MINISTRY OF TRANSPORT AND HIGHWAYS
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

No. 1

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

JULY 1998

JAPAN INTERNATIONAL COOPERATION AGENCY
ORIENTAL CONSULTANTS CO., LTD.

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PREFACE

In response to a request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a basic design study on the Project for Reconstruction of Bridges and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sri Lanka a study team from March 8 to April 11, 1998.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka for their close cooperation extended to the teams.

July, 1998

Kimio Fujita
President
Japan International Cooperation Agency

July, 1998

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Reconstruction of Bridges in the Democratic Socialist Republic of Sri Lanka.

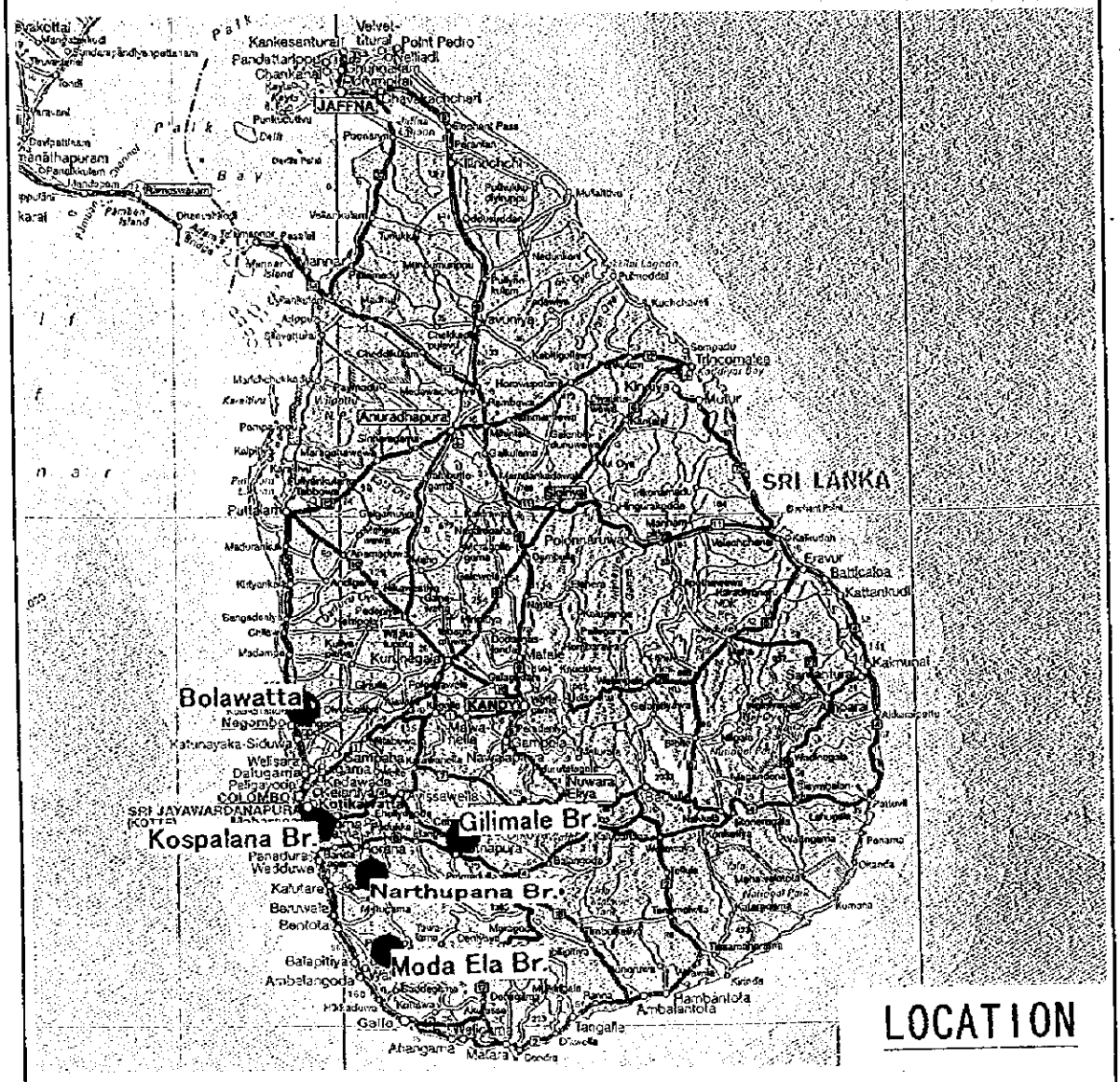
This study was conducted by Oriental Consultants Company Limited, under a contract to JICA, during the period from March 2 to July 31, 1998. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Sri Lanka and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

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

Very truly yours,

Kazuro Yanagida
Project manager,
Basic design study team on
the Project for Reconstruction of Bridges
in the Democratic Socialist Republic of
Sri Lanka
Oriental Consultants Company Limited

SRI LANKA



LOCATION

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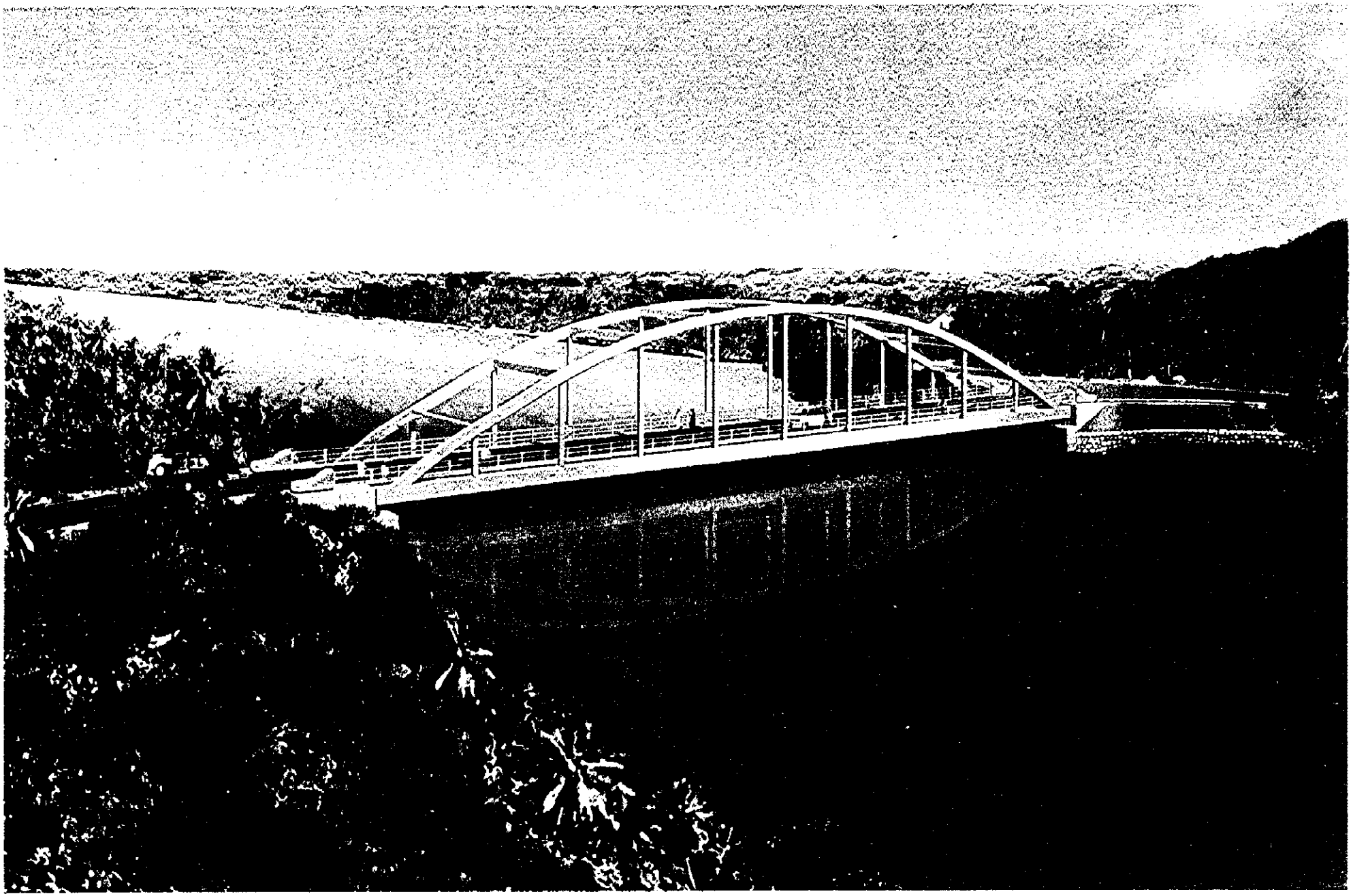


Definition and Abbreviation

A Authorities and Agencies

ADB	Asian Development Bank
IDA	International Development Association
JICA	Japan International Cooperation Agency
JRA	Japan Road Association
MOFP	Ministry of Finance & Planning
MOTH	Ministry of Transport & Highways
OECF	The Overseas Economic Cooperation Fund
RDA	Road Development Authority

B Other Abbreviations

A	Drainage Area
AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ADL	Actual Datum Level
@	At the rate
B	Name of Live Load in Japan
B/D	Basic Design
BS	British Standard
C	Coefficient of Drainage Area in Sri Lanka
CBR	California Bearing Ratio
℄	Center Line
cm	Centimeter
cm^2	Square centimeter
D/F	Draft Final Report
Ec	Young's modules of Concrete
Es	Young's modules of steel
Esp	Modules of elasticity
Ex	Existing
El	Elevation
H	Height
HB	Name of Live Load in BS5400
HWL	High water level
I	Coefficient of impact
Kgf/cm^2	Kilogram force per square centimeter
Kgf/cm^3	Kilogram force per cubic meter
Kgf/mm^2	Kilogram force per square millimeter
Km	Kilometer
Km^2	Square kilometer
Km/h	Kilometer per hour
L	Length of Span
l	Length of Span
LWL	Low water level
m	Meter
M	Million
m^2	Square meter

m^3	Cubic meter
m^3/s	Cubic meter per Second
MSL	Mean sea level
N	N-value or Number of wheel load application
n	Number of Ratio of Es to Ec
%	Percent
Φ	Diameter
PC	Prestressed concrete
Q	Discharge volume of River
RC	Reinforced concrete
Rs.	Rupees
S	Scale
SD	Deformed Steel
σ ck	Allowable stress of concrete
σ sa	Allowable stress of steel bar
t	Ton or Thickness
W	Width
W.L	Water level

page

Chapter 1

Chapter 1: Background of the Project

In Sri Lanka, the domestic transport network has been developed to transport agricultural products of the growing plantation agriculture. For domestic (inland) transport, road transport has replaced transport by rail recently. Actually, as of 1995, about 95% of freight and about 84% of passenger transports are dependent on the road. The roads are indispensable for the economy and civil life and the road traffic volume has increased remarkably in these days. Yet the road improvement is lagging behind the growth of traffic volume and strengthening of their traffic capacity and establishment of their safety are subjects to overcome by Sri Lanka.

The total length of the Sri Lanka's road network runs up to about 100,000 km, but the length of the arterial roads or national highways of Class A and B is as small as about 11,000 km. Though most of national highways are paved, various road facilities are heavily obsolete. Sri Lanka places a stress of its policy on rehabilitation and maintenance of existing facilities while depending on the foreign aid on funds. On the other hand, Sri Lanka is proceeding with improvement and capacity strengthening of arterial roads as well as with development of principal road network (construction of new roads, etc.).

Bridges of this country are substantially outdated. Actually, 250 bridges of more than 4,000 bridges all over the country are said to need rehabilitation. Because of budgetary and technical restrictions, only 20% of them have been rehabilitated. In spite of considerable damage and increased possibility of collapse, remaining bridges are being used as they are. There are also many bridges that can not cope with growing traffic demand because of their narrow width. Besides, most of these bridges are small with a length of several ten meters as rivers in Sri Lanka are mostly small. In

any case, these bridges are used daily by regional residents and their rehabilitation is required because of their needs as a social infrastructure.

In view of the situation described above, the government of Sri Lanka (Ministry of Transport and Highways, with project implemented by the Road Development Authority) requested the Japanese government to establish Master Plan related to the national bridge rehabilitation project in 1990. The Japanese government conducted the Project Formation Study on roads and bridges during a period from February to March, 1993 while conducting further Master Plan Study on Bridge Development from March 1995 to July 1996. Later, in May 1997, on the basis of the Master Plan, the government of Sri Lanka requested the Japanese government to implement rehabilitation under grant aid on 13 of 35 bridges with the top priority (requiring rehabilitation by the year 2000) among 100 bridges that were covered by the above Master Plan Study. In response, the Japanese government dispatched the preliminary study team in November 1997 to Sri Lanka for discussions with the Sri Lankan government. As the result of investigation, five bridges for the full-scale investigation was selected from among those 35 bridges with top priority in terms of the urgency of replacement, degree of damage, and socio-economic contribution. It was decided to conduct the full-scale investigation on these bridges.

Chapter 2

Chapter 2: Contents of the Project

2-1 Objectives of the Project

For domestic (inland) transport of Sri Lanka, road transport has replaced transport by rail. Actually, about 95% of freight and about 85% of passenger transports are dependent on the road. As the road traffic volume has increased remarkably in these days and the roads are indispensable for the economy and civil life, strengthening of their traffic capacity and establishment of their safety are subjects to overcome by Sri Lanka.

Plantations of the tea, an export source of revenue of Sri Lanka, are scattered within many basins along medium to small rivers originating in the central mountainous district. To connect these plantations, there are bridges at 4,400 locations (1997) all over the country. Most of them are of a small scale, with the average bridge length being about 13 m/bridge. Besides, they were constructed mostly around 1950 when Sri Lanka was still a self-governing dominion of UK, and are currently outdated. About 250 bridges require rehabilitation. In line with increase in the land transport volume, rehabilitation of bridges is an urgent subject to ensure the safety.

Japan conducted the "Project Formation Study" in 1993 and the development study called "National Bridge Rehabilitation Plan" from March 1995 to July 1996. Development investigation included listing of bridges that are obsolete and must be rehabilitated to ensure the safety in addition to ensure compatibility with increase in the traffic demand. Later on, Sri Lanka requested the Japanese Government on rehabilitation, under grant aid, of 13 bridges out of 35 bridges in the list, which were judged to be the top priority ones (requiring rehabilitation by the year 2000). In

response to this request, the Japanese Government dispatched the preliminary study team for investigation in November 1997. As a result, five bridges to be covered by the full-scale investigation were selected from among top priority ones. This project will replace five bridges concerned in consideration of the damage, urgency of replacement, maintaining of the economy of the regional society of the area around bridges.

2-2 Basic Concept of the Project

For the geometric design, width composition, and pavement construction concerning roads and for the design standard including the live load concerning bridges, the Sri Lanka standards were compared with those of Japan to select the optimum standard. In addition, the optimum plan for the bridge location, bridge length, clearance under girder, superstructure, substructure, foundation type, and revetment and bed protective works was selected through comparison in terms of the economy, maintenance, construction, and workability. The length of access road was planned minimum.

As a result of above discussions, the basic concept of this plan was determined to ensure the safe and smooth traffic appropriate to the traffic volume by type in the area concerned through rehabilitation of bridges concerned.

2-3 Basic Design

2-3-1 Design Concept

1) Considerations for basic design

(1) Dry and rainy seasons

Dry and rainy seasons must be taken into account. Though varying depending on the district concerned, there are two rainy seasons usually; April to June and September to November. In particular, the rainfall concentrates in May and October. Even during the rainy seasons, heavy rains do not continue every day, but there are days with and without rain. Namely, the rainfall is concentrated in certain days. There are two dry seasons, each between rainy seasons. In particular, due attention must be paid during the work of Kalu River because the precipitation is the highest in October during the rainy season. Embedment of the substructure must also be protected thoroughly from erosion or scour by water flow.

(2) Establishment of the road and bridge standards based on consideration of present and future road utilization condition

Though the road concerned is a national highway, it is ranked at "B" and increase in the traffic volume is inevitable. Bridges constructed from 1930s to 1950s have been damaged increasingly due to increasing traffic volume and growing vehicle weight. RDA has completed the Bridge Design Manual in November 1997, which is based on BS and assumes the HB loading to be 30 units. This live load appears to be smaller for each span more or less than the B loading currently employed in Japan, as shown in Fig. 2.3.1. Since heavy vehicles are increasing as Sri Lanka's road condition shows, the B loading of the Japanese standard will be employed for this project.

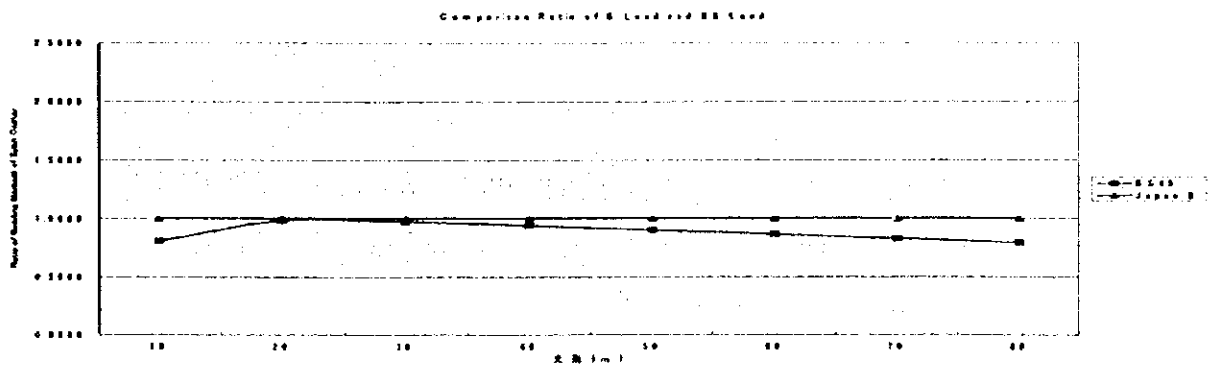


Fig. 2.3.1 Comparison of live load

(3) Effective utilization of the local equipment and materials

Little construction equipment has universal applicability. Heavy machines, such as cranes, etc. are limited in quantity, and difficult to be leased if the work is congested. They have to be brought into Sri Lanka from the third country or Japan. Accordingly, identification of locally available equipment and material and their utilization as much as possible will be planned in the study.

(4) Technical level of local engineers

There are large numbers of superb local engineers, mainly of RDA, who have rich field experiences. Considering that there is a government-owned PC girder manufacturing company and that domestic workers erect them, the technical level is high. However, there appear to be gaps in terms of quality when compared with advanced countries. Since the foundation, substructure and the access road as well as the superstructure will be of a PC girder or steel girder type in this project, the local engineers will be allowed to be thoroughly familiar with these structures while ensuring comprehensive technology transfer. Note that superior engineers will be dispatched from Japan for this portion of the work.

(5) Easy to maintain construction and type

RDA earmarks the appropriate sum in the budget for maintenance of the road and bridge in Sri Lanka. But the budget concerning roads and bridges, including the maintenance costs, account for about 2% of the national budget. Accordingly, this project will involve study on the method, construction, material, and type, which enable cost reduction for maintenance in the future, so that national highways ranked at A and B can be maintained without fail.

(6) Reduction of the work costs and the work period

The study will be made on the work content which can reduce the work costs and work period as much as possible to comply with the intent of our grant aid.

2) Applicable standard

As a rule, the Sri Lanka standards will be applied as the road design standard. As described previously, the Sri Lankan government agreed to use the B loading of Japan for the live load. It was also agreed to employ following Japanese standards on bridge design and river management as governing standards and codes;

Specification for Highway Bridges and its Explanation, Japan Road Association, December 1996

Explanation: Cabinet Order concerning Structural Standards for River Management Facilities, etc., Sankaido, March 1978

Table 2.3.1 shows the summary.

