance, the girders will be articulated.

(3) Utilization of local engineers, materials and equipment

Due to the prolonged economic recession under the previous governmental administration, there is a shortage of skilled engineers in both the public and private sectors. Even including skilled labor, it can be said that Tanzania's engineering level is at the developing stage. Therefore, from the aspect of promoting transfer of skills, throughout the execution of this project, the staff of the Department of Road, Ministry of Public Works will be involved as closely as possible.

(4) Utilization of local constructors

As mentioned above, local constructors are not quite at a mature level of development in terms of engineering skills. However, a number of those which have subcontracted with similar aid projects (including those from the Japanese government) over recent years are improving their level of skill. Therefore, assigning general construction tasks to subcontractors under the supervision/direction of a Japanese constructor as an opportunity for participation in the project will contribute to the raising of construction engineering levels in Tanzania.

(5) Dispatch of engineers from Japan

Items of construction which require special attention and whose roles are crucial to the quality of the completed product will be in the charges of engineers sent from Japan. Items requiring special skills include PC tensing, main girder placement, etc.. Items for which quality control are important to guarantee quality of finished product include earthfill works, roadbed work, and pavement work.

(6) Executive establishment of Tanzania

The Tanzanian counterpart to this project is the Department of Road, Ministry of Works. Maintenance and management following the project is to be executed by regional offices of the Ministry.

3.1.3 Implementation Conditions

In composing a construction schedule for the project, consideration must be taken in regards to Tanzania's rainy/dry season cycle, circumstances regarding procurement of materials and equipment before making a final proposal.

(1) Construction concentrated in dry season

Due to the fact that Tanzania's rainy season from December to April makes construction inefficient and/or impossible, construction will be carried out during the dry season. Therefore equipment schedule will also be centered around the dry season.

Preparation works and setting-up of work bases should commence immediately following agreement of terms and signing of contracts between Tanzanian government and contractors. Procurement of materials and equipment from Japan takes from two to three months, therefore, initial stages of construction should full utilize equipment available in Tanzania.

(2) Acquisition or leasing of site land

Acquisition or leasing of land to be used for site office, PC main girder manufacturing yard, etc., is to be handled by Tanzanian counterparts. It will be necessary for these to be procured before the commencement of construction. The site office will be procured in Mtwara and manufacturing yards near each project bridge. The liaison office, as mentioned previously, will be opened in Dar es Salaam.

(3) Customs

Materials and equipment procured from Japan or third-party countries will arrive in Tanzania at Dar es Salaam port. In order for there to be a smooth passing through customs, measures are necessary to obtain understanding of government authorities concerned.

(4) Safety measures

In the case of Mkwaya Bridge, the transport of heavy items and work in high places are involved, making it highly important to take thorough safety measures. Work on Mkwaya and the other bridges will involve large numbers of transport vehicles, making necessary measures for traffic safety as well.

It will not be possible to make communication by telephone between the Mtwara office and Dar es Salaam, thereby necessitating establishment of wireless radio facilities to ensure a communication system for emergencies, etc..

3.1.4 Scope of Works

The scope of works in the charge of the Tanzanian side are shown below. All other items of the construction process are the responsibility of the Japanese side.

① Land acquisition
② Compensation of housing lying within acquired land
③ Demolition of houses in housing lying within acquired land
④ Securing of construction yard
⑤ Supplying parts and maintenance of Bailey bridges for diversions during the construction of new bridges.

3.1.5 Consultant Supervision

Japanese staff, who will be working on the project following signing of consultant contract until tendering, on detailed design as well as the preparation of tender documents, will consist of the following:

-Project manager
-Substructure engineers (A,B,C)
-Superstructure engineers (A,B,C)
-Access road engineers (A,B)
-Surveyor of natural conditions
-Tender documents specialist
-Construction planner / Cost estimate specialist
-Tender/contract specialist, etc.

During the construction period, the consultant will dispatch personnel to act as resident engineers and supervisions/directors of major construction. The division of responsibility among staff members is indicated below.

(1) Project manager

Oversees all work related to detailed design, tendering and construction.

(2) Substructure engineers (A,B,C)

Responsible for planning and designing of foundations, substructures and related structures during the detailed design period. During construction period, responsible for supervising temporary structures, verification of soil conditions, foundations, substructure work, bank protection and other attendant works.

(3) Superstructure engineers (A,B,C)

Responsible for designing of superstructure and related structures during the detailed design period. During construction period, responsible for supervising and personally inspecting girder manufacture, placement work, bridge surface work and other attendant works.

