CHAPTER 2

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Object of the Project

The request presented by the Government of Kenya in 1998 concerning this project was related to restoration of five bridges among those washed out by flooding which many feel was caused by the El Nino phenomenon. The five bridges are the Athi and Ikutha Bridges in the Eastern Province and the Marere, Eshueshu, and Mwache Bridges in the Coast Province.

The Athi, Marere, Eshueshu, and Mwache Bridges suffered considerable damage, including wash-out of their superstructure, piers, and embankment on the backside of the abutment, and are now impassable. The Ministry of Roads and Public Works (MORPW) took ad-hoc measures for some of the washed out bridges under foreign assistance such as installation of a temporary bridge using a Bailey bridge, etc. Sufficient countermeasures have not been taken for most of these bridges and obstacles to road traffic remain. At the sites for the Athi and Marere Bridges, temporary bridges are constructed to provide a traffic path. The Ikutha Bridge, though not suffering serious El Nino damage, was an obsolete wooden bridge and replaced by a temporary Bailey bridge in 1988, however, the life of piers seem not reliable.

Two bridges in the Eastern Province, the Athi and Ikutha Bridges are located on a Kenyan trunk road, a B-class national highway B7. The three bridges in the Coast Province, the Marere and Eshueshu Bridges are on the principal road, a C-class road, while the Mwache Bridge is on a secondary road, a D-class road. The highway B7 is an important route not only for transport of agricultural products from roadside areas, but also to connect principal cities in Eastern Province (e.g., Embu) with Mombasa the international trade port. The C- and D-class roads where other bridges are located are access roads to the nature reserve and not included in critical routes though they are important for tourism and regional residents.

It was decided to implement basic design study on the project for reconstruction of Athi and Ikutha bridges located on the national highway B7 because their urgency and importance are in high levels.

2-1-2 Higher National Plan and Project Targets

Since independence in 1963, Kenya has implemented national development plans up to a seventh phase with economic and industrial growth as national targets. Because of failure to achieve the target, past plans were reviewed and an eighth national development plan was established for the period from 1997 to 2001. This plan aimed at shifting from past development plans largely dependent on agriculture and the transition of Kenya to a newly industrializing country (NIC). A political priority was placed on savings growth, expansion of investment, and development of an environment conducive to private sector investment.

However, the road network is worsening because of insufficient operation and maintenance. This is now one of the most critical hindrances to economic development, exerting substantial effects on the production capacity of all economic sector, because of increased vehicle transport costs and decreased transport efficiency, uncertainty in distribution plans, and restricted investment in the transport sector.

Considering these circumstances and for the road sector in transport infrastructure development, the eighth national development plan places a priority on operation and maintenance of existing road functions while limiting new investment. The goal is to eliminate bottlenecks in economic activities. Specifically, this project aims at realizing safety and smooth traffic on the B7 highway to secure functions of trunk roads in Kenya and thus to vitalize the economic activities.

2-1-3 Contents of the Project

This project covers two bridges, Athi and Ikutha Bridges, on the B7 highway to achieve above targets. It is expected that the project will improve bridges that are currently bottlenecks because large vehicles cannot pass temporary bridges and vitalize the economic activities through the highway B7. The project will include construction of the following structures and facilities:

(1) Construction of new permanent bridges
(2) Construction of an access road before and after the bridge up to transition to the existing road
(3) Construction of revetments for abutments and access roads

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

The content proposed in the basic design was drawn up on the basis of the concepts described below.

1) Basic concepts

The content of the project includes structures related to construction of the main structure of Athi and Ikutha bridges, a part of approach roads before and after the bridge and auxiliary structures.

Demolishment of existing bridges, extension of the approach road, and repair of existing road are basically excluded from the scope of the project and included in the scope of the counterpart, except that they may be implemented if substantial hindrance to implementation of the project is expected without their incorporation during construction of the bridges.

2) Policy for natural conditions

Because these bridges span rivers, the number, shape, and size of piers constructed in the river affect the river flow. The bridge type should be determined with due consideration for the effect on the river during construction.

The old Athi Bridge was washed away during flooding caused by the El Nino phenomenon. Setting the river flood level is vital for determination of the planned height of the bridge. For ground conditions and seismic forces that are important factors in bridge structure considerations, the water level during work, and rainfall, values are set by taking into account the result of a survey of natural conditions and field conditions. Since no observation has been made on the water level at bridge site, in particular, observation data in the neighboring areas and local hearing results need to be fully considered to set the appropriate values.

In the Kitui area where bridges are to be constructed, rainy seasons are classified as a major season from March to May and a minor season from November to December. During the dry season, the Tiva River which the Ikutha Bridge crosses, has a riverbed

which is so exposed except for underflow water as to allow crossing on foot. The water level of the Athi River also drops to 2 m or less. During the rainy season, the water flows over the entire width with a maximum depth of 4 m or more. Accordingly, due attention must be paid on the timing of construction of the bridge substructure because the work is to be done in the river. As both rivers have a wide drainage area, rainfall in the upstream area may cause high water at the site even if there is no rain there. It is essential to fully understand the meteorological conditions on the upstream side during construction. The superstructure erection method must therefore be basically not be susceptible to the impact of the rainy season.

3) Policy for socio-economic conditions

The two bridges concerned are on the B7 national trunk road for which development is sequentially under way from its northern end. Of the entire length of about 313 km, about 108 km on the north section has been developed and paved with asphalt. The south section is not yet paved and remains a gravel road at present. As improvement and development of road alignment has been pushed forward, from the north end, the Road Department requests that design of the section concerned be based on the Class B standard during implementation of the project.

However, the bridge width exerts more substantial effects on the work costs than the road width. Its determination must therefore be made with due consideration for current and future socioeconomic conditions.

In particular, drifts existing at present on this road and in the crossing of other rivers make passing of large vehicles such as trailers impossible, and the traffic volume is small. In the case of the Athi Bridge, many people gather when the market is opened in the town on the left bank of the bridge, so that the width composition must be established by taking into account the safety of pedestrians crossing the bridge.

4) Policy for construction situation

It was confirmed that the environmental impact analysis (EIA) normally required for new road construction in Kenya will be handled by Road Department because there are certain procedures needed in terms of environmental laws.

The standard available on road and road design in Kenya is the Road Design Manual.

Concerning the bridge design, however, this manual stipulates only that BS 5400 must be complied with. In practice, bridge construction supported by international aid is often implemented according to the donor's standard.

In this project, the Kenya road design standard will be applied and Japanese standards including the Road Structure Ordinance, etc. will be applied to items not contained in the Kenya standards.
Regarding bridge design, Japanese Specifications for Highway Bridges will be applied.
Note that the live load will be the HB30 unit of BS 5400 to ensure consistency of load conditions for design.

There is no construction machinery lease market in Kenya, but contractors there have road construction material and equipment which can be procured without a problem. However, these contractors are not experienced in bridge construction. The superstructure mostly erected in Kenya are either of a reinforced concrete or simple plate girder type. Prestressed concrete type is mostly constructed by foreign contractors. The foundation is a spread foundation in many cases and pile foundations have been constructed mostly by foreign contractors. Therefore, there is no prestressing jack for prestressing steel for prestressed concrete superstructures, pile drivers for pile foundations, and large cranes. As a result, heavy machines such as cranes 25 tons or larger are difficult to procure locally and will be shipped to Kenya from Japan or other countries.

5) Policy for utilization of local contractors

Construction of high-rising buildings and other buildings as well as roads has rapidly progressed in recent years in Kenya. But experience in the design and field for bridge construction is limited. Therefore, it is rather difficult to say that local contractors have attained sufficient technical levels for bridge construction. The only structures they can independently construct are reinforced concrete structures. When the steel bridge is selected, the only type of work that can be implemented by local contractors is erection because all manufacturing, working, and girder production cannot be implemented in Kenya. In this respect, many engineers must be dispatched from Japan.

The use of a reinforced concrete superstructure for the size of this bridge may restrict span lengths with an increased number of substructures, resulting in an uneconomical situation as a whole. Therefore, mainly the prestressed concrete bridge was considered

here because this is structurally adequate while allowing utilization of local contractors, and the bridge technology needed in the course of future development can be transferred.

6) Policy for operation and maintenance capacity of implementing agencies

In Kenya, operation and maintenance of roads are divided among separate agencies and implemented independently. Though budgets are earmarked for operation and maintenance, the road is not in a well-maintained condition because of shortage of funds. In order to ensure implementation of efficient operation and maintenance, the JICA study team is currently reviewing the system and operation and maintenance plans.

Severe fund deficiency is also encountered in bridge operation and maintenance and bridges are not in a satisfactory condition. This project also involves a review of construction, type, and materials to minimize operation and maintenance costs.

7) Policy for grade setting for facilities

Project goals are to improve two bridges that cause bottlenecks on highway B7 and determine the structures effective for grant aid by integrating the above concepts and by reviewing and comparing the following items:

- Less impact on the river after completion
- Less restrictions from natural conditions during construction work
- Due consideration on the future road plan and traffic volume
- Safety of pedestrians
- Less impact on the environment and compliance with applicable design standards
- Utilization of the capacity of local contractors
- Easy and economical operation and maintenance after completion

8) Policy for construction methods and period

Two bridges are planned in this project. Because their sites are relatively near to one another, accommodation of temporary materials and machinery are possible between them. Standardization of the type of superstructure, substructure, or foundation as much as possible will make procurement of materials and equipment easier and economical.

Such accommodation requires staggering of construction timing of the two bridges for the same type of work on each, resulting in the correspondingly longer time for completion than in cases of simultaneous construction.

The rainy season occurs twice a year at the bridge crossing point. The dry season is five months long at most from June to October. If implementation of foundation and substructure works in the river is restricted to the dry season, the work may be interrupted in the rainy season, resulting in extremely long work period and increased construction costs.

Therefore appropriate work methods selected will be that can be implemented even during the rainy seasons.

2-2-2 Basic Plan

On the basis of a review of the study, the content of the project is determined as follows.

Content of the project

- Main structures of two bridges, the Athi and Ikutha Bridges
- Approach road (for transition to the existing road) before and after two bridges and accessories to the road
- Revetment and slope protection of abutment and approach road

The scope of the project was determined according to the plan outlined as shown in figure 2-1 for the basic concept in 2-1, Design Concept.

Request for restoration of five bridges from the Government of Kenya
Eastern Province: Athi and Ikutha Bridges
Coast Province: Marere, Eshueshu and Mwache Bridges

↓

Preliminary diplomatic confirmation of content
The only Athi and Ikutha Bridges in the Eastern Province are to be covered by the Project

↓

Confirmation and negotiation on the field study
- Project content for the Athi and Ikutha Bridges
  Bridge main body, Approach road (for transition to the existing road), Revetment
- Demolishment of existing bridges to be in the scope of work by the Kenyan counterpart,
  But it may be implemented by Japanese side if it substantially hinders implementation

↓

Design review result for the basic concept
Review of the bridge site
- Possibility of bridge construction as shifted from existing road
  (width of river, road alignment)
- Possibility of new bridge being located upstream of the existing bridge
  (possibility of land acquisition)
- Demolishment of existing bridges before implementation of the project not necessary (existing bridge dose not affect the permanent work)
- Possibility of demolishment of existing bridge in view of technical capacity of the Kenyan counterpart

Existing bridge removal will be made by the Kenyan counterpart

Fig. 2-1 Project content selection flow

On the basis of the field study at the bridge site and from the comparison result shown in Table 2-1, it was decided to newly construct a bridge parallel to these two bridges.

Table 2-1 Comparison of bridge locations

	Existing location	Construction of a parallel bridge upstream of existing bridge
Demolishment of existing bridge	Necessary before construction of a new bridge	Removal may be made after completion of the new bridge
Demolished by	Included in the permanent work because its removal is closely related to setup of new bridge construction	The Kenyan counterpart can remove the existing bridge because there is not much time restrictions.
Diversion during construction	Construction including a temporary bridge and approach road is necessary.	Not necessary (the existing bridge can be used.)
Work period	Long because removal of existing bridge and temporary bridge work are included	Short because only construction of a new bridge is included.
Road alignment	Nearly linear alignment similar to the existing one	S-shaped curve provided before and after the bridge
Land acquisition	Not necessary if the land is secured at present. Only leasehold during work period	Additional land acquisition necessary in correspondence to the shift of horizontal alignment. For the Athi Bridge, relocation of few houses on both right and left banks necessary.
Economical feasibility	Temporary bridge construction cost required	Embankment cost for the approach road necessary
Overall evaluation	Inferior in terms of work period and economical feasibility	Superior in terms of work period and economical feasibility

Considering possible delays in removal of the existing bridge, it is recommended that the new bridge be located upstream where construction will be less affected by the existing bridge.

2-2-2-1 Overall plan

(1) Scope of implementation

The scope of implementation of the project includes, for both the Athi and Ikutha Bridges, the main bridge body, approach road, revetment around abutments, and road safety and drainage facilities, as shown in Table 2-2 and Fig. 2-2 and 2-3.

Table 2-2 Scope of implementation

		Athi Bridge	Ikutha Bridge
Bridge length		120 m	75 m
Approach road	Left bank	200 m	268 m
	Right bank	340 m	177 m
Revetment		Around A1 and A2 Abutments	Around A1 Abutment
Guardrail		152 m	12 m
Superstructure		Prestressed concrete 4-span connected composite girder	Prestressed concrete 3-span connected composite girder
Substructure	Abutment	Inverted-T type abutments, 2 units	Inverted-T type abutments, 2 units
	Piers	Wall type piers, 3 unit	Wall type piers, 2 units
Foundation		Spread foundation	Spread foundation

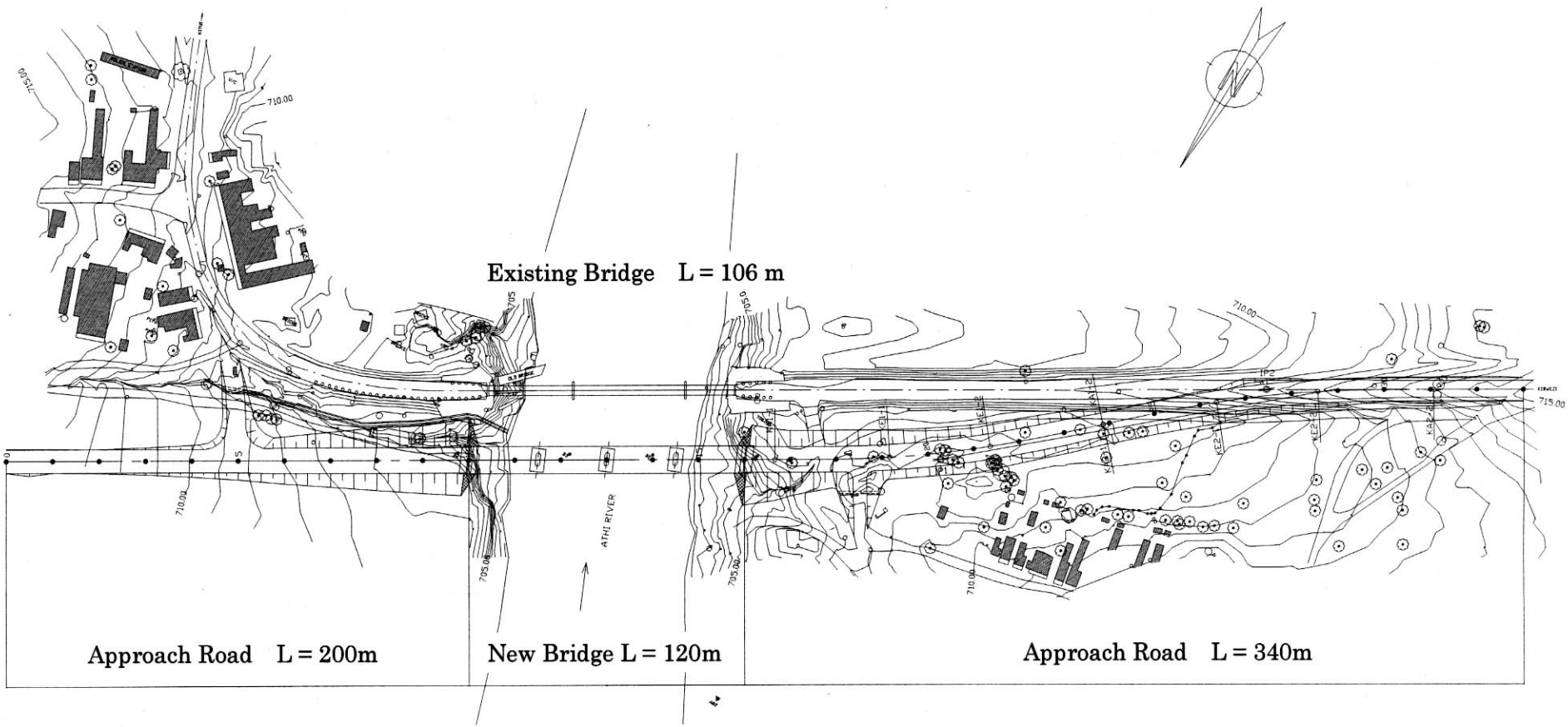


Fig. 2-2 Project Area (Athi Bridge)

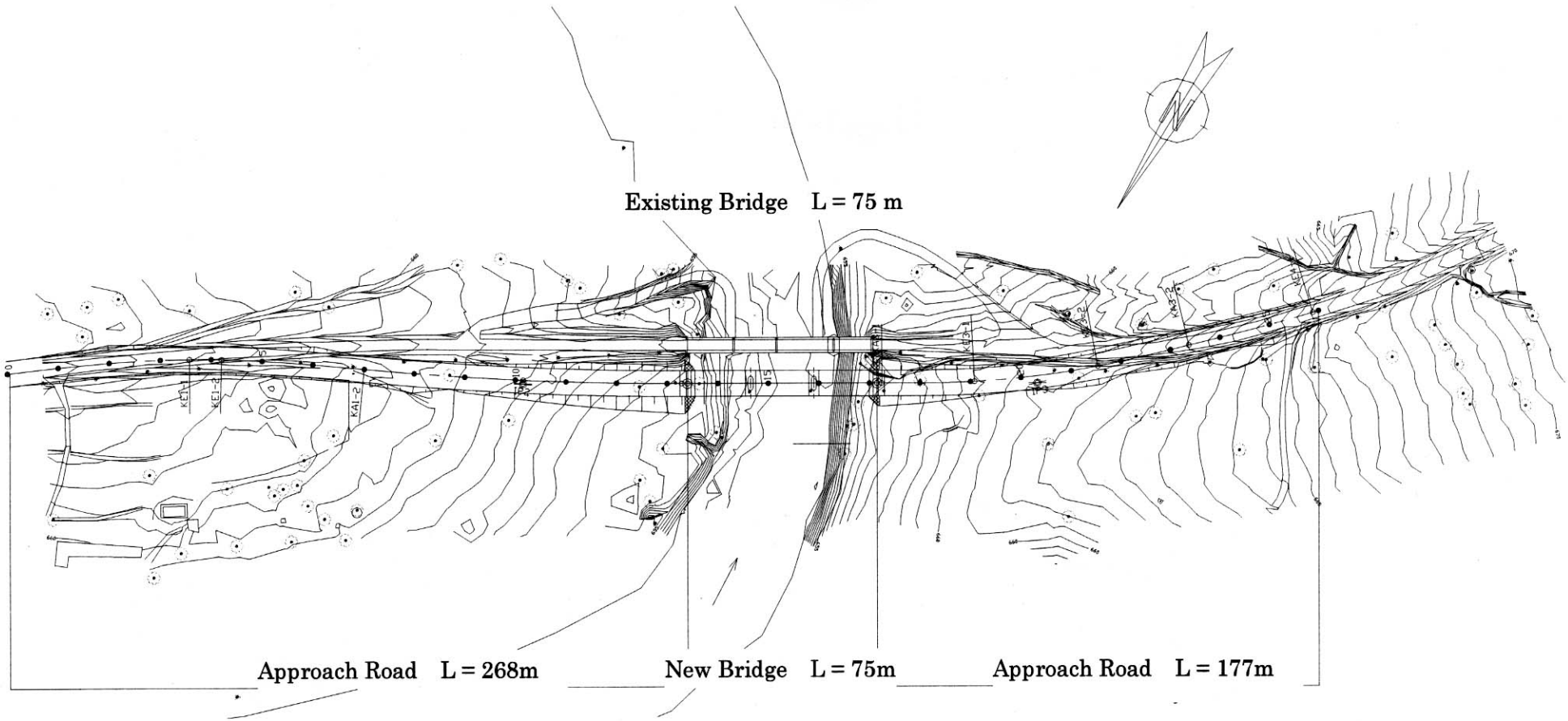


Fig. 2-3 Project Area (Ikutha Bridge)

(2) Design standards

The following three manuals are used in developing the design standards for bridges and roads in Kenya. Basically, the designs will be based on these standards.

"Road Design Manual"

- Part 1 Geometric Design of Rural Roads (January 1979)
- Part 3 Materials and Pavement Design for New Roads (August 1987)
- Part 4 Bridge Design (Revised August, 1993)

For any matters not contained in these manuals, Japanese design standards, including Parts of the Specification for Highway Bridge and Road Structure Ordinance and Cabinet Order concerning Structural Standards for River Management Facilities, will apply.

Above manuals related to design of bridges stipulate basically compliance with BS 5400 of UK, with HA and HB30 employed for the live load. Actually, however, the standards of donor are used for the design. Accordingly, design will be made according to the Japanese Specification for Highway Bridge with appropriate compensation made to the B live load of this Specification.

(3) Road structural standards

The national highway B7 along which the bridge is planned is located in a hilly section of a Class B road, so that the following standards will be applied according to the above manual:

- Road classification : Class B road (National trunk road)
- Design speed : 80 km/hr (Class B road, regional hilly section)
- Road alignment : Values listed in the table below are used for the design speed of 80 km/h used in the Road Design Manual.

Table 2-3 Road alignment standard values

Item				Description
Horizontal alignment	Minimum curve radius	Maximum super elevation 6 %		350 m
		5 %		450 m
		4 %		630 m
	Minimum curve length (intersection angle 8˚ or less)			200 m
Vertical alignment	Minimum curve radius	Crest	Grade 6%	3,500 m (2,300 m)
			Grade 3%	3,800 m (2,500 m)
		Sugg	Grade 6%	3,500 m (2,500 m)
			Grade 3%	3,100 m (2,400 m)
	Minimum curve length			160 m
	Highest gradient			5 %
Maximum superelevation of curve				10 %
Crossfall				2.5 %

Note ( ): Minimum value

(4) Road width composition

The road width is set according to standards for Class B roads.

a) Width of earth works

The width of earth works will be for two-lane roads in line with the Road B7 Improvement Project, with two carriageways @3.5m=7.0m, and shoulder 1.5m (2.0 m for the section to be provided with guardrails). (See Fig. 2-4 and 2-5)

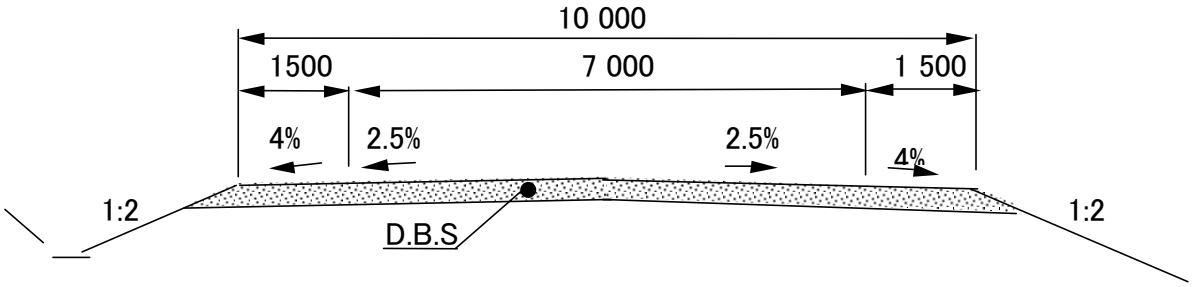


Fig. 2-4 Typical cross section of approach road

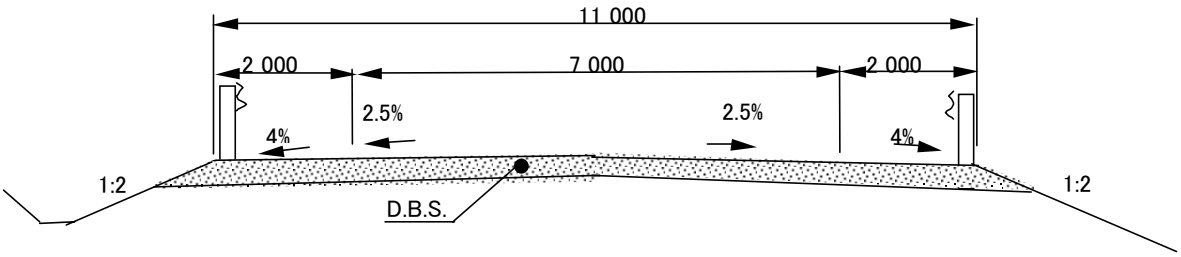


Fig. 2-5 Typical cross section with guardrail

b) Bridge width composition

The bridge width will be for a two-lane road in line with development concepts for the B7 road, with the sidewalk provided basically because of the following reasons to secure the safety of pedestrians. Sidewalks will be provided on both sides of the Athi Bridge for the large volume of pedestrians and bicycle traffic and one side of the Ikutha Bridge. The reasons of sidewalk construction are as follows;

- This is the carriageway with a design speed of 80km/h. A space is necessary for protection to ensure the safety of pedestrians during the passage of vehicles.
- The bridge has no 1.5m shoulder as provided to the earth works. The 0.5m marginal strip cannot ensure safe sheltering from the carriageway.
- Two bridges are longer than other bridges on the road B7. As an attempt to evade an oncoming vehicle is made only after its confirmation, the bridge is too narrow to take shelter.