Table 2.3.1

Road	Geometric design of road	Sri Lankan standard
	Width composition	"
	Pavement construction	"
Bridge	Bridge design standard	Japanese standard
	Cabinet Order concerning River management	Japanese standard (no equivalent Sri Lankan standard

3) Design standard

(1) Road

a) Geometric design of the road

For roads to be rehabilitated according to this standard design, the geometric design standard of Table 2.3.2 will be employed. Design standard: Sri Lankan Road Design Standard (Draft)

Table 2.3.2 Values employed in the road geometric design

Item		Unit	Design value	
Traffic volume		Units/day	<300	300~25,000
Design speed		Km/h	50	70
Roadway width		M	3.7	7.4
Plane	Minimum radium	M	270	
Vertical profile	Minimum curve length	M	85	
	Minimum curve length	M	980	
	Maximum gradient	%	5	

b) Road width composition

The width of the existing access road is narrower than the bridge width, so that the access road will be constructed from the bridge side. The road width of the two-lane ordinary section with sidewalks is shown in Fig. 2.3.2.

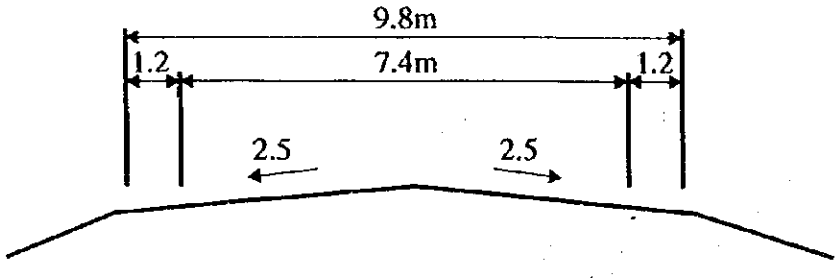


Fig. 2.3.2 Road width composition

c) Pavement design standard

For the pavement design, the Sri Lankan Road Design Standard (Draft) or asphalt concrete pavement will be applied.

(2) Bridges

a) Applicable standard

Japanese standards; Specification for Highway Bridges and its Explanation (December, 1996) by Japan Road Association will be employed.

b) Load conditions

Loads used for bridge design is classified into principal, secondary, and particular loads according to the acting method, loading frequency, and effects on the bridge. Each load has following features:

a. Principal load

① Dead load

The dead load is a total weight of the self weight of the bridge and the attachment, which is calculated on the basis of the unit volume weight shown in Table 3.3.3.

Table 2.3.3 Unit volume weight of materials

Material	Unit volume weight (kgf/m^3)	Material	Unit volume weight (kgf/m^3)
Iron, cast steel	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		

Note that the Kospalana bridge will have the water supply pipe (800 mm in dia., or equivalent). The design must there take this weight into account beforehand.

② Live load

B load (Load equivalent to 25 tons , which is applied to the principal trunk road)

③ Impact

The impact coefficient "i" is calculated by an equation shown in Table 2.3.4.

Table 2.3.4 Calculation of the impact coefficient

Type	Impact coefficient i	Remarks
Steel bridge	$T = \frac{20}{50 + \text{span length}}$	Not affected by whether the T load or L load is used.
Reinforced concrete bridge	$T = \frac{20}{50 + \text{span length}}$	T load used
	$T = \frac{7}{20 + \text{span length}}$	L load used
Prestressed concrete bridge	$T = \frac{20}{50 + \text{span length}}$	T load used
	$T = \frac{10}{25 + \text{span length}}$	L load used

④ Prestress force

⑤ Effect of concrete creep

⑥ Concrete drying shrinkage

⑦ Ground pressure

⑧ Water pressure

⑨ Buoyancy or uplift

b. Secondary load

This load must always be taken into account for combination of loads:

① Wind load

Considering the topographical situation, the wind load complying with the Japanese standard will be applied to the Narthupana bridge.

② Effect of temperature change (According to the air temperature fluctuation of Sri Lanka)

Concrete: ± (average 35℃, maximum 50℃, and minimum 20℃)

Note that 0.1 of the dead load or equivalent will be considered as a shoe horizontal component due to temperature change.

③ Effect of the earthquake

There is almost no observation record of the earthquake in Sri Lanka. Accordingly, the effect of earthquake is not taken into account.

c. Particular load

Particular loads are those to be taken into account depending on the bridge type, construction type, and bridge point condition of this project:

① Load during construction

② Effect of movement of the fulcrum

③ Braking force

④ Collision load

c) Increase in the allowable stress due to combination of loads

Increase in the allowable stress due to combination of loads is shown in Table 2.3.5.

Table 2.3.5 Increase in the allowable stress due to combination of loads

Load combination	Increase coefficient
Principal load	1.0
Principal load + temperature load	1.15
Principal load + braking force	1.25
Principal load + collision load	1.5
During construction	1.5

d) Superstructure design conditions

① Bridge type: Concrete and steel bridges

② Live load: B load.

③ Width composition: As shown in Table 3.3.7

④ Horizontal alignment: The Moda Ela bridge is to be diagonal by considering the river flow direction.

⑤ Crossing gradient: 2.5%

⑥ Bridge surface pavement: Asphalt pavement 50 mm

⑦ Attachment: Weight of water supply pipe (800 mm in dia) to be added to the weight of the Kospalana bridge

⑧ Erection method: Erection with truck crane and cable erection

e) Substructure design conditions

① Substructure type

Abutment: Inverted T abutment

Pier: Pile bent type (Kospalana Bridge)

Embedment: Footing levee crown will be embedded by 2.0 m from the riverbed to prevent erosion and scour by the river, except for the rock mass portion

② Foundation

Direct and pile foundations will be used.

f) Revetment and bed protection design conditions

Judging from interview on the flood condition and in-site investigation, flooding of rivers is attributed to followings:

① Collapse of upstream bank, projection of the abutment into the river, and rising river water level due to rain (Bolawatta, Moda Ela, Narthupana bridges)

② The road is located on the base of mountain, which suffers increase in the flow rate due to rain running down the steep slope (Gilimale bridge)

These are main factors to cause erosion of the river (natural) revetment, flooding of the

bridge and surrounding roads, and collapse of the abutment and slope.

In view of above description, the following design conditions will be applied to the revetment and riverbed protection works according to the Cabinet Order concerning Structural Standards for River Management Facilities, etc. (Japan). Note that mats and gabions will be used which are readily available.

③ Bank protection

The height of bank protection is set according to the above Cabinet Order by adding the value exceeding those values shown in Table 2.3.6 to HWL.

Table 2.3.6 Height of bank protection

Planned precipitation flow rate (m^3/s)	200<	200≦ <500	500≦ <2000	2000≦ <500	5000≦ <10000	≦10000
Standard value (m)	0.6	0.8	1.0	1.2	1.5	2.0

- Planned precipitation flow rate <200m3/s:Moda Ela, Bolawatta, Gilemale, Kospalana bridges

  500 m^3/s </= planned precipitation flow rate < 2000 m^3/s:Narthupano bridge

- The installation range will match the topographical situations.

④ Bed protection work

Judging from the in-site investigation, the bed protection work will be provided to around abutments and piers before and after the bridge, except for the rock mass portion.

(3) Materials used and basic strength

a) Concrete

The design standard strength and Young's modulus of concrete are shown below:

① Design standard strength (28-day strength)

PC girder :$\sigma ck=350kgf/cm^2$

RC slab, Cross beam, RC girder :σ ck=240kgf/cm^2

RC sidewalk, railing :σ ck=240kgf/cm^2

Abutment :σ ck=210kgf/cm^2

Piles :σ ck=240kgf/cm^2

② Young modulus

Design standard strength (kgf/cm^2)	210	240	350
Young modulus (kgf/ cm^2)	2.35×10^5	2.5×10^5	2.95×10^5

b) PC steels

PC steel twisted wire :T – 12.7 mm

Ultimate strength : 190kgf / mm^2

Yield strength : 160kgf / mm^2

Relaxation ratio : 5 %

Young modulus : Esp = 2.0×10^6kgf / cm^2

c) Reinforcement

Standard : SD295, SD345

Yield strength : 3000kgf / cm^2

Young Modulus : Esp = 2.0×10^6kgf / cm^2

Young modulus ratio : n = 2.1×10^6 kgf / cm^2

d) Steels

Standard : SS and SM

Young modulus : Esp = 2.0×10^6kgf / cm^2

2-3-2 Basic Design

1) Design plan

(1) Rehabilitation policy

As a result of in-site investigation on bridges concerned, it was judged that five bridges must be replaced by shifting the existing bridge position or the center of the bridge. The rehabilitation policy based on each in-site investigation result of bridges is shown in Table 2.3.7.

2) Bridge location

On the basis of in-site investigation result and by considering the existing topographical and surrounding environmental conditions, and possibility of traffic control, the bridge center will be shifted as shown in Table 2.3.8.

Table 2.3.7 Bridge location

Name of bridge	Shift distance	Remarks
Moda Ela bridge	Slightly toward downstream side	To smoothen the horizontal alignment of the existing road
Bolawatta bridge	Slightly toward downstream side	To smoothen the horizontal alignment of the existing road
Narthupana bridge	11m toward upstream side	To use the existing bridge as a bypass in view of the topographical conditions
Gilimale bridge	8m toward the downstream side	To use the existing bridge as a bypass in view of the topographical conditions
Kospalana bridge	3m to the north	To smoothen the horizontal alignment of the existing road.

3) Bridge length

The bridge length must be determined with due consideration of location characteristics, such as upstream and downstream river widths, river flow capacity, scour condition around abutments and position of existing abutments, flood record, etc. In order to prevent adverse effect on the cross-sectional area of a river and scouring due to river

runoff when piers are constructed, the bridge length is calculated while minimizing construction of piers in rivers. The span length must be more than the value calculated in Fig. 2.3.3 according to the Cabinet Order Concerning Structural Standards for River Management Facilities, etc. of Japan while taking the surrounding topography into account.

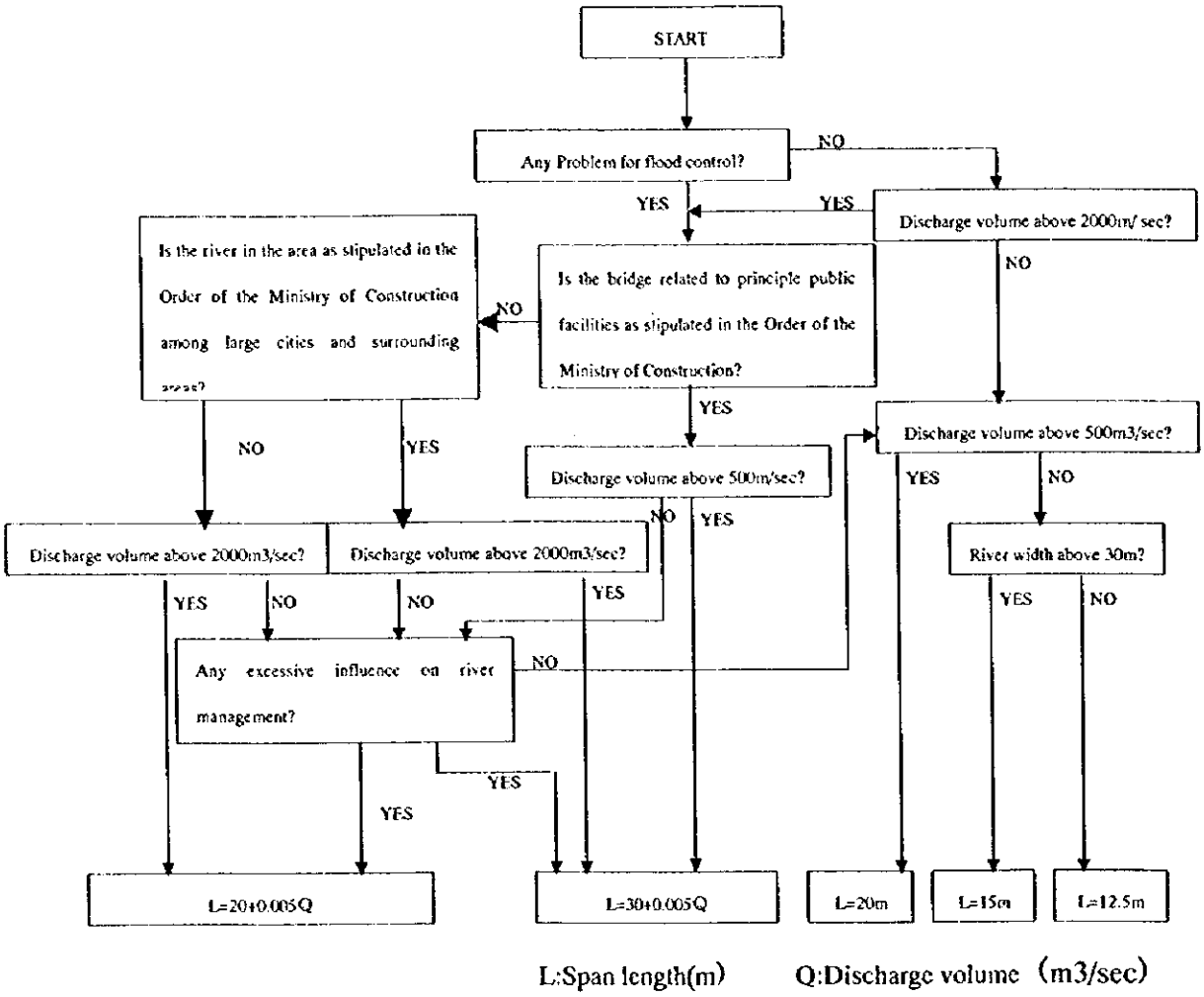


Fig. 2.3.3 Calculation of the span length

Table 2.3.8 Design Concept

Bridge Name	Actual	Existing Width	Design Concept	Planned Location
No. 31 Moda Ela Bridge		3.5m Bridge Length : 12.2m	9.8m 1.2m 3.7m 3.7m 1.2m Carriage Way: 2 Lanes Sidewalk : Consider in the future Bridge Length : 14.0m	Existing
No. 32 Bolawatta Bridge		3.7m Bridge Length : 10.2m	9.8m 1.2m 3.7m 3.7m 1.2m Carriage Way: 2 Lane Sidewalk : 2 x 1.2m Bridge Length : 14.0m	Existing
No. 33 Narthupana Bridge		3.6m Bridge Length : 68.85m	9.8m 1.2m 3.7m 3.7m 1.2m Carriage Way: 2 Lane Sidewalk : 2 x 1.2m Bridge Length : 75.0m	Upstream side
No. 38 Gillimale Bridge		3.5m Bridge Length :17.0m	6.1m 1.2m 3.7m 1.2m Carriage Way: 1 Lane Sidewalk : 2 x 1.2m Bridge Length : 25.0m	Downstream side
No. 70 Kospalana Bridge		5.9m Bridge Length : 43.5m	9.8m 1.2m 3.7m 3.7m 1.2m Carriage Way : 2 Lane Sidewalk : 2 x 1.2m Bridge Length : 42.0m	Existing

4) Design high water-level

a) Flood run-off and channel discharge capacity calculation methods

To estimate the flood discharge at a bridge location, the empirical equation used by RDA and the method using a rational formula are applied. For the Narthupana bridge, the flow rate determined on the basis of the level observation record on the downstream side will be referred to. The flood discharge result is shown in Table 2.3.9.

Table 2.3.9 Flood discharge

No. of Bridge	Name of Brodge	Drainage area (km^2)	Past Record of Max. Discharge Volume (m^3/s)	Discharge Volume Calculated by RDA (m^3/s)	Discharge Volume Calculated by Manning Formula (m^3/s)
31	Moda Ela	3.34	–	14.5	17.5 ~ 26.5
32	Bolawatta	23.4	–	53.2	38.3 ~ 57.7
33	Narthupana	2576.4	1670.7	1601.6	–
38	Gilimale	7.79	–	33.4	62.9 ~ 93.4
70	Kospalana	56.3	–	95.6	128.6 ~ 194.0

(Note 1) Existing maximum flood discharge at the water level station (Putupabula Station, the drainage area 2597.8 km^2) of Kalu River.

(Note 2) Ryves's empirical equation : $Q=C*A^{2/3}$

(according to Essentials of Bridge Engineering)

Q: Maximum flood discharge (m^3/s)

A: Drainage area (km^2)

C: Topographical condition of the river drainage basin and coefficient related to the location of the drainage basin

C = 6.5: Flat drainage basin near a coast

C = 8.5: Drainage basin located within 25 - 50 km from the coast

C = 10.0: Restricted drainage basin near a hilly district

b) Maximum flood level

The maximum flood level at the bridge location will be established on the basis of the inventory data of RDA and the hearing data conducted during this study. The information collected concerning the maximum flood level is shown in Table 2.3.10.

Table 2.3.10 Clearance under Girder

No. of Bridge	Name of Bridge	Information from RDA	Information of Interview Floodmark and hearing result of this in-situ study (Distance to the flood level under the girder)
31	Moda Ela	Nothing	Flooding of the living rooms up to about 5 cm in residences on the downstream side on the left bank in 1992 (hearing result) (0.0 m; as converted to the height from under the girder)
32	Bolawatta	1.6m up from road surface	Flooding to +1.50 m from the road surface (during flood of Maja River in 1978) and the level under the girder (hearing result)
33	Narthupana	0.65m (4 March, 1989) 0.50m (8 August, 1989) 1.20m (21 September, 1991)	About 1.50 - 1.80 m (hearing result and floodmark on the right bank) About 0.30 m (hearing result on the left bank)
38	Gilimale	Nothing	About 2.0 m above the pier foundation (hearing result) (1.40 m as converted to the height from under the girder)
70	Kospalana	1.30m (28 February, 1994)	About 0.30 m above the pier foundation (hearing result) (1.80 m: as converted to the height from under the girder)

c) Hydraulic study (flood level, etc.) at existing bridges

The result summarized on the basis of cross-sectional and longitudinal profiles of the channel at existing bridges is shown in Table 2.3.11.

Table 2.3.11 Hydraulic study result at existing bridges

Name of bridges (Bridge No.)	Eda Mola (No.31)	Bolawatta (No.32)	Nathupana (No.33)	Gilimale (No.38)	Kospalana (No.70)
Drainage area (km^2)	3.34	23.4	2576.4	7.79	56.3
Discharge Volume (m^3/s)	Less than 200	Less than 200	More than 500~ less than2000	Less than 200	Less than 200
Clearance	0.60	0.60	1.00	0.60	0.60
Planned river width	12.50	12.50	72.00	24.00	70.00
Bridge surface height	ADL 99.91	MSL2.80	ADL100.51	ADL101.01	ADL100.20
Bridge girder height	0.50	0.65	0.75	0.50	0.60
Clearance under girder	ADL99.41	MSL2.15	ADL99.76	ADL99.61	ADL99.60
Past record of clearance	0.0	0.0	0.50	1.50	1.30
Past record of HWL	ADL99.41	MSL2.15	ADL99.26	ADL99.01	ADL98.30
Planned flood level	ADL99.41	MSL2.15	ADL99.26	ADL99.01	ADL98.30
Planned water depth	2.77	3.15	15.55	3.73	4.25
River-bed height	ADL96.64	MSL-1.00	ADL83.71	ADL95.28	ADL94.05

5) Clearance under girder

From hearing and fact-finding study, flooding, with the water level rising under girder had ever overtopped five of bridges concerned. In other cases, flood woods blocked the channel at the bridge position, causing scour of the area around abutments, resulting in crack in a part of abutments.

Accordingly, the clearance under girder in compliance with the standard established on the basis of the Cabinet Order of Japan will be employed. Relationship between the design flood discharge and clearance under girder must be more than the values specified in Table 2.3.12.