(4) Access road engineers (A,B)

Responsible for detailed designing of road improvement as well as drawing and calculations during the detailed design period. During construction period, responsible for supervising and personally inspecting earthfill works, subbase course work, pavement and other major related construction items.

(5) Surveyor of natural conditions (site surveying, boring, CBR test)

Responsible for site surveying, boring and CBR testing necessary for detailed design, referring to data from the basic design stage.

(6) Tender documents specialist

Responsible for the preparation of tender documents and contracts during the detailed design period.

(7) Construction planner / Cost estimate specialist

Examines and reviews details of construction plan during the detailed design period, as well as re-examining construction and project costs based on estimates made in the basic design period, for a more detailed estimate.

(8) Resident supervising engineer

Resides in Tanzania from the beginning to the completion of the construction, responsible for management of the construction process, quality control, etc., as well as related clerical matters. Also responsible for supervising and personally inspecting earthfill works, subbase course work, pavement work and other incidental to the road construction.

3.1.6 Procurement Plan

(1) Labor situation in Tanzania

1) Construction engineers

Among institutions for training skilled engineers in Tanzania, the University of Dar es Salaam, the only university in the country, is most important, with a four-year course in civil engineering. In addition, there are also technical secondary schools, technical colleges, vocational training centers, and institutes. Most graduates of Dar es Salaam University are employed as registered engineers in elite positions in government offices or for local consulting. Very few join construction firms. Although such engineers have high social status, due to the shortage of projects they lack opportunity to gain on-site experience, therefore do not have a high level of skill in their field. Furthermore, engineers who have received training or have studied abroad find it difficult to maintain their attained level of skill in these circumstances.

Japanese corporations in Tanzania mainly employ graduates of technical secondary schools and train them on the job, but their numbers are still small.

2) Labor manpower

The number of experienced skilled workers is extremely small. The situation of each labor field is discussed below.

- Carpenters
  Skill level is low due to the small number of projects, therefore lack of continuous experience opportunity. In Japan, any carpenter has his own tools for basic work (hammers, saws, planners, etc.), but in Tanzania these are lent to the carpenters by their employers as they do not have their own.
- Steel-rod workers, stone workers, steeplejacks
  There are few who can follow drafted directions for assembly. There needs to be a director in this area.
- Construction machinery operators
  There is considerable experience in the handling of all-purpose machinery for road construction. However, there are practically no people who have experience in operating specialized machinery such as large cranes (35 ton +) or pile drivers.
  There is no problem in employing unskilled labor locally.

(2) Construction machinery

The type and numbers of construction machinery available in Tanzania is extremely limited. On the event of the Southern Coastal Highway construction project in 1980, large machinery for road construction was purchased by the Ministry of Public Works with a yen loan. Afterwards, other smaller types of equipment were donated mainly for road repair. However, at present most of this equipment has not been well maintained, especially larger types for which demand is small.

There is still little demand for construction machinery in Tanzania; therefore there is not much a leasing system either. All that is available for leasing, aside from what private construction firms keep for their own use, are small types of construction machinery and some vehicles from the Construction Machinery Lease Organization (PEHOOL).

Large-type cranes, etc., which are required for the highway and bridge construction in this project are not available in Tanzania and need to be procured from Japan or a third country. As far as procuring from Japan is concerned, there would be no problems concerning warranty, export procedures, etc.

From the above, procurement of construction machinery will be carried out according to the following policies.

① All-purpose machinery equipment, particularly small and medium-scale, which is comparatively available in Tanzania, will be procured locally.

② Construction machinery which is available in Tanzania but limited in number and/or is crucial to the construction process or overall quality of the project will be procured from Japan or a third country.

③ Construction machinery which is not available in Tanzania will be procured from Japan or a third country.

(3) Construction materials

1) Cement

The three companies listed below each have their own cement factory in Tanzania and manufacture Portland cement. These companies suffice in supplying the domestic cement market and imported cement is not found on the market. There is no problem with quality even when high-strength concrete (350 kgf/cm2) is involved.

- Tanzania Portland Cement Dar es Salaam, Wazo plant (Twiga brand)
- Tanga Cement Tanga plant (Simba brand)
- Mbeya Cement Mbeya plant (Tembo brand)

2) Ready-Mixed Concrete

There are no specialized plants or market distribution of mixed concrete within Tanzania. However, there are two Japanese firms which have mixed concrete plants in Dar es Salaam (Capacity: 40m3/h, 25m3/h, 15m3/h, 8m3/h). Portable plants will be set up at the construction sites.

3) Steel materials

(reinforcement piles, sheet pile, structural steel)

Reinforcement bars

There are three companies in Tanzania which manufacture and/or sell reinforcement steel bars, but there are problems in quality, supply volume and timing.