The lane width on the bridge is 3.50m similarly to that of the earth works, with a 0.50m marginal strip provided on both sides. According to the Japanese standard, the width of sidewalk is 1.50 m, which is sufficient for pedestrians walking in both directions.
(Fig. 2-6 and 2-7 show the width of the bridge and related structures.)

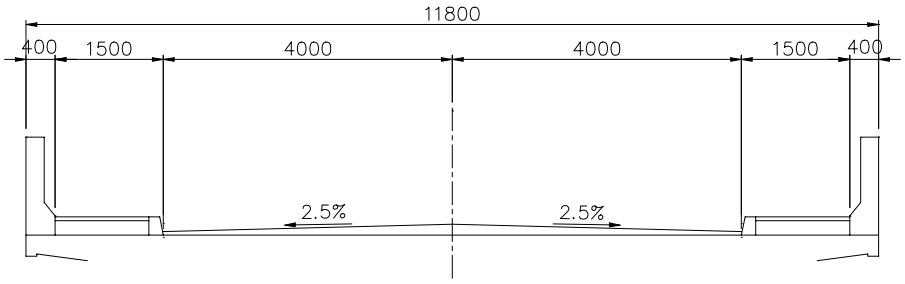


Fig. 2-6 Width composition of Athi Bridge

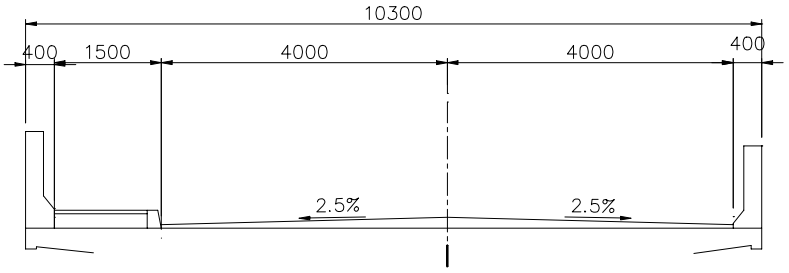


Fig. 2-7 Width composition of Ikutha Bridge

(5) Bridge load design conditions

a) Compensation of live load

The Specifications for Highway Bridges are used as the design standard for bridge of this basic design. Note that the live load is the HB30 unit stipulated in BS 5400 according to the Kenya standard. By taking into account the difference of the method used to determine material strength, the B live loads in the Specifications are multiplied so that values equivalent to HB unit values are obtained.

Fig. 2-8 and 2-9 show the live load diagram of BS HB30 and B live loads in the Specification. Fig. 2-10 and 2-11 show the comparison chart of maximum bending moment under live load that takes into account the difference in allowable design values.

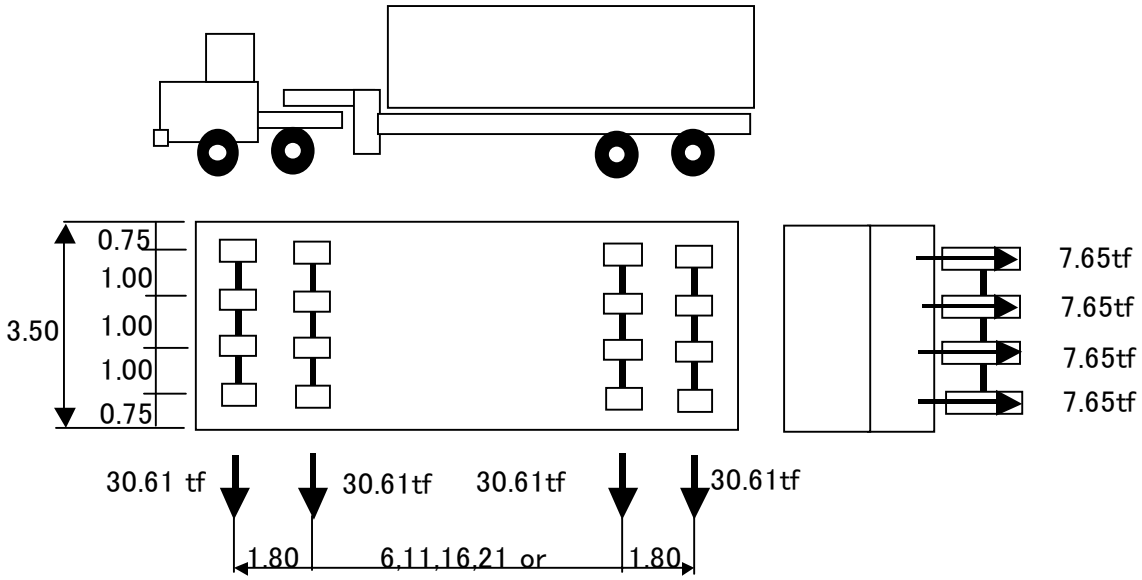
From these figures, the B live-load multiplying factor of 1.1 is used because the span length of these bridges is about 25m to 40m.

British Standard (BS 5400)

HB Loading (30 Unit)

Maximum Axle Load: 300 kN/Axle =30.61 tf/Axle

Maximum Truck Load：300 kN= 30.61 tf



HA Load (Distributed Load)

HA(UDL)= 336 x $(1/L)^{0.67}$ kN/m Lane

= 34.4 kN/m Lane = 35.11 tf/m Lane (for L=30m)

= 38.9 kN/m Lane = 39.69 tf/m Lane (for L=20m)

HA(KEL)=120.0 kN/Lane = 12.2 tf/Lane

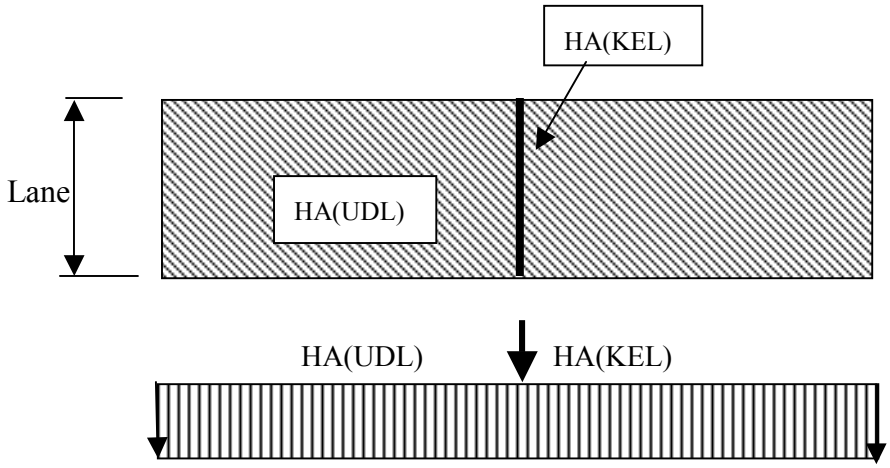
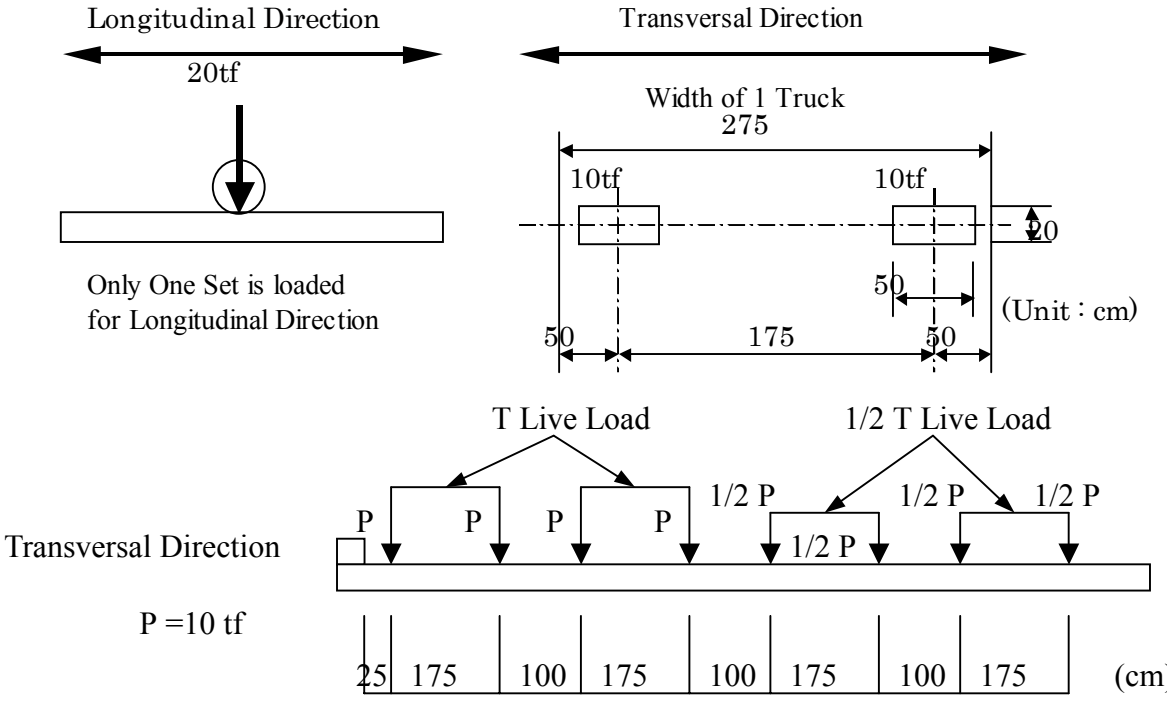


Fig. 2-8 BS HB 30 unit live load diagram

Japanese Standard

T Load T=20tf (for Transversal Design)

For 8.0m width, Total Load is 50tf



No limited Set of T Load for Transversal Direction

L Load (for Longitudinal Design)

B Live Load

UDL p1 = 1.00 tf/m^2

UDL p2 = 0.35 tf/m^2

P1 = 1.0 x 5.5 x 10 = 55 t

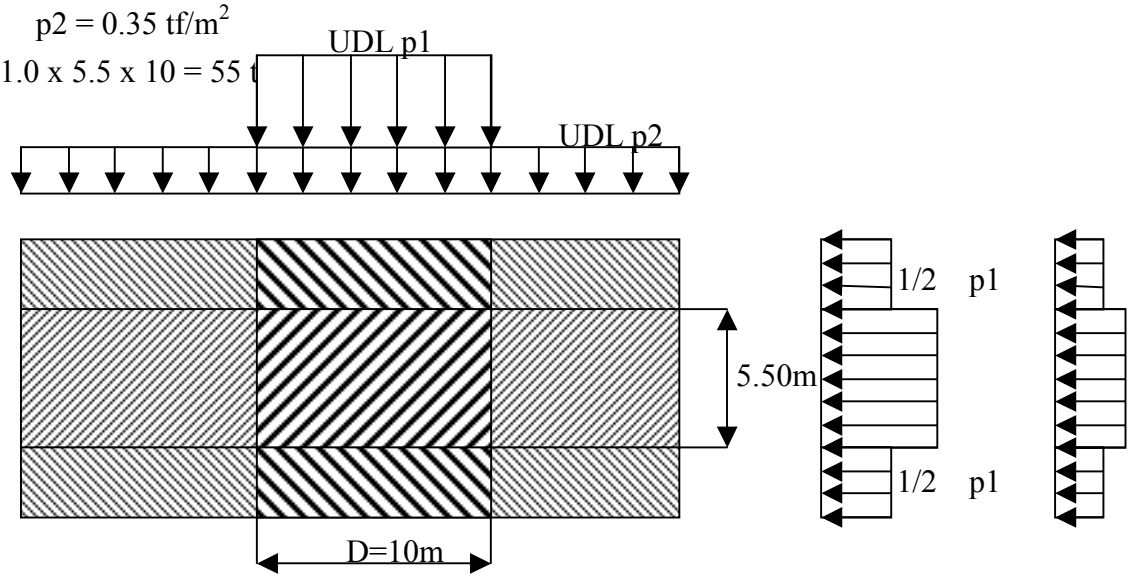


Fig. 2-9 B live load diagram in Japanese Standard

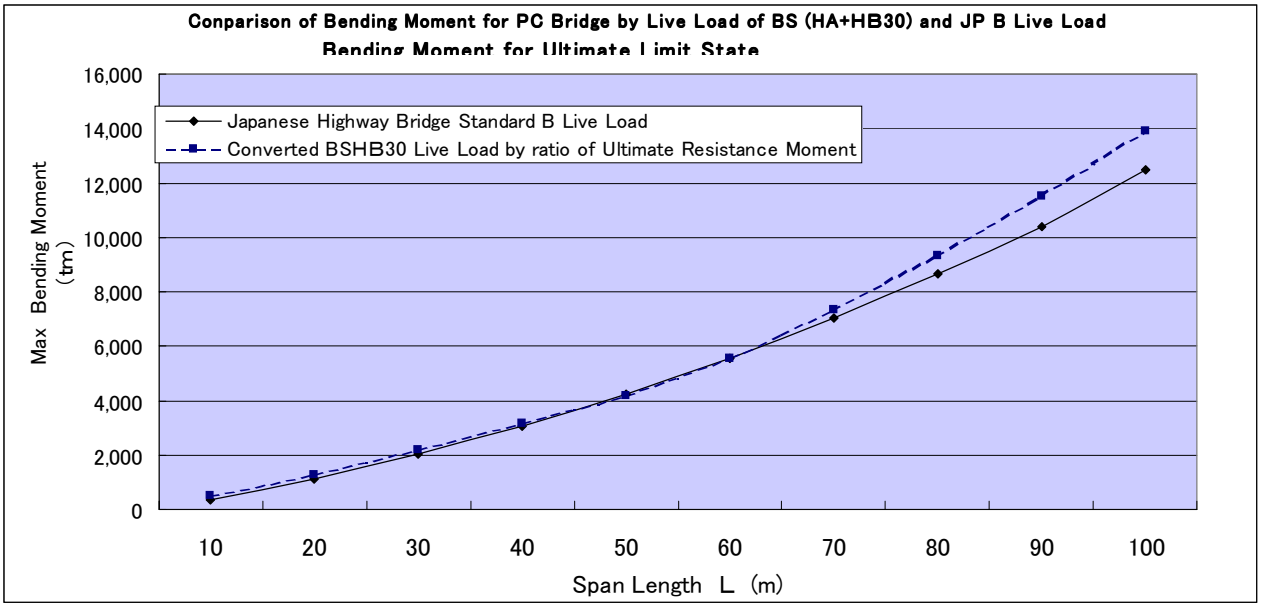


Fig. 2-10 Comparison of the maximum bending moment with live load under ultimate limit state

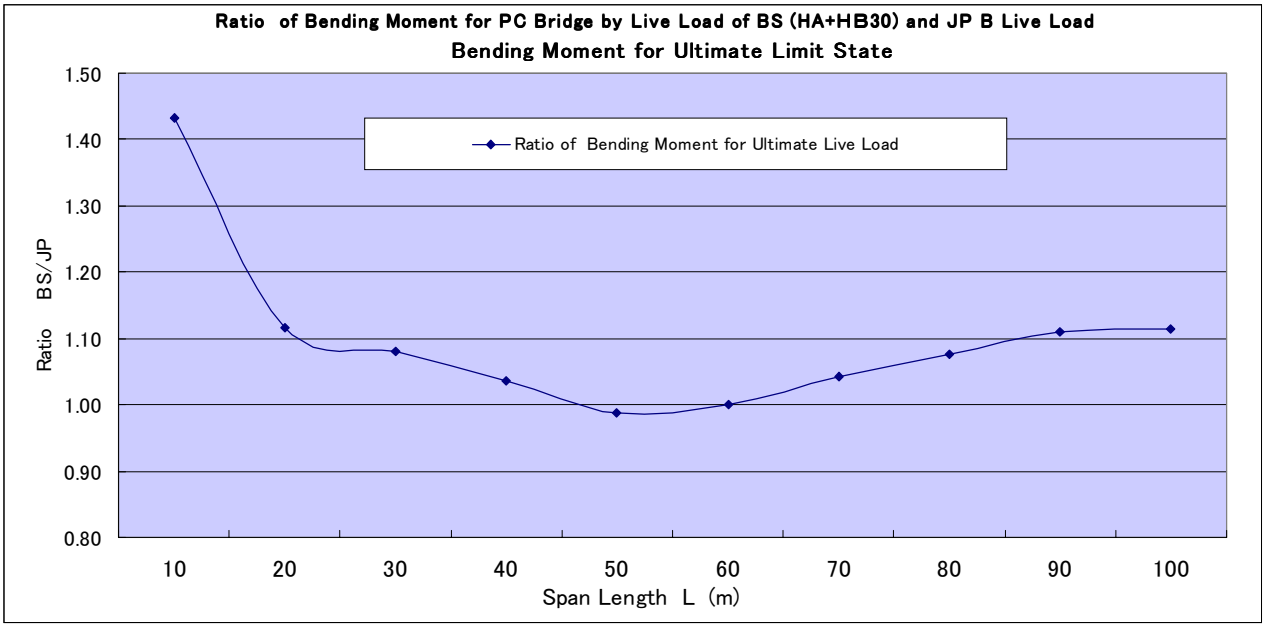


Fig. 2-11 Maximum bending moment ratio with live load under ultimate limit state

b) Load conditions

The load used for bridge design is classified into primary, secondary, and particular loads according to the loading method, loading frequency, and effects on the bridge. The features of each type of load are described below.

a. Primary load

① Dead load

Dead load is the total weight of the bridge itself and its appurtenances and calculated on the basis of unit weight shown in Table 2-4.

Table 2-4 Unit weight of materials

Material	Unit weight (kgf/m^3)	Material	Unit weight (kgf/m^3)
Iron, steel casting	7,850	Plain concrete	2,350
Cast iron	7,250	Cement mortar	2,150
Aluminum	2,800	Asphalt concrete	2,300
Reinforced concrete	2,500	Wood	800
Prestressed concrete	2,500		

② Live load : As described previously, the B live load of the Specifications for Highway Bridges is multiplied to obtain the load equivalent to HB30 of BS.
The multiplying factor is 1.1.

③ Impact

④ Prestressing force

⑤ Effects of concrete creep

⑥ Drying shrinkage of concrete

⑦ Earth pressure

⑧ Water pressure, dynamic water pressure

⑨ Buoyancy or uplift

b. Secondary load

This is the load that should always be taken into account when loads are to be combined.

① Wind load

Considering the topographical features, the wind load in accordance with the Japanese standard is applied to the superstructure.

② Effects of temperature change (according to temperature fluctuation in Kenya)

Concrete: 15 degree to 40 degree

③ Seismic effects

In the design standards of Kenya, bridge sites are classified as being in an area with the least earthquake frequency. As weak felt earthquakes occurred even during the in-situ survey period, the lateral seismic factor relative to the tare is set at 5%.

c. Particular load

Particular load is the load that should be specifically taken into account depending on the bridge type, structural type, and bridge site conditions, including loads during construction, etc.

c) Load factor for allowable stress depending on the load combination

The load factor for allowable stress depending on the load combination is as shown in Table 2-5.

Table 2-5 Load factor for allowable stress depending on the load combination

Load combination	Load factor
Primary load	1.0
Primary load + temperature change	1.15
Primary load + braking load	1.25
Primary load + seismic effects	1.5
Primary load + collision load	1.5
Load during construction	1.5

(6) Superstructure design conditions

① Bridge type : Principally a concrete bridge that is superior in operation and maintenance

② Width : See Fig. 2-6, 2-7

③ Live load : B live load × 1.1 (multiplication used to determine the load equivalent to BS 5400 HB30 unit)

④ Cross-fall : 2.5%

⑤ Bridge pavement ：Grade compensation with concrete only

⑥ Appurtenances ：Piping duct（sidewalk、PVCφ100mm x 3 conduits）

(7) Substructure design conditions

① Substructure type (For the history of review, refer to 2-2-2-2 Facilities Plan.)

Abutment : Inverted-T abutment

Piers :Wall type

Embedment :For stratums of these two bridges sites, the sand layer that consists of river sediments is observed with the thickness of 4 to 10 m on the bearing stratum or rock mass. Since piers are susceptible to scouring in the river, the footing top end of piers is to be embedded to a minimum depth of 2 m.

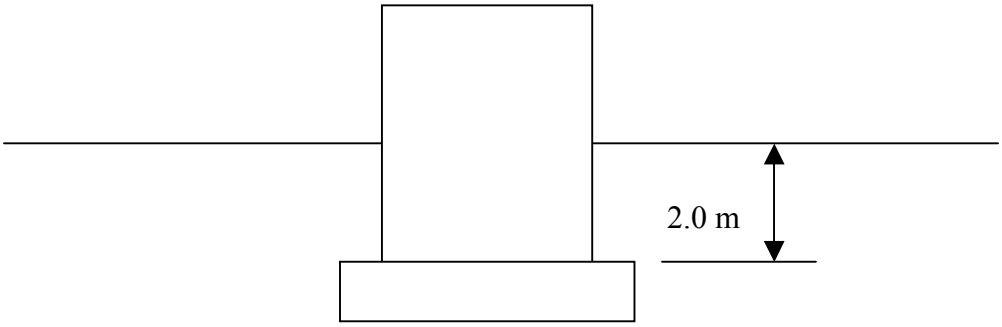


Fig. 2-12 Embedding of footing top end

② Foundation structures

According to the boring survey result, a sand layer with an N value less than 30 or a gravel layer of river sediments is observed at a depth of about 5 to 9 m below the riverbed. The bearing stratum is the rock mass below the sand or gravel layer. The foundation is therefore a spread foundation. The construction method was selected according to the ground condition, acting forces, and material/equipment procurement conditions.

Table 2-6 List of bearing stratum (rock mass) depths for the Athi Bridge

Bor.No.	Boring position	Ground height (m) M.S.L	Rock appearance depth (m)		Rock (not weathered) appearance depth (m)	
			Depth	G.L	Depth	G.L
BH-1	Upstream right bank abutment	706.18	-1.30	704.88	-3.90	702.28
BH-2	Upstream right bank piers	701.48	-5.70	697.58	-6.50	694.98
BH-3	Upstream left bank piers	701.82	-9.55	692.27	-9.55	692.27
BH-4	Upstream left bank abutment	706.02	-4.00	702.02	-5.65	700.37

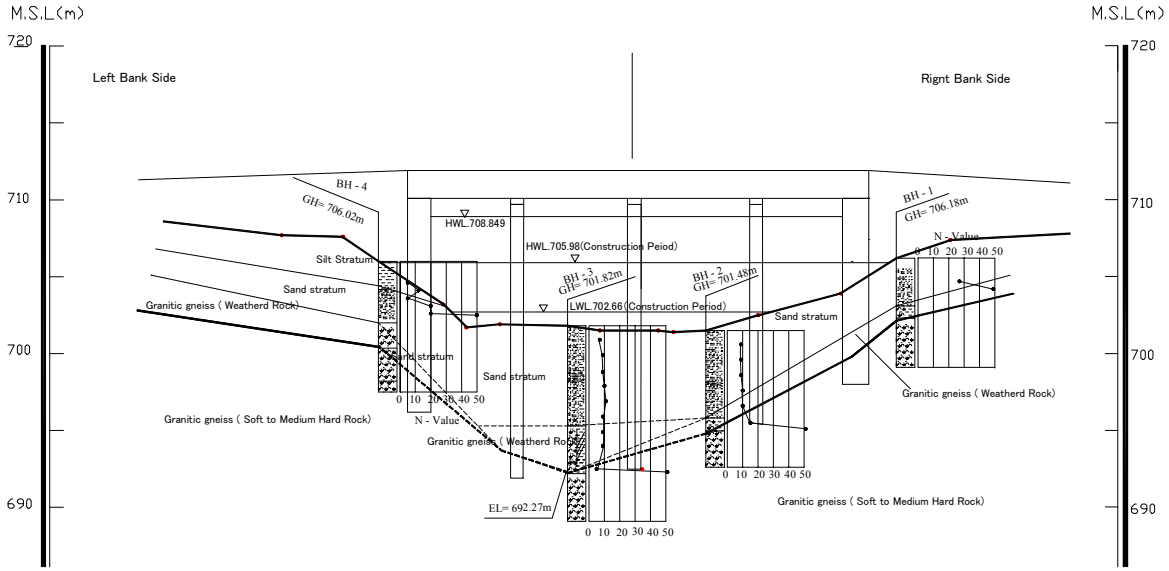


Fig. 2-13 Geological vertical profile at Athi Bridge

Table 2-7 List of bearing stratum (rock mass) depths for the Ikutha Bridge

Bor.No.	Boring position	Ground height (m) M.S.L	Rock appearance depth (m)		Rock (not weathered) appearance depth (m)	
			Depth	G.L	Depth	G.L
BH-1	Upstream right bank abutment	657.66	-2.00	655.66	-4.45	653.21
BH-2	Upstream right bank piers	651.11	-3.00	648.11	-3.95	647.16
BH-3	Downstream left bank piers	651.93	-4.20	647.73	-5.40	646.53
BH-4	Downstream left bank abutment	655.92	-5.40	650.52	-7.85	648.07

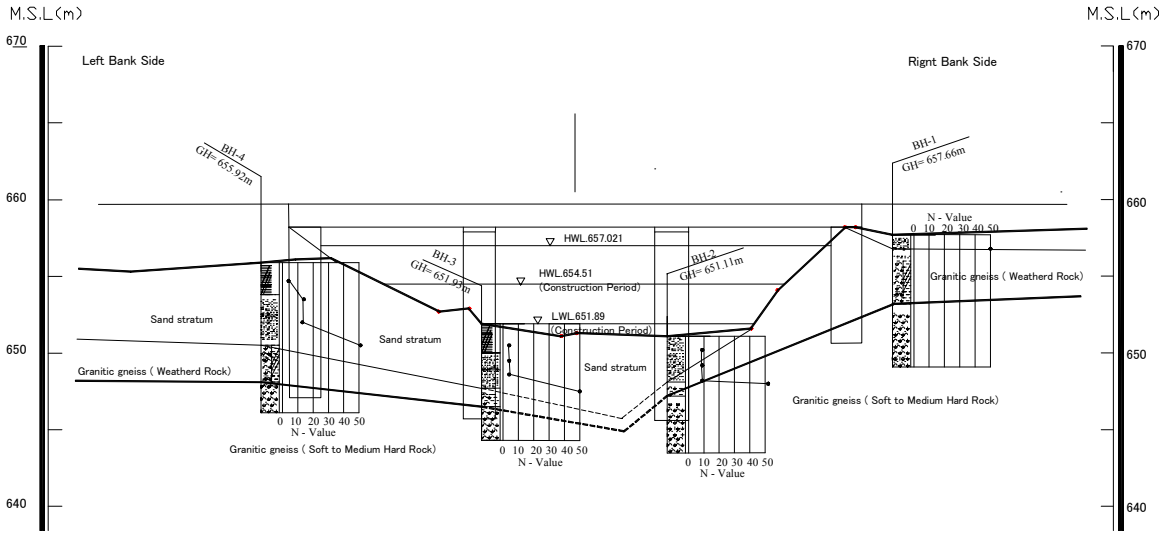


Fig. 2-14 Geological vertical profile at Ikutha Bridge

(8) River conditions

Considering the hydraulic data for bridge design and the river condition at the bridge site in Kenya, the design specifications concerning rivers comply basically with Kenyan standards. If no specifications are available, the design conditions are set in compliance with Japanese Cabinet Order Concerning Structural Standards for River Management Facilities (Japanese River Association). Design conditions deemed necessary for river flood control due to construction of the new bridge are described below.