Table 2.3.12 Relationship between design flood discharge and clearance under girder

Design flood discharge Q (m3 /s)	Q<200	200≦Q <500	500≦Q <2000	2000≦Q <5000	5000≦Q <10000	10000< Q
Clearance under girder (m)	0.6	0.8	1.0	1.2	1.5	2.0

6) Bridge type

The bridge type will be selected while paying due attention on following fundamentals:

① Easy to maintain structure

- The steel bridge may suffer shortened service life due to corrosion of steel materials. Such corrosion must be prevented by applying the paint over the steel surface.
- Painting to the steel materials require periodical treatment, resulting in increased maintenance costs.
- The concrete bridge is free from surface corrosion and does not cause increase in the maintenance costs.
- Accordingly, the concrete bridge is advantageous in terms of maintenance.

② Low cost and superior economical feasibility

- Generally, the steel bridge tends to be higher in the unit price than the concrete bridge.
- This is due to expensiveness of material import and painting treatment.
- The concrete type with less import materials is economically advantageous.
- Generally speaking, the reinforced concrete bridge will be economically advantageous up to the bridge length of about 15 to 18 m.
- Note that even the concrete type may have different economical feasibility depending on the bridge length.

③ Type employing materials procurable in Sri Lanka

- Principal materials (part of aggregates, cement, and reinforcing bars) must be easily

available.

- Abundant materials can be procured and material availability after construction must be easy.

- The use of domestically produced materials will reduce the standard costs.

④ Type with a few special equipment, which ensures high technology transfer effect

- Employment of large number of local workers will offer economical effects, such as measure against unemployment, etc.

- Transfer of various Japanese technologies to local engineers will help them behave independently.

a) Superstructure type

Selection of the bridge type of whether the superstructure should be of a concrete or steel is made in this project while taking following points into account:

- Economical feasibility and workability including work costs of substructure and foundation

- Type with easy and inexpensive maintenance

- Use of the bridge and technology transfer in Sri Lanka

- Topographical condition and stream flow

For bridges concerned in this project, the flow velocity in the rainy season is basically high considerably, so that pier construction within the channel will be avoided as much as possible. The bridge length is as shown in Table 2.3.12, and the optimum bridge type is closely related to the bridge length.

It is clear that the concrete bridge is less expensive in maintenance than the steel bridge. In the past, Sri Lanka constructed concrete bridges mainly while using steel bridges for heavy vehicles (railway bridges). As maintenance on steel bridges will become increasingly necessary, thorough technology transfer will be necessary.

b) Substructure type

Following points will be taken into account when selecting the substructure type, particularly, the abutment:

- The abutment front wall is planned so that the bridge axis becomes normal to the channel. In addition, due attention will be paid on prevention of scour and the protection around abutment.
- The abutments will be of a construction safely resistant against flowing water at the flood stage. The adequate embedment will be secured according to the flow velocity and river bed soil quality. Floods in the past caused scour around the abutment frequently. Accordingly, embedment will be made so that the top of the footing will be minimum 2.0 m from the river bed.
- The most economical inverted T type will be employed for abutments.
- The economical pier type most stable against scour will be employed.

Table 2.3.13 Standard applicable span

Type		Span (50m, 100 m, 150 m)	Girder height/span ratio
Steel bridge	Simple composite girder		1/18
	Simple girder		1/17
	Continuous girder		1/18
	Simple box girder		1/22
	Continuous box girder		1/23
	Simple truss		1/9
	Continuous truss		1/10
	Deck Langer girder		1/6.5
	Deck Lohse girder		1/6.5
	Arch		1/6.5
PC bridge	Pretensioning girder		1/15
	Hollow slab		1/22
	Simple T girder		1/17.5
	Simple composite girder		1/15
	Continuous composite girder		1/15
	Continuous composite girder		1/16
	Simple box girder		1/20
	Continuous box girder (cantilever type)		1/18
	Continuous box girder (support type)		1/18
	π type rigid frame		1/32
RC bridge	Hollow slab		1/20
	Continuous spandrel-filled arch		1/2

c) Foundation type

The bearing layer for bridges of this project is distributed widely over the depth. The foundation when the bearing layer is shallow will be the spread foundation while the foundation when it is deep will be the pile foundation. Among RC, PC, H steel, steel pipe, cast-in-place piles shown in Table 2.3.14, the cast-in-place piles are chosen in view of following reasons.

① Relatively long and advantageous in terms of workability and economy

② Easy work in the field

③ Because there will be no effect of earthquake, concrete piles may be used.

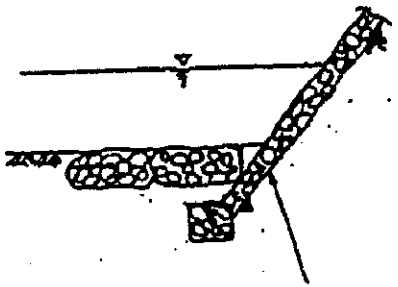
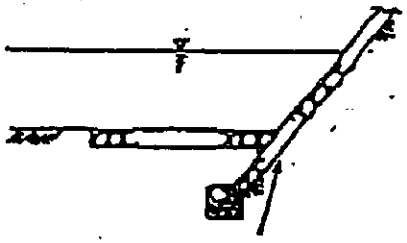
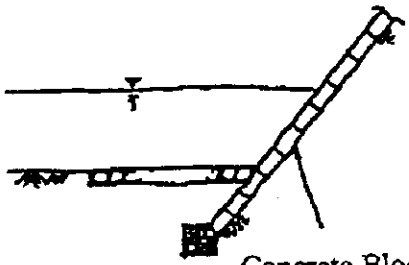
Table 2.3.14 Features of applicable pile types

Pile type	Applicable pile length	Supply route	Characteristics
RC pile	About 5 – 10m	Manufacturing possible in Sri Lanka	· Since the driving method will be employed, this type of piles may be applied generally to the softer upper statum and bearing statum depth of about 10m. · Applicable when vertical and horizontal loads are small · Due attention must be paid on damage (crack, etc.) during pile driving. · Difficult joint treatment · Slightly advantageous in terms of economy
PC pile	About 30m	Import (Thailand, Singapore, Japan)	· Since the driving method will be employed, this type of piles may be applied generally to the softer upper statum and bearing statum depth of about 30m. · Applicable when vertical and horizontal loads are small. · Higher concrete strength when compared with RC piles, resulting in less damage during driving, such as crack, etc. · Slightly advantageous in terms of economy.
H steel pile	About 30m	Import (Thailand, Singapore, Japan)	· Applicable even when the pile is long because welded joint present not much problem · Applicable when vertical and horizontal load is small. · Slightly advantageous in terms of economy
Steel pipe pile	15 – 60m	Import (Thailand, Singapore, Japan)	· Applicable even when the pile is long because welded joints present not much problem. · Advantageous when vertical and horizontal load is large. · Slightly disadvantageous in terms of economy
Cast-in place concrete pile	15 – 60m	Procurable in Sri Lanka (Possible if the excavation machinery is available)	· Applicable even when the pile is long because joints present not much problem. · Advantageous when vertical and horizontal load is large. · Slightly advantageous in terms of economy.

d) Revetment and river bed protection work type

The channel is determined by revetment and river bed protection works. They will be constructed to stabilize the channel and to ensure the safety of bridges. Basic concept is shown in Table 2.3.14-2.

Table2.3.14-2 Comparison Table of River Bank Protection

	Alternative 1: Gabion	Alternative 2: Stone Riprap	Alternative 3: Concrete Block Pitching
General View			
Structure	– There are two types which are cylinder and mattress, made from wire mesh. – The structure is flexible. ○	– The stones should be regularly set. – The structure is not flexible. △	– The concrete block should be regularly set. – It needs the leveling gravel under the concrete black. – The structure is not flexible. △
Construction	– It is easy to make the gabion because of setting the stones in the wire mesh. ○	– After the ground was grading , the stone riprap are set. And the stone are connected by mortar or concrete. – It needs the curing period for mortar or concrete. △	– After the ground was grading , the concrete blocks are set. And the concrete blocks are connected by mortar or concrete. – It needs the curing period for mortar or concrete. △
Maintenance	– Easy because of stone ○	– Difficult to set the same shape stone △	– Difficult to set the few concrete blocks ×
Economy	1.00 ×	1.20 ○	1.30 ×
Evaluation	○	△	×

7) Basic construction and dimensions

a) Moda Ela bridge (No.31)

① The ground is relatively soft.

② The river is watered even during the dry season, but there is almost no flow.

③ The abutment position will be extended to the revetment slope, so that it does not hinder the river flow.

④ The road alignment on the right bank is extremely winding.

⑤ Considering the vertical alignment of the road before and after the bridge, the road surface can not be raised much from the existing level. Accordingly, the girder construction with high girders is less advantageous than the slab construction.

⑥ The cost of steel bridge will increase due to repainting requirement for maintenance purpose. Accordingly, the concrete construction will be advantageous.

Therefore, the concrete culvert, PC pretension slab, or RC hollow slab bridge will be chosen. Considering the road alignment, the bridge will be a skew bridge of about 60 degrees.

Comparison of construction types is shown in Table 2.3.15.

As a result, it was decided to employ the concrete culvert type as the optimum bridge type.

Table2.3.15(1) Comparison of Superstructure of Moda Ela Bridge(No.31)

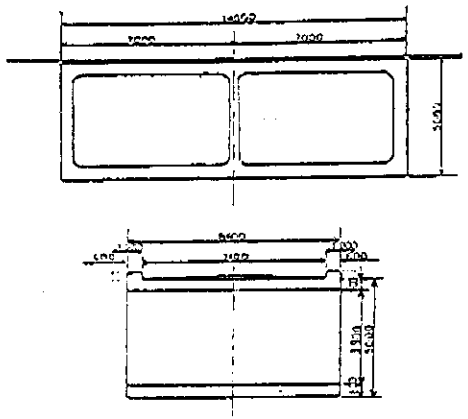
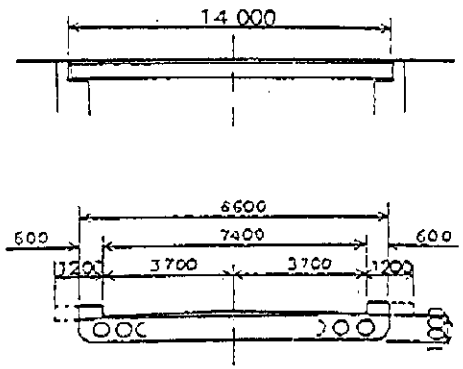
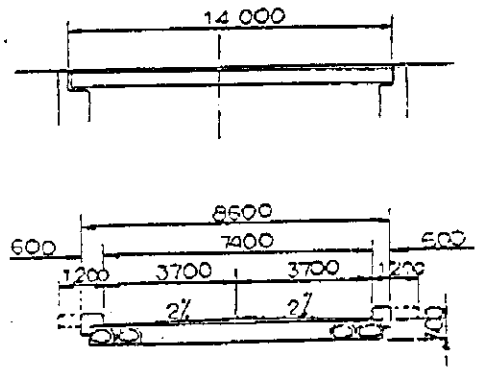
	Plan 1 : R C box culvert	Plan 2 : RC hollow slab bridge	Plan 3 : PC hollow slab bridge (pretnsioning)
Schematic diagram			
Structural characteristics	◆Rational structure to support without pile foundation though the ground is soft. ◆Slabs can be thinned, so that the roadway surface can be set to the lowest level. ◆Easy structural calculation. ○	◆ Thick slabs, making a bridge according to this plan the heaviest. ◆ Similar to the above, that is, thick slabs cause the roadway surface to be set tot the highest level. ◆ Pile foundation structure. ×	◆ Slab thickness can be made smaller than the case of Plan 2. ◆ Slab weight is smaller than the case of Plan 2. ◆ Lateral tightening with PC steel wire necessary. ◆ Pile foundation structure. △
Workability	◆ Sheet pile cofferdam is necessary to exclude river flow. ◆ During he work period, the river must detour the construction site. ◆ The work period will be shortest. ○	◆ Cast-in concrete used according to the all-staging method ◆ Sheet pile cofferdam is necessary to exclude river flow. ◆ The work period will be the longest. ×	◆ Manufacturing of the superstructure is possible while constructing the substructure. ◆ Sheet pile cofferdam is necessary to exclude river flow. ◆ The work period will be shorter than Plan 2. ○
Maintenance	◆ Easy because of concrete. ○	◆ Easy because of concrete. ○	◆ Easy because of concrete. ○
Economy	◆ Lowest cost 1.00 ○	◆ Highest cost 1.15 ×	◆ Slightly lower cost. 1 .10 △
Evaluation	○	×	△

Table2.3.15(2) Comparison of Superstructure of Moda Ela Bridge(No.31)

	Plan 4 : H-beam bridge		
Schematic diagram			
Structural characterristics	◆ Increasing the number of girders can reduce the bridge height. ◆ The rigidity is lower than the case of other plan. ◆ Pile foundation structure. △		
Workbility	◆ Manufacturing of the superstructure is possible while constructing the substructure. ◆ Slabs can be constructed with a suspended support using H-beams. ◆ The work period will be approximaely the same as for Plan 3. ○		
Maintenance	◆ Periodical painting is necessary, which pushes up the maintenance cost. ×		
Economy	◆ Slightly lower cost 1.10 △		
Evaluation	△		

b) Bolawatta bridge (No.32)

① The ground is relatively soft.

② The existing bridge has the abutment protruding into the river, hindering the flow.

③ The abutment position will be withdrawn to the width portion to ensure smooth river flow.

④ Construction of piers in the river will hinder river flow, increasing the opportunity of flood.

⑤ Accordingly, a single span bridge will be appropriate.

⑥ The concrete construction will be advantageous in terms of maintenance and economy.

⑦ Considering the vertical road alignment on the left bank, the road surface can not be raised much from the existing level. Accordingly, the slab bridge will be more advantageous.

As a result, the PC pretension slab or RC hollow slab bridge where the slab height is small will be appropriate. The reinforced concrete slab bridge will have higher girders, with increased embankment work of the access road, and is not economically feasible. Considering the road alignment, the bridge will be a right bridge.

Comparison between construction types is shown in Table 2.3.16. As a result, it was decided to employ the PC pretension slab type as the optimum bridge type.

Table2.3.16(1) Comparison of Superstructure of Bolawatta Bridge(No.32)

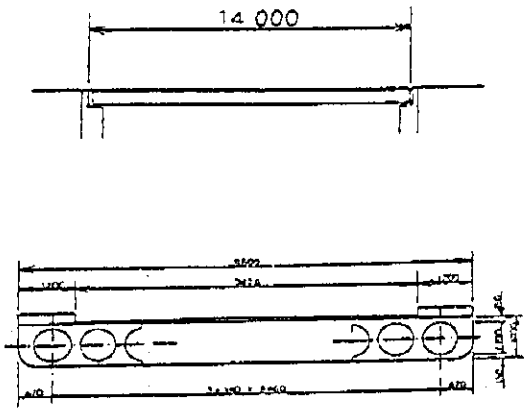
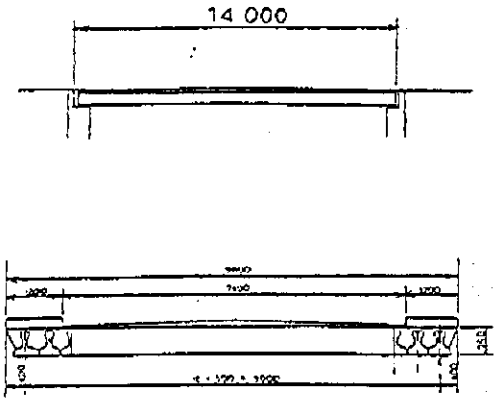
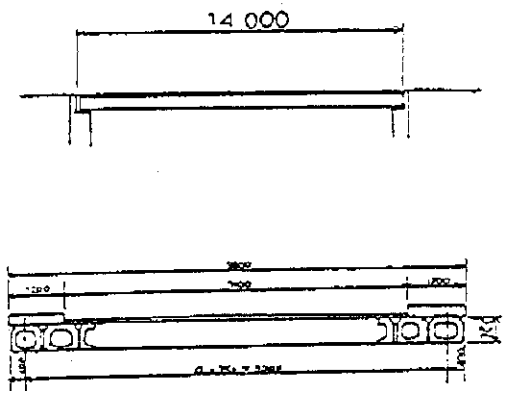
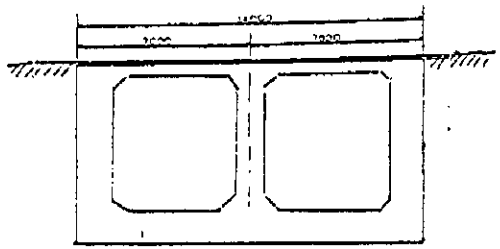
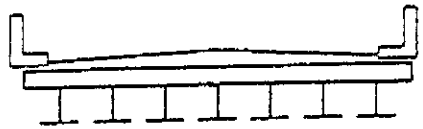
	Plan 1 : RC hollow slab bridge	Plan 2 : PC slab bridge (Pretension inverted – T girder)	Plan 3 : PC hollow slab bridge (Pretension hollow girders)
Schematic diagram			
Structural characteristics	◆ Heaviest due to thick slabs ◆ Similar to the above, that is, thick slabs cause the roadway surface to be set to the highest level. ◆ Pile foundation structure. ×	◆ Slab height is larger than the case of Plan 3. ◆ Girder weight is the lightest among these plans. ◆ Lateral tightening of girders not necessary. ○	◆ Structure with the lowest girder height. ◆ Lightest slab weight. Lateral tightening of girders necessary. △
Workability	◆ Cast-in-concrete used according to the all-staging method. ◆ The work period will be longest. ×	◆ Manufacturing of the superstructure is possible while constructing the substructure. ◆ Light girders ensure easy erection. ○	◆ Manufacturing of the superstructure is possible while constructing the substructure. ◆ The work period will be shortest.
Maintenance	◆ Easy because of concrete. ○	◆ Easy because of concrete. ○	◆ Easy because of concrete. ○
Economy	◆ Highest cost 1.10 ×	◆ Lowest cost 1.00 ○	◆ Slightly higher 1.05 △
Evaluation	×	○	△

Table2.3.16(2) Comparison of Superstructure of Bolawatta Bridge(No.32)

	Plan 4 : RC box culvert	Plan 5 : H-beam bridge	
Schematic diagram			
Structural characteristics	◆ Rational structure to support without pile foundation though the ground is soft. ◆ Slabs can be thinned, so that the roadway surface can be set to the lowest level. ◆ High structure, with thick side walls, which is structurally disadvantageous. △	◆ Increasing the number of girders can reduce the bridge height. ◆ The regidity is lower than the case of other plans. ◆ Pile foundation structure. △	
Workability	◆ Sheet pile cofferdam is necessary to exclude river flow. ◆ During the work period, the river must detour the construction site. But there is no space to allow detouring. ◆ Accordingly, the construction work must be made on one side at a time, resulting in deterioration of the work efficiency and increase in the work cost. ×	◆ Manufacturing of the superstructure is possible while constructing the substructure. ◆ Slabs can be constructed with a suspended support using H-beams. ◆ The work period will be approximately the same as for Plans 2 and 3. ○	
Maintenance	◆ Easy because of concrete. ○	◆ Periodical painting is necessary, which pushes up the maintenance cost. ×	
Economy	◆ Slightly higher cost. 1.05 △	◆ Slightly higher cost. 1.05 △	
Evaluation	△	△	

c) Narthupana bridge (No.33)

① The ground contains exposed rocks.

② The existing bridge has the abutment protruding to a great extend into the river, narrowing the river width.

③ The vertical alignment of the road must be determined by considering the maximum water level in the past.

④ Construction of piers in the river will hinder river flow, increasing the opportunity of flood. Accordingly, pier construction and installation of temporary equipment in the river are difficult.

⑤ Considering the maximum water level of the river and the vertical alignment of the road before and after the bridge, the through type superstructure will be advantageous.

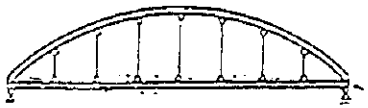
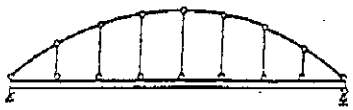
⑥ Considering the topographical and river condition, the appropriate bridge superstructure type will be of 75 m or more single-span through girders.