① M.M Integrated Steel Mills
- Manufacturing, Sales
- Manufactured from scraps by electrical furnace
- Manufacturing dimensions: 8mm - 25mm
- Official manufacturing volume is stated at 25tons/day, but reliability is questionable

② National Steel Co., Ltd.

③ Timbers, Ltd.
- Both companies stock and sell imported materials from Turkey, Kenya, United Kingdom, Belgium, Germany, etc.
- There is a small amount of stock, but in general stocked through order. Foreign manufacturers manufacture on demand.

Steel sheet pile, H-steel pile, steel pipe piles, other general structure steel materials

Procurement difficult in Tanzania; must be imported from Japan or third country.

4) Concrete aggregates (crushed rock, sand) and earthfill for roads

For the regions of Mtwara and Lindi, there is a rock (granite) quarry and crushing plant in Nanganga under the jurisdiction of the Mtwara Regional Engineer's Office. However, at present it is not in operation due to the shortage of machinery parts. Considering the need for a stable supply, it is necessary to plan procurement of a portable aggregate manufacturing plant from a third country. Besides Nanganga, there is also potential for procuring rock material

from a site near Masasi.

As for procurement of sand, local procurement is possible from mountain sand near the Mtwara Airport, river sand and laterite from the vicinity of Ndanda, etc.

However, transport depends on National Roads B2 and B5, which entails some long distance traveling, as shown below

Nanganga------	65km from Mingoyo
	145km from Mtwara
Ndanda--------	80km from Mingoyo
	160km from Mtwara
Masasi---------	120km from Mingoyo
	200km from Mtwara

5) Pavement materials (subbase materials, bituminous materials)

The surface layer employed in this project is to be bitumen surface treatment (BJT).

Crushed rock to be used for subbase material is procurable from the same source in Mtwara and Lindi Regions, as mentioned above. However, considering the amount to be transported and the distances involved, these cannot be considered appropriate. Therefore, subbase materials are planned to be attained by stabilizing treatment of cement.

Bituminous material, which is processed by the TPDC from imported crude oil, is manufactured and sold as fuel and as bitumen. A company in Dar es Salaam, AGIP, also sells it. However, since there is some concern regarding volume and stability in supply, it will basically be imported.

6) Lumber

Tanzania is a country of rich lumber resources, but preciseness in processing (surface smoothness, perpendicularity, line straightness) is somewhat lacking and not expected to suffice as mold-casting material for bridges. Plywood of good quality is not available; import is the only solution (It may be necessary to consider use of metal molds)

7) Other construction materials

Procurement plans for construction materials, including the above-mentioned, are shown Table 3.1.1. In general, there are not many South African products on the market in Tanzania at the present time, due to the Tanzanian government's former stand against the apartheid policy, which was abolished in 1994. Trade between the countries is still not very active.

Table 3.1.1 Procurement of Construction Materials

Construction material	Procured locally	Procured from Japan	Procured from third country	Remarks
Cement	○			
Concrete mixer		○		
Reinforcing steel	○ partially	○	○	Quality maintenance
Structural steel		○	○	Schedule/quality maintenance
PC steel wires, bars		○	○	Schedule/quality maintenance
Bitumen	○		○	
Crushed rock	○			Rock-crushing plant; procurement from third country
Sand	○			
Earth for road	○			
Lumber	○			
Mold (plywood, steel)		○	○	Quality maintenance
Scaffolding, supports		○	○	Quality maintenance
Expanding-contracting joints (rubber type)		○		Quality maintenance
Support (rubber type)		○		Quality maintenance
Concrete pipe	○			
Corrugated pipe		○	○	
Gabions		○		Import market

3.1.7 Implementation Schedule

Following conclusion of Exchange of Notes, this project will be carried out according to the following process.

(1) Consultant contract, detailed design

Following signing of consultant contract, detailed design is conducted; design documents and tender documents prepared.

(2) Establishment of construction period

The construction contract is a direct agreement between the Government of Tanzania and Japanese contractors. The selection of Japanese contractors is by a public tender open to Japanese companies.

Before the bidding, points of examination will be discussed with Japan International Cooperation Agency (JICA), and there will be an examination of qualifications of authorized contractors. The consultant will conduct examination of qualifications as a representative of the executive body of the Government of Tanzania.

Examination of tenders and selection of the most qualified bidder will be conducted with the attendance of Tanzanian government officers, the consultant, and participating bidders, in the presence of the concerned JICA official, followed by signing of construction contract.