① Design high water level and flood discharge

The design high water level of the river at which the bridge is located was set as shown in Table 2-8. Fifty-year probabilities were established after review and analysis of meteorological and river data at the bridge site and observation points as well as information collected through hearings at the site. The water level during construction was set as shown in Table 2-9 after similar review and analysis.

Table 2-8 Design high water level, flood discharge, and flow

	Athi Bridge	Ikutha Bridge
Design high water level (m)	708.849	657.021
Flood discharge (m^3/s)	2,900	1,200
Flood velocity (m/s)	3.7	4.1

Table 2-9 High water level, flood discharge, and flow during construction

	Athi Bridge		Ikutha Bridge	
	Wet season	Dry season	Wet season	Dry season
Design high water level (m)	706.0	702.7	654.5	651.9
Flood discharge (m^3/s)	1,080	65	440	25
Flood velocity (m/s)	2.4	0.8	3.3	1.2

Fig. 2-15 shows the flow to set the design high water level.

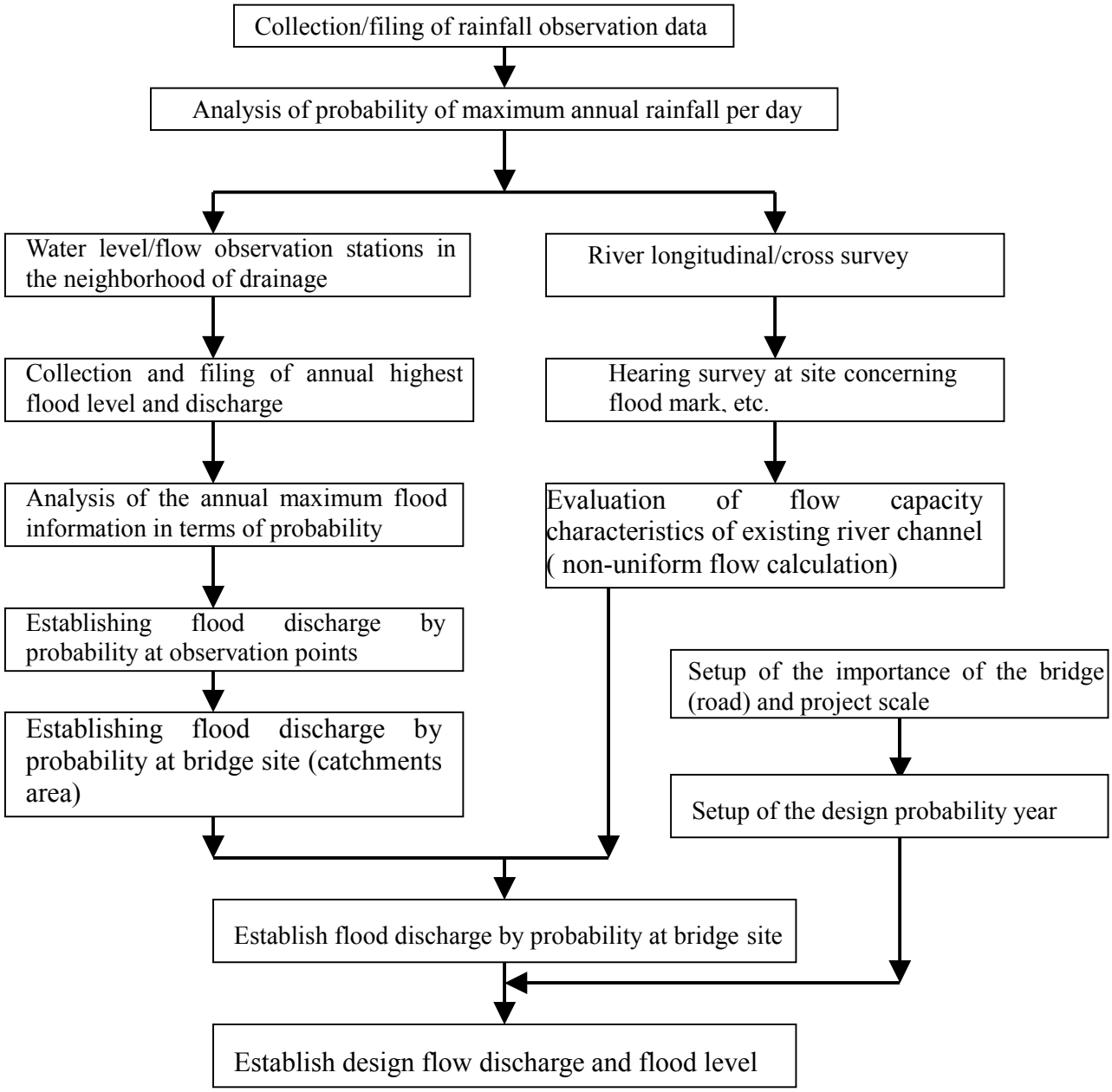


Fig. 2-15 Design high water level setup flow

② Clearance under girder

At the Athi Bridge, the highest water level during flooding in 1998 was about 709.9 m near the bridge, which is nearly equivalent to the existing road height. The reinforced concrete girder of the old bridge was directly damaged by flowing water. In the case of the Ikutha Bridge, the highest water level was assumed to reach during flooding in 1961, which was estimated to be 656.5 m below haunch of piers.

According to the Kenyan standard, the design manual specifies a clearance appropriate to the river flow while taking into account the river condition and trees. The bridge design will use values shown in the table below for the above design high water level.

Table 2-10 Clearance for the design

Name of bridge	Discharge flow (m3/sec)	Clearance under girder (m)
Athi Bridge	Approx. 2,900	1.20
Ikutha Bridge	Approx. 1,200	1.20

③ River cross-section hindering ratio

The Athi River has an almost linear flow direction and the river width is about 120 – 140 m near the bridge site. At the existing bridge position, however, the abutment is located forward, so that the width is as narrow as about 100 m. Therefore, the flow was faster around the bridge site during flooding, causing abnormal scouring of riverbed, which is considered to be one of the reasons for the wash-out of the pier. The Tiva River where the Ikutha Bridge is located meanders with a fan-shaped and an angle of about 180 degrees before and after the bridge site, with the flow direction changed suddenly, so that the river width is narrowest at the existing bridge.

When the river cross-section is hindered substantially, the water level may rise substantially during flooding. There is a concern that adverse effects may be inflicted on the area around the bridge when the river cross-section is hindered substantially, so that a hindering ratio of 5% as specified in the Cabinet Order Concerning Structural Standards for River Management Facilities will be applied to the bridge plan.

(9) Pavement design standard

In accordance with the design manual of Kenya, asphalt concrete pavement was selected on the basis of an in-situ CBR test and material test results. The present state of

roads before and after the bridge is gravel and procurement of asphalt material is difficult. Accordingly, the pavement level in this project will be up to the base course, over which DBS pavement with asphalt emulsion will be placed. Fig. 2-16 shows the pavement composition of the road.

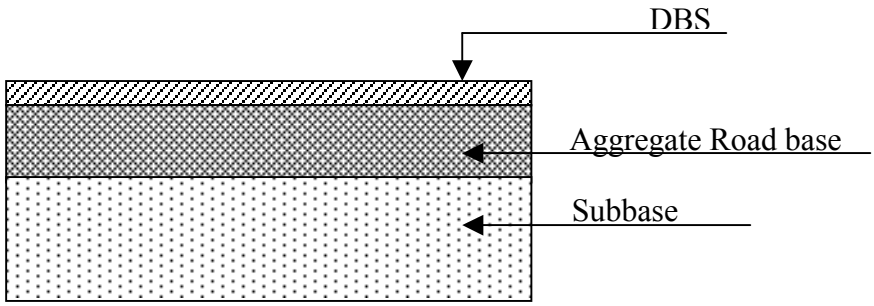


Fig. 2-16 Approach road pavement composition

(10) Traffic signs and safety facilities

Traffic signs and safety facilities are provided according to Kenyan standards.

(11) Materials used and basic strength

a) Concrete

Concrete to be used will be ready mixed concrete. The design standard strength is according to values shown below that has been determined from a strength test with cylindrical test pieces.

Since the strength test is conducted with square test pieces, the strength value thus obtained becomes about 15% higher than that obtained with a cylindrical test piece. Accordingly, the strength test method is described clearly in the design drawing and technical specifications.

- Design standard strength (With cylindrical test piece, 28-day strength)

Prestressed concrete main girder	:σ ck= 40 N/mm^2
Prestressed concrete slab and cross beam	:σck= 30 N/mm^2
Prestressed concrete plate (precast)	:σck= 50 N/mm^2
Reinforced concrete structures (piers and abutment)	:σck= 24 N/mm^2
Reinforced concrete piles	:σck= 30 N/mm^2

b) Prestressing steels

Prestressing steels are not produced in Kenya and thus imported from Japan or a third country.

Prestressing strand	Basically 12S-12.7 mm
Tensile strength	1,850 N/mm^2
Yield strength	1,600 N/mm^2

c) Reinforced bar

Though not produced in Kenya, rebar available in the domestic market, will be used. The product standard is stipulated according to BS, and values shown below are used according to the BS standard:

Standard	BS 4449 Type II Grade 460
Yield strength	460 N/mm^2

2-2-2-2 Facility plan

(1) Road plan

a) Bridge location

Considering local situations, both bridges are constructed on the upstream side of parallel existing bridges. The distance to existing bridges is 30 m in the case of the Athi Bridge and 15 m in the case of the Ikutha Bridge for the following reasons.

Table 2-11 Reasons for selecting the Athi Bridge position

	Reasons for selecting the Athi Bridge position
Upstream side	- Remains of a washed-out old bridge are at downstream of the existing bridge. - A large number of houses on the left bank are close to the downstream of the existing road. On the right bank houses are on the upstream side. However, they are away from the existing road and not so much affected by construction of the bridge. - The existing road on the left bank enters the town after curving with a small radius immediately after the bridge. When the new bridge is planned on the downstream side, transition of the approach road to this existing road cannot be made.
Distance from the existing road (30m)	- There is a small valley on the upstream side of the existing abutment on the left bank, which acts as a drainage channel during rainfall. The drainage channel should therefore be secured between new and old abutments. - The existing abutment and embankment slopes do not present hindrance to construction of the new bridge. - The existing bridge may be removed after completion of the new bridge. - Relocation of houses on both banks may be minimum required.

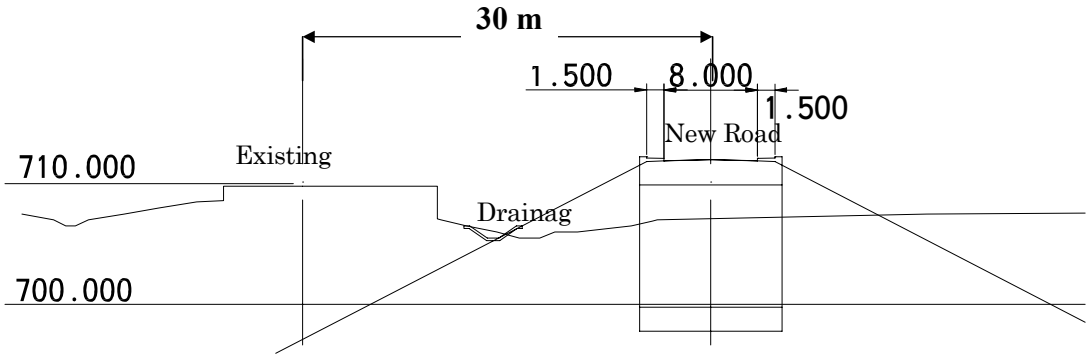


Fig. 2-17 New Athi Bridge location (Left bank)

Table 2-12 Reasons for selecting the Ikutha Bridge position

	Reasons for selecting the Ikutha Bridge position
Upstream side	- There is an approach way into the river area on the downstream side on both banks. - The approach way is gently curved toward the downstream side. The curve can be more gentle if the bridge is constructed on the upstream side. - According to the topographical condition, the abutment position on the left bank may be brought nearer to the river area if the bridge is constructed on the upstream side.
Distance from existing road (15m)	- Existing abutment and embankment slope do not present hindrance to construction of the new bridge. - Existing bridge may be removed after completion of the new bridge.

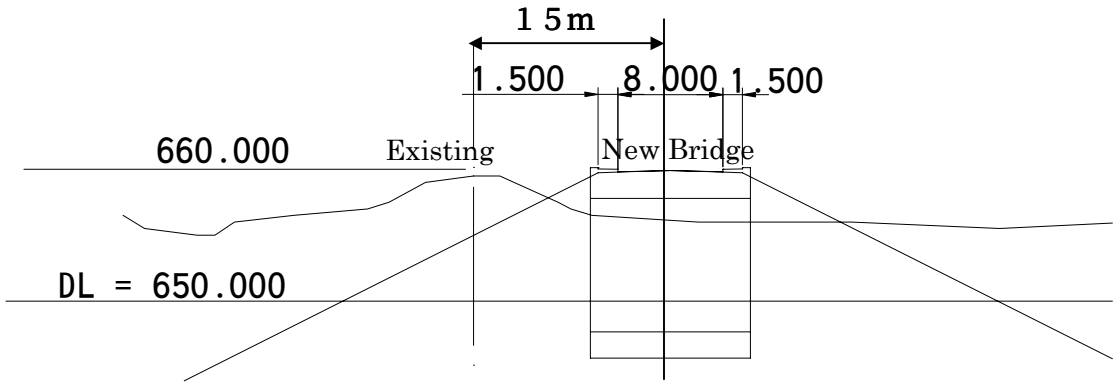


Fig. 2-18 New Ikutha Bridge location

b) Road alignment

[Athi Bridge]

Horizontal alignment is shifted by 30 m parallel to the existing road at the bridge. On the right bank, clothoid and circular curves are combined for transition by means of 340 m approach road.

On the left bank, the new road of about 3 km will be provided because of the following reasons. In this project, the horizontal alignment after bridge is set linear and the vertical alignment is constructed to the existing ground.

- The existing road is bent almost at a right angle, drawing a curve with a radius of about 70 m, after the bridge. With the horizontal alignment value specified for the design speed of 80 km/h, transition to the existing road cannot be made.

- The existing road beyond this point has a poor alignment, and forced transition within the short section may result in an overall poor alignment.
- There is a local road on the backside of the bridge. A road complying with the design standard can be planned by extending it along the local road.

The vertical alignment becomes 4 to 5 m higher than the ground height before and after the bridge when the design high water level and clearance as well as the bridge structural height is secured. To prevent an increase in the embankment height, a convex vertical curve is provided to the bridge section. On its backside, concave curves are provided consecutively for transition to the existing road.

[Ikutha bridge]

The horizontal alignment is shifted by 15 m parallel to the existing road at the bridge. On both banks, clothoid and circular curves are combined to achieve transition to the existing road by means of an approach road 280 m long on the left bank and 200 m long on the right bank.

The planned road height determined from the design high water level is approximately similar to the existing road height. If the road height on the bridge is extended directly to the backside, the embankment height does not increase. Therefore, it was decided to set the road on the bridge approximately linear, with the vertical curve provided in sections before and after the bridge for transition to the existing road.

(2) Bridge plan

a) Determination of the bridge length

The bridge length was determined on the basis of the following concepts according to the site topography and river condition.

[Athi Bridge]

① River condition

- The length of existing Bailey bridge is about 108 m, with the distance between abutment front sides being about 102 m.
- The existing abutment is projecting forward when compared with upstream and downstream river widths, considerably hindering the cross section of river during flood.
- The bank elevation for a distance of 200 m on the upstream and downstream sides

ranges from about 708 to 709 m, and the river width is about 140 m. The slope grade of bank becomes gentle at an elevation around 707 m, and the river width at this elevation is about 120 m.

② The position at an elevation of 707 m where the bank slope grade becomes gentle is assumed to be the river shoulder. The river section is determined at this position.

③ The line connecting the river shoulder positions at about 200 m and 100 m on the upstream side and about 100 m on the downstream side of the existing bridge is assumed to be the river width.

④ The abutment is positioned at the intersection between this line and the center line of new bridge.

⑤ As a result, the distance of the bridge abutment front is about 118 m, so that the bridge length becomes about 120 m when the shoe width is taken into account.

[Ikutha Bridge]

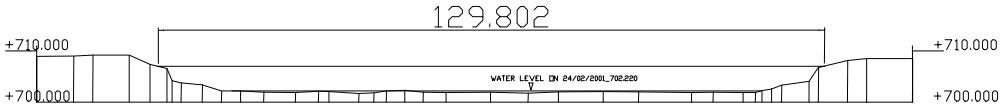
① River condition

- The length of the existing Bailey bridge is about 73.2 m. The distance between abutment front sides is about 71 m.
- The flow of Tiva River bends considerably to the left, forming a U shape. Sedimentation occurs on the left bank while scouring occurs on the right bank. The left bank has a gentle appearance with sand sedimentation while the right bank has a precipitous appearance with exposed rocks.
- The flood level near the bridge is about 657 m, which is approximately equal to the height of right bank shoulder.

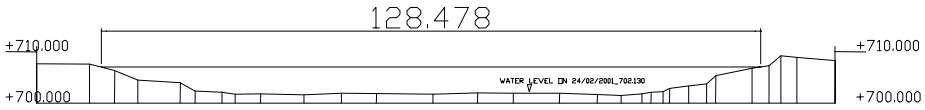
② The left bank with sedimentation is matched approximately to the existing bridge position. On the left bank, the river width is determined at the design flood level position.

③ On the left bank, the position is determined in such a manner that excavation during construction of abutment will not adversely affect the rock slope in front of the abutment.

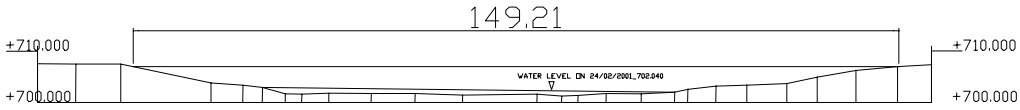
④ The distance between abutment fronts is consequently about 73 m and the bridge length is about 75 m when the shoe width is taken account.



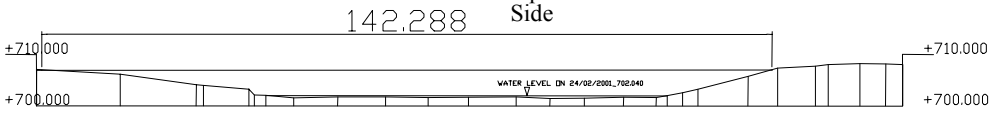
209.845m Up Stream Side



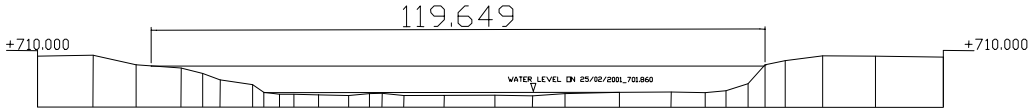
111.184m Up Stream Side



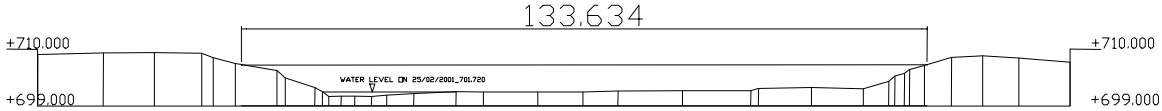
35.517m Up Stream Side



15.437m Up Stream Side



114.851m Down Stream Side



208.042m Down Stream Side

Fig. 2-19 Sections of Athi River near the bridge

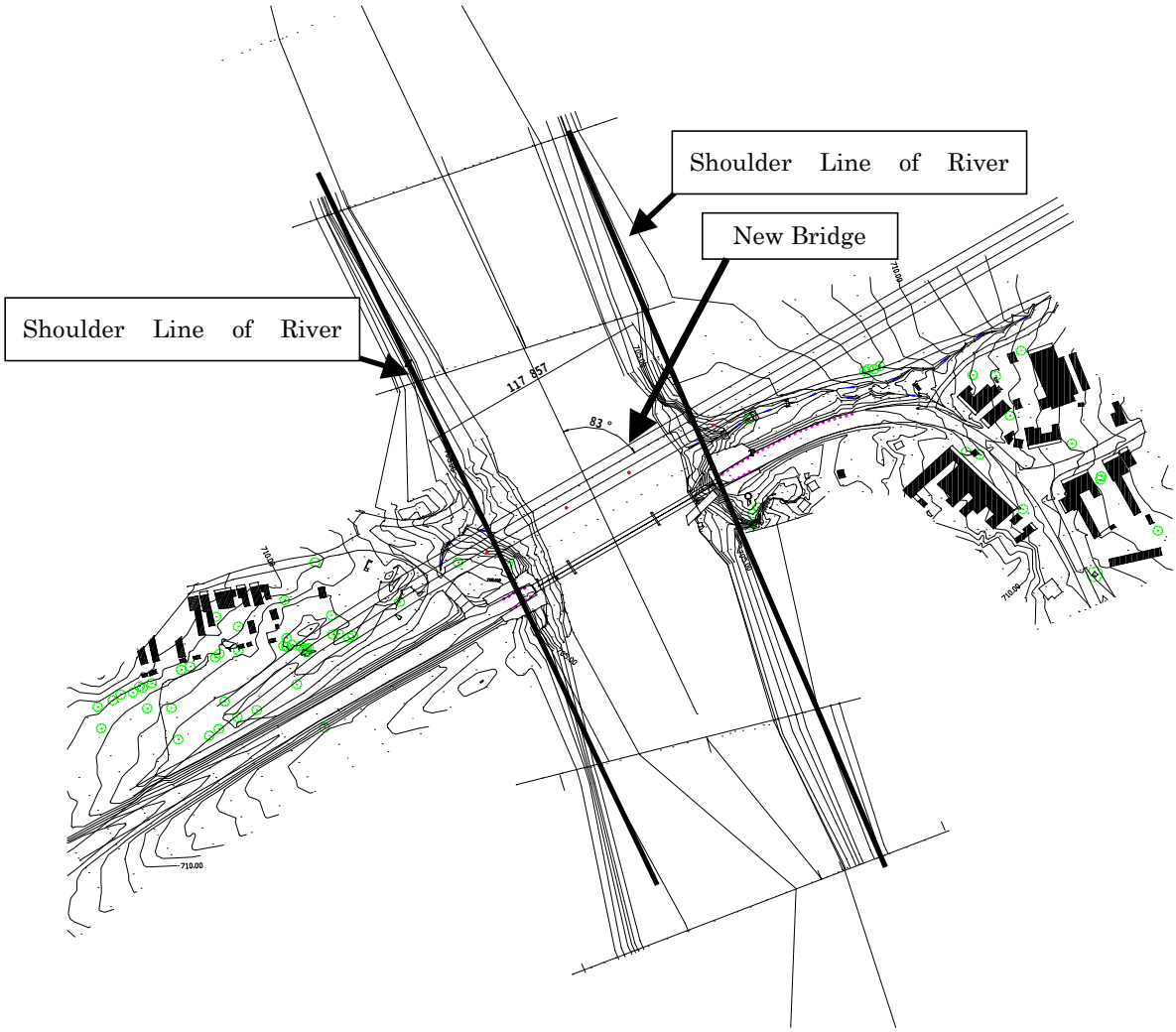


Fig. 2-20 River bank line positions at the Athi Bridge site

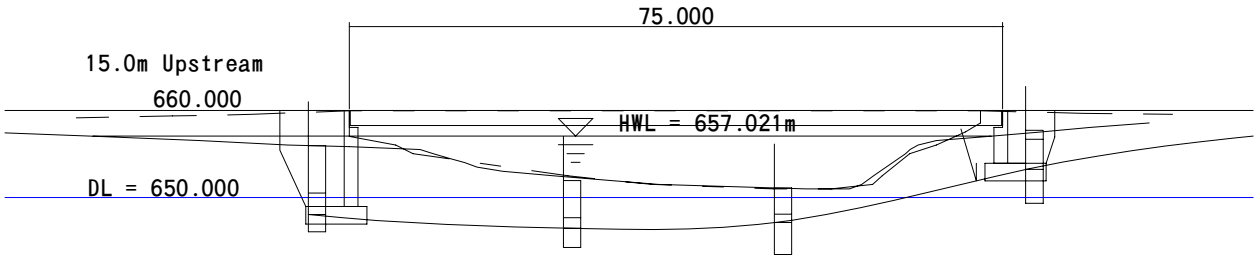


Fig. 2-21 Sections of River around the Ikutha Bridge

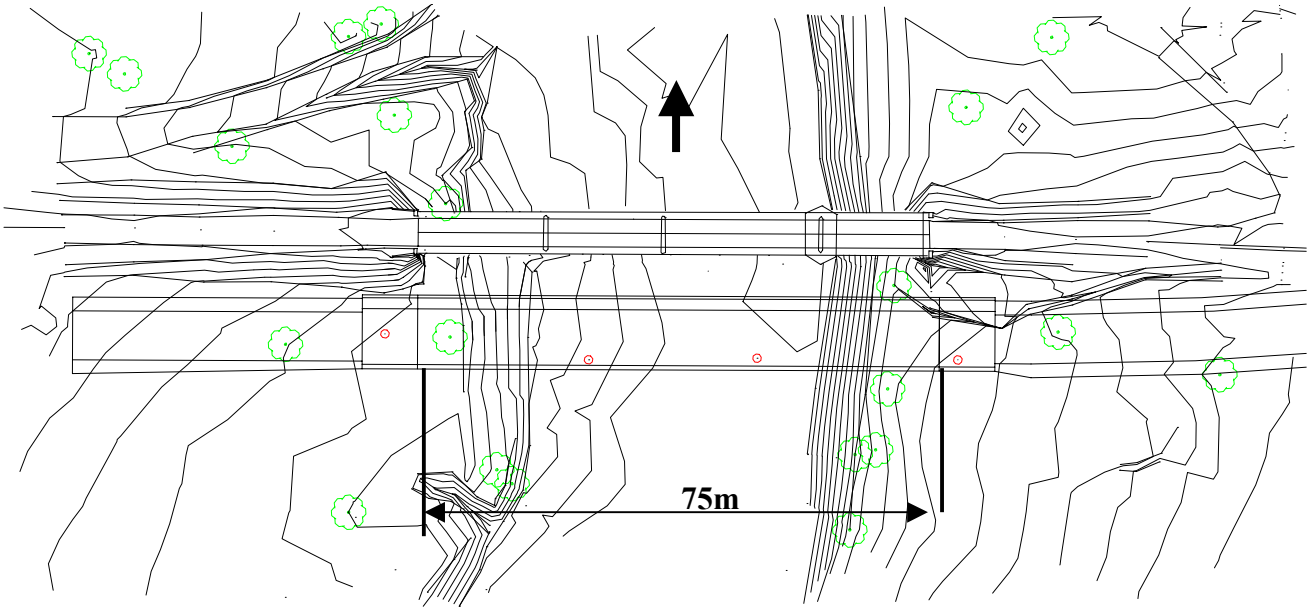


Fig. 2-22 River bank condition around the Ikutha Bridge site

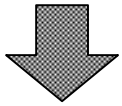
b) Type of the superstructure

① Selection of basic bridge type of superstructure

The basic bridge type of superstructure in this project will be determined by the following factors:

- Availability of construction materials and machinery
- Economy including substructure and foundation work cost and constructibility
- Type allowing inexpensive and easy operation and maintenance
- Application record and technology transfer in Kenya

Maximum span length to be used as a reference for comparison is about 40 m
Steel bridge to be manufactured outside Kenya



Prestressed concrete structure is considered appropriate.
Operation and maintenance is easier with the concrete bridge than with the steel bridge.