Judging from past record, the steel truss or arch construction will be appropriate. In the case of a concrete construction, the cable stayed bridge plan will be chosen because of workability.

Comparison between construction types is shown in Table 2.3.17.

As a result of comparison on the first stage, steel arch and truss bridges were left as candidates. Two types of arch bridge and the truss bridge were compared in terms of steel weight, and it was decided to employ the steel arch type (Lohse type) as the optimum bridge type.

Table2.3.17 Comparison of Superstructure of Narthupana Bridge(No.33)

	Plan 1 : Steel arch bridge (Lohse type)	Plan 2 : Steel arch bridge (Langer bridge)	Plan 3 : Steel truss bridge
Schematic diagram			
Structural characteristics	◆ Through bridge type employed to reduce the road vertical alignment. ◆ Main truss height is about 1.3m. ◆ Steel weight ; about 330 t ○	◆ Through bridge type employed to reduce the road vertical alignment. ◆ Main truss height is about 1.8m. ◆ Steel weight ; about 346 t △	◆ Through bridge type employed to reduce the road vertical alignment. ◆ Main truss height is about 1.3m. ◆ Steel weight ; about 345 t △
Workability	◆ Cable erection ◆ Anchor to support the cable necessary. ◆ The required quantity of erection materials is the smallest. ○	◆ Cable erection ◆ Anchor to support the cable necessary. ◆ The required quantity of erection materials is slightly higher. △	◆ Cable erection ◆ Anchor to support the cable necessary. ◆ The required quantity of erection materials is the same as for Plan1. ○
Maintenance	◆ Periodical painting necessary. △	◆ Periodical paining necessary. △	◆ Periodical painting necessary. △
Economy	◆ Low cost. 1.00 ○	◆ Highest cost 1.05 △	◆ Slightly higher cost 1.03 △
Evaluation	○	△	△

d) Gilimale bridge (No.38)

① There are many rolling stones on the ground surface. There exist partially weak layers till the bearing layer is reached.

② The existing bridge has the abutment protruding to a great extend into the river.

③ The abutment is planned to withdraw to the width portion to ensure smooth river flow.

④ Construction of piers in the river will hinder river flow. Accordingly, the single-span bridge will be appropriate.

In view of maintenance, the concrete bridge will be advantageous. The reinforced concrete bridge will have higher girders, with increase in the overall weight, exerting adverse effect on the substructure. This construction is therefore not economical and the PC type will be more advantageous.

Considering the current high water-level, the girder type superstructure will be appropriate. Judging from the span length, either a cast-in-place PC girder bridge or a composite girder bridge in which girders are fabricated beforehand, then transported and erected.

Comparison between construction types is shown in Table 2.3.18.

As a result, it was decided to employ the PC composite girder type as the optimum bridge type.

Table2.3.18(1) Comparison of Superstructure of Gilimale Bridge(No.38)

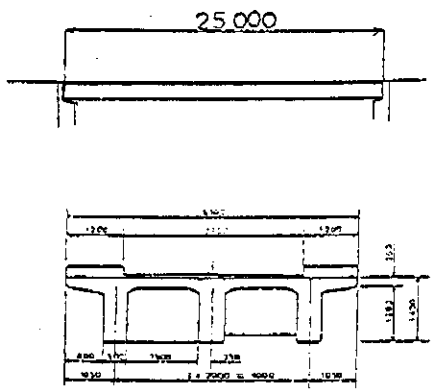
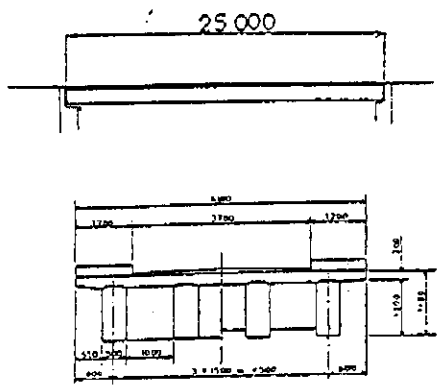
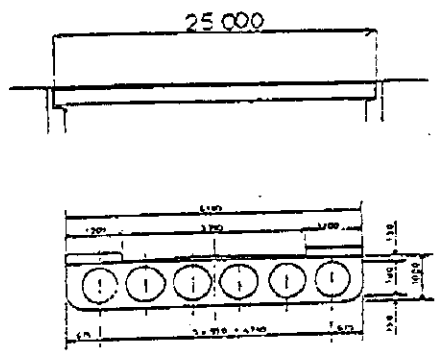
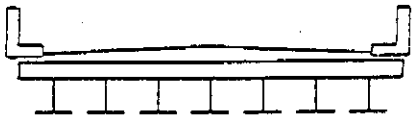
	Plan 1 : PC T-girder bridge (Post-tension)	Plan 2 : PC composite T-girder bridge (Post-tension)	Plan 3 : PC slab bridge (Post-tension)
Schematic diagram			
Structural characteristics	◆ The rigidity is higher slightly when compared with that of Plan 2. ◆ The superstructure is the lightest in this plan. ○	◆ Structure with high girders ◆ Structure with composite girder and slab △	◆ The rigidity is the highest in this plan. ◆ The superstructure is the lightest. △
Workability	◆ Cast-in-place concrete according to the all-staging method ◆ The work period is the longest. △	◆ Manufacturing of the superstructure is possible while constructing the substructure. ◆ Erection with truck crane possible. ○	◆ Cast-in-place concrete according to the all-staging method. ◆ The work period is the longest. △
Maintenance	◆ Easy because of concrete. ○	◆ Easy because of concrete ○	◆ Easy because of concrete. ○
Economy	◆ Slightly higher cost. 1.05 △	◆ Lowest cost 1.00 ○	◆ Higher cost 1.10 △
Evaluation	△	○	△

Table2.3.18(2) Comparison of Superstructure of Gilimale Bridge(No.38)

	Plan 4 : H-beam bridge		
Schematic diagram			
Structural characteristics	◆ Structure type with highest girders ◆ The rigidity is smaller than that of other plans. ◆ Disadvantageous when there is a limit to the height of roadway. ◆ The superstructure is the lightest. △		
Workability	◆ Manufacturing of the superstructure is possible while constructing the substructure. ◆ Slabs can be constructed with a suspended support using H-beams. ◆ The work period will be approximately the same as for Plan1. ○		
Maintenance	◆ Periodical painting is necessary, which pushes up the maintenance cost ×.		
Economy	◆ Higher cost 1.10 △		
Evaluation	△		

e) Kospalana bridge (No.70)

① Ground is relatively soft, but the ground settlement where the existing bridge is located is nearly completed.

② In view of ground settlement, therefore, the bridge center will be shifted only slightly to the north. Shifting to a great extent will not be made, which may require a large-scale settlement preventive work.

③ Though this bridge exists in the lake, seawater flows in from the south when the tide is high.

④ The existing bridge has both abutments protruding to a great extent into the lake, but this is not much of a problem in terms of the river run-off.

⑤ The lake contains the seawater, and the concrete construction will be advantageous in view of prevention of corrosion.

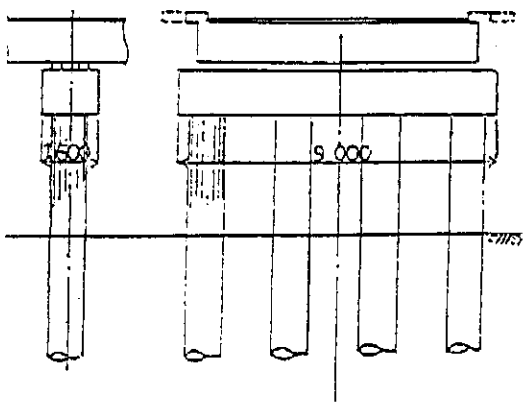
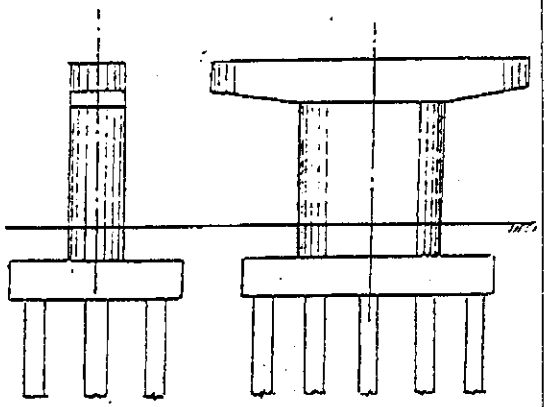
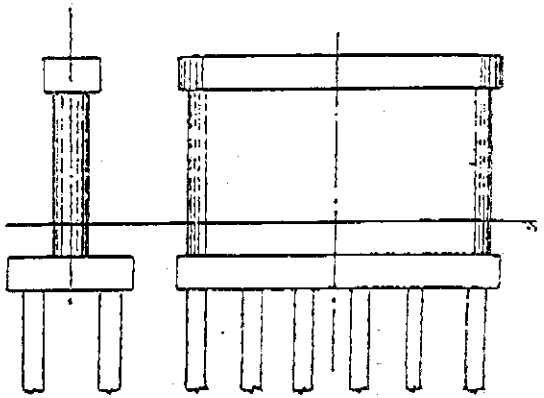
⑥ It is desirable that the superstructure will have three spans, each span being about 14 m. Namely, the PC pretension slab bridge, the same one as for the Bolawatta bridge will be appropriate.

⑦ Continuous girders will eliminate necessity of expansion joints on piers while ensuring smooth travel.

⑧ For piers of the substructure, the pile bent type, which is economically feasible, will be appropriate because of lack of the earthquake load. Comparison of substructures is shown in Table 2.3.19. In this type, pile caps are provided to large size piles.

As a result, it was decided to employ the PC pretension slab type as the optimum bridge type.

Table2.3.19 Comparison of Substructures of Kospalana Bridge(No.70)

	Plan 1 : Pile bent type piers	Plan 2 : Column type piers	Plan 3 : Elliptical column pier
Schematic diagram			
Structural characteristics	◆ Most reational structure with capped pile heads. ◆ Flexible structure ○	◆ General construction ◆ The largest number of piles because of large overall weight. △	◆ General construction ◆ Shape appropriate to the flow direction ○
Workability	◆ Underground and submerged sections will be constructed using casing pipes. ◆ The quantity of temporary material / equipment is relatively small. ○	◆ Increase in the number of temporary equipment and materials ◆ Sheet pile cofferdam necessary during work. △	◆ Increase in the number of temporary equipment and materilas ◆ Sheet pile cofferdam necessary during work △
Economy	Lowest cost 1.00 ○	Highest cost 1.10 △	Slightly higher cost 1.05 ○
Evaluation	○	△	△

Chapter 3

Chapter 3 Implementation Plan

3-1 Implementation plan

3-1-1 Implementation Concept

Considering the study results described above, the project implementation plan is proposed as follows.

1) Construction period

The construction work includes the preparation, installation of the detour route during the bridge construction period, removal of the existing bridge, bridge construction, construction of the access road, revetment, and miscellaneous works. The work period will be 12 months for the first-phase and 18 months for the second-phase. Of the total work period, four months from mid-April to mid-June and from October to November fall in the rainy season. During the period, bridge construction will not be made as a rule, except for rivers with relatively small flow, and the work during the period will be devoted to detouring route construction or superstructure girder manufacturing.

2) Work execution method

The typical flow of the work as a whole is shown in Fig. 3.1.1 (for Moda Ela and Bolawatta bridges)

(1) Detouring route construction

The detouring route is necessary for travel of ordinary vehicle during bridge construction. The route will be a temporary landing bridge made from H steels.

Remedial work is planned at a frequency of about once during the use of detour route (four to five months).

(2) Removal of the existing bridge

Upon completion of the above detouring route, the existing bridge will be immediately demolished and removed. For foundation piles, if any, which may exert influence on

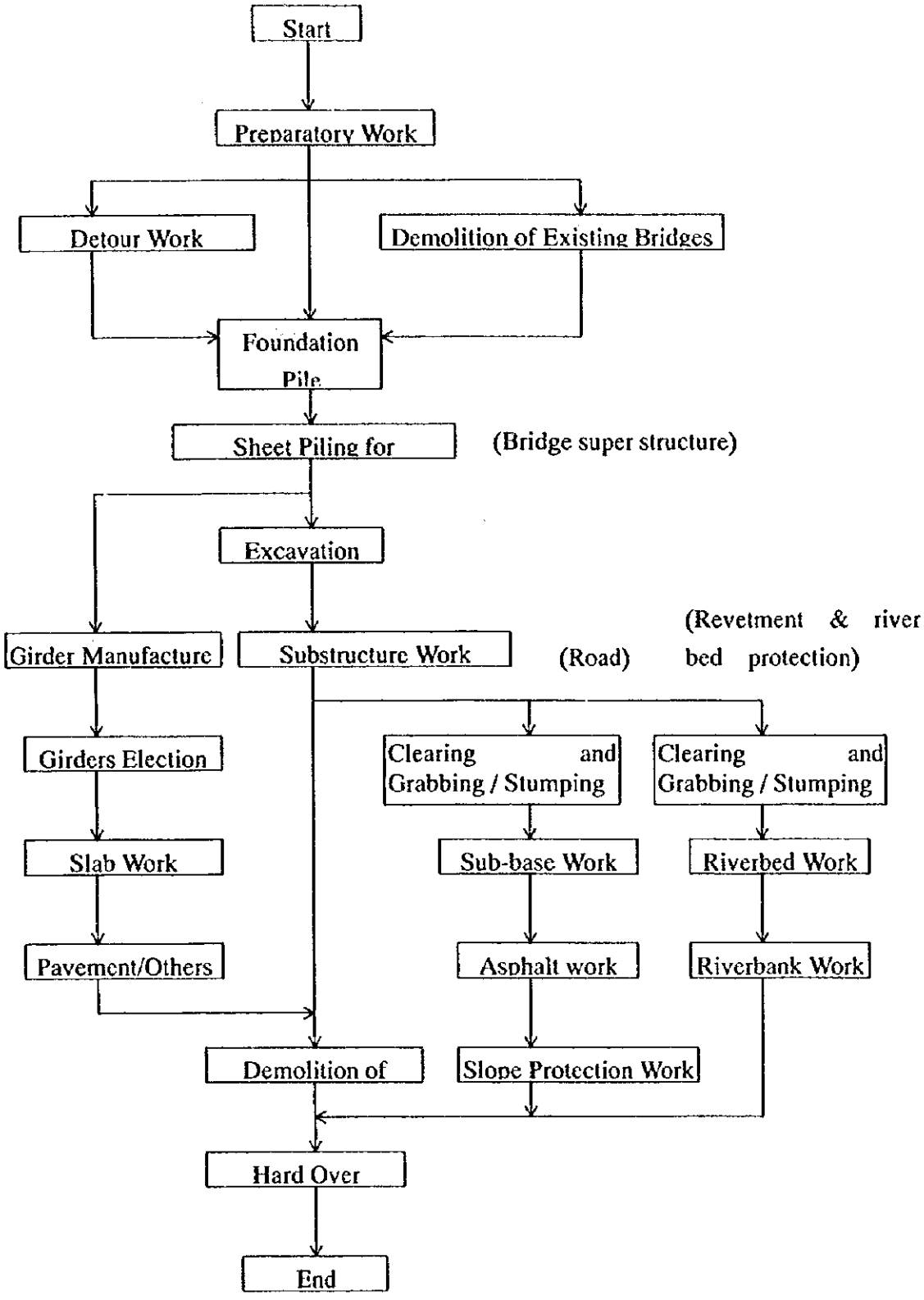


Fig. 3.1.1 Flow Chart

the location of a planned bridge, those only on the upstream side of the existing river bed will be removed.

(3) Foundation

In this project, either cast-in-place piles or spread foundation will be employed. For pile foundation, pile portions will be excavated under the ground with an excavator (reverse circulation method) while filling bentonite to stabilize the surface of trench walls in groundwater. Upon completion of excavation, pre-assembled reinforcements (cage) will be installed in water, followed by placement of underwater concrete to the specified position. The excavator will be procured in (or imported from) Singapore or Japan and transported to the site. Since the Bolawatte bridge will be constructed in the position of existing ones, any old structure, which may hinder piling, must be removed beforehand.

(4) Substructure

For the substructure, the inverted T abutment will be economically feasible. Basically, this will be the work within the river, so that the common practice described below will be used.

① Excavation will be made after construction of the sheet pile cofferdam.

② Excavation will be made with a backhoe. If excavation is to be made in the depth, waling or struts will be installed, if necessary, for excavation with care.

③ After excavation to the specified depth, the excavation bottom surface will be leveled, followed by cobblestones laying and concrete laying on the designated surface.

④ After pile top treatment, footing reinforcement assembling, form installation, footing concrete placement, etc. will be made. The substructure is erected from the

bottom upward.

⑤ While back-filling, struts and wailing will be removed sequentially.

⑥ After arrival at the specified height, back-filling of the surrounding ground will be made thoroughly.

⑦ The revetment (gabion) will also be constructed.

Works within the river will be avoided as much as possible during the rainy season because of the possible natural accident (flooding, etc.) and completely abandoned in the height of rainy season.

(5) Superstructure

The superstructure will be constructed as follows for the PC girder bridge (Bolawatta bridge).

① The girder manufacturing/stock yard will be prepared near the site during construction of the substructure.

② The required number of girders will be manufactured. Concrete will be supplied from a nearby simple (movable) concrete plant.

③ Materials necessary for manufacture of girders (reinforcement, form, PC steel, cement, and others) will be prepared beforehand. Sands will be taken from rivers.

④ After completion of the substructure, girders will be erected with two cranes.

⑤ Following installation of required girders, placement of filling concrete, placement of stringer, lateral stressing will be made. Finally, the work will proceed to the bridge surface work.

⑥ The bridge surface will be paved with asphalt.

3) Utilization of local engineers and materials/equipment

There are large numbers of superb local engineers, mainly of RDA. Considering that

there is a government-owned PC girder manufacturing company and that domestic workers erect them, the technical level is not low. However, there appear to be gaps in terms of quality when compared with advanced countries. Little construction equipment has universal applicability. Heavy machines, such as cranes, etc. are limited in quantity, and difficult to be leased if the work is congested. They have to be brought into Sri Lanka from the third country or Japan. Accordingly, identification of locally available equipment and material and their utilization as much as possible will be planned in the study.

4) Utilization of local contractors

Local contractors can not be said to be sufficiently matured in terms of technology. For work types other than those requiring special technology, an opportunity to participate as a subcontractor will be provided under supervisory and guidance of Japanese contractors, promoting thereby improvement of the construction technology of Sri Lanka.

5) Dispatch of engineers from Japan

For work types requiring special technology or which may govern the quality of completed work, the engineers will be dispatched from Japan. Such work types include, fabrication of PC block girders, PC stressing, girder installation, and embankment, subbase course, and pavement works, and girder installation for a steel arch bridge.

3-1-2 Implementation Conditions

For preparation of the project implementation plan, meteorological conditions unique to Sri Lanka (dry and rainy seasons), material/equipment procurement situations, etc. must be considered to establish the practical plan.

1) Schedule mainly in the dry season

In Sri Lanka, dry and rainy seasons are definite. Any work types whose execution is impossible or whose working days ratio decreases extremely during periods from mid-April to mid-June and from October to November will be completed in the dry season. The equipment operation plan must be established mainly for the dry season.

It is recommended to commence the preparation and setup of the work bases as soon as possible after conclusion of the agreement between Sri Lanka and contractor. It is also necessary to fully utilize the material and equipment possessed by contractors of Sri Lanka during the initial period because the considerable days (two to three months) will be needed for transport of necessary materials and equipment from Japan.

2) Land acquisition and lease

The contractor must be ready for complete securing of the land for the work office, block main girder manufacturing yard, etc. once the agreement is concluded.