In conjunction with the finalization of the construction contract, the Government of Tanzania will open a special account for receiving aid funds from the Japanese Government and for paying the Japanese contractor. To operate this account, the finalization of Banking Arrangements (B/A) with an authorized money-exchanging Japanese bank must be settled as soon as possible. This arrangement is necessary for two main reasons; one being that it is needed for the Japanese contractor to receive advance payment (as mentioned in contract clause); another being that it is required as grounds when Tanzanian Government acquires Authorization to Pay (A/P), which in turn is required when Japanese contractors procure export approval by the Japanese Ministry of International Trade and Industry (MITI). Therefore, arrangement should be made simultaneously with finaization of contract.

Next, the certification of the contract is necessary. Contract certification is proof from the Japanese Government that this contract is appropriate as an object of concerned grant assistance, and a necessary part of the issuing of contract. More specifically, the Ministry of Foreign Affairs obtains the contract from the Government of Tanzania via the Japanese embassy in that country and then makes the decision of whether to certify it or not. The Japanese contractor, by receiving the certified contract documents and A/P, carries out the contract.

(3) Construction Schedule

Construction, which begins with preparatory works, consists of improvement of access road (including drainage work), construction of detour route, removal of original bridge, construction of substructure and superstructure (girders and bridge surface); also embankment protection and attendant works, followed by removal of construction equipment. Work on drainage facilities and bridges on project sites in Tanzania have a limited time frame due to the rainy season from December to April.

The construction schedule for this project is shown in Table 3.1.1. The time involved is 23 months.

3.2 Project Cost Estimation

Tanzania is responsible for the following estimated expenses.

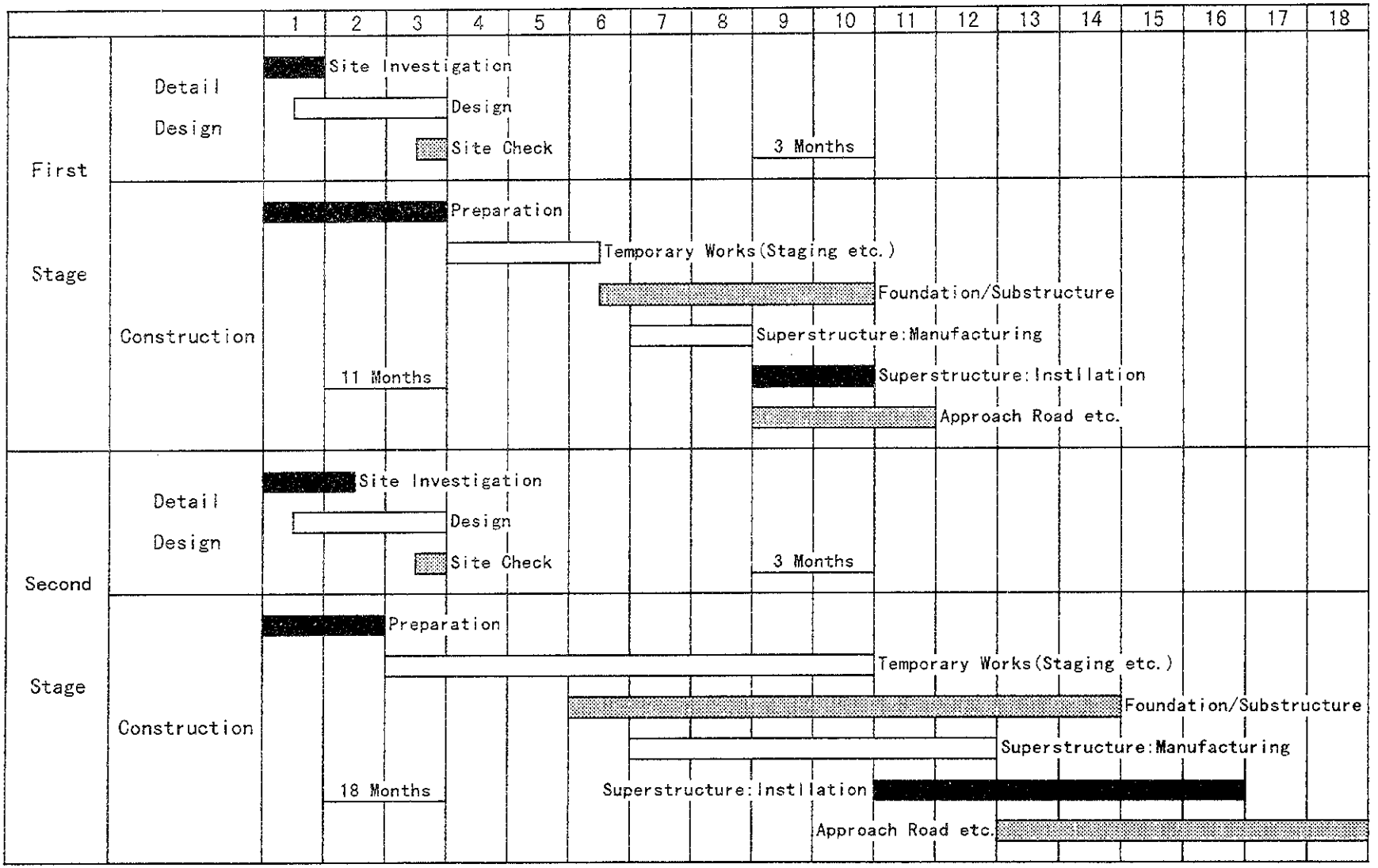
(1) Land acquisition
(2) Compensation for houses inside acquired land
(3) Cost of demolishing houses inside acquired land
(4) Expense of workyard leasing
(5) Supplying parts and maintenance of Bailey
(6) Operation and Maintenance Costs of Bailey bridges for diversions.