②Review of the type of superstructure

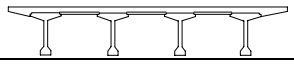
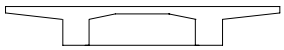
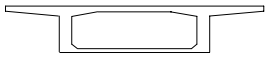
The bridge length is 120 m for the Athi Bridge and 75 m for the Ikutha Bridge. The maximum span length may range from 25 to 40 m as shown in the table below for each span arrangement.

Table 2-13 No. and length of spans

	Bridge length	Two spans	Three spans	Four spans	Five spans
Athi Bridge	120m	－	40.0m	30.0m	24.0m
Ikutha Bridge	75m	37.5m	25.0m	－	－

Types of Prestressed concrete superstructure appropriate to these span lengths is shown in Table 2-14.

Table 2-14 Span length and superstructure type

Main girder type	Main girder section	Applicable span	Girder height / Span
Prestressed concrete T-girder bridge		20～40m	1/16
Prestressed concrete composite girder bridge		20～40m	1/15
Prestressed concrete hollow slab bridge		20～40m	1/22
Prestressed concrete main slab girder bridge		20～40m	1/17
Prestressed concrete box girder bridge		30～60m	1/20

Both the Athi and Ikutha Bridges are to be constructed within the river. There are two rainy seasons a year, and the meteorological and river conditions at the bridge site must be taken into account. Considering the overall work period, therefore, the method not susceptible to effects of rainy seasons is recommended at least for the superstructure. Namely, the full falsework cannot be erected inside the river, so that the method shown in the table below may be considered for the superstructure.

Table 2-15 Erection method and superstructure type

Erection method	Compatible superstructure type	Economy
Special falsework using H-steel and truss girder	Prestressed concrete hollow slab Prestressed concrete main slab girder Prestressed concrete box girder bridge	○
Movable form carrier	Prestressed concrete hollow slab Prestressed concrete main slab girder Prestressed concrete box girder bridge	×
Cantilever, incremental launching	Prestressed box girder bridge	×
Erection by erection girder	Prestressed concrete T-girder bridge Prestressed concrete composite girder bridge	◎
Erection with truck crane together with bent	Steel I-girder bridge	○

Note; ◎: Very good, ○: Good, ×: Bad

For comparison in terms of economy when selecting bridge type, total work cost including not only the superstructure, but also substructure and foundation work must be taken into account. In particular, the foundation construction method is vital for these

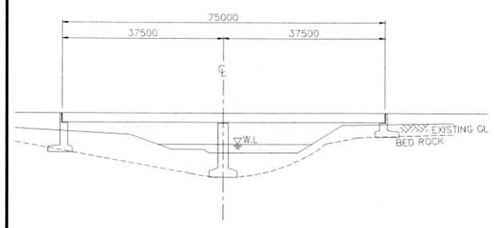
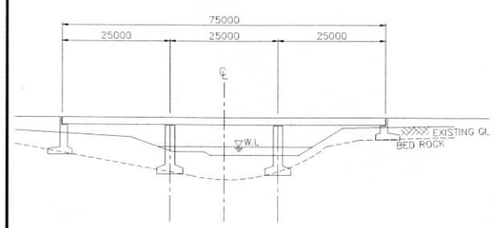
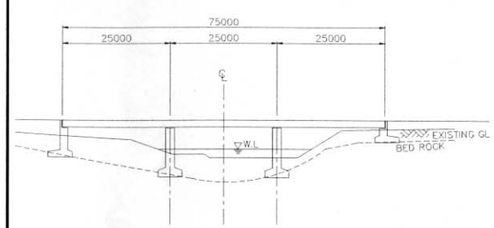
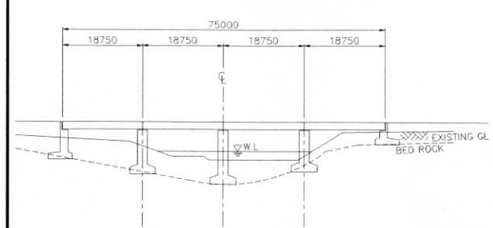
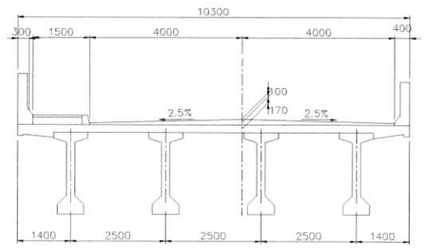
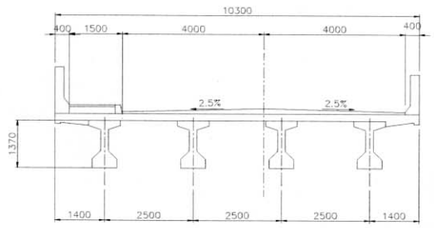
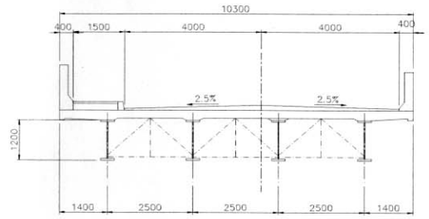
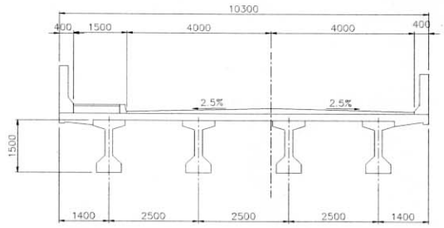
bridges because of river and geological conditions. The number of spans and superstructure type may have to vary depending on the foundation construction cost.

In this project, the superstructure type will be selected for each number of spans, after selection of the spread foundation, in view of constructibility, economy and safety. As shown in Tables 2-16 and 2-17, these are evaluated from a comprehensive point of view, and the superstructure types listed below were selected for each bridge:

- Athi Bridge： Four-span Prestressed concrete connected composite girder bridge
  (4 @ 30.0m = 120.0m)
- Ikutha Bridge： Three-span Prestressed concrete connected composite girder bridge
  (3 @ 25.0m = 75.0m)

Table 2-16 Bridge type comparison table for Athi Bridge

Table 2-17 Bridge type comparison table for Ikutha Bridge

Bridge type	Plan 1 Prestressed concrete two-span connected composite girder bridge	Plan 2 Prestressed concrete three-span connected composite girder bridge	Plan 3 Steel three-span continuous non-composite girder bridge	Plan 4 Reinforced concrete four-span connected composite girder bridge
Side view				
Cross Section				
Structural outline	・Prestressed concrete two-span connected composite girder bridge with piers on spread foundation provided in middle. ・Approximate maximum span length for continuous precast girders ・At middle support, girder is RC structure against secondary dead load and live load. Large tensile stress is caused by these loads on upper side of slab at middle support. Many RC bars required at this point and it is very hard to place them. Crack comes on upper side. ・Span length exceed a substantial limit span length (35m) for durability against cracking. (Span length is limited in the design manual of Japan Highway Corporation) ・Girder height is 2.2m, about 1/16 of span length ・The river cross-area hindrance ratio is the lowest at about 2.7% of four plans.	・Prestressed concrete three-span connected composite girder bridge with two piers on spread foundation. ・Standard span length for continuous precast girders ・Girder height is 1.4m, about 1/16 of span length. ・The river cross-area hindrance ratio is about 5.3%, higher than that of Plan 1.	・Steel three-span continuous non-composite girder bridge with two piers on spread foundation ・Approximately the minimum span length for continuous steel I beam ・Substantial tension occurs in slabs at middle fulcrum ・The river cross-section hindrance ratio is about 4.8%, almost same as for that of Plan 2.	・Reinforced concrete four-span connected composite girder bridge with three piers on spread foundation. ・Since main girders are of a reinforced concrete structure, main materials can be procured and manufactured in Kenya. ・Girder height is 2.2m. ・The river cross-section hindrance ratio is about 8.0%, highest among four plans.
Constructibility	・Large erection girders corresponding to a 37.5m span are introduced to construct superstructure. As the erection is made for two spans only, this method is not efficient. ・The 37.5m prestressed concrete girder is small in rigidity in lateral direction and not easy to keep stable during erection.・Footing is provided at lowest position of rock mass line, so that temporary cofferdam scale is large.	・Erection girders corresponding to the 25.0m span are used. ・Two sets of temporary cofferdam materials are necessary. ・Almost no problem in the stability of prestressed concrete girder during erection	・Steel girders are lighter than prestressed concrete girders, so that they can be erected using a large crane from the abutment. ・Similarly to Plan 2, two sets of cofferdam materials for substructure are necessary.	・The work schedule is very tight because four piers must be completed in one dry season while accommodating two sets of cofferdam materials for substructure, ・Erection girders corresponding to the 20m span used.
Economy	・For the substructure, the cost is low because number of substructures is small. For the superstructure, the construction cost is the highest because of long span. ・It is necessary to carry large erection girders manufactured outside Kenya into site. 1.03	・The number of substructures increases and the cost becomes higher because two sets of cofferdam materials are to be prepared. But the span length for superstructures is standard and thus economical. ・Construction plan is feasible for both superstructure and substructure. This plan is the most economical among four plans. 1.00	・When compared with Plan 2, size of substructure will be slightly smaller in proportion to weight reduction of main girders. ・The superstructure is carried into Kenya after completion from material procurement to manufacture outside Kenya. The plan using steel tends to be expensive compared with plan using concrete. 1.20	・Large number of piers and girder height tends to increase with reinforced concrete than prestressed concrete, resulting in increase in substructure construction cost. ・The superstructure is of a reinforced concrete structure, so that prestressing steel is not necessary. But temporary materials are not much different from those of Plan 2, and the superstructure cost does not decrease much. 1.03
Operation and maintenance characteristics	Basically, maintenance is not necessary for concrete structures. Expansion joints require regular inspection.	Basically, maintenance is not necessary for concrete structures. Expansion joints require regular inspection.	Anticorrosion coating of main girders is necessary every ten years.	Basically, maintenance is not necessary for concrete structures. Expansion joints require regular inspection.
	△	◎	△	△
Overall rating	・Though plan proposing smaller number of spans is desirable from viewpoint of river cross-section hindering ratio, longer span causes increase in the girder height, so that the road elevation as a whole including the approach road must be higher. ・With less number of spans, the cost of substructure decreases, the cost of erection girder tends to be higher. Considering total construction cost, the three-span plan is considered most economical. ・As is described above, the three-span plan is to be selected for both superstructure and substructure because of the structure, constructibility and economy.			

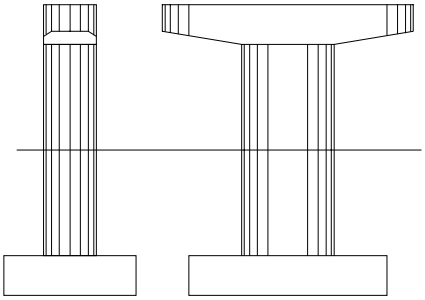
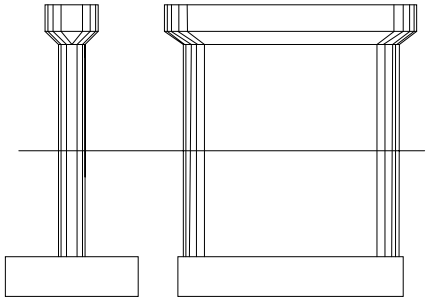
Note: ◎: Very good, △: bad

c) Type of substructure

- The river flow does not change significantly at the bridge position.
- Minimization of hindrance in the river cross-section The riverbed is made up of a sand layer.
- Considering scouring, the embedment depth of 2.0 m from the riverbed is secured to the footing top end.
- As the height exceeds 10 m, the abutment type is an inverted T type, which is the most economical.

Table 2-18 shows comparison of pier types.

Table 2-18 Pier type comparison table

	Plan 1 Columnar pier	Plan 2 Wall pier
Illustration		
Structural characteristics	- Ordinary structure type - Effective when the river flow changes - Width in the direction of normal water flow is larger than the wall type pier. - Large column diameter, resulting in higher hindering ratio of river cross section	- Ordinary structure type - Effective for particular river flow direction - Width in the direction of normal water flow can be minimized, resulting in lower hindering ratio.
Constructibility	- Girder support becomes slightly larger. - No particular problem	- No particular problem
Economy	△	○
Evaluation	△	○

Note; ○: Good, △: Bad

d) Foundation structure type

The bearing stratum around the two bridges in this project is found in the geological survey to be rock mass at a depth of about 5 – 9 m from the riverbed. A layer of sand river sediment and a gravel layer are distributed over this rock mass.

At this depth, the appropriate foundations are a spread foundation, driving pile foundation, or caisson.

As the foundation is situated in the river, various types are compared for review, taking into account the effects of scouring after completion, construction method in the river with attention to the rainy season, and material/equipment procurement in Kenya.

A spread foundation was selected for abutment and piers of both bridges in view of construction, constructibility, and economy after completion as shown in Table 2-19 of comparison result.

Spread foundation requires excavation to the bearing stratum. As excavation is to be made in the river, and the bearing stratum is the rock mass in the depth at the bridge site of this project, securing the safety and cut-off performance of the cofferdam method is critical. As shown in Table 2-20, the steel pile single cofferdam method is used together with rock excavation using a water jet because of safety and economy.

e) Revetment and slope protection

Revetment and slope protection are provided to protect embankment around the abutment. Revetment generally employed around abutment includes gabions and mortar riprap, and gabions covered with concrete is provided near the abutment of the existing bridge.

In this project, the protection with mortar riprap superior in economy and constructibility as shown in Table 2-21 is provided as revetment around the abutment.

Mortar riprap is used up to transition from the revetment gradient of 1:0.5 to the embankment slop gradient of 1:2.0, followed by planting over subsequent slope with a gradient of 1:2.0.

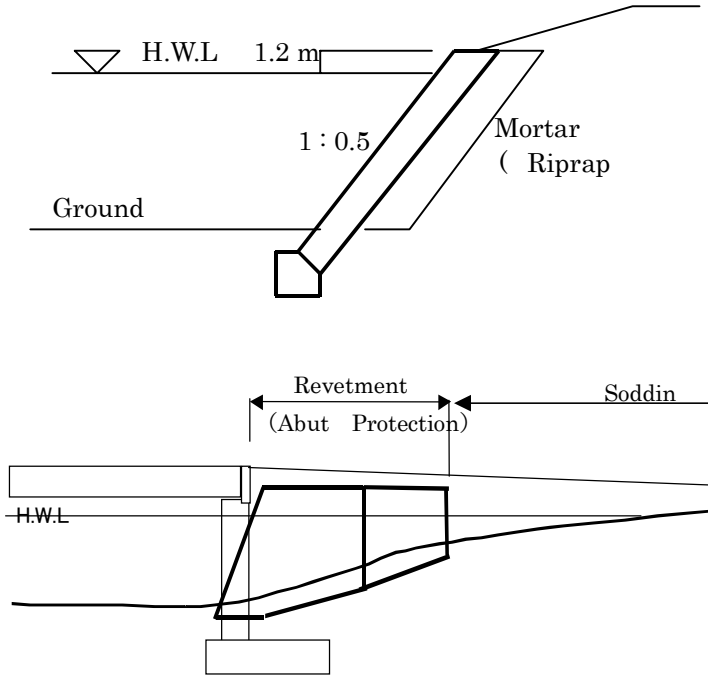


Fig. 2-23 Revetment work range

Table 2-19 Foundation type comparison table

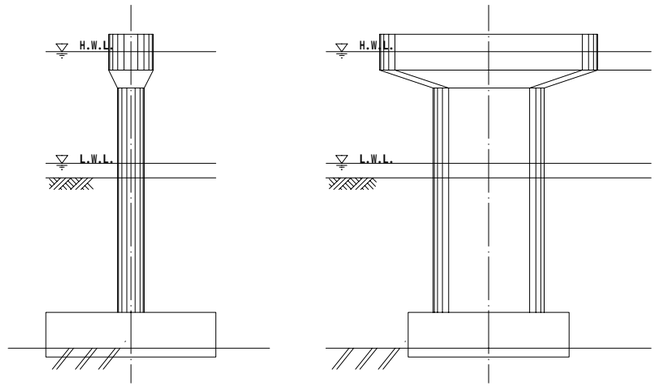
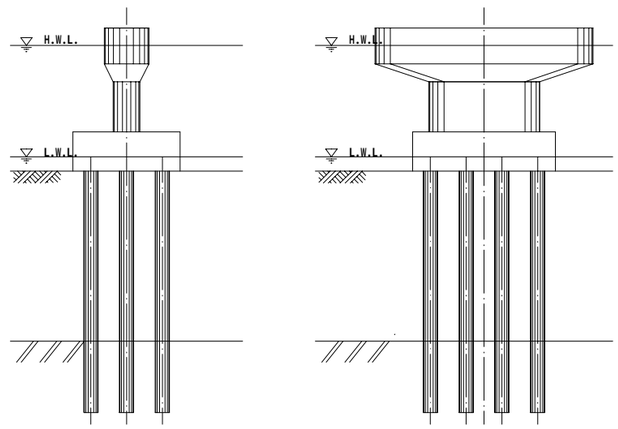
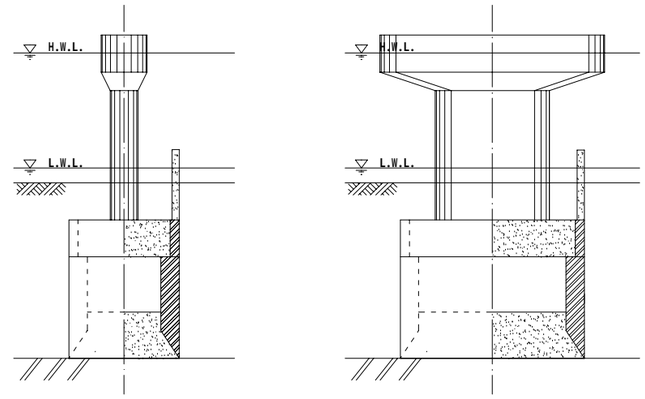
	Spread foundation	Pile foundation (multi-column pile foundation)	Caisson foundation (open caisson)
Structural Shape			
Structural outline	・The bearing stratum is rock mass. As the ground can be confirmed at excavation, the foundation becomes firm and stable. ・As horizontal resistance is not expected in the design, river scouring will not present safety problems.	・Considering constructibility, a pile foundation with the footing bottom surface placed on the riverbed is used. The ratio of hindering to the river cross-section is the largest of the three plans. ・When the footing top face is set under the scouring depth (Approx. 2 m), pile foundation is not required at all where the sand layer is thin. ・Scouring occurs readily and drift timbers tend to be caught in piles, threatening the safety of structure.	・Bed rock is inclined at site, making excavation with the bottom surface of cutting edge extremely difficult. This may cause unstable bearing capacity of ground under caisson, presenting a problem in terms of structural stability. ・When the caisson main body is exposed due to scouring, the section to receive the flow water becomes large, which is dangerous. Accordingly, it is necessary to lower main body to the scouring depth (about 2 m). ・When the pier is wall type, the use of oval caisson will prove effective.
Constructibility	・Excavation to the bearing stratum is necessary. In certain points, large cofferdam with excavation as deep as 12 m is necessary. ・For stabilization of Sheet-piles of cofferdam, and sheet-piles should be set in bed rock.. Water jet system is also required to drive piles. ・The river cross-section hindrance width during work is same as pile foundation, but narrower than plan with caisson. ・Substructure can be completed within one dry season.	・It is necessary to carry the lager pile driving machine which can excavate the bed rock into Kenya from outside. ・Piles may be exposed when river bed scoured. As the horizontal force is small, this does not present any structural problem if piles penetrate into the rock bed. ・Cofferdam required for footing. works ・The river cross-section hindrance width during work is not different from that of spread foundation.	・Rock excavation is difficult for open caisson. ・Inclination encountered during excavation is difficult to cope with by modification. ・Drifting timbers obstructing excavation difficult to remove. ・Sand layer causes high friction resistance, possibly making equipment to cope with settlement necessary. ・Watertight wall is necessary. Its removal requires cofferdam with concrete or steel piles, taking considerable time before removal. ・The river cross-section hindrance is wide and completion within one dry season is difficult. ・Bottom slab of caisson must be constructed with underwater concrete.
Economy	・Temporary construction cost is higher than that of Plan 2. But, because of inexpensive permanent work, this plan is the most economical ・A platform is necessary for cofferdam and excavation. Installation of platform on one side is enough for construction, so that the platform cost is small.	・A platform for cofferdam and piling is necessary over entire periphery of footing. ・Large pile driver is necessary for rock excavation. ・Machinery and materials are needed for two pile foundations, which is extremely uneconomical.	・Temporary construction cost for filled cofferdam and watertight wall is high. ・The cost for main body is lower than that of Plan 2. This plan has highest overall cost.
Rating	○	△	×
	・Cofferdam with steel piles is necessary. This method is most inexpensive while ensuring stability after completion, compatibility with ground condition, and work accuracy.	・Effects of river after completion, such as riverbed scouring, drifting timbers, etc. are the greatest. ・High rent of pile driving machine	・When rock mass is inclined, it is difficult to ensure work accuracy. Besides, there are problems such as river cross-section hindrance, work period, etc. Finally, the work cost is the highest.