3) Customs clearance

Materials/equipment to be procured in Japan and third countries will be transported via Singapore. For smooth customs clearance, it will be necessary to ensure thorough understanding of those concerned on the side of the Sri Lankan government.

4) Safety measures

Construction of the Narthupana bridge will involve transport and installation of heavy materials and the operation at an elevated place in the neighborhood of the existing bridge girders. The safety measures are therefore essential. The traffic safety measures are also necessary because a large number of vehicles will pass for other bridge works. The site guard station will be constructed in each bridge location. Though the local telephone system is available for communications at present, it is necessary to carry around the wireless transceiver to secure the communication system in case of unexpected random terrorism.

3-1-3 Scope of Works

This project will be implemented while Japan will bear the total responsibility.

3-1-4 Consultant Supervision

During the construction period, the Japanese resident engineer and the staff for supervisory and guidance of principal works will be dispatched to the site from a consultant. Job assignment of principal staffs will be as follows:

1) Project manager

Project manager concerning the detailed design, bidding, and project supervision as a whole.

2) Bridge engineer (planning, superstructure and substructure)

The engineer will be in charge of construction supervision, witnessing, and inspection of each work type.

3) Roads engineer (road design)

The engineer will be in charge of supervision, witnessing, and inspection of embankment, subbase course, and pavement which will govern greatly the quality of completed facilities.

4) Resident engineer

This engineer will be resident in the site from the beginning to end of the work while in charge of technical duties (quality, process, and safety controls) and a series of clerical works. During the bridge construction period, this engineer will be in charge of construction supervision and witness inspection for the bridge proper, subbase course, pavement, and auxiliary works.

5) Supervisor for bridge

The supervisor will be in charge of technical duties (quality, process, and safety controls) and a series of clerical works for each work type. During the bridge construction period, this supervisor will be in charge of construction supervision and witness inspection for the bridge proper, subbase course, pavement, and auxiliary works.

3-1-5 Procurement Plan

1) Domestic labor situation

Sri Lanka is said to be a Buddhist country, but there are lots of devotees of other religious sects. Understanding and coordination with local religions and habits are considered to be an essential factor to complete the work successfully through labor

management.

This fact must be thoroughly born in mind because laborers follow agitation blindly and unquestioningly.

Most of construction engineers are graduates from Peradeniyan and Moratuwa colleges. Among 1,500 or so graduates from these colleges every year, about 100 are for civil engineers. Though some of graduates are employed by the government, the government agencies offer no job at present, and the excellent personnel may be employed for the project. In addition, there are a vocational school and an industrial high school in each province, sending out superior engineers every year.

In Sri Lanka, the labor visa is obtained with relative ease and the government is making efforts to introduce the superior technology from the outside of the country, It is reported that enterprises are making entry not only from Japan, but also from India, Korea, Singapore, the USA, and Europe year by year. Note that the unskilled workers are difficult to work in Sri Lanka.

2) Equipment and material procurement condition

This project has a policy of using the construction materials/machinery as much as possible, which can be manufactured or procured in Sri Lanka. The study was made therefore on the quality and availability. At a time of basic design (March, 1998), most of construction materials/machinery were not produced in Sri Lanka, but the considerable number of imports were used. The quantitative balance of the materials/machinery as a whole is not satisfactory. The result of study on the present state of principal materials/machinery is summarized below.

3) Construction materials

(1) Cement

Because of the problem related to the national security, only two plants, respectively in the western and southern provinces, are producing cement.

Because the production can not meet the demand, cements are imported from India and South Africa. Besides, the contractor is not free to import the cement, but has to rely on Mahaweli Marine Cement Co., Ltd. for import and purchase.

(2) Ready mixed concrete

There are eight companies at present which can produce and supply the ready-mixed concrete in Sri Lanka, as shown in Table 3.1.1. Except for Maga Engineering Co., Ltd, each manufacturer has only one plant and limited number of ready-mixed concrete trucks. Supply of ready-mixed concrete to the outside of Colombo is considered extremely difficult.

As described above, only Mega Engineering can construct its own plant in the bridge construction site at the request of contractors and supply the ready-mixed concrete. But the number of plants owned by this company is only three.

In order to ensure stable supply of ready-mixed concrete in timing with the progress of the construction when a contractor is to construct a bridge in the area outside Colombo, it may be necessary to import its own plant.

Table 3.1.1 Ready mixed concrete suppliers

Name of suppliers	Address
1. SANKEN LANLA (PVT) LTD	Colombo 14 & Peliyagoda, Sri Lanka
2. DEVCO SHOWA (PVT) LTD	Nage Road, Pelifadoga, Sri Lanka
3. INFORMAX CONSTRUCTION (PVT) LTD	Colombo 10, Sri Lanka
4. TUDAWA SROTHERS	Colombo 5, Sri Lanka
5. SUNBEE READY MIXED	Battaramulla, Sri Lanka
6. MAGA ENGINEERING	Gothatuwa, Sri Lanka
7. INTERNATIONAL CONSTRUCTION CONSORTIUM	Bekundara, Sri Lanka
8. KEANGNAM READY MIXED	Malabe, Sri Lanka

(3) Asphalt

Enterprises, which can manufacture and supply asphalt, are in the Colombo area as shown in Table 3.1.2. When the construction work is to be made in areas not covered by these enterprises, it is necessary to construct its own plant for supply.

Table 3.1.2 Asphalt suppliers

Name of supplier	Address
INTERNATIONAL CONSTRUCTION CONSORTIUM LTD	MADAOATHA (No.291 Modara Street Colombo 15)
SHAKEN ENGINEERING (PVT) LTD	PAPPLIYAWELA (401-8-1/1 Gall Road Colombo 4)

(4) Steel (reinforcement and steel materials)

Concerning reinforcement, the domestic production is not enough to meet the demand similarly to the case of cement. Besides, due to the limit in standard, the reinforcements of 25 mm or more in diameter or 6 m or more in length must be imported.

Most of imports are BS-based products from South Africa and Singapore.

Other steel materials, excluding special and large steel materials, are available within Sri Lanka. PC steels and steel sheet piles used in large quantity in the bridge

construction work are all imported, mostly from South Africa, Singapore, and Thailand.

(5) Concrete aggregates, and embankment and subbase course materials for roads

Concrete aggregates are available thoroughly within Sri Lanka. Domestic suppliers have 10 or more large and small aggregate production plants. In particular, W.A. Perera & Co., Ltd has 3,000 ton/h and 1,000 ton/h aggregate plants while having a quarry site in Aturugiriya and Arangala-Malembe.

At present, contractors, which are in charge of construction, but do not have their own plants, purchase concrete and asphalt aggregates from this supplier.

(6) Pavement material (bituminous materials)

There is no private company, which produces and supplies the pavement material, and the government-owned Ceylon Petroleum Corporation is the sole company in this field. To obtain asphalt, the construction company has to purchase the required quantity from this corporation. Except for asphalt of the special specifications imported from the third country like Singapore, all of asphalt materials used are produced within Sri Lanka. Domestic supplies meet demand.

(7) Lumber

All of lumber materials are available in Sri Lanka, except for the special form and 15-mm or more thick plywood which are not available. The material is of a relatively good quality and applicable without problem to construction of bridges.

(8) Other construction materials

Bricks and roofing tiles are supplied in sufficient quantity in Sri Lanka. Special

materials, such as PC steel materials for bridge construction, must be imported. Table 3.1.3 shows the source of supply for principal construction materials.

Table 3.1.3 Principal suppliers of construction materials

Construction materials	Locally procured	Procured in Japan	Procure in third country	Remarks
Cement	*			Produced made by India and South Africa
Concrete admixture		*		Quality retaining
Reinforced	*	*		Products made by Sri Lanka and Japan
Structural steels			*	Import from Singapore
PC steel wires and rods		*		Quality retaining
Bituminous materials	*			
Crushed stones and sand	*			
General woods	*			
Form (plywood, steel)	*(ply wood)		*	Manufacturing in Singapore
Support and scaffold materials	*			
Expansion joint (rubber)		*		Quality retaining
Bearing support (rubber)		*		Quality retaining
Concrete pipe	*			

4) Construction machinery

Construction machinery includes those possessed by the government agency and those possessed by private enterprises. Contractors are generally engaged in the work using the machinery of their own. Some enterprises are dedicated to leasing the machinery. Since nearly 80% of them are used, failure of thorough maintenance may cause trouble to the construction work.

In particular, each enterprise does not have a sufficient amount of stock of machine parts. In the case of failure of the machine, the work will be suspended for a few days, a few weeks, or a few months in the worst case while waiting for import of necessary parts from the outside. Before start of the work, it is necessary to grasp fully the condition of machinery possessed by or leased to the contractor. This is necessary to avoid suspension of the work or other worst situation.

(1) Construction machinery and plant (ready-mixed concrete, asphalt) owned by government agencies

The construction machinery possessed by the government agency is shown in Table 3.1.4. Though the machinery can not be leased to any ordinary construction company, lease may be granted exceptionally in the case of projects under control of the agency concerned.

Table 3.1.4 Construction machinery possessed by the government agency

Name of machinery	Specification / performance	Quantity
Bulldozer	50HP-140HP	48
Scraper	less $10m^3$	1
Motor grader	3m – 4m	37
Wheel loader	$1.5m^3$ – $2.0m^3$	23
Drilling machine		1
Compressor	350C.F.H	33
Pilling machine		3
Vibration roller	10 ton or less	2
Dump truck	10 ton or less	220
Truck crane	10 ton or less	20

(2) Construction machinery and plant which can be procured or leased in Sri Lanka

Almost all of ordinary construction machines are procurable within Sri Lanka, but their quantity is limited and the working days ratio is extremely low. A considerable time is also necessary to obtain replacement parts. With this background, it is necessary to carry the machinery into Sri Lanka while preparing the sufficient quantity of replacement parts when there is not much allowance in the construction period.

Construction machinery, which can be procured and leased in Sri Lanka, is shown in Table 3.1.5. However, the number of heavy machinery (crawler crane, etc.) available for this site is small.

Table 3.1.5 List of construction machinery procurable in Sri Lanka

Name of machinery	Specification / capacity	Quantity
Backhoe	0.5m3 less	6
	1.5m3 - 1.0m3	44
	1.1m3 - 1.5m3	7
	1.5m3 and more	3
Bulldozer	50 H.P - 100 H.P	143
	101 H.P - 139 H.P	88
	140 H.P - 179 H.P	25
	180 H.P - 250 H.P	41
	251 H.P - 350 H.P	32
	350 H.P and more	17
Motor grader	3.0m	13
	3.5m	67
	4.5m	6
Wheel loader	1.5m3 and less	14
	1.5m3 - 2.0m3	70
	2.0m3 - 2.5m3	33
	2.5m3 and more	12
Tire backhoe	1.0m3 and less	68
Compressor	175 C.F.M	40
	175 – 350 C.F.M	42
	350 C.F.M and more	13
Vibration roller	5ton and less	8
	5ton - 10ton	10
Dump truck	5ton and less	55
	5ton - 7ton	147
	7ton - 10ton	97
	10ton - 16ton	120
	16ton and more	35
Asphalt plant	50ton/h and less	1
	50ton/h and more	3
Distributor	1,000 litter	19
	4,000 litter	4
Trick crane	10ton and less	2
	10ton and more	24
Crawler crane	37ton	3
	80ton	2
Stone crusher	20ton/h and less	1
	20ton/h - 50ton/h	30
	50ton/h - 100ton/h	11
	100ton/h and more	4

(3) Construction machinery possessed by foreign contractors (India, South-Eastern Asia, Europe, etc.)

Construction projects have been made by Japanese and foreign contractors. Table 3.1.6 shows principal machinery possessed by foreign enterprises. But most of them have been in possession for individual projects and will be transported to the outside of Sri Lanka as a re-export machinery once the project is completed.

Table 3.1.6 Construction machinery possessed by foreign countries

	Name of company	Name of machinery	Specification /performance
1. Japanese enterprise	Kajima Corp.	Truck crane Vibration hammer	90ton 25ton 5ton
	Joint venture of Kumagai, Hazama, and Kajima	Dump truck Truck crane	4ton 45ton
	Joint venture of Goyou and Wakatsuki	Dump truck Backhoe Truck crane Crawler crane Bulldozer Wheel loader Compressor Generator	10.0ton and less 0.35m3 60ton 100ton/50ton 15ton 1.4m3 7.0m3/min. 100kva/50kva
2. Korean enterprises	Keangnam Enterprise	Backhoe Bulldozer Wheel loader Motor grader Tire backhoe Compressor Vibration roller Dump truck Asphalt plant Asphalt finisher Distributor	0.5m3/1.0m3 100 H.P-250H.P 2.0m3 3.0m/3.5m 1.0m3 7.0m3 10ton 5ton-10ton 100ton/h 20TOn/h 1,000liter

(4) Construction machinery to be procured outside of Sri Lanka

Special construction machinery is difficult to procure in Sri Lanka. Table 3.1.7 shows the machinery to be imported into Sri Lanka to ensure smooth implementation of the work.

Table 3.1.7 Machinery to be imported

Name of construction machinery	Specifications/capacity
Truck crane	45 ton
Diesel hammer	45
Vibro-hammer	90kw
Generator	250 kva
Compressor	11 m3
Earth auger machine	1,000m3 - 1,200m3
Reverse excavation machine	S320
Grouting machine	
Crawler drill	38mm,50mm
Drilling machine for blasting	38mm,50mm

(5) Maintenance of construction machinery

Maintenance of the machinery is extremely important and one of factors on which the success of the project is dependent.

Fuel and oil/grease materials are all imported in Sri Lanka. The fuel is supplied in sufficient quantity to meet the demand. For the oil/grease, it may be necessary to import the necessary one after selection of the machinery beforehand because special oil/grease may become necessary in certain cases. Machine components must be kept in stock in the site after confirmation of the model regardless of whether the machinery used is the one of local contractor, the one controlled by the project contractor over a long time of period, or the leased machinery.

(6) Local contractors

Contractors to be engaged in the bridge construction project include government-owned and private survey and research companies, design offices, and constructors. Enterprises listed below are competent ones registered in the Road Development Agency (RDA):

a) Government-owned enterprises

① State Development & Construction Corporation

② State Engineering Corporation

b) Affiliated companies to RDA

① Road Construction & Development Co.

c) Private enterprises

① CML Edwars Construction Co., Ltd.

② Samuel Sons & Co., Ltd.

③ International Construction Consortium Ltd.

④ Mega Engineering (PVT) Ltd.

⑤ Tudawe Brothers Ltd.

⑥ Dharmasena & Company

⑦ Daya Construction (PVT) Ltd.

⑧ Keangnam Enterprises Ltd.

⑨ Walker Sons & Co., Engineers (PVT) LTD.

5) Access of construction materials and machinery to the site

Construction materials and machinery will be transported into the site mainly by trucks on land. Materials and machinery which are difficult to procure in Sri Lanka will be unloaded at the Colombo Port when imported by sea from the foreign countries and at the Katunayaka International Airport when imported by air, for transport to the site.

(1) Inland route

Materials and machinery procurable within Sri Lanka will all be available within Colombo City while imported ones will be unloaded in Colombo Port. Accordingly, the access route from Colombo City to the site must be established.

a) Moda Eta Bridge

Route A2 runs to the south and connects to Route B14 in the Ambalangoda district, reaching Elipitiya. The bridge is located north along Route B217 and at about 3 km on Route 114 from Waturawalabanda.

b) Bolawatta Bridge

Route A3 runs to the north from Colombo, passing through Kochchikade and turning right at about 45 km point to enter Route B437. This bridge is located about 2 km in the east along this route. For detour, there are two routes. The one is to change from Route A3 to B419 at Kochchikade for travel to the north, then to travel west along Route B437. The other is to change from Route A3 to B473 at Wennappuwa for travel to the east, followed by travel to the south along B419 at Kirimetiyana, then travel to the east along Route B437.

c) Narthupana Bridge

Route B84 runs to south-east from Colombo, changing to Route A8 at Pakunuwita and travel south from Horana along Route B157. This bridge is located about 13 km from Bellapitiya.

d) Gilimale Bridge

Route A4 runs to south-east from Colombo, reaching Ratnapura at about 100 km point, from there the route changes to B391 for travel north. The route changes to Route B265 at Malwala for travel north to reach this bridge at about 8 km point.

The road from Malwala to the site is extremely narrow with sharp curves. Besides, the existing bridge facilities are damaged. These factors will present difficulty for running of heavy vehicles.

3) Kospalana Bridge

Route A2 runs to the south from Colombo, entering Route 295 at Moratuwa. The bridge is located at about 2.6 km point.

(2) Sea route

Materials and machinery imported by sea from foreign countries will all be unloaded at Colombo Port for transport on land along the route described above. In the case of procurement in Japan, about 1.5 months will be necessary from the shipment in Japan to the arrival at the site.

(3) Air route

Material and machinery imported by air from foreign countries will all be unloaded in the Katunayaka International Airport, transported into Colombo via Route A3 for further transfer to the site along the route as described above.

(4) Import procedure

Following procedures must be cleared when importing construction materials not available in Sri Lanka and the machinery whose procurement in Sri Lanka is difficult.

a. Preparation of the master list of materials and machinery to be imported and its submission to the owner for approval

b. Submission of this master list to various agencies of Sri Lanka for approval

c. Transport of imported materials and machinery after clearance by paying various taxes (import tax, etc.) for those concerned. During clearance, defense cost added, value added tax, etc. will also be paid. The tax rates of value added tax is currently 8% and is said to be raised to 12%. Though the timing is not known at present, it is not far in the future.

3-1-6 Implementation Schedule

This project will be put into practice as follows after conclusion of the Exchange of Note:

1) Consultancy contract and detailed design

After conclusion of consultancy service contract, the detailed design will be made and design and tender related documents will be prepared.

2) Construction bidding contract and contract approval

The work agreement will be the direct agreement between the government of Sri Lanka and Japanese contractors. As a rule, open bidding will be made for Japanese contractors to select the appropriate one.

The examination items will be coordinated beforehand with JICA and the approved contractors will be qualified. A consultant who acts on behalf of the implementation agency of Sri Lanka will make qualification.

Bid evaluation and designation of the successful bidder will be made under attendance of the personnel of Sri Lanka government, consultant, and bidders in the presence of JICA personnel in charge, followed by the construction agreement.

In parallel with conclusion of the construction agreement, the Sri Lanka government will accept the fund from the Government of Japan and conclude the banking arrangement with a bank in Japan for the purpose of opening and operating the special account for payment to the Japanese contractor. This banking arrangement is necessary to start implementation simultaneously with conclusion of the construction agreement. This arrangement is a basis for the Sri Lanka government to receive the

Authorization to Pay (A/P), which is necessary for the Japanese contractor to receive the advance payment according to the terms and conditions of payment of the agreement or to obtain the approval of export from the Ministry of International Trade and Industry.