3.3 Operation and Maintenance Costs

Following completion of the project, operation and maintenance of the bridges will be in the charges of the local offices of the Department of Roads. The budget of the Ministry of Public Works allotted to maintenance of roads and bridges is about 40% of the entire budget. Out of this, about 45% is allotted to major roads. However, budget allotted to bridges is extremely low at less the 5%.

Maintenance management work forecast for the first ten years following completion of the project is shown in Table 3.3.1.

Table 2.1.1 Construction Schedule



① Maintenance work and cost

Table 3.3.1 Contents of Maintenance Work and Cost

Frequency	No	Works	Unit Cost	Ten Year Cost
Yearly	1	General cleaning and weeding, drainange US$0.06 x whale area (14,000m2)	US$840	US$8,400
	2	Repair on access roads and shoulders US$1.0 x surface area (3,400m2)	US$3,400	US$34,000
	3	Repair on bridge banks (minor) US$2.0 x bank area (1,700m2)	US$3,400	US$34,000
	4	Repair on river-bed and training (minor) US$43 x facility area (500m2)	US$21,500	US215,000
	5	Pavement patch-up US$17.7 x ten percent of surface area (500m2)	US$8,900	US$89,000
Five Yearly	6	Repair on embankment (medium) US$2.0 x bank area (1,700m2)	US$3,400	US$6,800
	7	Pavement over-lay US$17.7 x Total surface area (5,200m2)	US$92,600	US$185,200
Ten Year Total of Maintenance				US$572,400

Note : a Bridge components repair on as-need basis shall be conducted when necessary.

② Operational costs

Operational costs estimated for routine checkups and scheduled checkups are shown below

-Personal costs :US$25,000/year

-Inspection vehicle fuel costs :US$5,000/year

Total :US$30,000/year

Chapter 4 : Project Evaluation and Recommendation

Chapter 4 Project Evaluation and Recommendations

4.1 Project Effect

The purpose of this study is the reactivation of the local economy, sustenance of the lives of local inhabitants, and amelioration of the regional transportation network as a whole. Specific results desired are shown below.

- Present conditions and issues
  - The maximum vehicle weight limit of project bridges is 20 tons, due to being temporary structures
  - The present structures are at the same height or lower than those which were washed away in the 1995 flooding, meaning that even a flood of smaller scale could cause further damage
- Solutions offered by project
  - Adopting BS5400 live load HB45, a bridge capable of bearing vehicles including large-size trailers will be built
  - Permanent bridge design will be conducted considering likelihood of a flood at a scale occurring once in 120 years
- Effect of project / Level of amelioration
  - Revived function of a main route; contributing to the economic development of the region as well as the entire nation
  - Procurement of a stable main route used for daily necessities involving schools (primary and intermediate levels), clinics, hospitals, marketplaces, churches, mosques; thereby eliminating insecurity in daily situations

The transport of agricultural products (cash crops such as cashew nuts, etc.), the production of which has increased eight times over the past six years, will be greatly facilitated by the project. Furthermore, the lives of the 300,000 people inhabiting the route area will directly benefit.

4.2 Recommendation

As mentioned above, the project will have great efficacy in contributing to the upgrading of the basic human needs of the inhabitants over a wide area; thereby more than justifying that the implementation of the Project by Japan's Grant Aid System is evaluated as appropriate. Furthermore, in terms of operation and management of the project, there is considered no problem on the Tanzanian side regarding staff and/or capital.