Table 2-20 Pile cofferdam method comparison table

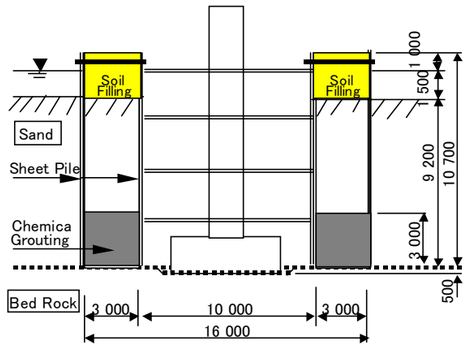
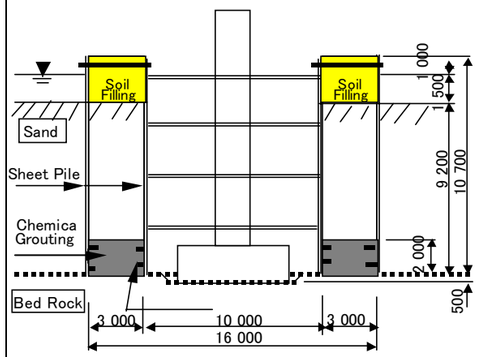
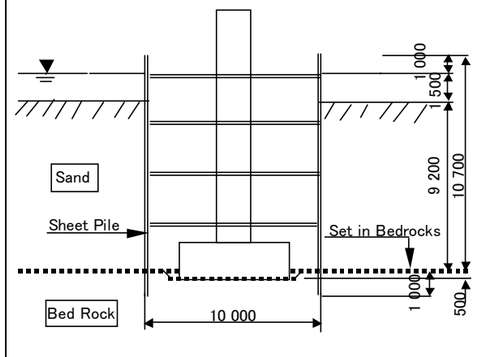
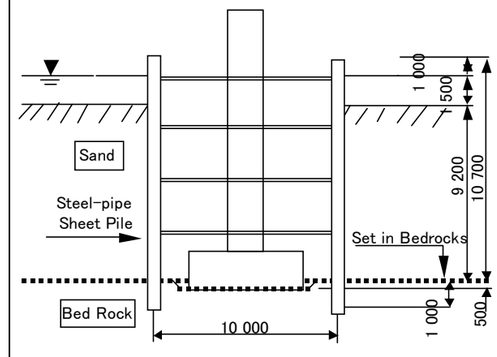
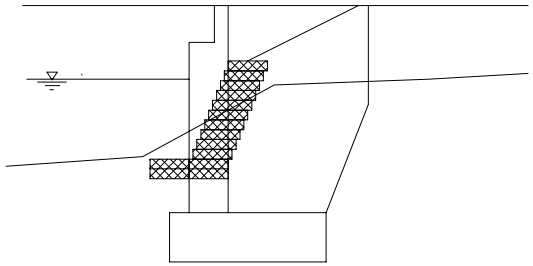
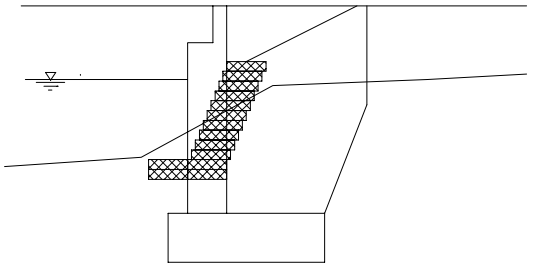
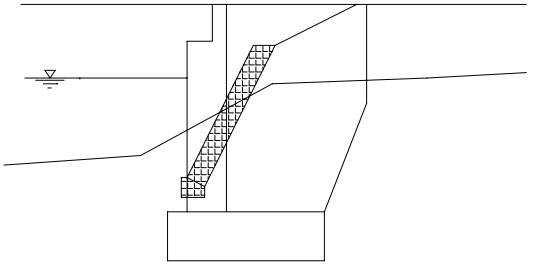
Method	Steel sheet pile double cofferdam + Chemical grouting	Steel sheet pile double cofferdam + Jet grouting for watertight	Steel sheet pile single cofferdam (Water jet used also for pile driving)	Steel pipe sheet pile single cofferdam (Pre-drilling with rock auger)
Illustration				
Outline of the method	Steel sheet piles are driven with vibro hammer to achieve double cofferdam. As steel sheet piles do not penetrate into rock bed, chemical grouting is made within double cofferdam watertight.	Steel sheet piles are driven with vibro hammer to achieve double cofferdam. As steel sheet piles do not penetrate into rock bed, jet grouting is made within double cofferdam for watertight. Steel sheet piles and jet grout are fixed with dowel.	With the help of water jet, vibro hammer is used to drive steel sheet piles to penetrate into rock bed. Grout mortar at ends for watertight.	Steel pipe sheet piles are driven through advance drilling with rock auger to penetrate into the rock bed for 1.0 m. The sequence is “drilling with rock auger” – backfilling with sand – driving of steel pipe sheet piles. For joints and ends, watertight is achieved by mortar grouting.
Principal machinery	・Crawler crane (50 t capacity) : 1 unit ・Vibro hammer (45kw) : 1 unit ・Grouting equipment (boring machine : 5 units	・Crawler crane (50 t capacity) : 1 unit ・Vibro hammer (45kw) : 1 unit ・JG equipment (boring machine) : 3 units	・Crawler crane (50t capacity) : 1 unit ・Special vibro hammer (45kw) : 1 unit ・Water jet equipment : 1 set	・Pile driver with auger : 1 unit ・Crawler crane (80t capacity) : 1 unit ・Vibro hammer (60kw) : 1 unit
Drive – Sand layer (N=10)	Pile driving is possible with usual vibro hammer.	Pile driving is possible with usual vibro hammer.	Pile driving is possible with usual vibro hammer.	Pile driving is possible with usual vibro hammer.
Drive – Rocks mass (qu=1000kg/cm2)	For the weathered rock mass with qu=50kg/cm2, pile driving is possible when the water jet method is also used.	For the weathered rock mass with qu=50kg/cm2, pile driving is possible when the water jet method is also used.	For the rock mass with qu=1000kg/cm2, pile driving is possible with the special equipment when the water jet method is also used.	Pile driving possible up to the rock mass strength of about qu=500kg/cm2. Above this strength, the special method (direct piling method), etc. is necessary.
Watertight	Watertight to a certain degree, but not reliable	Reliable watertight	Watertight enabled though pump-up is necessary.	For joints and ends, complete watertight is possible by grouting.
Structural safety	Not enough safe because the end is not fixed	Safety ensured because of fixing with JG and dowel	Safety ensured because piles are fixed in rock bed.	Safe because piles are fixed in rock bed.
Removal of steel sheet piles	Pull-out and removal possible	Pull-out impossible. Cutting and partial removal	Pull-out and removal possible	Pull-out and cutting at arbitrary position, and removal possible
Contractor	Not specified	Not specified	Various types. Not specified	Possibly related to the specific contractor (general contractor)
Principal quantity	Steel sheet pile : A=1,198m2 (loss) Grouting : V = 504m3 Double cofferdam : W=8.5t Filling soil : V=420m3 Internal excavation : V=213m3	Steel sheet pile : A=1,198m2 (loss) CJ grouting : V = 336m3 Double cofferdam : W=8.5t Filling soil : V=420m3 Internal excavation : V=213m3	Steel sheet pile : A=537m2 (loss) Internal excavation : V=213m3	Steel pipe sheet pile : A=559m2 (loss) φ600x12mm Internal excavation : V=213m3
Temporary work cost ratio	1.8	2.7	1.0	2.1
Overall work period (including structural works)	6 months	7 months	5 months	7 months
Overall rating	Costs including grouting is considerably high and the work period of double cofferdam and grouting is long. Less reliable steel sheet pile end fixing structure ×	liability of steel sheet pile end fixing structure considered to be without problem. The jet outing cost is high and its work period is long. sides, steel sheet piles cannot be pulled out. △	Steel sheet pile end fixing structure is considered to be reliable. Though complete cut-off cannot be expected, drainage is possible. Besides the work period is shorter and the work cost is relatively inexpensive. ○	There is no problem in reliability of steel pipe sheet pile end fixing structure and cut-off. Rock excavation becomes difficult when its strength exceeds Qu-800kg/cm2. △

Table 2-21 Slope protection around abutment (protection work)

	Gabion (wire mat) work	Concrete covered gabion	Mortar riprap
Illustration			
Structure	・Structural height of 10 m or more ・Suction preventive measures are necessary in the case of sandy soil. ・Compliance with displacement △	・Wire mat is used, over which concrete covers, preventing suction even in sandy soil. ・Type used in the existing abutment ○	・The foundation position must be determined by taking into account scouring effects. ・Depending on the case, the foundation scouring preventive work must be provided. ○
Constructibility	・The structure is simply a cage assembled with wire mesh, in which stones are filled. Easy to construct ◎	・Stones are filled in wire mesh assembly and gabion is covered with concrete after completion. ○	・Excavation and leveling of foundation site are necessary. ・Construction in water is difficult. ○
Operation and maintenance	・Wire mesh is readily damaged, making maintenance necessary △	・Though wire mesh is damaged less because of concrete cover, maintenance is still necessary. ○	・Less damage and easy to maintain and repair because only filling in defective portions is sufficient. ○
Economy	1.05 △	1.20 △	1.00 ○
Rating	△	△	○

Note; ◎: Very good, ○: Good, △: Bad

2-2-3 Basic Design Drawings

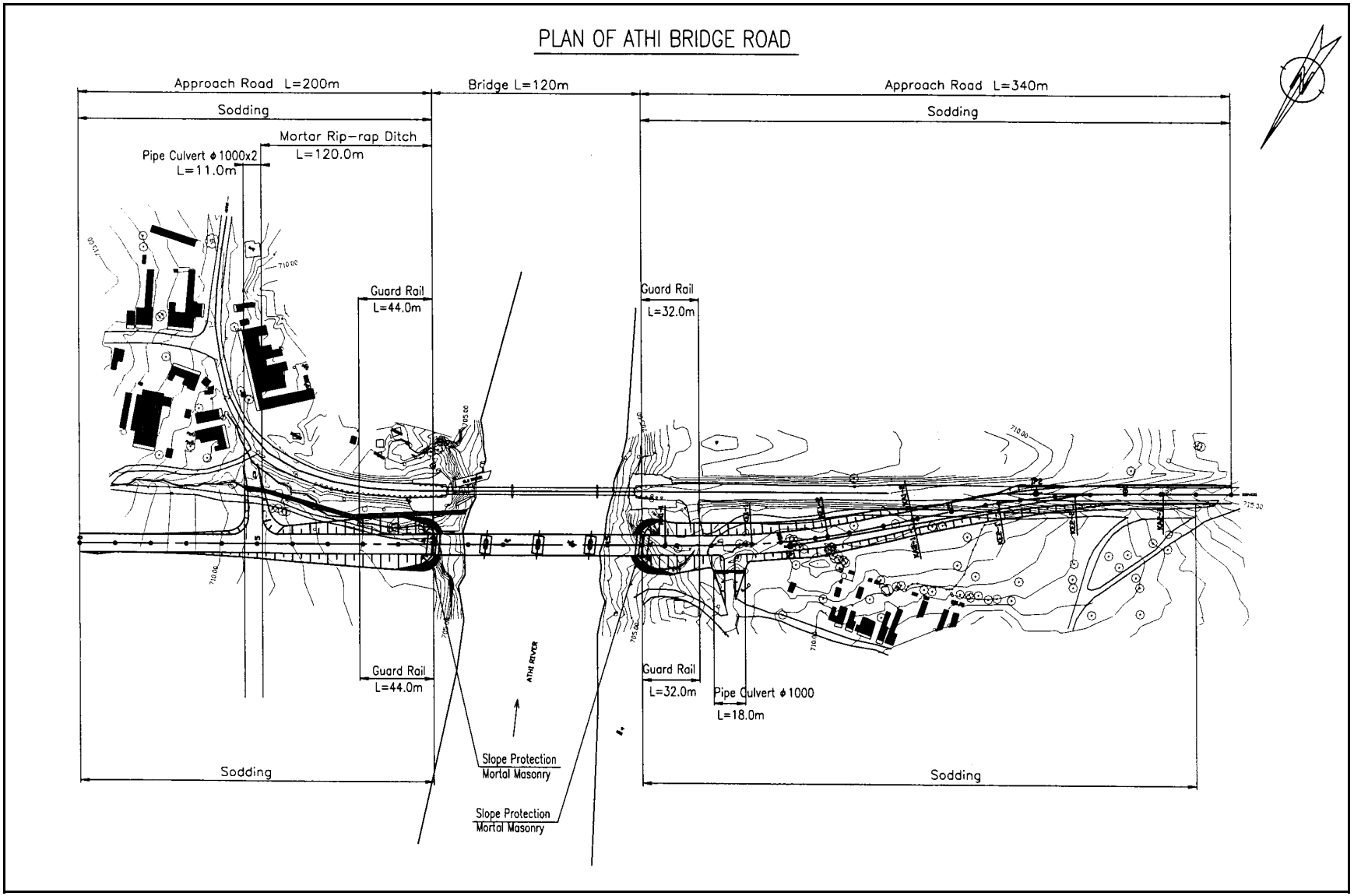


Fig. 2-24 Plan of Athi Bridge Road

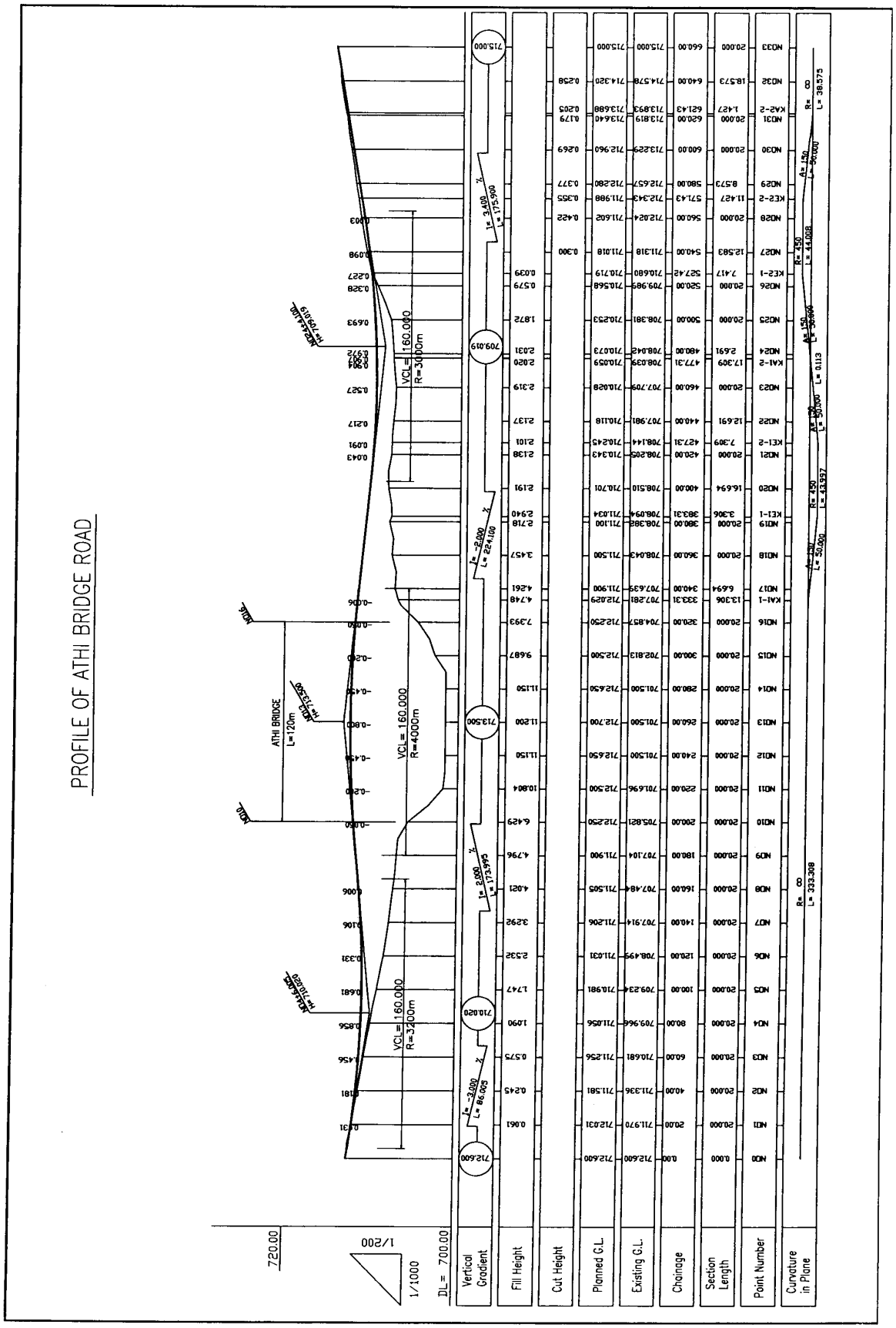
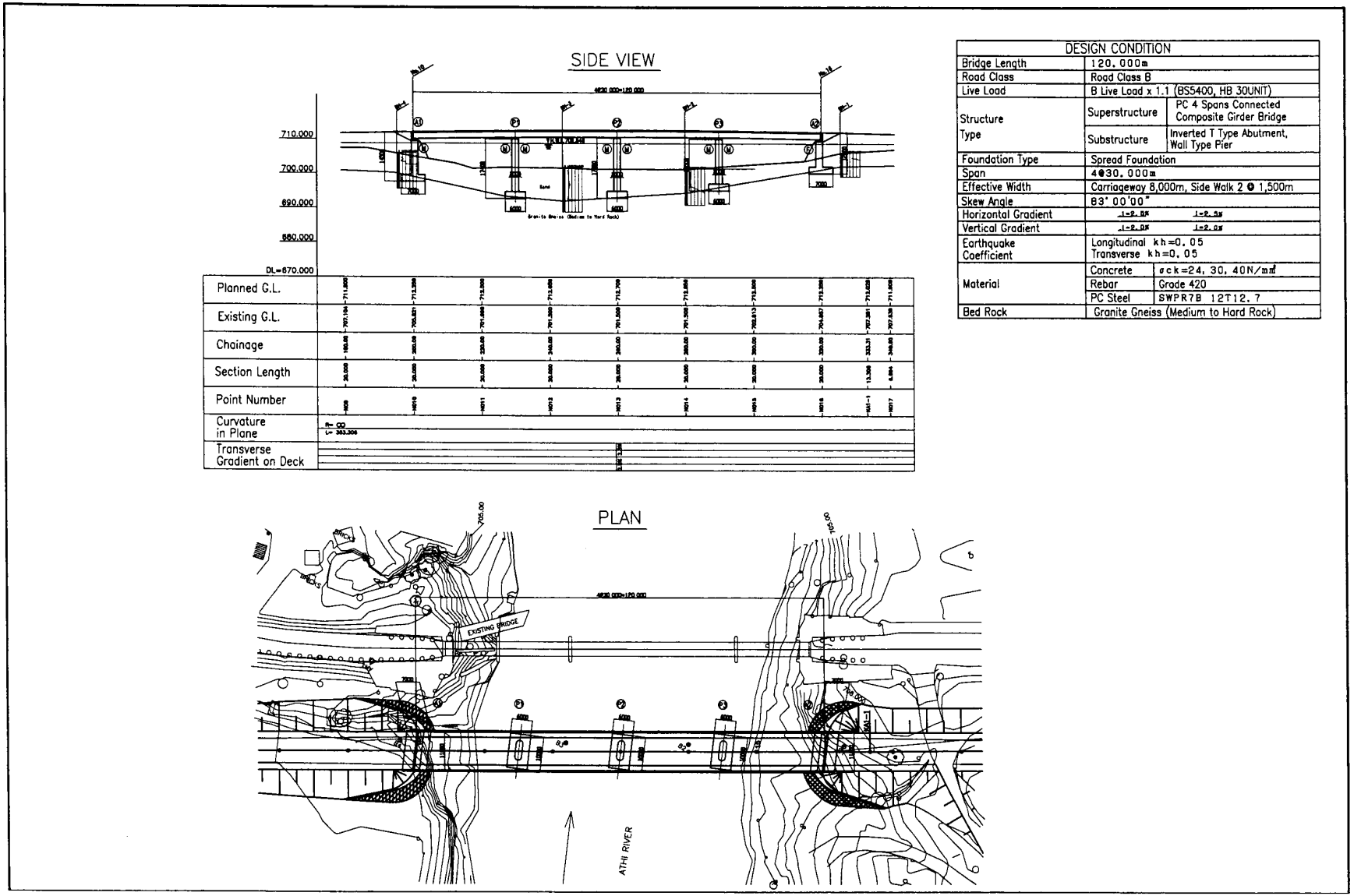


Fig. 2-25 Profile of Athi Bridge Road



DESIGN CONDITION		
Bridge Length	120.000m	
Road Class	Road Class B	
Live Load	B Live Load x 1.1 (BS5400, HB 30UNIT)	
Structure Type	Superstructure	PC 4 Spans Connected Composite Girder Bridge
	Substructure	Inverted T Type Abutment, Wall Type Pier
Foundation Type	Spread Foundation	
Span	4@30.000m	
Effective Width	Carriageway 8,000m, Side Walk 2 @ 1,500m	
Skew Angle	83° 00'00"	
Horizontal Gradient	i=2.5%	i=2.5%
Vertical Gradient	i=2.0%	i=2.0%
Earthquake Coefficient	Longitudinal kh=0.05 Transverse kh=0.05	
Material	Concrete	σck=24, 30, 40N/mm²
	Rebar	Grade 420
	PC Steel	SWPR7B 12T12.7
Bed Rock	Granite Gneiss (Medium to Hard Rock)	

Fig. 2-26 General View of Athi Bridge (1)

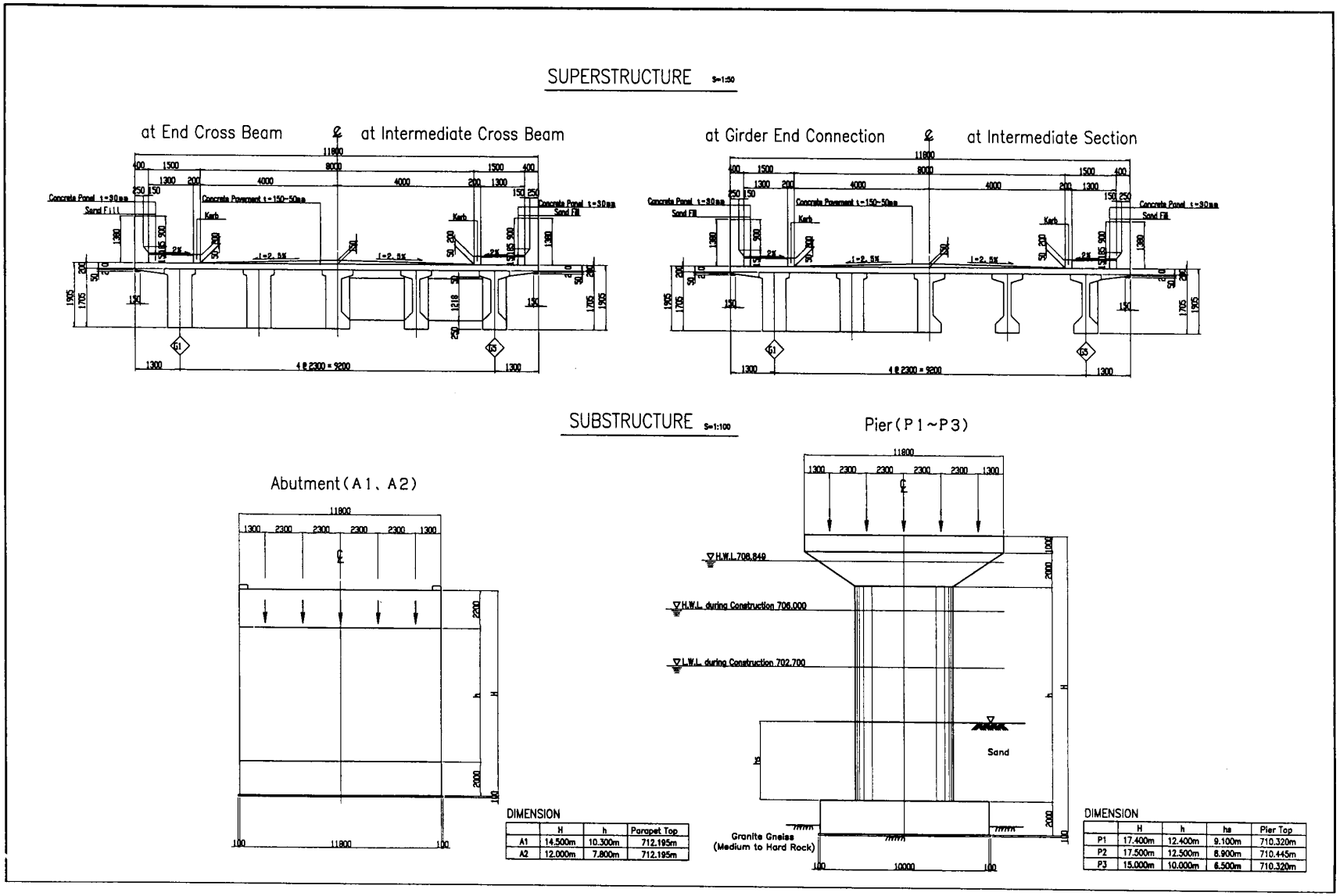


Fig. 2-27 General View of Athi Bridge (2)