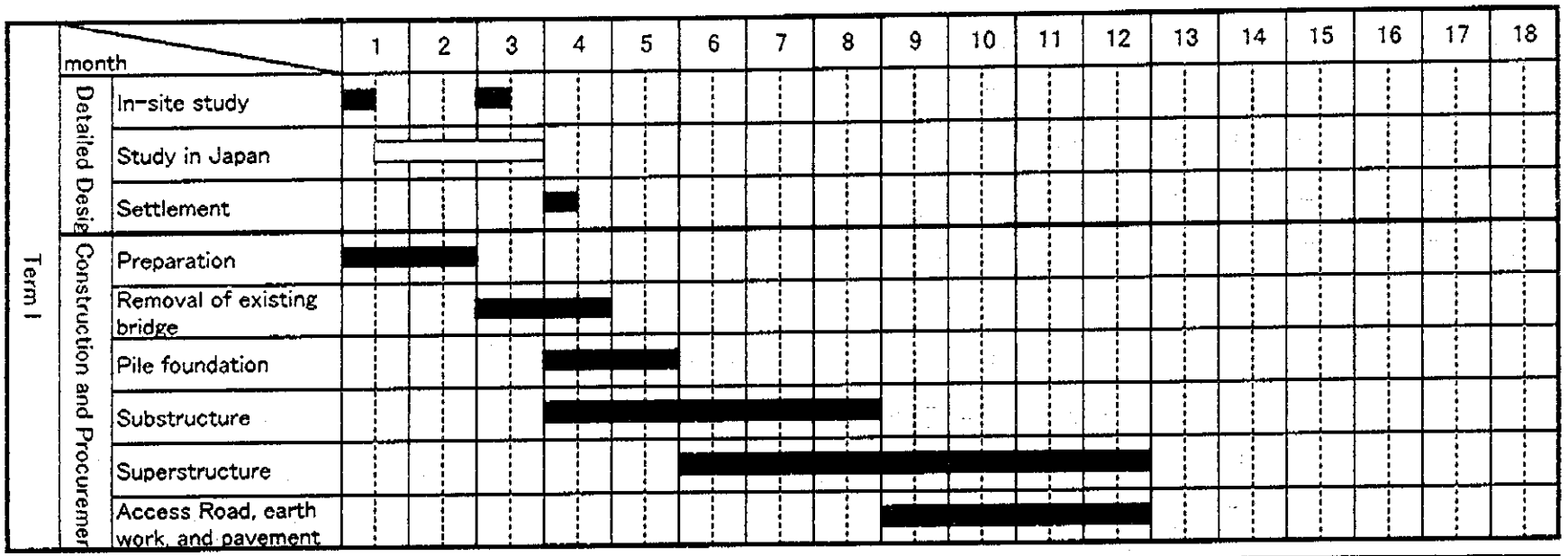
The next step is approval of the agreement. Approval means that the Government of Japan confirms that the agreement is appropriate for an objective of this assistance (grant), and is a requirement for coming into force of the agreement. Specifically, the Ministry of Foreign Affairs will have the agreement to be sent from the Sri Lanka government through our diplomatic establishment aboard, determining whether or not the approval is given. The Japanese contractor will implement the agreement upon reception of the approved agreement and the Authorization to Pay (A/P).

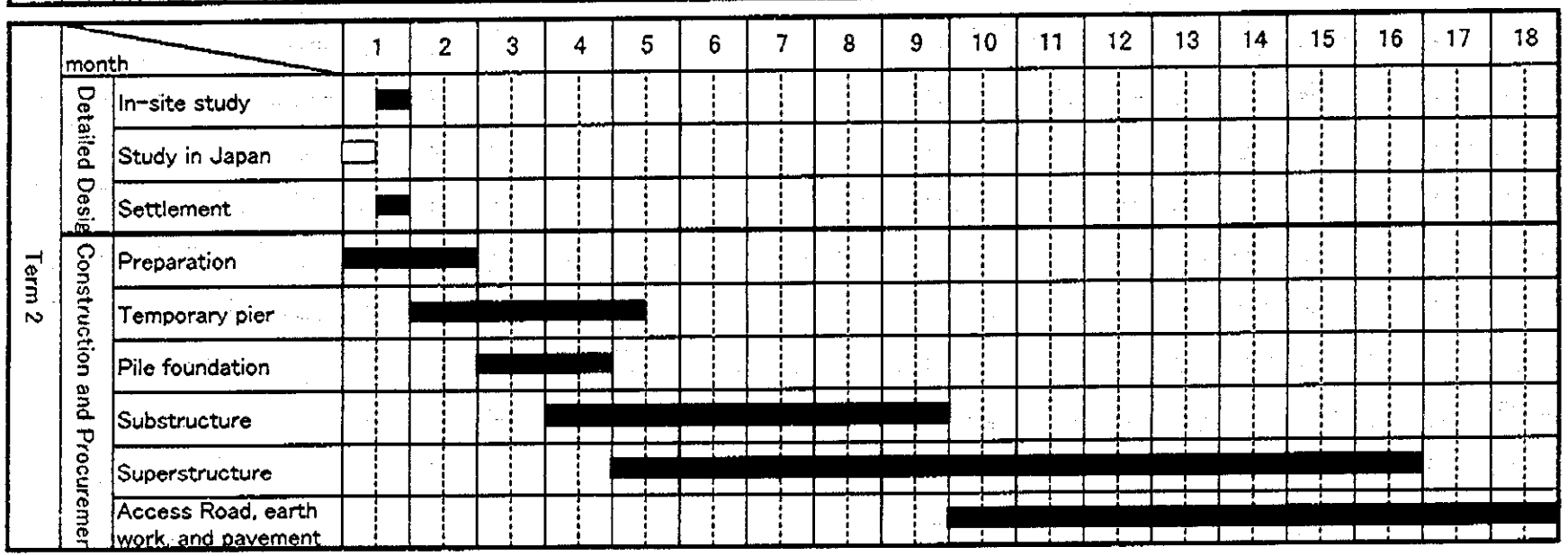
3) Construction work

The work begins with preparation, followed by the permanent works including detouring route construction, removal of existing bridge, substructure, superstructure (girders, bridge surface), and access road, as well as subsidiary works (revetment, etc.), and ends with removal of materials and equipment related to the work. Since the periods from mid-April to mid-June and October to November are the rainy seasons around the site in Sri Lanka, drainage and bridge substructure works will be restricted.

On the basis of the Japanese grant aid cooperation system, the project will be implemented as scheduled, shown in Table 3.1.8.

Table 3.1.8 Schedule





3-1-7 Obligations of Recipient Country

Obligations of Sri Lanka for this project are as follows:

① Land acquisition and demolition of buildings in the yards

② Securing of the construction yard

③ Transfer of the power transmission line and water supply pipes

④ Tax exemption, grant of accommodation, bank agreement (B/A) and Authorization to Pay (A/P) issue procedures for this project and their charges

3-2 Operation and Maintenance Plan

Upon completion of this project, RDA will maintain the rehabilitated bridge.

1) Maintenance method

To effectively utilize the limited budget of RDA, the maintenance method to be employed will be based mainly on routine and periodical inspection for early detection and countermeasure of damage, thereby preventing scouring of the abutment, collapse of the river revetment, and slope collapse by river flow.

(1) Routine inspection

An inspection vehicle will be run in an interval of about once a month on the route concerned, with check made from the vehicle on the road surface, shoulder, and slope. The inspection result will be recorded in the form and reported to the engineer. A three-person system of an inspector, recorder, and driver will be employed.

(2) Periodical inspection

This inspection will be made at the end of rainy season when the water level has

lowered. River revetment, river bed protection, and scouring of river bed will be checked. The inspector will walk around the bridge to check for damage and the repair plan will be drafted according to the damage condition.

On the basis of these check results, the engineer will determine the necessity of repair. If necessary, the repair will be made immediately to prevent worsening of damage.

2) Maintenance system

To execute the maintenance method described in 1) above, the maintenance plan must be established within the maintenance system of RDA.

① The routine inspection group will be established in RDA, with personnel composition as follows:

Engineer: 2 persons

Inspector, recorder, driver: 12 persons (3 persons x 4 shifts)

Inspection vehicle: 4 units

Record storage personnel: 1 person

② A repair group will also be established, which can perform rapid repair if minor repair is found necessary on the basis of routine check result.

③ The maintenance manual will be established and training of inspectors and recorders will be made by dispatching the expert personnel.

④ Routine check result will be compiled in a database to be used for appropriate estimation of the required maintenance expenses.

⑤ A system will be established, which will store drawings of this project for effective utilization in the future repair.

3) Maintenance and operation costs

Details and expenses of maintenance jobs expected for ten years after completion of this project are shown in table 3.1.9.

(1) Maintenance jobs and expenses

Table 3.1.9 Details and expenses of maintenance jobs

Period	Jobs	Expenses	1,000Rs.
Every year	①Cleaning, weeding	5 Rs.×5,700m²	= 28.5
	②Minor repair of slope	350 Rs.×2,000m²×5%	= 35.0
	③Minor repair of river bed	1,750 Rs.×1,600m²×5%	= 140.0
	④Repair of pavement (patching)	400 Rs.×4,0000m²×5%	= 80.0
	Total		283.5
Every five years	①Repair of bridge surface	400 Rs.×1,700m²	= 680.0
	②Medium repair of slope	350 Rs.×2,000m²×10%	= 70.0
	③Medium repair of river bed	1,750 Rs.×1,600m²×10%	= 280.0
	④Overlay of pavement	400 Rs.×5,700m²	= 2,280.0
	Total		3,310.0
Expenses for 10 years			Rs. 9,455.0

(2) Working expenses

The working expenses necessary for routine inspection, periodical inspection and operation of the maintenance are estimated to be as follows:

Personnel expenses	: 1,000Rs./year	1,500
Inspection vehicle fuel expenses	: 1,000Rs./year	300
Total	: 1,000Rs./year	1,800

The ratio which the total (2,928 thousand Rs./year) of above maintenance and operation costs and working expenses accounts for in the current maintenance and operation costs (about 200,000 thousand Rs./year) of RDA will be about 1.5% and RDA is considered to be capable of bearing such costs without problem.

Chapter 4

Chapter 4 Project Evaluation and Recommendation

4-1 Project Effect

The objectives of this project is to achieve economical development and improvement of the public life along the road including bridges concerned. It is also the objective of the project to avoid physical and personnel damages due to bridge fall and stagnation of regional social activities and administrative functions caused by incidental traffic shut-off by replacing heavily damaged bridges.

The district concerned has equipment necessary for the social life, but rehabilitation of existing bridges that are obsolete or that do not allow facing traffic is urgently necessary. To support these activities, expectation on the grant aid cooperation for development and improvement of the social infrastructure is great. In particular, all bridges concerned are located in places where the use of another route is impossible or extremely difficult, and the population which will enjoy benefit of rehabilitation of these bridge will run up to 600,000.

Effects of this project are listed below.

Present condition and problems	Countermeasure in this plan	Effect and improvement by the project
①Bridges including abutment are outdated, presenting problems concerning the safety of traffic, including fall of bridge.	① Replacement by a new bridge and raising of the road to achieve the construction highly resistive against flood while paying attention to embedment of abutment and slope protection of the access road.	① Through ensuring of the traffic throughout the year and improvement of the running performance, the bridge is expected to contribute to securing of the medical service and safety in case of emergency and stabilization of the public life.
② Bridges covered by this project can not withstand the heavy traffic and are so narrow as to make smooth operation of industrial large trucks difficult.	②B loading will be employed to rehabilitate the bridge to the one which can withstand traffic of heavy vehicles including large trailers.	②Demonstration of functions as a national highway, contributing thereby to economical development of the region and country.
③The width and number of lanes of bridges are not complying with the Sri Lanka standard, making the interconnected through service impossible, resulting in trouble for traffic.	③ The bridges will be rehabilitated so that their width and number of lanes are appropriate to the present state and can comply with the Sri Lanka standard	③Rehabilitation of bridges so that they may have the appropriate width and number of lanes, thereby ensuring smooth traffic.
④The bridge portion has no sidewalks, so that the traffic is of a mixed type of pedestrians, cyclists, and automobiles, presenting the problems related to the traffic safety.	④Separation of the sidewalks and motorways according to the traffic volume, ensuring the safety.	④Separation of the sidewalks and motorway, ensuring higher safety
⑤The river water level rises in the rainy season, and certain bridges can not have the sufficient clearance under girder.	⑤The bridge will be provided with the sufficient clearance under girder, eliminating the danger of inundation.	⑤ Establishment of the sufficient capacity of rivers flowing under bridges, thereby avoiding traffic congestion caused by closing of the road due to flood and contributing to stabilization of the society and economy.

Moreover, implementation based on the grant aid cooperation has been judged appropriate as a result of investigation on Sri Lankan maintenance and operation capacity for this project.

4-2 Recommendation

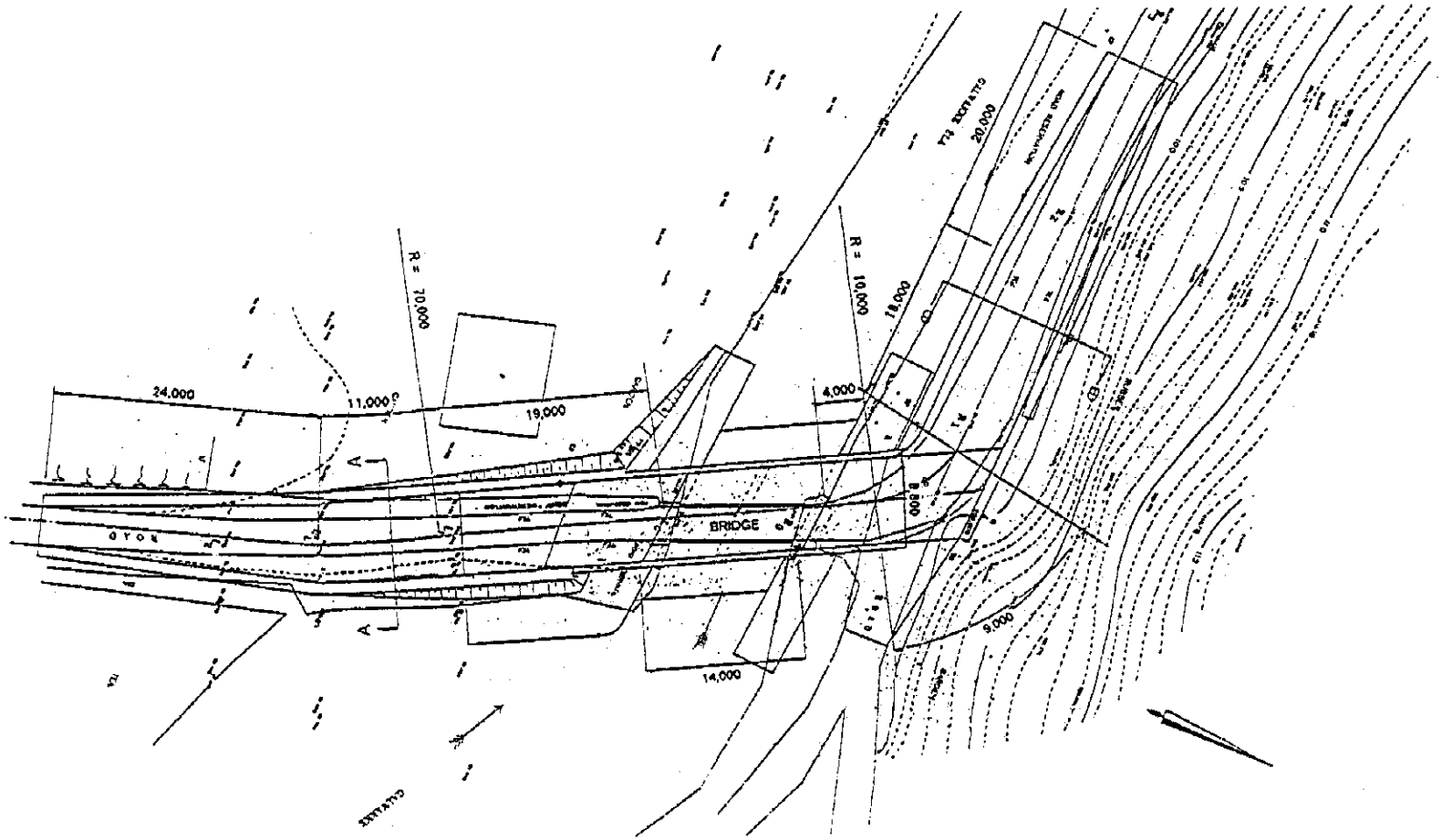
As described above, implementation of this project on the basis of grant aid cooperation

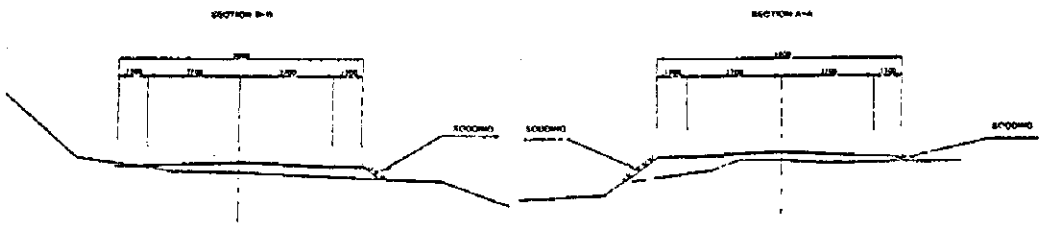
has been judged appropriate in view of great favorable effects expected from such implementation and contribution on comprehensive improvement of BHN of residents. Concerning the operation and maintenance of this project, the Sri Lankan organization is enough and without any problem in terms of personal and financial resources. Note in particular that implementation of repainting without fail every ten years is essential for the Narthupana Bridge.

Drawings

Plate No.

GENERAL PLAN

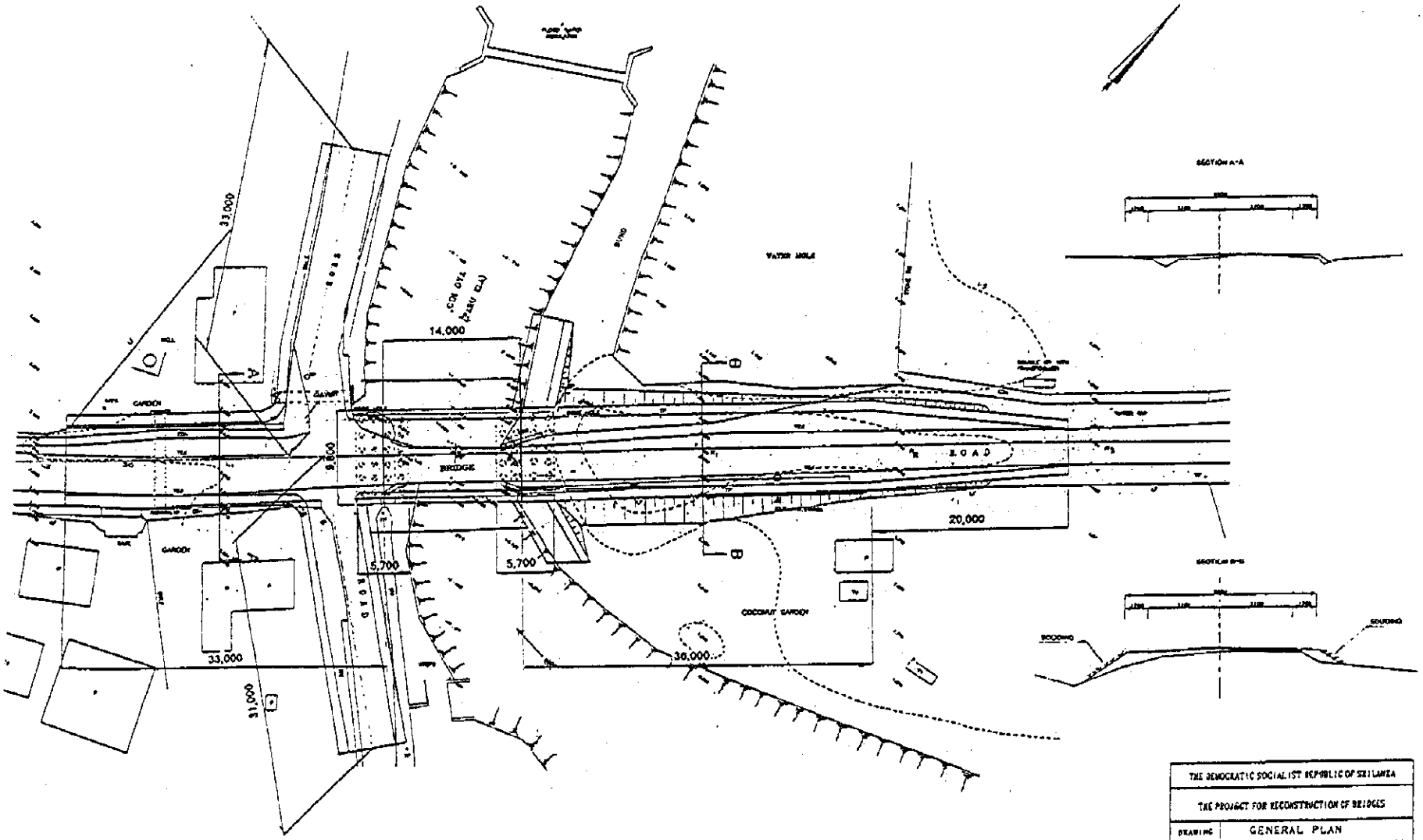




THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL PLAN MODAELA BRIDGE (No. 31)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	

Place No.