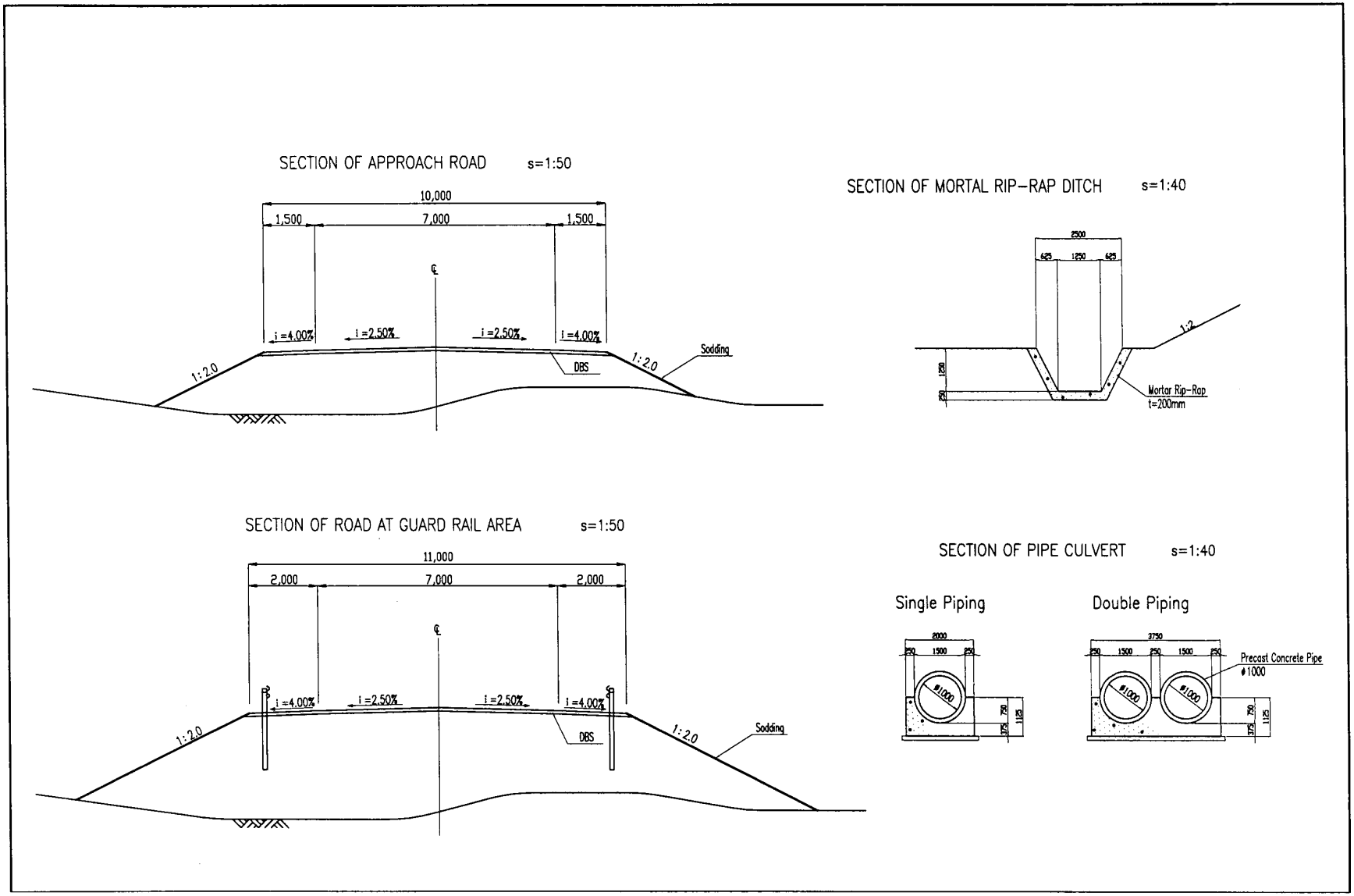


Fig. 2-28 Typical Cross Section of Athi Bridge Road

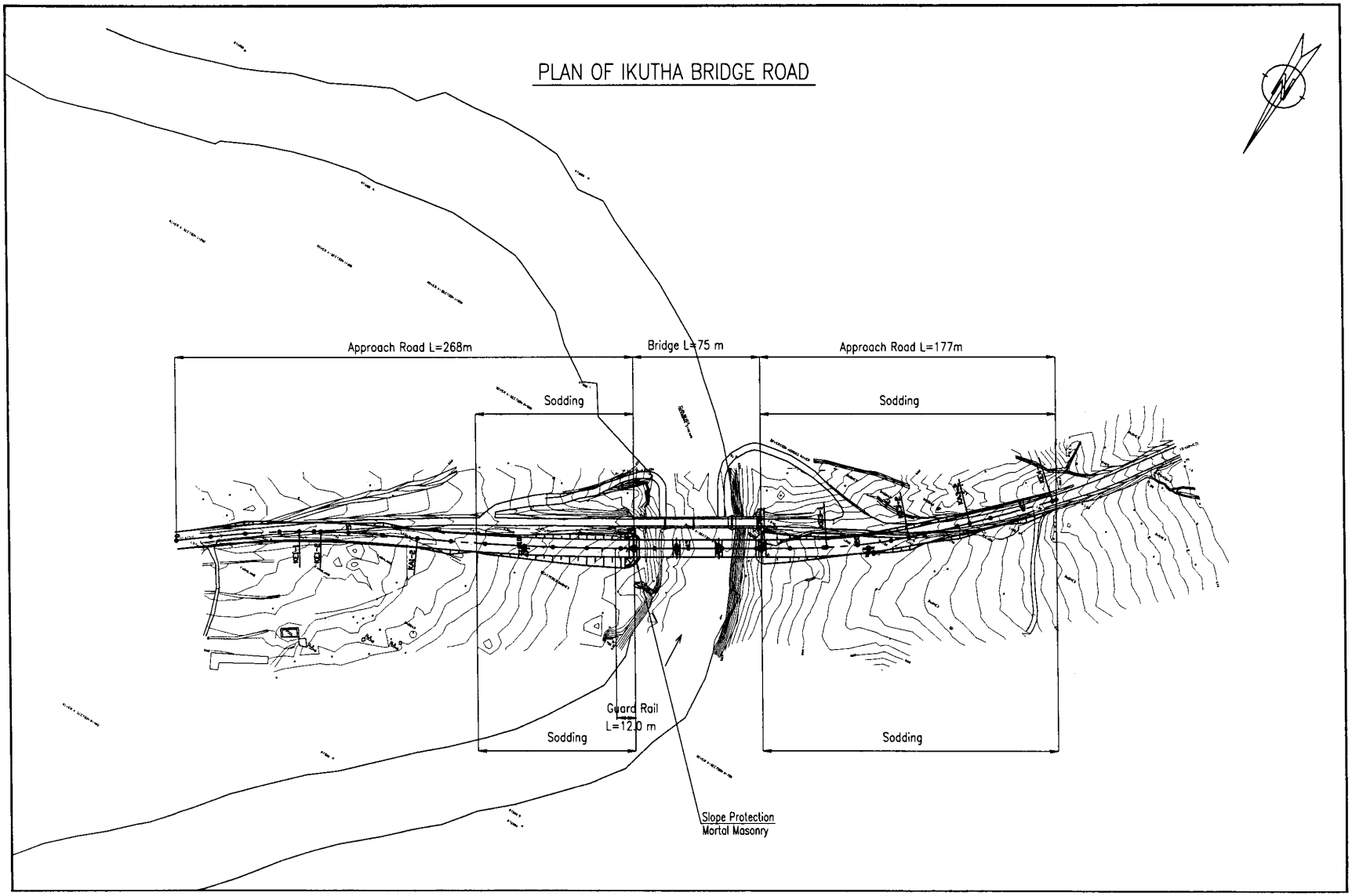


Fig. 2-29 Plan of Ikutha Bridge Road

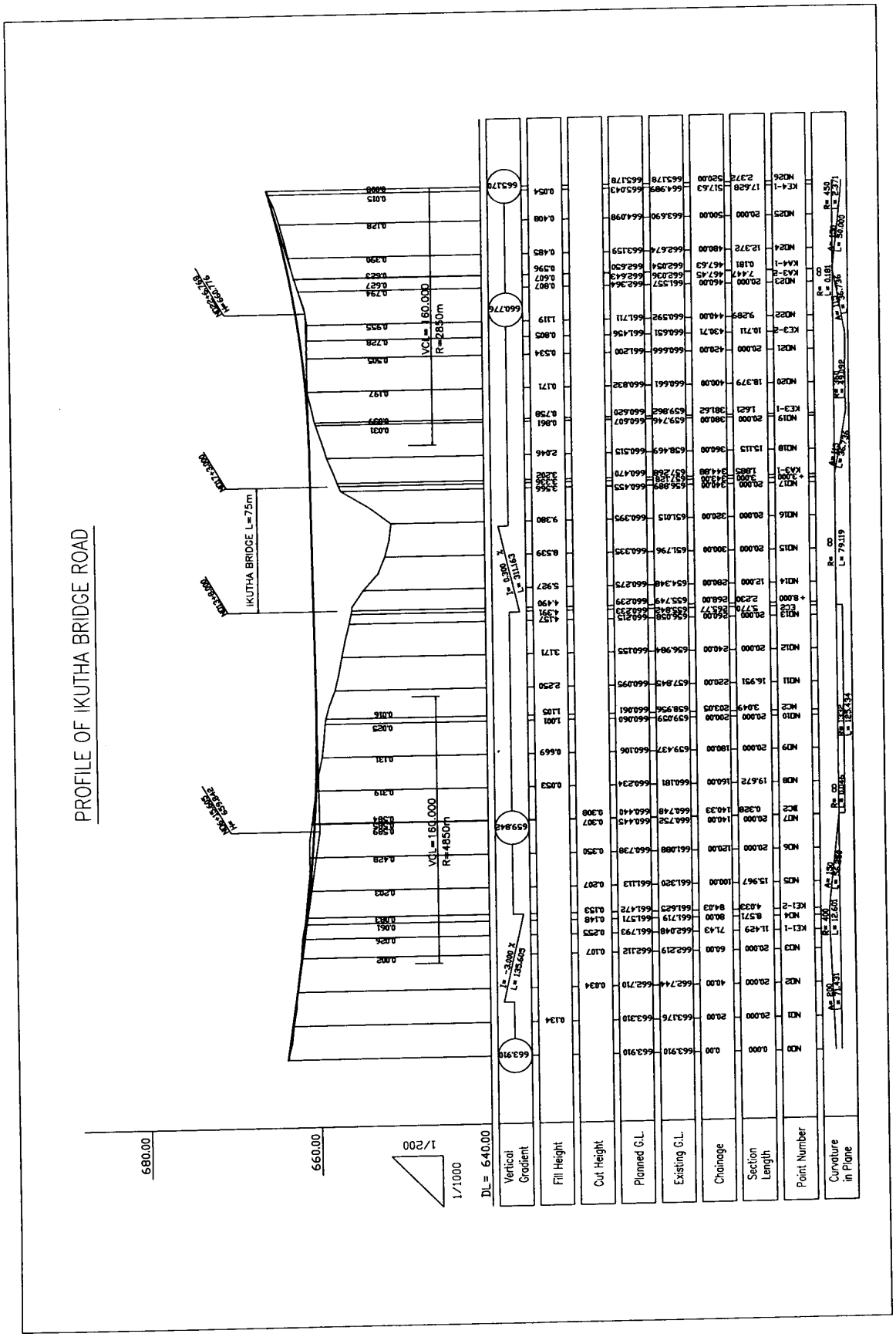
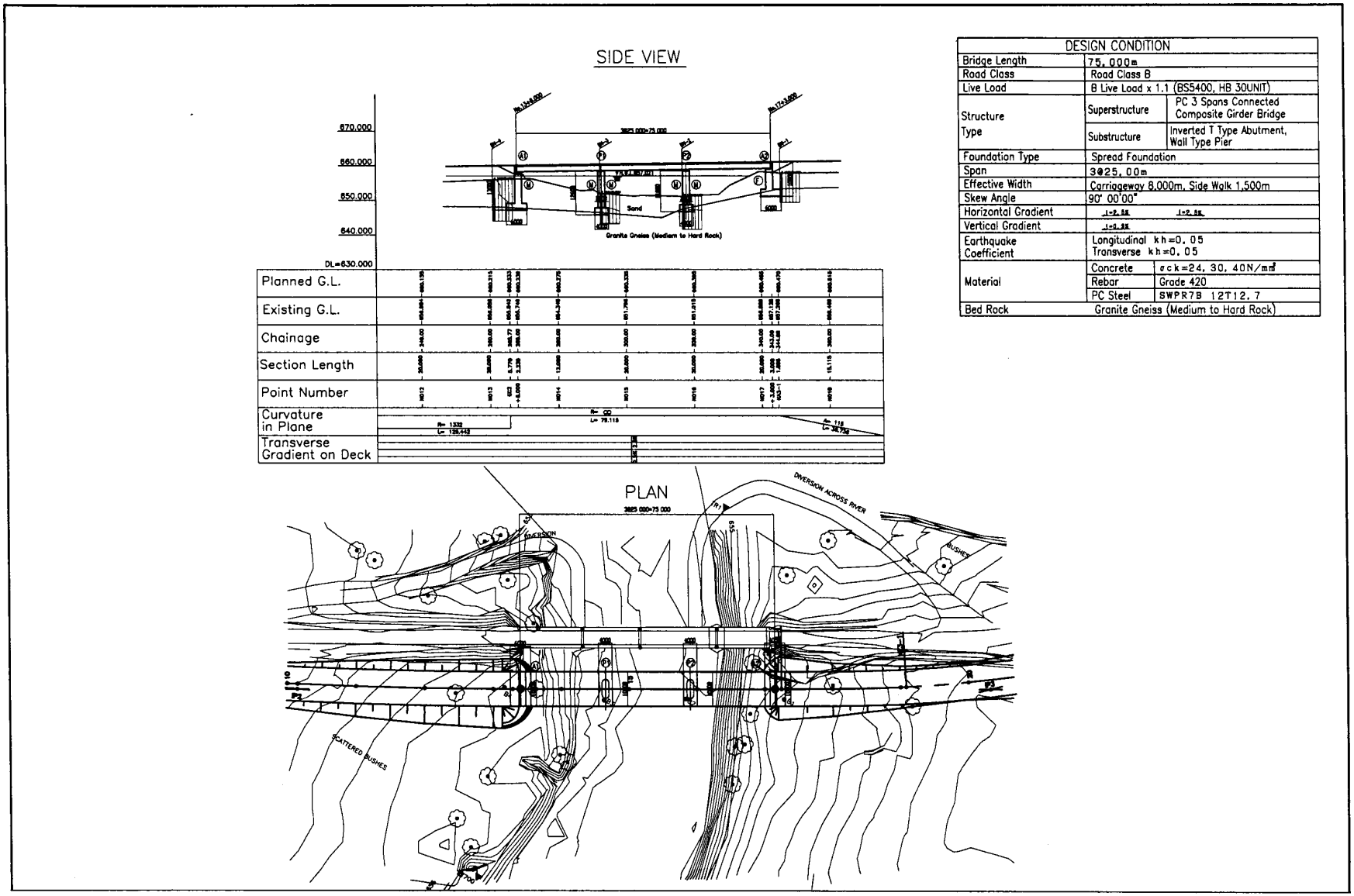
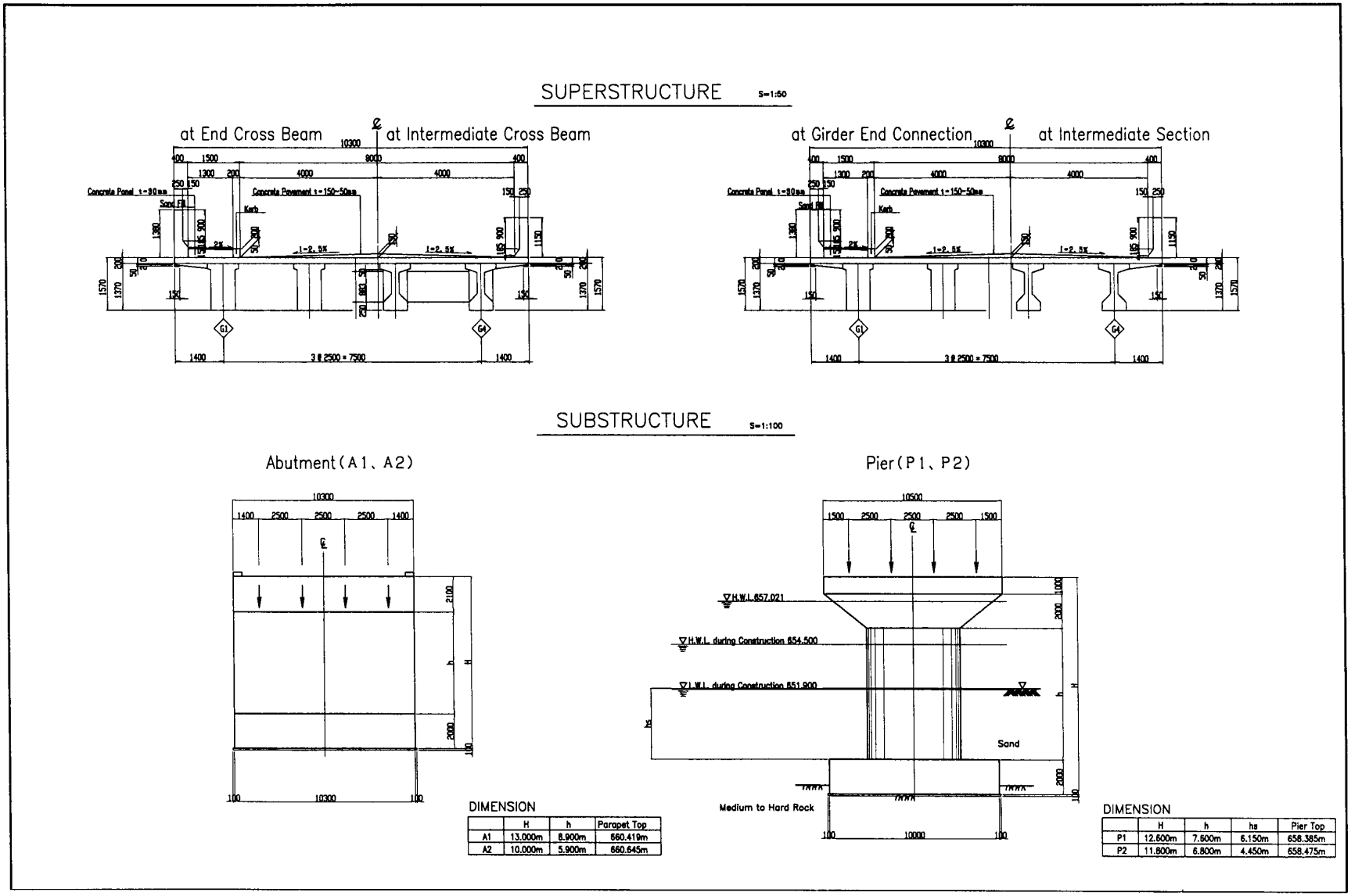


Fig. 2-30 Profile of Ikutha Bridge Road



DESIGN CONDITION		
Bridge Length	75.000m	
Road Class	Road Class B	
Live Load	B Live Load x 1.1 (BS5400, HB 30UNIT)	
Structure Type	Superstructure	PC 3 Spans Connected Composite Girder Bridge
	Substructure	Inverted T Type Abutment, Wall Type Pier
Foundation Type	Spread Foundation	
Span	3@25.00m	
Effective Width	Carriageway 8.000m, Side Walk 1.500m	
Skew Angle	90° 00'00"	
Horizontal Gradient		
Vertical Gradient		
Earthquake Coefficient	Longitudinal kh=0.05 Transverse kh=0.05	
Material	Concrete	σck=24, 30, 40N/mm²
	Rebar	Grade 420
	PC Steel	SWPR7B 12T12.7
Bed Rock	Granite Gneiss (Medium to Hard Rock)	

Fig. 2-31 General View of Ikutha Bridge (1)



	H	h	Parapet Top
A1	13.000m	8.900m	660.419m
A2	10.000m	5.900m	660.645m

	H	h	hs	Pier Top
P1	12.600m	7.600m	6.150m	658.385m
P2	11.800m	6.800m	4.450m	658.475m

Fig. 2-32 General View of Ikutha Bridge (2)

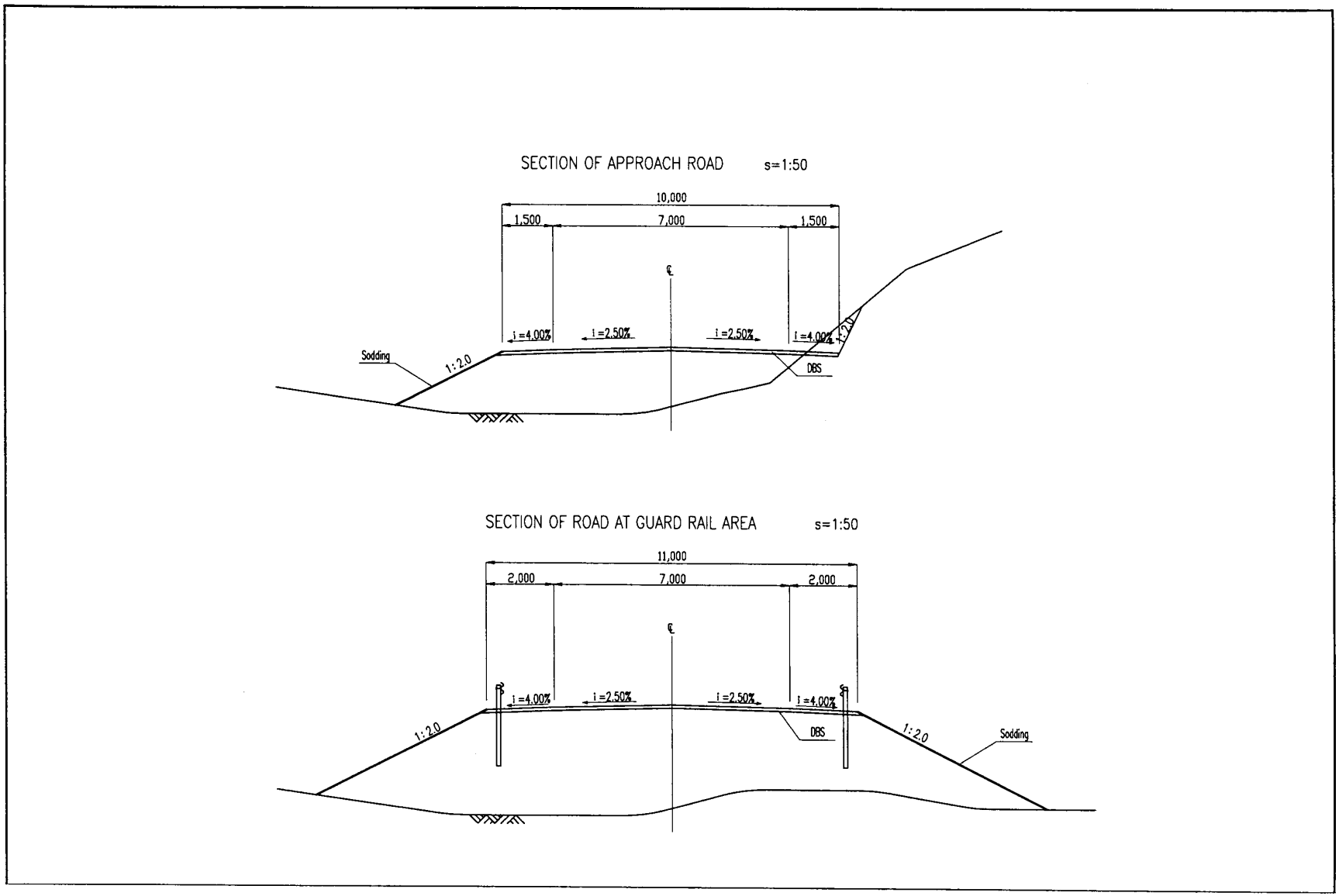


Fig. 2-33 Typical Cross Section of Ikutha Bridge Road

2-2-4 Implementation plan

This plan will be implemented after conclusion of an exchange of notes (E/N) between the two governments when implementation has been approved by cabinet decision subsequent to a review by Japanese governmental agencies. For implementation, design and construction supervision will be conducted by the Japanese corporate consultant, and construction work will be executed by the Japanese corporate contractor, upon conclusion of a contract with the Government of Kenya. These contracts will become effective upon approval by the Japanese Government.

The agency implementing this plan is the Roads Department of the MORPW. Service coordination related to grant aid agreed upon by the two countries, preparation, and technical management, supervision, and maintenance will be under control of the Roads Department.

The Japanese corporate consultant who has contracted with the Government of Kenya will thoroughly understand its role in this grant aid project and provide the following services:

- Detailed design including preparation of Tender documents
- Prequalification of Tenderers and auxiliary services related to Tender and contracts
- Construction supervision

The Japanese corporate contractor selected according to the grant aid system will procure equipment and materials efficiently and adequately and construct the planned facility in accordance with the plan.

2-2-4-1 Implementation Policy

1) Basic policy

The implementation policy for the plan takes the following points into account while assuming that the plan is implemented within the framework of Japanese grant aid:

- Maximum utilization of local laborers and materials/equipment to contribute to the creation of job opportunities, promotion of technology transfers, and regional economic development

- Establishment of a close communication system between the Government of Kenya, consultant, and contractor to ensure smooth implementation
- Establishment of a practical plan based on consideration of the impact of the local rainfall and river conditions, the period necessary for procurement of materials/equipment, and employment of an appropriate construction method
- Employment of temporary structure plan and construction method complying with Kenyan environmental standards and consideration of appropriate environmental measures
- Planning of a field work schedule that does not cause inconvenience by closing existing traffic

2) Establishment of the work period

The project work consists of preparation (including transport of equipment and materials), bridge work, approach road work, and revetment. The work period is scheduled to be 24 months. Since the project site is in a semi-arid area, where precipitation and the number of rainy days are limited, the river flow rate will exert greater influence on the work period than rain.

The cofferdam for construction of piers is planned for the dry season to reduce risk.

3) Work implementation method

The flow of the construction work as a whole is shown in Fig. 2-34.