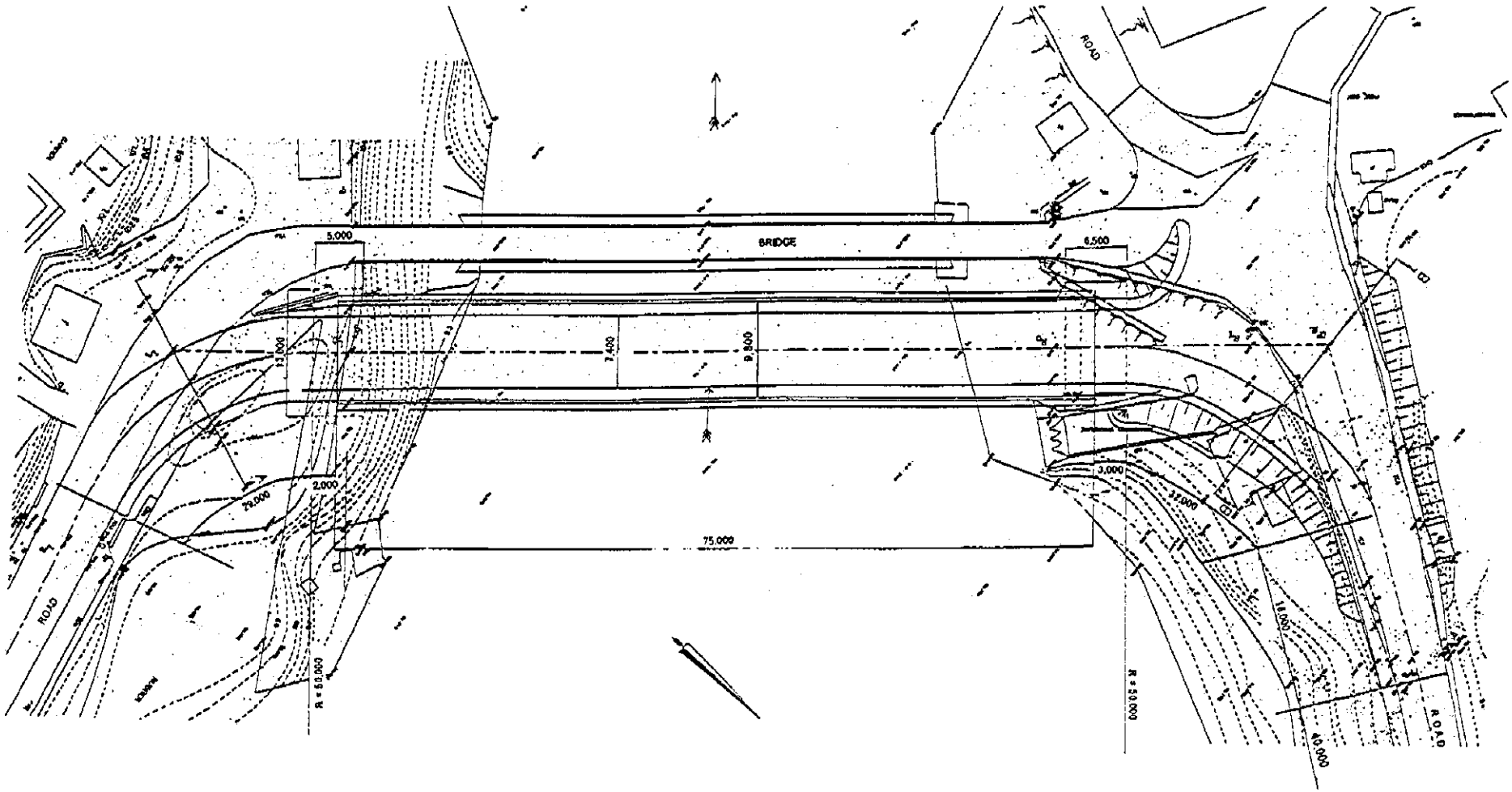
GENERAL PLAN

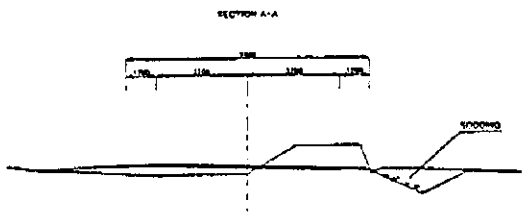


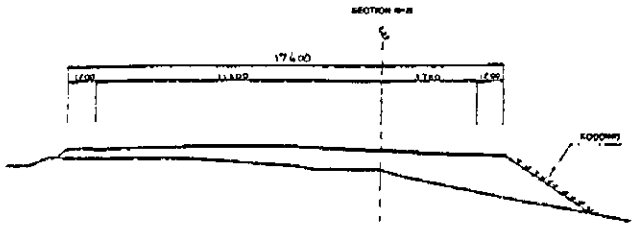
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL PLAN BOLAWATTA BRIDGE (No. 32)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	

Plate No.

GENERAL PLAN







THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL PLAN NARTHUPANA BRIDGE (No. 33)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	

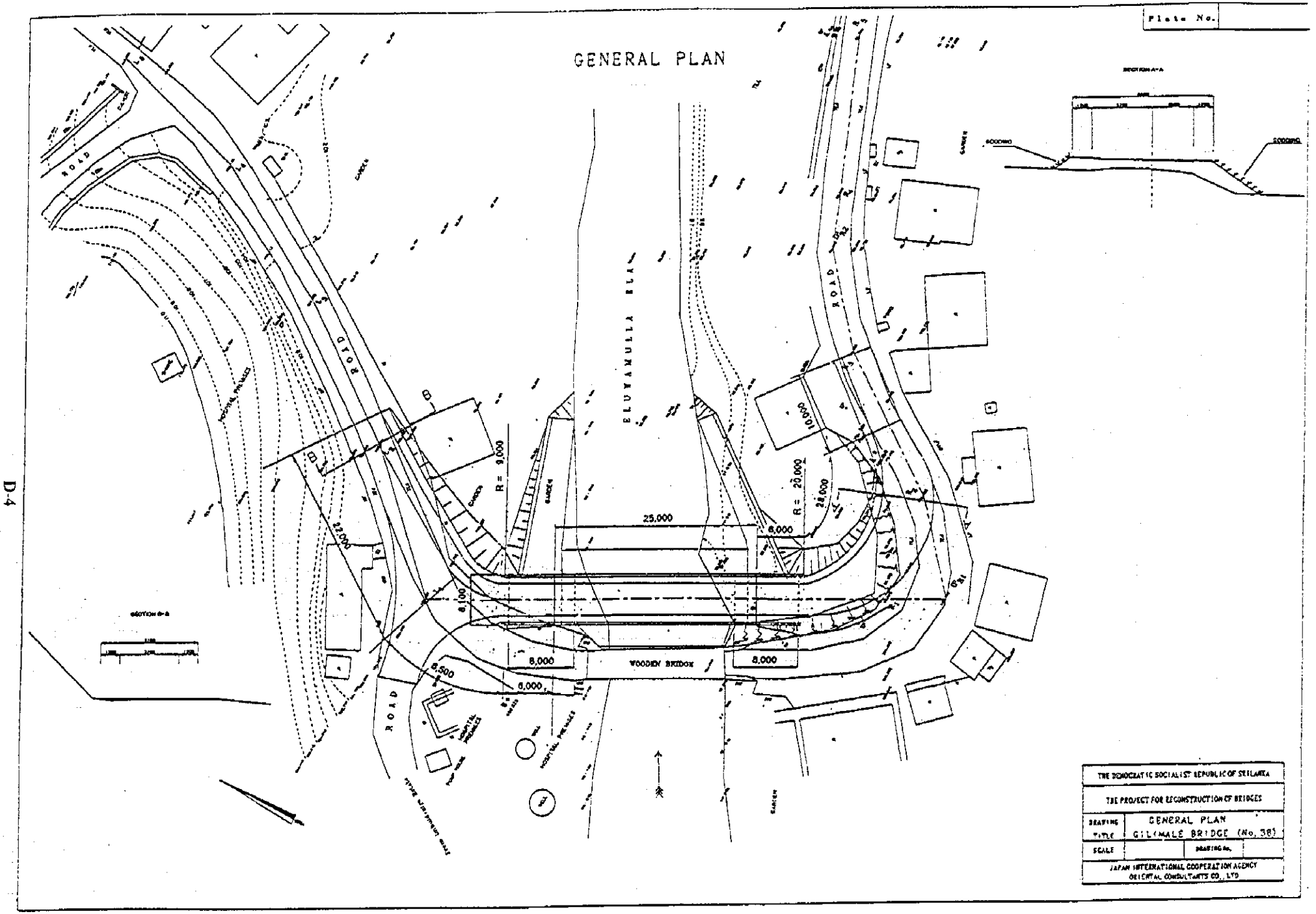
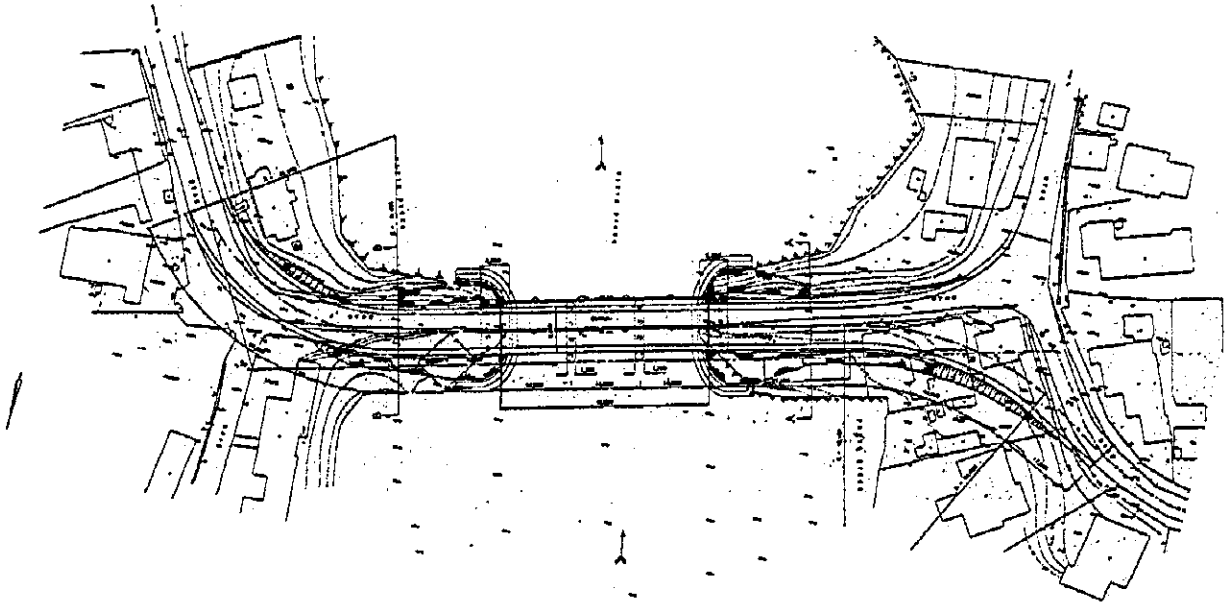
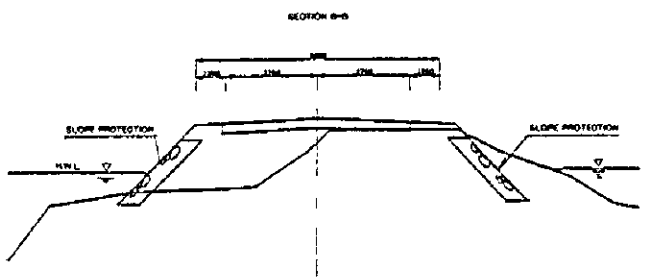
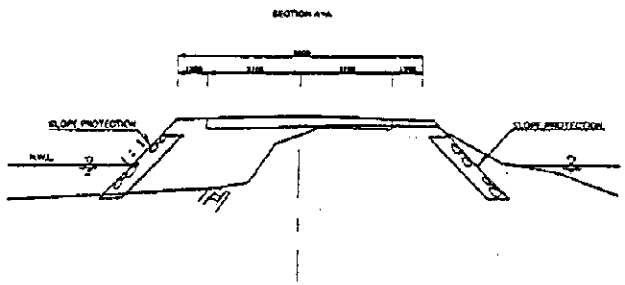

GENERAL PLAN
Plate No.
ROAD
ELUVAMULLA ELA
R= 9,000
R= 20,000
10,000
25,000
6,000
8,000
WOODEN BRIDGE
8,500
22,000
GARDEN
HOSPITAL PREMISES
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
THE PROJECT FOR RECONSTRUCTION OF BRIDGES
DRAWING TITLE
GENERAL PLAN
GILIMALE BRIDGE (No. 38)
SCALE
DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY
ORIENTAL CONSULTANTS CO., LTD

Plate No.

GENERAL PLAN





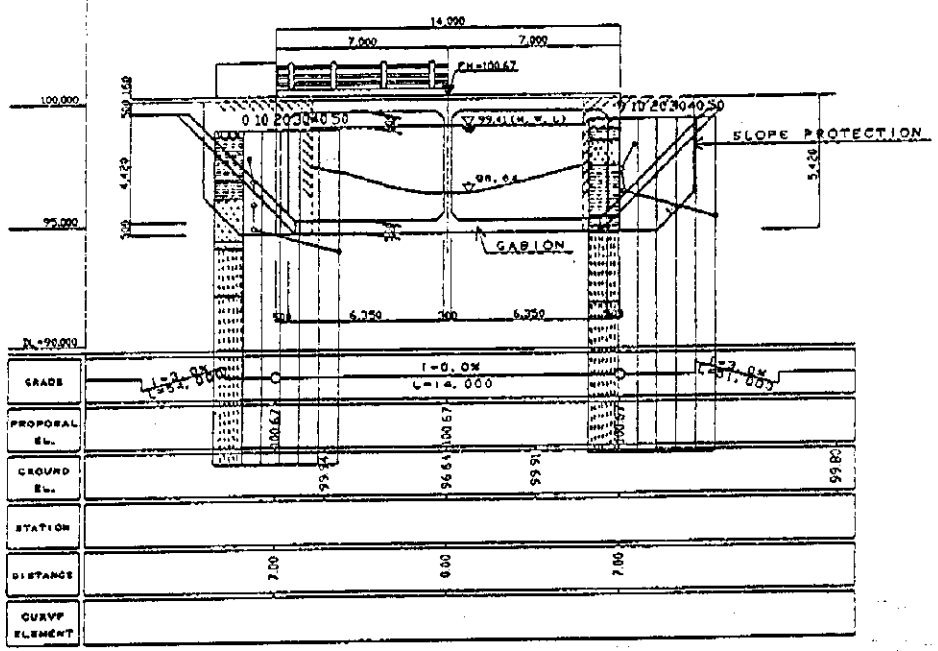


THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL PLAN KOSPALANA BRIDGE (No. 70)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD.	

Plate No.

GENERAL VIEW

SIDE ELEVATION SCALE 1 : 100



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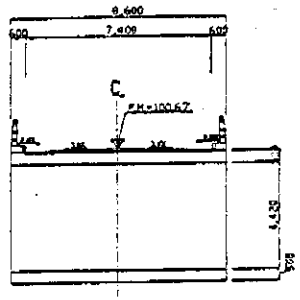
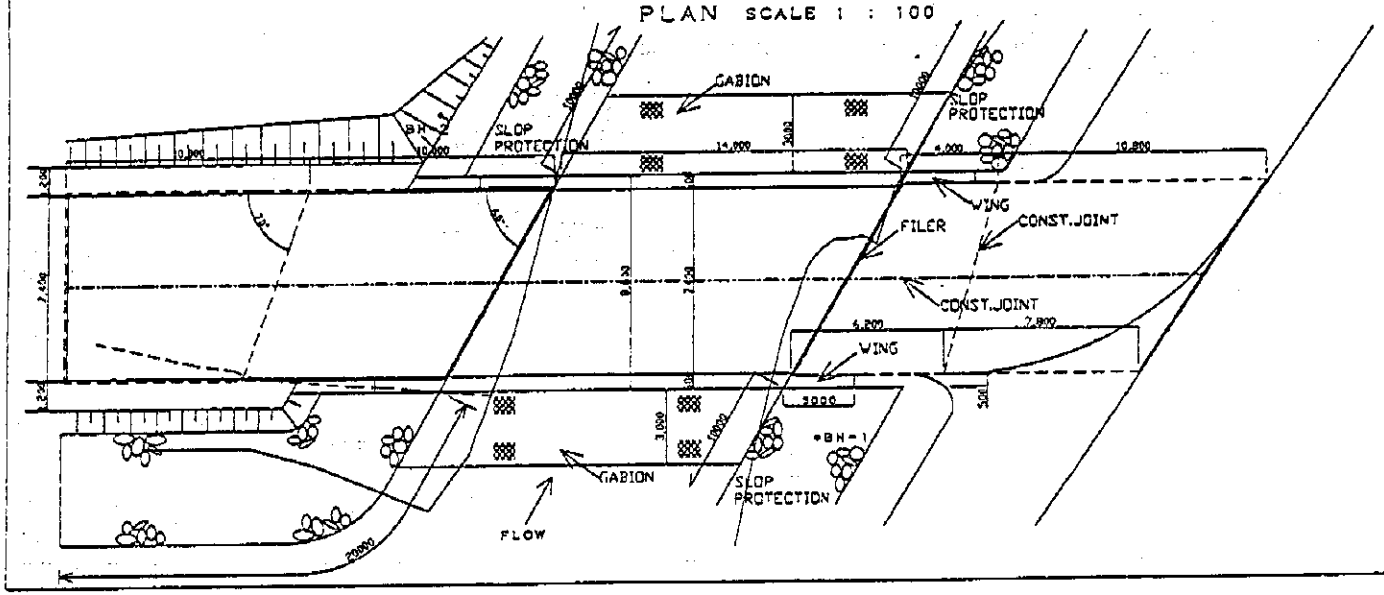