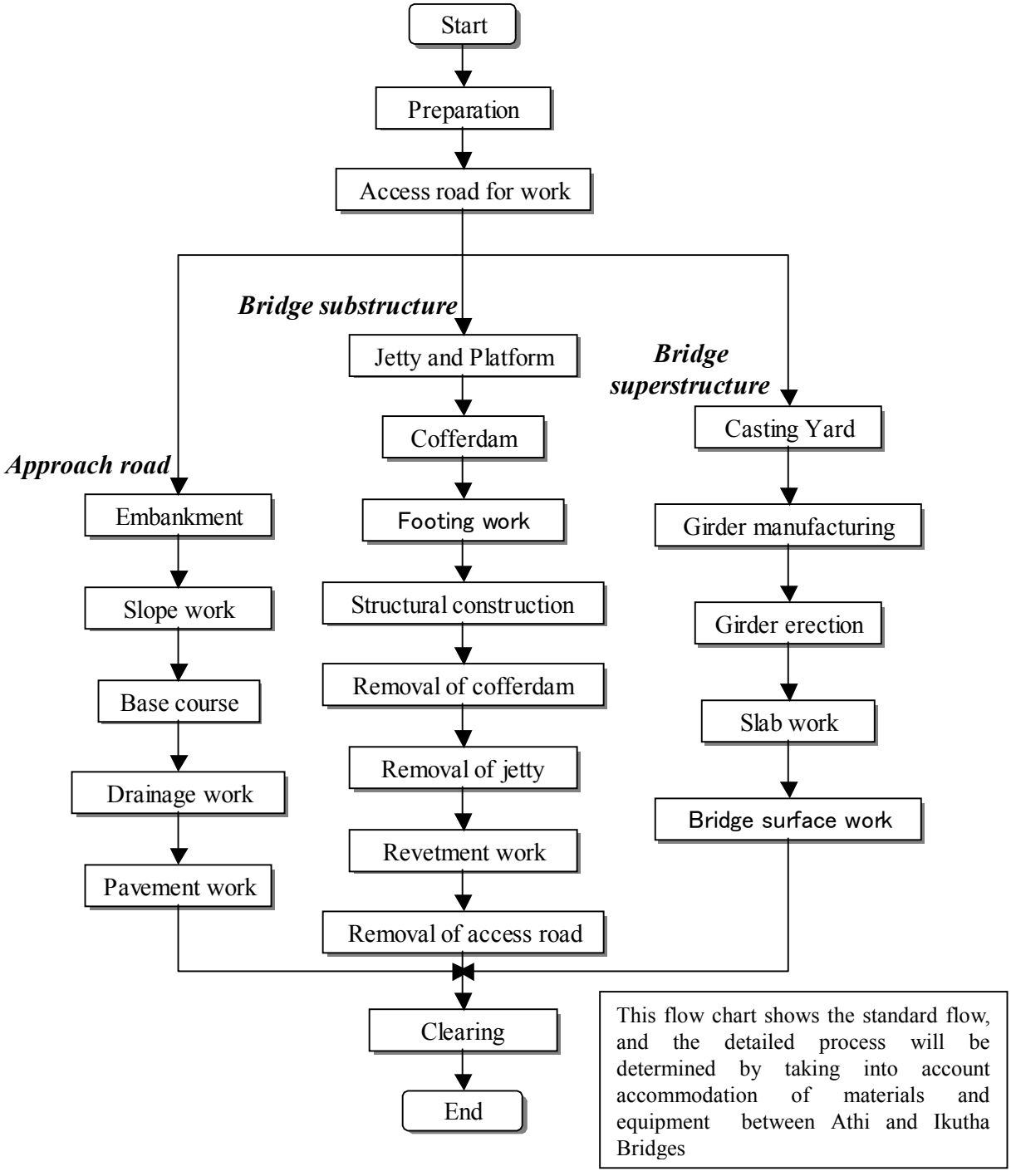


Fig. 2-34 Construction flow chart

a) Access road

During bridge construction, ordinary vehicle traffic will use the existing bridge. Construction vehicle traffic will be separated from ordinary vehicles by constructing an access road. For the Athi Bridge, a temporary landing bridge (such as Jetty and Platform) will be constructed for use during construction of the substructure. The access road is necessary to connect the existing road and landing bridge. In the case of the Ikutha Bridge, an access road must be provided to connect the existing road to the riverbed because a landing bridge is not used. The existing road will be used as this access road after improvement.

b) Temporary jetty and platform works

The temporary landing bridge will be necessary for construction of the substructure of the Athi Bridge, which is of a structure using H steels. As this will be used for about a year, the planned construction will prove durable during the rainy season and repair will be made as required.

c) Cofferdam

Cofferdam (steel-sheet piles) will be used in construction of the substructure. To allow the footing to rest on the rock, the cofferdam must penetrate into the rock to ensure the stability. Due to economic considerations, a vibro hammer will be used with a water jet, to ensure penetration into the rock (about 800 kgf/cm^2). Cement milk will be filled into gaps and cut-off material will be provided to sheet pile joints.

d) Substructure construction

Wall type piers with cantilever were selected after considering making impact exerting river minimum and economic factors. The work method described below will be used because the piers are to be constructed inside the river.

① Excavation will be made after completion of the steel-sheet pile cofferdam.
② Excavation will be made with a backhoe and clamshell bucket. Waling and struts will be provided at specified positions, and excavation will be made carefully without advance excavation.

③ After excavation of the sand layer, leveling of rock will be made and leveling concrete will be placed.
④ Rebar assembly, form placement, and concrete placement are to be carried out for footing, column, and beam in that order, erecting the pier. The false work for girder construction will be assembled from below.
⑤ While performing refill to the specified thickness with specified refilling material, strut, waling, etc. are removed.
⑥ Pull out steel-sheet piles after refilling to the specified height (riverbed). Pile portions penetrating into the rock will be left buried when the need arises.

As the work inside the river is susceptible to flooding, safety must be ensured by using comprehensive rainfall information for work during the rainy season.

e) Construction of the superstructure

Prestressed concrete precast girders for the superstructure will be manufactured in the yard and erected with an erection girder. Erection can be completed without problems even in the river flood season, but due care must be taken to ensure safety when the heavy machine is operated on rainy days. The construction procedure is described below.

① The main girder-manufacturing table is manufactured from concrete.
② Main girder form, rebar, and prestressing wire are assembled.
③ Concrete is placed and wet-cured.
④ When concrete is reached to have attained the required strength, prestressing of the prestressing tendon is done, followed by grouting. Check if grouting is done completely.
⑤ Main girders are transferred and stocked in the temporary yard. During transfer, measures must be taken to prevent overturn.
⑥ Girders are erected, one by one, with an erection girder. Girders are taken out of the yard with a winch moving on tracks. A portal erector on the pier moves the girder laterally to the specified position for installation.
⑦ The suspended scaffolding is provided under girders.
⑧ Cross beams are installed with the suspended falsework.
⑨ Formwork and placing reinforced bar of footing are executed.
⑩ Slab concrete is placed. Adjustment concrete for super elevation is placed at

the same time.

⑪ Finally, the bridge surface work, including railings, expansion joints, and drainage facilities, is carried out.

f) Approach road work

The approach road is a new road to connect to the existing road. It will be constructed after completion of the substructure.

① Soils appropriate for embankment are to be quarried from the nearby borrow pit, carried into the site, placed and spread, and compacted.
② When embankment is completed to a certain level, revetments around the abutments are built in the same time.
③ The base course is divided into a sub base and base course, and thorough compaction is made after placement and spreading.
④ Pavement is DBS with asphalt emulsion.

4) Utilization of local contractors

a) Consultants

There are several local private consultant companies, but only three foreign-affiliated local subsidiaries are capable of design and supervision of prestressed concrete bridges. As Kenya is now facing economic stagnation, there is a labor surplus and it is expected that construction engineers can be readily employed.

b) Contractor

There are five construction-related quality enterprises registered in MORPW in Kenya, which are engaged as subcontractors in Japanese grant-aid and loan-aid projects. Certain local contractors have their own construction machinery, and construction machinery may be leased from private enterprises in certain cases. Accordingly, ordinary construction machinery can be procured from the private sector. The opportunity for these enterprises to participate as subcontractors under supervision and guidance of the Japanese corporate contractor will contribute to the improvement of construction technology in Kenya.

c) Dispatch of engineers from Japan

Engineers will be dispatched from Japan for the type of work that may substantially affect the special technology or the quality of the work. This includes special technicians related to building the cofferdam with steel-sheet piles, prestressing work related to the manufacture of prestressed concrete girders, bridge construction assistants for girder erection, and mechanics for maintenance and repair of construction machinery.

5) Implementation system

The agency responsible for implementation of the project is the Bridge Section of the Roads Department, MORPW. This section consists of one senior engineer (the position is currently vacant), two engineers and assistant engineers, under the Chief Super Intending Engineer (Bridge), and rank and file employees under these engineers. The MORPW organization chart is shown in Fig. 2-35.

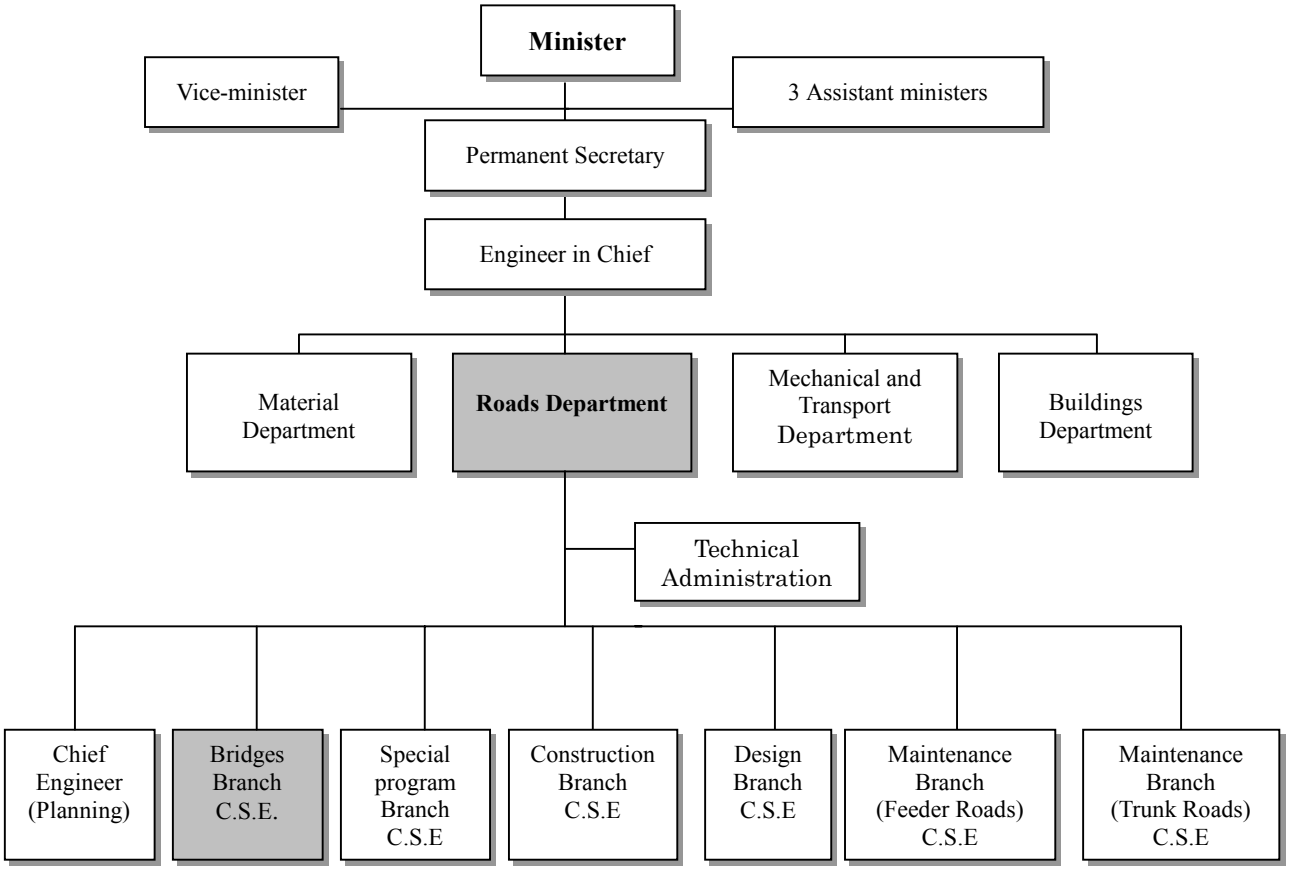


Fig. 2-35 The Organization Chart of Roads Department

2-2-4-2 Implementation Conditions

When the implementation plan of the project is drafted, it is necessary to take into account meteorological conditions (dry and rainy seasons) unique to the Eastern Province and material/equipment procurement conditions.

1) Work schedule considering rainy and dry seasons

Rainy seasons occur twice a year in Kenya. The minor rainy season is from November to December and the major rainy season is from March to May. However, the bridge site is in a semiarid area where precipitation is low and the number of rainy days is small. Attention should be paid more to adverse effects of rainfall on the upstream side of the Athi and Tiva Rivers because rain can cause high water in the river, making construction impossible or reducing the number of workdays. Construction of a cofferdam with steel-sheet piles is planned, so driving of steel-sheet piles most affected by the river flow rate and flow velocity should as a rule be done in the dry season. Once the cofferdam with steel-sheet piles is completed, other types of work may be implemented even in the rainy season though their operation ratios may vary.

It is better to start preparation and construction of the work base immediately after conclusion of the agreement with the Kenyan counterpart and contractors. Since a considerable number of days (about two months) is necessary for transfer of materials and equipment from Japan and third countries into Kenya, it is essential to fully utilize machinery owned by local contractors during the initial period after commencement.

2) Access to the site for transportation of construction materials and equipment

Transport of construction materials and equipment into the site is mainly by truck. Those whose procurement in Kenya is difficult will be imported from foreign countries. Materials and equipment transported by sea will be unloaded at Mombasa Port, while those transported by air will be unloaded at the Jomo Kenyatta International Airport, and carried to the site by land.

a) Inland Transportation route

Materials and equipment procurable in Kenya will be transported from Nairobi or Mombasa, the second largest city in Kenya. The distance is approx. 200km from Nairobi to Kibwezi where the road A-109 branches off from the road B-7, approx. 300 km from Mombasa, plus 30km to the Athi Bridge and a further 20km from there to the Ikutha Bridge.

Road B-7 is a road over which only crusher is laid, with a drift located at five to six points, so that concentrated rainfall may cause closing of the road from several hours to several days.

b) Sea route

All materials and equipment imported by sea from foreign countries are to be unloaded at Mombasa Port and transported by land as described above. In the case of procurement from Japan, a minimum 1.5 months is required from shipment from Japan to arrival at the site, plus taking custom clearance into account, so that it is crucial to place orders earlier.

c) Air route

When materials and equipment are imported by air from foreign countries, they will be transported via the Jomo Kenyatta International Airport to the site by land as described above.

d) Import procedures

To import materials and construction machinery not available or difficult to procure in Kenya, the procedure described below must be followed:

(1) Prepare, submit to the owner, and gain approval for the master list of materials and equipment to be imported
(2) Obtain approval of the Ministry of Finance and Planning for tax exemption on the basis of the master list
(3) Submit tax exemption application letter, together with the shipping papers, from the owner to the Ministry of Finance and Planning when imports of materials and

equipment have been decided. After examination, the Ministry of Finance and Planning issues a notice of approval of tax exemption to customs and the applicant. Taxes can be exempted at the time of customs clearance.

(4) For heavy machinery used during construction, import based on tax exemption is possible for re-exports. Note that a bond equivalent to the custom duty must be presented to customs at the time of import.

3) Land necessary for construction and transfer/removal of obstructions

Land acquisition for the work and transfer/removal of obstructions are included in the scope of work of the recipient government. The Roads Department of the MORPW, an implementing agency, will handle the procedures. Table 2-22 shows obstructions to be transferred. Utilities, such as electricity, water supply, gas, etc. are not in the neighborhood.

Table 2-22 Obstructions to be transferred

Obstructions to be transferred	Agency concerned
Private houses (removal): On the right bank of Athi Bridge	MORPW

4) Land for temporary facilities for work

Land for temporary facilities must be secured for installation of temporary buildings and equipment and for storage or materials and equipment during work. Table 2-23 shows candidate lands and applications that are currently planned.

Table 2-23 Land for temporary facilities for work

Candidate place	Application
Upstream on Left bank of Athi Bridge	Construction materials and machinery storage land、Girder manufacturing yard, Concrete plant, Rebar and form work yard
Upstream on Right bank of Ikutha Bridge	Construction materials and machinery storage land, Girder manufacturing yard, rebar and form yard

2-2-4-3 Scope of works

As shown in Table 2-24, work on the bridge main body, approach road, and revetment structures in this project are the responsibility of Japan. Removal of existing bridges and extension of the approach road on the left bank of the Athi Bridge are the responsibility of the Kenyan counterpart.

Table 2-24 Scope of works

	Work item	Content of the work
Responsibility of Japanese side	1. Bridge work All construction works related with bridges Superstructure, Substructure, Foundation, Bridge surface	-Athi Bridge Prestressed concrete four-span connected composite girder bridge -Ikutha Bridge Prestressed concrete three-span connected composite girder bridge
	2. Approach road work Transition to existing road Earthwork, Base course, Road structures	-Athi Bridge (including connection to the existing road) Right bank: Approx. 340m entire route Left bank : Approaching section approx. 200m only -Ikutha Bridge Right bank: Entire route, approx. 177m Left bank : Entire rout, approx. 268m
	3. Revetment work Revetments around abutments of two bridges	Wet Masonry
Responsibility of Kenyan side	1. Demolishment of existing bridges Demolishment and transport of existing superstructure Demolishment existing piers	-Athi Bridge Superstructure, all piers, A2 abutment and 20 m embankment section -Ikutha Bridge Superstructure, all piers
	2. Road improvement work Extension of approach road on the left bank of Athi Bridge	Approx. 3km long approach road after the 200m of the bridge up to connection with existing B7 road. The existing local road will be improved to the B7 road.

2-2-4-4 Consultant Supervision

Japanese staff responsible for the Project Management (general affairs), bridge (superstructure, substructure) and tender documents will execute duties up to detailed design, tender document preparation, and bidding after conclusion of the consultant agreement. During the period of construction, the consultant will dispatch the Japanese resident supervisor and the staff for supervision and guidance of major works to the site. Job assignments of main staff are as follows:

1) Detailed design and preparation of tender documents

- Project Manager: General affairs related to the detailed design, bidding, and supervision as a whole
- Bridge engineer : Design of the superstructure, substructure, foundation, temporary works, and works auxiliary to erection, preparation of drawings, and quantity calculation.
- Tender documents Engineer: Preparation of tender documents and contract during a period of detailed design and execution of duties related to bidding and contract.

2) Supervision

During the period of construction, a bridge engineer will be assigned in addition to the resident supervisor to ensure work quality, process control, and safety control.

- Resident Supervisor:
  The Resident Supervisor will be resident on the site from commencement to completion of construction, being responsible for technical duties such as quality, process, and safety controls as well as a series of clerical jobs. During the bridge construction period, the supervisor will be in charge of supervision and conduct an inspection on the bridge structure, road, pavement, and appurtenances.

- Bridge engineers:
  In charge of technical duties that require expertise such as quality supervision during prestressed concrete girders, prestressing supervision, erection supervision, and safety control for the bridge work.

This project covers construction of the bridge substructure, prestressed concrete superstructure, approach roads (for transition to the existing Roads), and revetment. The contractor will be requested to present preparatory plans on implementation, quality control, work progress, process, safety and hygiene, and procurement to the consultant for advance verification and approval of ensuring the quality of the structure and the safety during the period of construction.

The following are very important supervisory points for this project:

- Temporary cofferdam construction method during construction of the substructure
- Supervision of manufacture of prestressed concrete girders and prestressing of PC cables
- Erection of prestressed concrete girders using erection girders

2-2-4-5 Procurement plan

1) Labor conditions

Kenya is suffering economic stagnation due to delayed economic aid from foreign countries and international agencies as well as some outflow of foreign capital due to recent deterioration of security.

In this situation, the labor market is characterized by over-supply. This situation is favorable for obtaining unskilled laborers, skilled laborers, and construction technical workers with relative ease. However, laborers available near the site are unskilled. Skilled laborers such as carpenters, rebar workers, plasterers, electricians, can be found in large cities of Nairobi and Mombasa. Namely, a camp must be provided near the site before employing these skilled workers. Since they have no experience with prestressed concrete bridge construction technologies and special substructure work methods, it is indispensable to employ experienced workers from Japan or a third country for this type of work.

a) Technical workers

Among technical workers, those of engineer class are graduates from Nairobi University and Jomo Kenyatta Agricultural Engineering University. About 90 civil engineers graduate every year.

b) Laborers from third countries

In Kenya, there is usually a surplus of skilled and unskilled laborers. Basically, there will be no need to seek laborers from a third country. In addition, work permits are difficult to obtain for laborers from third countries.

c) Conditions of employment in Kenya

Conditions of employment for those engaged in construction in Kenya are stipulated in the Kenya Association of Building and Civil Engineering Contractors (KABCEC).

2) Construction materials and equipment procurement condition

(1) Construction machinery

Construction machinery includes that possessed by the government agency and that belonging to private enterprises. Generally, construction companies will conduct their work by using machinery in their possession. Leasing of machinery from private enterprises is also done.

There is a shortage of heavy machinery for bridge construction in Kenya and only a few skilled heavy machinery operators. Accordingly, it is mandatory that these be procured from a third country. Unless thorough maintenance is ensured for construction machinery, the work progress will be hindered.

Similarly, procurement of spare parts is difficult in Kenya. It is essential to procure required quantity in advance based on consideration of the work period and processes required for procurement from a third country.

(a) Construction machinery and plant held by the governmental agency

Construction machinery owned by the Kenyan Governmental agency is shown in Table 2-25. This cannot be leased to ordinary contractors. In certain exceptional cases, machinery for the project may be leased from a competent governmental agency. Private constructors generally cannot lease machinery.

If the machinery is possessed, detailed investigation is necessary to determine whether or not it is practically applicable.

Table 2-25 Construction machinery held by governmental agency

Machine	Type, specification, capacity	Quantity
BULL DOZER	D6	10
	D7	7
	D8	2
MOTOR GRADER	3.1 m	20
	3.7 m	10
WHEEL LOADER	1.5 m^3	10
DUMP TRUCK	5-10 Ton	30

(b) Construction machinery and plant that can be procured in Kenya

Ordinary construction machinery for road construction and building work can mostly be procured in Kenya, but there is almost no machinery for civil works, particularly, for construction of bridges. Besides, the available quantity is limited and the operating rate is extremely low. Machines may have to be brought into Kenya from third countries, and a sufficient quantity of replacement parts must be procured and prepared beforehand for works without time allowance for the period or bridge works.

Construction machinery procurable in Kenya is shown in Table 2-26.

Table 2-26 List of construction machinery procurable in Kenya

Name of machine	Type, specification, capacity	Quantity
BACK HOE	0.5m^3	10
BACK WHEELED	1.0 m^3	12
BULL DOZER	D5	1
	D6	10
	D7	7
	D8	7
MOTOR GRADER	3.1m	11
	3.7m	5
WHEEL LOADER	1.5m^3	7
	1.5-2.5m^3	6
	>2.5m^3	6
TRAILER	40 Ton	21
	40 Ton	20
COMPRESSOR	175 C.F.M	14
	175-350	18
DUMP TRUCK	5 Ton	5
	5-10 Ton	42
	10-16 Ton	10
	16 Ton	22
CONC. MIXER CAR	3-6m^3	3
VIBRATION ROLLER	5 Ton	11
	12 Ton	12
TYRE ROLLER	8-20 Ton	12
MACADAM RROLLER	10 Ton	12
ASPHALT PLANT	100Ton-200 Ton/H	4
DISTRIBUTOR	2000	1
	6000	5
TRUCK CRANE	10 Ton	3
CRAWLER CRANE	40 Ton	1
STONE CRUSHING	50 Ton/H	4
PLANT	100 Ton/H	1
GENERATOR	50 KVA	3
	50-100 KVA	7
	100 - 200 KVA	0
	200 KVA	6

(c) Construction machinery owned by foreign contractors

Principal machineries are owned by foreign contractors (Yugoslavia, Israel, UK, Italy). Note that most of them are used for specific projects and re-exported after completion according to re-export requirements.

(d) Construction machinery that must be procured outside Kenya

Procurement of special construction machinery is difficult in Kenya and, if procurement is possible, it is expensive, limited in quantity, and degraded. Therefore, procurement outside of Kenya is necessary to ensure smooth execution of the work. Table 2-27 shows machinery to be transported from outside.

Table 2-27 Machinery to be imported

Machine	Specification/capacity
Crawler crane	45Ton
Truck crane	25 Ton
Crane truck	6 Ton
Generator	45 KVA、100KVA、200KVA
Concrete plant	25-30m 3 /H
Concrete mixer	4.5-6.0m^3
Concrete pump vehicle	75m^3
Vibro hammer	1.0 Ton
Portal crane	5 Ton,120 Ton
Girder car	60Ton
Erection girder	120Ton
Grout mixer and pump	1 m^3
Prestressing jack and pump	200Ton class
Others	

(e) Maintenance of construction machinery

Maintenance is an extremely important factor that will determine the success of the project.

All raw material for fuels and oils/greases are to be imported by Kenya. Fuel supply is sufficient to meet the demand. As the site is distant from the city, it is necessary to construct storage facilities for each contractor at the site. An import plan must be established concurrently with machinery selection because certain machines use special

oils and grease.

Machine parts must be secured at the site after advance confirmation of machine models possessed by local contractors and even for machines that contractors bring into Kenya for use under lease over a long period of time. In addition, mechanics must also be resident at the site because failure of machinery may substantially affect the process.

(2) Construction materials

It is necessary to identify construction materials, that are procurable in Kenya and those that must be imported.

(a) Cement

There are two major cement manufacturers in Kenya: Humphreys (Mombasa) and EAPC (Nairobi). Both can produce cement of reliable quality that complies with BS, KS, and EN standards.

Since cement cannot be carried into the site in bulk, bagged cement will be carried by truck and stored in a cement warehouse at the site.

(b) Concrete

There is no company near the site that can produce and supply ready-mixed concrete.

Before start of construction, it is essential to procure a concrete plant from a third country for mixing at the site.

(c) Asphalt mixture

Enterprises that can produce and supply asphalt mixtures are shown in Table 2-28.

The distance to the construction site from Nairobi is about 200 km and the transport time will be three hours or more. Temperature drop during transport is inevitable, and thus an asphalt plant must be constructed near the site. Since this will cause an increase in the costs, it is necessary to consider other methods.

Table 2-28 Asphalt manufactures and capacity

Asphalt manufacturers and capacity	Plant location
Cresent Construction Co., Ltd. 20 Ton /h & 16 Ton /h	Militini
S.S.Metha Construction Co., Ltd. 50 Ton/h & 40 Ton /h (Mobile)	Kokotni（Near Mazeras）
Dhanjal Bros. Ltd 50 Ton/h & 30 Ton/h (Mobile)	Naliakani

(d) Steels（Steel bars and members）

Steel bars can be produced in Kenya. KUSCO in Mombasa produces steel bars 12 m in length and 8 – 32 mm in diameter in compliance with BS 449 standard. They can also obtain the required quality certificate.

However, special and large steels are not obtainable in Kenya and PC cables, earth-retaining members, and steel-sheet piles must be imported from Japan or a third country.

(e) Concrete aggregate and road embankment material, base course material

Concrete aggregate is available in Kenya. Stones of coarse aggregate quality are found near the site, but there is no crusher plant. Since the quantity is small, new construction of a plant will increase costs. Accordingly, these materials will be transported from a suburb of Nairobi, about 200km from the site.

The aggregate is completely free of problems in terms of specific gravity, water absorption, wear resistance, etc. for use in prestressed concrete.

Fine aggregate (sand) : Quality river sand is available near Kibwezi. As the truck is driven into the river to load quarried sand, quarrying becomes completely impossible during the rainy season and should be concentrated in the dry season. It is necessary to purchase them in principle.

Road embankment and
base course materials: Quality material is available near the site for embankment. For the subbase and base course, materials will be transported from Nairobi similarly to the case of concrete aggregate.

(f) Pavement material（bituminous material）

Eres Co. Ltd., Special Bitumens Ltd., and Shell produce and supply material that is satisfactory both in quality and quantity. Each company has also the means of transport to the site, supplying the material in bulk trucks and drums.

(g) Wood

Almost all wood needed is available in Kenya. Since they are irregular in dimensions, they have to be adjusted newly through planing after purchase. A great deal of the wood is deformed, so the sufficient loss factor should be taken into account. Plywood 12 mm and 15 mm thick for forms is readily available. The quality is relatively good and applicable for bridge construction. However, water-resistant form material is not procurable in Kenya. Therefore, there is a possibility to import them from a third country.

(h) Other construction materials

Concrete blocks and PVC pipes are supplied in sufficient quantity in Kenya. All others, particularly, special materials such as prestressing steels necessary for bridge construction must be imported. Table 2-29 shows suppliers of principal construction materials.

Table 2-29 Suppliers of principal construction materials

Construction material	Locally procured	Procured in Japan	Procured in a third country	Remarks
Cement	＊			
Concrete admixture		＊		
Steel bars	＊			
Structural steels		＊		
Prestressing steel wires		＊	＊	Made in South Africa
Bituminous materials	＊			
Crushed stone, sand	＊			
Ordinary wood	＊			
Form (plywood)	＊			
Falsework and scaffolding material	＊			
Expansion joint		＊		
Bearing support (rubber)		＊		
Railings	＊			

2-2-4-6 Quality Control Plan

Quality control of construction exerts considerable influence on the method of construction, safety, and durability of the structure. Therefore, adequate quality control is essential for each stage of construction.

Basically, bridge design standard in Kenya is based on the British standard. However standards have not been regulated adequately concerning quality control as Kenya Standards. Since this design, by compensating the live load in certain cases, is based upon Japanese standards, fundamentally Japanese control standards and test methods (JIS) will be conformed except for quality control of reinforcing bars procured locally.

1) Quality control

Quality control items of main construction works are summarized in Table 2-30.

- Earth works

  Earth works are applicable to the approach road section behind the abutment. A borrow pit will be secured in the neighborhood to provide embankment material. The base course will be of a granular base course and aggregates will be purchased.

- Concrete structures

As there is no concrete plant available in the neighborhood for the construction, a temporary concrete plant will be transported onto the site. Materials will be stored in a temporary stockyard, and an appropriate storage method must be established to prevent them from exposure to rainwater.

- Reinforced bars, form, and PC cable

Reinforced bars and form will be procured in Kenya while PC cable will be imported. It is essential to store this steel in an adequate stockyard for protection from rusting and mud adhesion.

- Prestressing of PC cable

Supervision of prestressing of PC cable is an important control item to ensure the specified structural performance of PC concrete structures. PC cable must be prepared in the presence of consultant engineers. This includes the supervision of prestressing equipment

- PC grout

PC grout is an important work to prevent rusting of prestressed steel. Thorough supervision is essential to ensure correct filling.

- Pavement construction

In this project, the earthwork consists of two layers; asphalt emulsion and gravel spray.

As the bridge section will be paved in concrete, it will be administered in accordance with the concrete structure control method.

Table 2-30 Quality control method (1/2)

Construction	Items concerned	Inspection, control test, etc.	Time of inspection/test
1) Earth work Filled-up ground, base course, backfilling of structures	Material Control	Soil test of embankment materials - Specific gravity of soil particles - Soil water content - Particle size of soil - Liquid, plastic limits of soil - Soil compaction -Dry density - CBR test	Before implementation
	Daily Control	Embankment construction test - Control of compaction density（sand replacement method, etc.）	Immediately after implementation Once a day for each implementation layer
2) Concrete structures	Batching Plant	Weighing equipment, mixing efficiency - Static load test - Weighing controller - Dynamic load test - Mixing efficiency	Before implementation、 Monthly（Every three months in the case of dynamic load）
	Materials	Cement, water - Checked by means of standard certificate Fine and coarse aggregate tests - Particle size - Specific gravity - Water absorption - Unit weight - Durability - Alkali-aggregate reaction	Before implementation and after change of materials
	Concrete standard test	Test mixing made to determine the mix proportion - Slump - Air content - Temperature - Strength of test piece	Before implementation
	Daily Control	Fresh concrete: - Air content - Slump - Temperature	Initial consecutive five units. Subsequently, every $50m^3$ and at preparation of sample
		Concrete casting method - Casting method - Consolidation - Order of Placing - Curing method - Curing method - Removal Laitance	Witness inspection at placement
		Concrete sample：・Sample compressive strength test - Preparation of the concrete control chart	Sample to be prepared once a day In seven and 28 days after placement
3) Reinforced bars, form, prestressed steel	Materials	Check reinforced bars and prestressed cable by means of the mill sheet issued by the manufacturer - Quality - Tensile test - Bending test	Before implementation
	Inspection of Works, Daily Control	The following checks should be made after assembly: - Material size - Dimensions - Layout - Lap length - Concrete cover - Fixing condition - Connection joint treatment condition	Before placement of concrete： 100% inspection for each placement area

Table 2-30 Quality control method (2/2)

Works	Items concerned	Inspection, control test, etc.	Time of inspection and test
4) Prestressing of PC cable	Concrete strength check	- Concrete sample compressive strength	Before prestressing
	Prestressing equipment	- Calibration of jack and pump	Before prestressing, Every 50-cable prestressing At change of combination of prestressing equipment
	Prestressing test	- According to the prestressing control chart	Before final prestressing
	Prestressing control	- Control of each cable - Control of cable group - Control of transverse prestressed cable	At prestressing Prestressing control chart
5) PC grout	Mixing design	- Consistency - Bleeding ratio - Expansion ratio - Strength - Total salt content	Before use
	Daily control	- Consistency - Temperature	Once a day, every five batches,
		- Bleeding ratio - Expansion ratio - Compressive strength	Once a day
6) Pavement (Double Surface Treatment)	Material control	Asphalt emulsifier test - Ordinary physical test (mill sheet) - Specific gravity	Before implementation
	Daily control at time of spraying	Spray amount inspection - Spray amount inspection	At implementation: Once a day for each implementation layer

2) Progress control

A sample of the progress control standard for each work is shown in Table 2-31.

Table 2-31 Progress control standard

Construction	Type	Item	Standard value	Remarks
Earth work	Base-course preparation	Design height	+2 cm～-5 cm	20m interval
		Width	More than the design value	
	Granular base course	Design height	±3 cm	
		Deviation from the design height at two points within 20 m distance	2 cm or less	
		Finish thickness	90% of design value	
		Width	More than the design value	
Foundation	Spread foundation	Base height	Less than the design height	4m mesh
Concrete structures	Footing	Design height	±5 cm	
		Thickness	±75 mm or ±3%	
	Piers, abutments, retaining walls	Plane position	±30 mm	
		Design height	-30 mm～+10 mm	
		Crown height, crown width	±30 mm	
		Section dimensions	-10 mm ～ +20 mm or±2%	
	Slabs	Bridge length	-25 mm ～ +30 mm	
		Width	0 ～ +20 mm	
		Slab/curb height	-25 mm～+25 mm	
		Thickness	0～+20 mm	
Prestressed concrete structures	Post-tensioned girders	Member length	±(L-5)mm	L: Girder length (m)
		Section dimensions	+(8+L/25) mm ～ -(5+L/40)mm	L：Length of each side (cm)

2-2-4-7 Implementation schedule

This project will be implemented as shown in the schedule below after conclusion of the Exchange of Notes.

1) Implementation design

The detailed design will be created and the design and tender documents prepared after conclusion of the consulting agreement.

2) Tender and Contract

The project agreement will be directly between the Government of Kenya and the Japanese contractor. Selection of the contractor will be based on open tendering addressed to Japanese contractors.

Examination items will be discussed beforehand with the Government of Kenya for approval, then prequalification of contractors will be conducted. A consulting company on behalf of the implementing agency of the Government of Kenya will handle prequalification.

Tender opening and determination of the successful tenderer will be done in the presence of Government of Kenya staff, the consulting company, and tenderers, and witnesses representing JICA. The construction agreement will be concluded after tender evaluation and determination of successful tenderers.

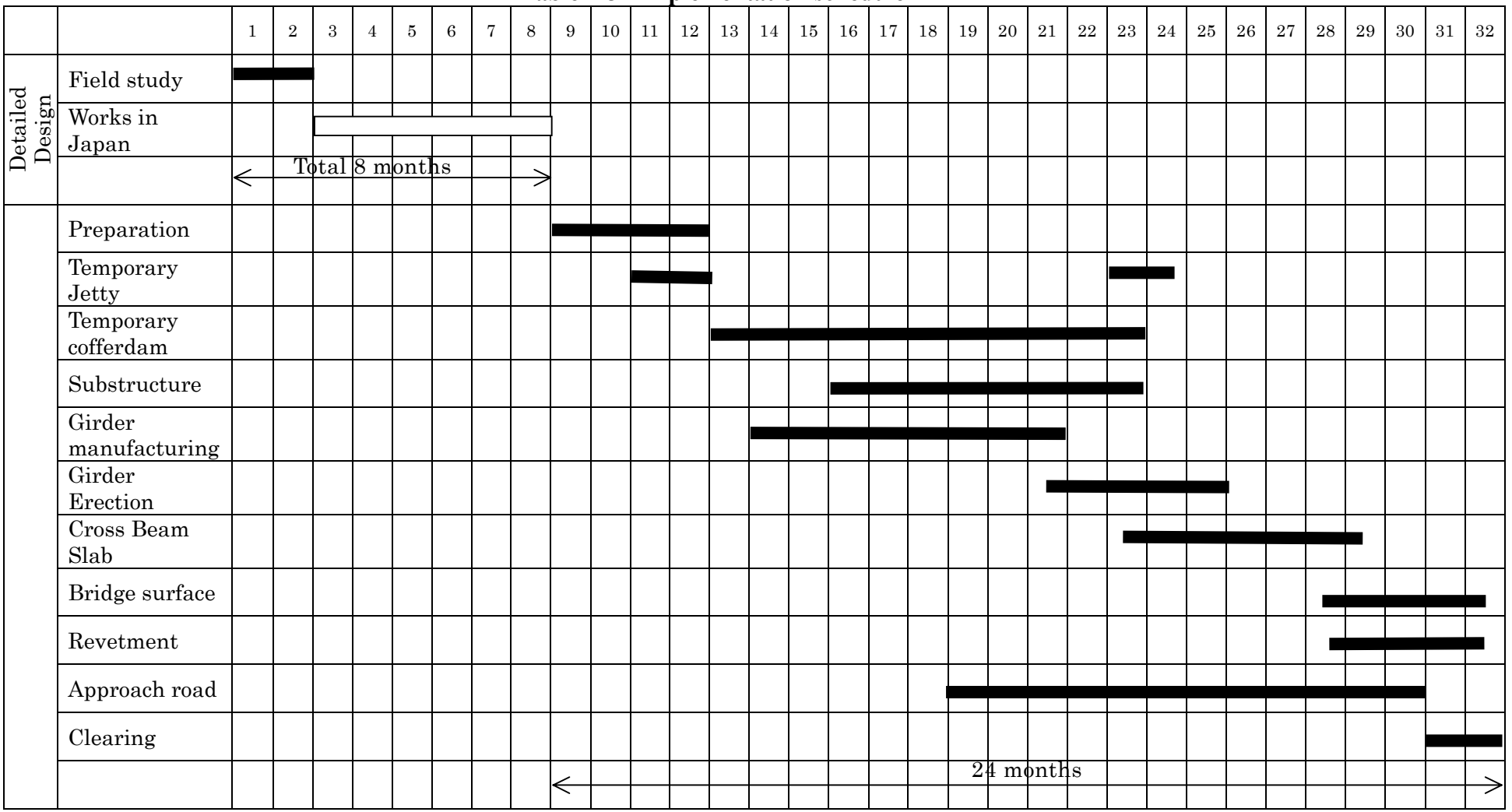
In parallel with the conclusion of the construction agreement, the Government of Kenya will conclude the banking arrangement as soon as possible with a Japanese authorized foreign exchange bank in order to receive aid funds from the Government of Japan and to make payment to Japanese contractors. The banking arrangement is the basis on which the Government of Kenya will issue the Authorization to Pay (A/P) necessary for reception of aid funds from the Japanese Government and advance payment to contractors as well as for application to obtain an export license from the Ministry of Economy, Trade and Industry (METI). This is also necessary to commence project implementation simultaneously with the conclusion of the construction agreement.

Then, approval of the contract is necessary. Approval means that the Japanese Government must verify the appropriateness of the contract as an object of this grant aid. It is also a prerequisite for the contract to go into effect. Specifically, the Ministry of Foreign Affairs receives the contract from the Government of Kenya via overseas establishment, determining the appropriateness of approval. The Japanese contractor will implement the contract after receiving the approved contract and Authorization to Pay (A/P).

3) Construction work

The construction work begins with preparation, followed by permanent works of bridge such as temporary landing bridges (such as jetty and platform), substructures, superstructure (girder manufacturing, girder erection, and bridge surface), and approach road work. Then, after auxiliary work such as revetments, etc., materials and equipment related to that work will be removed. There are two rainy seasons near the site; a minor rainy season from November to December and a major rainy season from March to May. The implementation schedule must take this into account. The project implementation schedule is shown in Table 2-32.

Table 2-32 Implementation schedule



2-3 Obligations of Recipient Country

2-3-1 Obligations of Government of Kenya

1) Necessary measures

In the implementation of this Project, the Kenyan Government is required to undertake such necessary measures as the following:

(1) To secure land necessary for the sites of the Project and to clear, level and reclaim the land prior to commencement of the construction,
(2) To ensure all the expenses and prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the this Project,
(3) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in Kenya with respect to the construction,
(4) To accord Japanese nationals, whose services may required in connection with the construction, such facilities as may be necessary for their entry into Kenya and stay therein for performance of their work,
(5) To bear the commissions, such as advising commission of A/P and payment commission to a bank of Japan for the banking services based upon the B/A.

2) Obligatory work

The following works shall be implemented by the Kenya counterpart

(1) Land acquisition

The area of the land to be expropriated for the project is estimated as follows:

a. Bridge and road construction site related to this project
   The right-of-way with 20 m width on both sides of new road center line is required.

Athi Bridge (30m distance between new road center and old one)

(20+15)m x (220+160)m + (20+15)m x 100m / 2 = 15,050 m^2

Ikutha Bridge (15m distance between new road center and old one)

(15 +0)m x (100 + 80)m + (15+0)m x (180+120) / 2= 4,950 m^2

Total Approx. 20,000 m^2

b. Temporary site yard

Girder fabrication yard and contractor office and camp yards are required at both bridge construction sites for the Project. Candidate site to be on left bank of the Athi River and right bank of the Tiva River both on upstream side of existing bridges. These Temporary yards will be prepared by a contractor.

(2) Demolishment of old bridges

This project includes construction of a permanent bridge on the upstream side of a neighboring bridge. Since this is planned on the basis of removal of the existing bridge, and the river flow is hindered if above bridge is not removed, problems arise in terms of new bridge construction, river bank maintenance, and safety of flood control for neighboring areas.

This removal need not be executed before start of the bridge construction work, and any delay in removal will not adversely affect the project. The Kenyan counterpart has the technical capacity to remove the old bridge. In consequence, it is therefore reasonable to expect the removal work to be one of obligations of the counterpart.

Table 2-33 Demolishment of old bridges

Bridges	Superstructure	Substructure
Athi Bridge	Bailey bridge 108m long	Pier 3 no. Abutment 1 no.
Ikutha Bridge	Bailey bridge 75m long	Pier 3 no.

(3) Extension of approach road for the Athi Bridge

The existing road B7 on the left bank of Athi Bridge bends with a small curve toward the downstream side after the bridge. It is impossible to connect the approach road while employing the road alignment complying with the design speed of road B7. Road improvement of the section is essential if the desired alignment is to be achieved, which involves the work of the 3 km section including the existing ordinary road which is running in a straight line from the bridge. Improvement of road B7 has been implemented sequentially from the north end by the Kenya counterpart. It is therefore reasonable that road improvement itself be handled as a part of B7 improvement work series by the Kenya counterpart, instead of relying on this grant aid. In addition, there is no technical problem.

2-3-2 Project Costs Estimation

1) Expenses by Kenyan Government

Table 2-34 Estimated project cost

Classification of project cost	Cost (million Ksh)	Remarks
(1) Demolishment of old bridges	5.00	
(2) Improvement of existing local road for extension of approach road on left bank of Athi River	10.00	
(3) Land acquisition cost, compensation	0.04	
Total	15.04	

2) Estimate conditions

- Time of estimate : March, 2001
- Exchange rate : 1 US $ = JPY 114.95
  : 1 Ksh = JPY 1.46
- Implementation period : The construction will be divided into two Phases. Detailed design and work periods are as shown in the implementation schedule.
- Others : This project will be implemented according to the Grant Aid system of the Japanese Government.

2-4 Project Operation Plan

Upon completion of the project, the Kenya Government will undertake maintenance of the constructed two bridges. The road maintenance system in Kenya is now renewing, and it supposed to be construct a bridge maintenance system.

1) Maintenance method

In order to effectively utilize the limited budget of the Kenyan Government, a maintenance method based mainly on daily and periodical inspections will be employed. The method will enable early damage detection and early countermeasures, thereby preventing major damages, such as scour of the abutment by river water, collapse of revetment, collapse of slope, etc.

(1) Daily inspection

Patrols with inspection vehicles is made on the route concerned about once a month, with check made on the road surface, shoulder, and slope. The condition is to be recorded on recording paper and reported to the engineer. The personnel assignment consists of a two-person system, including an inspector and recorder.

(2) Periodical inspection (after the rainy season)

In-depth inspection is made for adequate appreciation of the situation mainly at locations where no abnormality requiring emergency countermeasures has been reported and on the shoulder of the route immediately after completion. As regards the bridge, a survey must be made not only of the bridge main body, but also of the revetment condition around abutment, river scour condition, sand sedimentation in river bed, etc. after lowering of the water level. On the basis of survey reports, the engineer judges the necessity of repair and arranges for immediate repair if necessary.

2) Maintenance system

In order to establish the maintenance system as described above, the plan must be prepared within the maintenance system of MORPW.

(1) Establishment of the daily inspection group in the site area. The group composition is as follows:

- Engineer : 1
- Inspector, recorder : 2
- Record storage : 1

(2) The system must be developed for rapid action on the basis of daily inspection results when minor repairs become necessary.

(3) A maintenance manual must be developed, and personnel training of inspector and recorder must be made according to the plan through dispatch of an expert.

(4) The record of daily inspections must be data-based for use to achieve accurate estimates of required maintenance costs.

(5) A system must be established for storage of drawings (as-built drawings, property register) of this project for use in future repairs.

3) Operation and maintenance costs

The content and costs of maintenance services expected for the ten years after completion of this project are shown in Table 2-35.

Table 2-35 Maintenance services and costs

Interval	Description	Cost (Ksh)
Every year	(1) Bridge surface repair	2,032 m^2 x 200 = 406,400
	(2) Revetment repair	= 50,000
	Sub total	456,400
Every five years	(1) Bridge surface repair	1,032 m^2 x 500 = 1,016,000
	(2) Medium scale repair of revetment	= 200,000
	(3) Bridge facility repair	= 200,000
	Sub total	1,416,000
Cost for ten years		7,396,000

The required maintenance cost is estimated as follows:

7,396,000 Ksh ／10 years 739,600 Ksh／year

The ratio of the above maintenance cost （739,600 Ksh／year） to the existing maintenance cost （48,926,000 Ksh／year） is approx. 1.5%. Its ratio to the existing

MORPW budget（ 23,284 million Ksh／year）is approx. 0.003%.
Accordingly, it is judged that the Kenyan counterpart can bear the maintenance cost through priority allocation of maintenance costs to the management of the bridge concerned.

2-5 Other Relevant Issues

1) Environmental Management Plan

Environmental Impact Assessment (E.I.A.) is, becoming increasingly important in guiding environmentally friendly and sustainable decisions since road and bridge developments are quite common, such projects should be subjected to EIAs.

Section 58 of the Environmental Management and Coordination Act of 1999 requires that all projects listed under the second schedule be subjected to Environmental Impact Assessment. Roads / Bridges maintenance and rehabilitation activities are categorized under the transportation thematic area hence the need for the Environmental Impact Assessment (EIA).

Environmental Impact Assessment refers to the critical examination of the likely effects of a project on a particular environment and subsequent identification of mitigation measures required to ensure sound and sustainable development.

This Project being considered is the reconstruction of the existing structure from temporary bailey bridges to wider high capacity carrying concrete deck bridges. Therefore the proposed project will not result in significant impacts and such as it will not require a full Environmental Impact Assessment but a partial initial Environmental Impact Assessment.

The Environmental Impact Assessment Study for this Project has been carried out by MORPW and the draft report has been submitted to the JICA Study Team on July 2001.

The Environment Management Plan EMP for this Project was proposed in this report as below.

The Environmental Management Plan in roads and bridges project is one of the most important outputs of the Environmental Impact Assessment, which ensures that implemented mitigation measures are sustained. It outlines the monitoring frequency and individual institutions to undertake required actions. Some of the mitigation measures will be implemented under the contractual arrangements during construction

while some will be implemented during periodic and routine maintenance.

The EMP outlined in Table 2-36 is in respect of the environmental concerns, which have been derived from the potential impacts. The contractor shall minimize these negative impacts according the EMP during construction.

Table 2-36 Environmental Management Plan

ENVIRONMENTAL CONCERNS	MITIGATION MEASURES	RESPONSIBILITY		MONITORING MEANS	MONITORING FREQUENCY
		DURING RECONSTRUCTION	DURING MTCE		
Open Quarry and Borrow pits	Rehabilitate to acceptable standard -Edge trimming -Tree planting -Grassing -Fencing	Contractor , Consultant & EU / DRE and owner / PMO /DECO	DRE / EU Provincial Bridges Officer (PBO) and owner	Visual Inspection	Before the contractor leaves the quarry/ borrow pit and during hand over.
Oil spillages	Minimize oil spillage from source	Contractor/ Consultant/ DRE /EU	Not Applicable	By observation during Impromptu visits	Once a month during construction period
Soil erosion	-Grassing, Scour checks -Gabion works, cut water -Drains, prudent converting	Contractor/ Consultant /EU /DECO	DRE, PBO & EU	By observation	Four (4) times a year throughout the project life
Public Health (Health & Sanitation)	Public awareness campaign -Provide adequately located and maintained latrines -Create awareness on HIV/AIDS and other related diseases -Avail health care services	Contractor/ MOH, NGO, Provincial Administration, Media, DRE /DECO	MOH, NGO & Provincial Administration	By consultation	Bi-Annually
Pollution (Air, Dust & Noise)	Regular watering of the working areas, encourage use of dust masks, roadside tree planting, enforcement of standards	Contractor/ Consultant/ DRE /EU/ KEFRI/ DECO	Not Applicable	By observation	During site visits and also surprise visits
Road safety	Public awareness campaigning, road signs instillation and regular bush clearing on shoulders of approach roads which should be pedestrian friendly	Contractor/ Consultant/ Road safety Unit / Provincial Administration	DRE	By observation	Monthly
Disturbance of Aquatic life	Reduce period of working on substructure by better planning. Minimize concrete spillage and other debris.	Contractor/ Consultant/ DRE /EU/ DECO	Not Applicable	By observation	Monthly
Displacement of residents within new road reserve	Provide adequate compensation	GOK(MORPW)/ Contractor/ DLO /Provincial Administration	Not Applicable	By consultation	Monthly in site meetings
Disturbance of watering patterns of domestic animals	Provide alternative drinking points and or water troughs	Contractor/ Consultant/ Local population	Not Applicable	By observation & consultation	Monthly during the site meetings
Flora/ fauna disturbance	Minimize disturbance of vegetation, replant vegetation after reconstruction	Contractor/ Consultant/ DRE /EU/ DECO	Not Applicable	By observation	Every four (4) months
Increased litter from road users	Public awareness campaign provision of litter bins near the bridge and in public vehicles	Contractor/ Provincial Administration/ DRE/ EU/ DECO	DRE / EU	By observation	Every four (4) months
Encroachment by upcoming infrastructure such as market Kiosks	Enforce the existing laws and create awareness	DRE/ Provincial Administration	DRE/ Provincial Administration	By observation	Every four (4) months
Negative cultural influence	Create awareness	NGO/ Provincial Administration/ Community leaders/ DSSO	DSSO/ DRE/ DO	Consultation with the community	Bi-Annually

2) Improvement of B7 Road

Concerning the access road on the left bank of Athi Bridge, it is necessary to improve about 3 km of existing regional road and connect it to the existing B7 road to ensure smooth traffic flow. If this improvement is not completed until the completion of this reconstruction of bridges, the approach road on the left bank of the Athi Bridge will be ended at scheduled to be done by Kenya as a part of this project, and it is necessary to ensure that such improvements are continued without fail.

Reconstruction of Athi and Ikutha Bridges will enable the passage of large vehicles exceeding 25 tons. To enhance the effectiveness of both bridges, there is a need to continually ensure the implementation of improvement of the whole of B7, which is currently under way. Improvement of this road includes improvement of the road alignment as a B-standard road, conversion from the unsealed to asphalt paved road, and improvement of drift at crossings of small rivers that are the largest bottleneck in traffic flow.

There are about 12 drifts that require improvement. Reconstruction to the relevant pipe culvert, box, or small-medium bridges is necessary if smooth traffic flow is to be secured. Though the Kenya counterpart can perform construction of these structures technically, securing of the financial resources will be the largest issue to overcome.

(1) Extension of the access road on the left bank of Athi Bridge
- Improvement of the existing road of approximately 3 km as an access road to existing B7 road

(2) Implementation of the improvement plan of the whole of B7 road
- Improvement of road alignment appropriate as the B class road
- Rehabilitation of drifts at crossings of small rivers
- Improvement of road pavement：Improvement from gravel road to asphalt concrete paving.