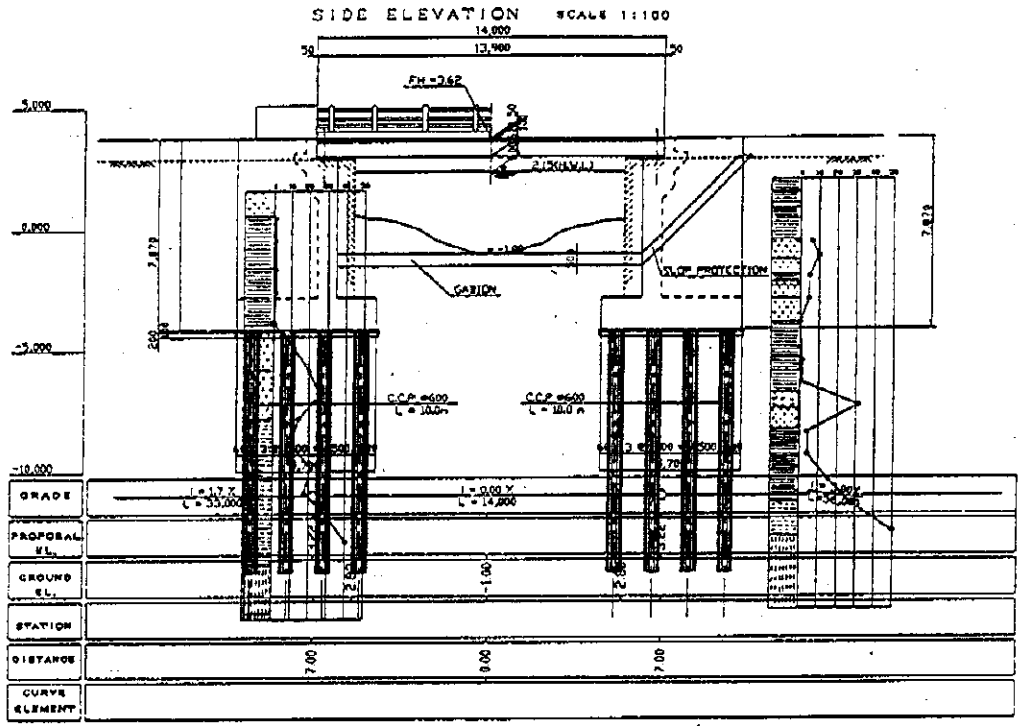
PLAN SCALE 1 : 100

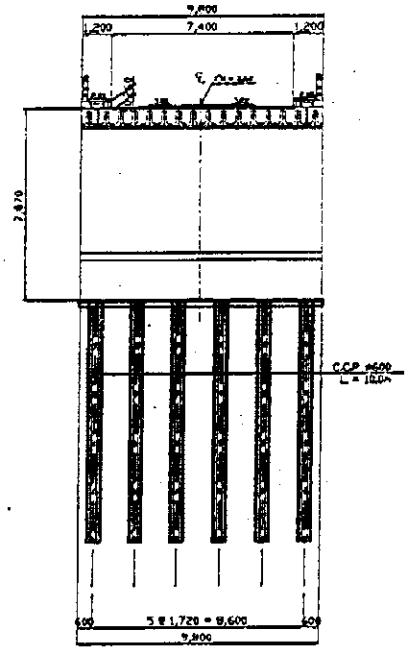


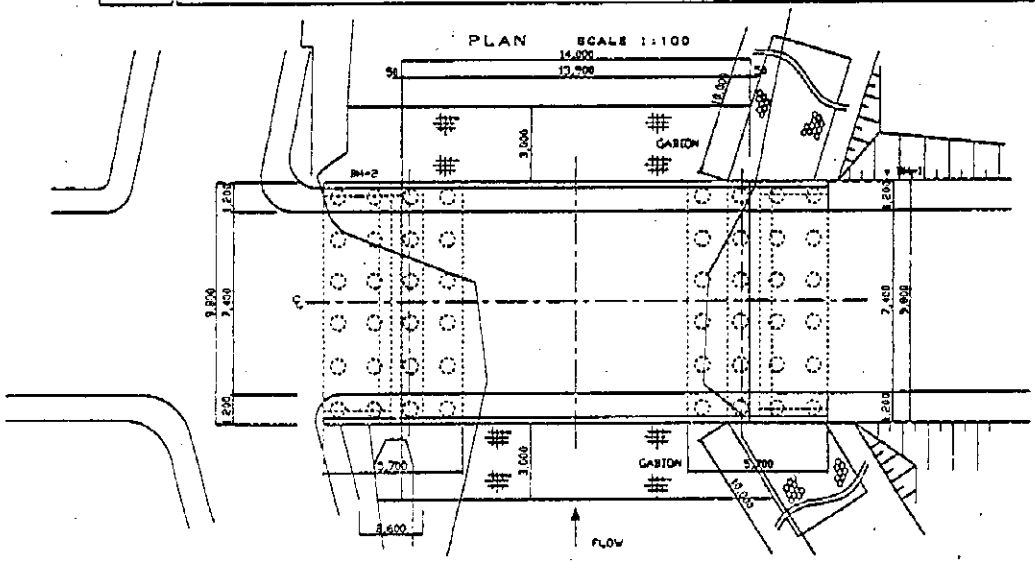
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL VIEW MODA ELA BRIDGE (No. 31)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	

Plate No.

GENERAL VIEW





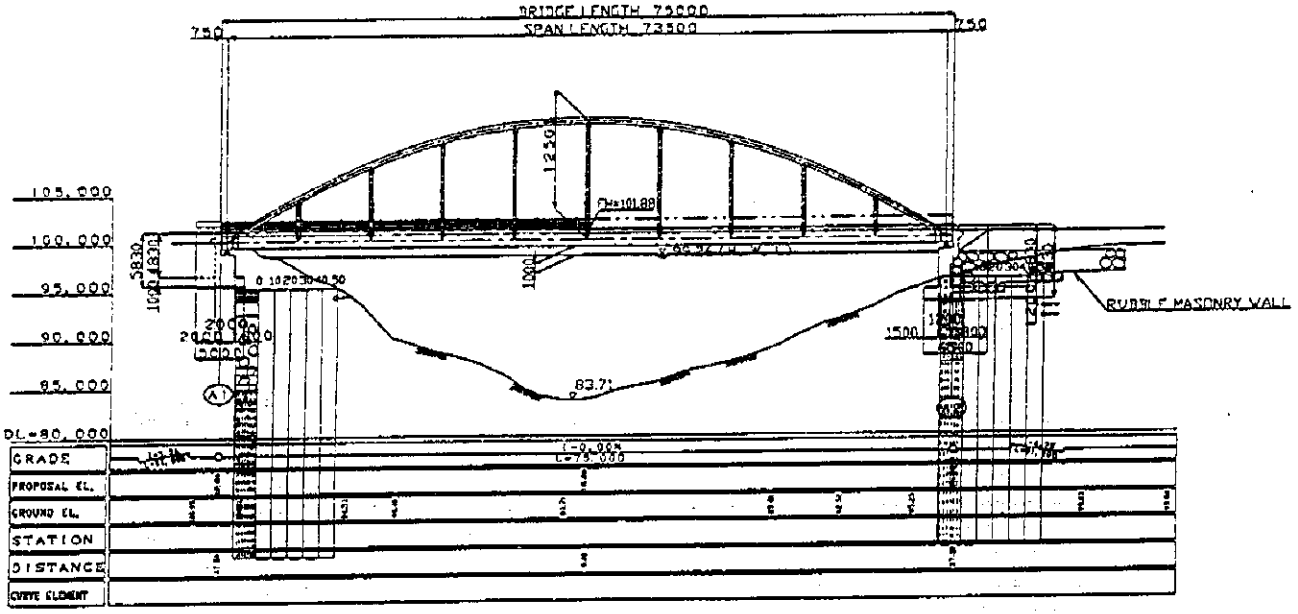


THE DEMOCRATIC SOCIALIST REPUBLIC OF SRILANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL VIEW BOLAWATTA BRIDGE (No. 32)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	

Plate No.

GENERAL VIEW (LOHSE GIRDER)

SIDE ELEVATION SCALE 1 : 250



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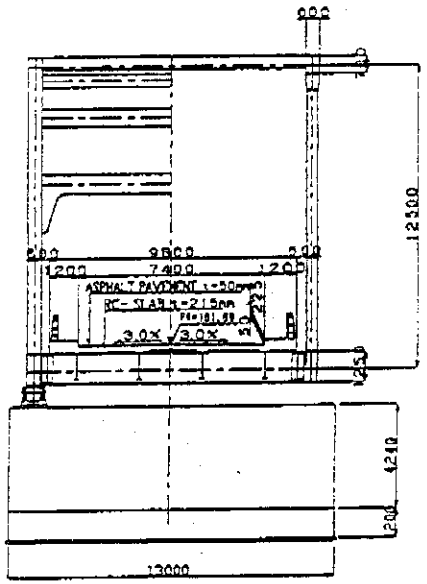
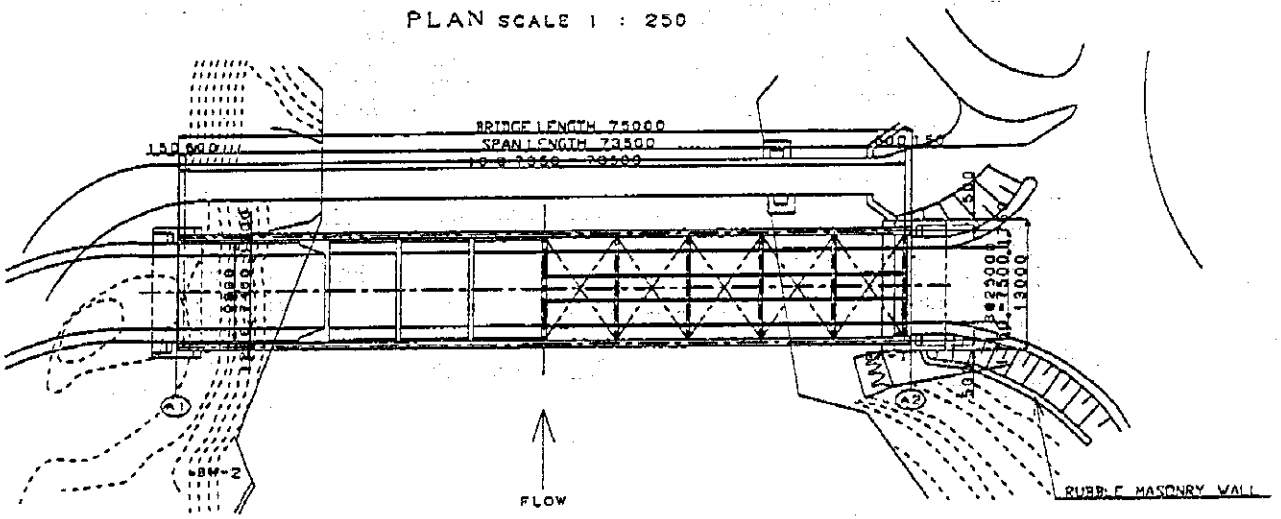


PLAN SCALE 1 : 250

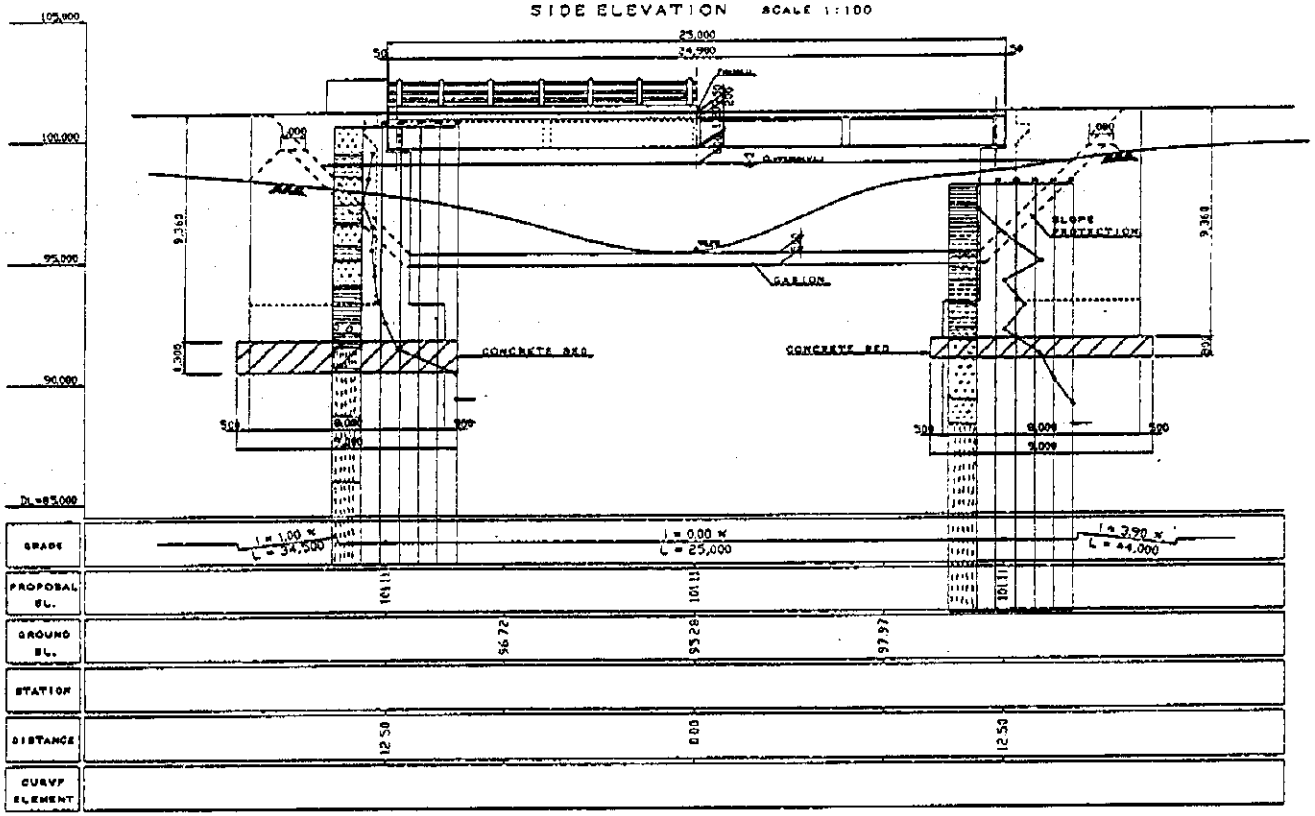


THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL VIEW NARTHUPANA BRIDGE (No. 33)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	

Plate No.

GENERAL VIEW

SIDE ELEVATION SCALE 1:100



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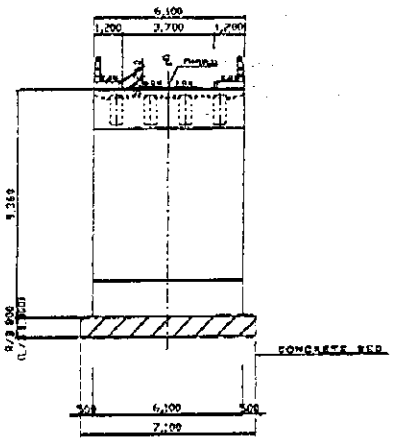

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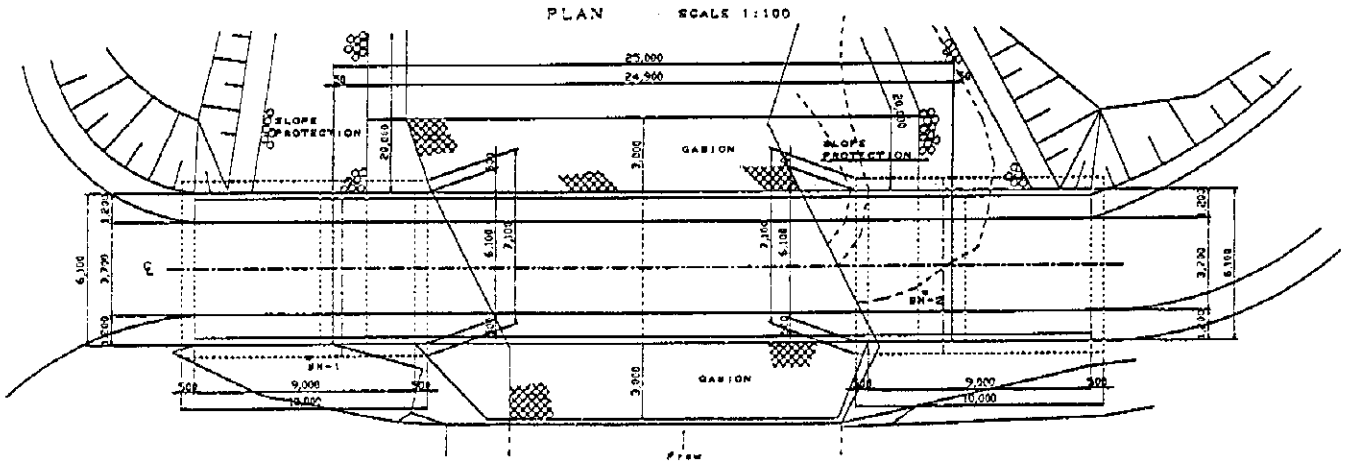
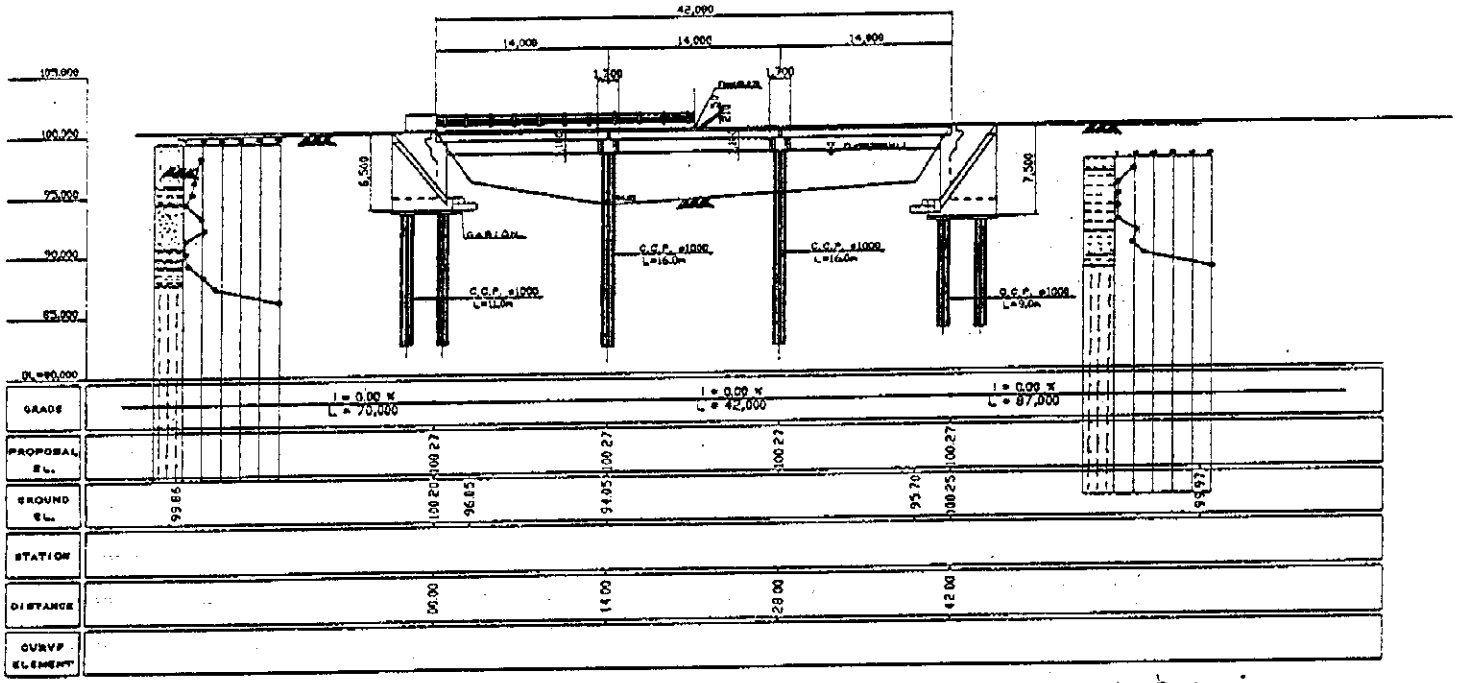


THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL VIEW GILIMALE BRIDGE (No. 38)
SCALE	DRAWING NO.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	

Plate No.

GENERAL VIEW

SIDE EVLEVATION SCALE 1:200



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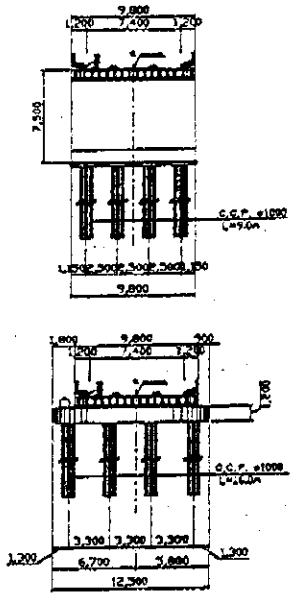

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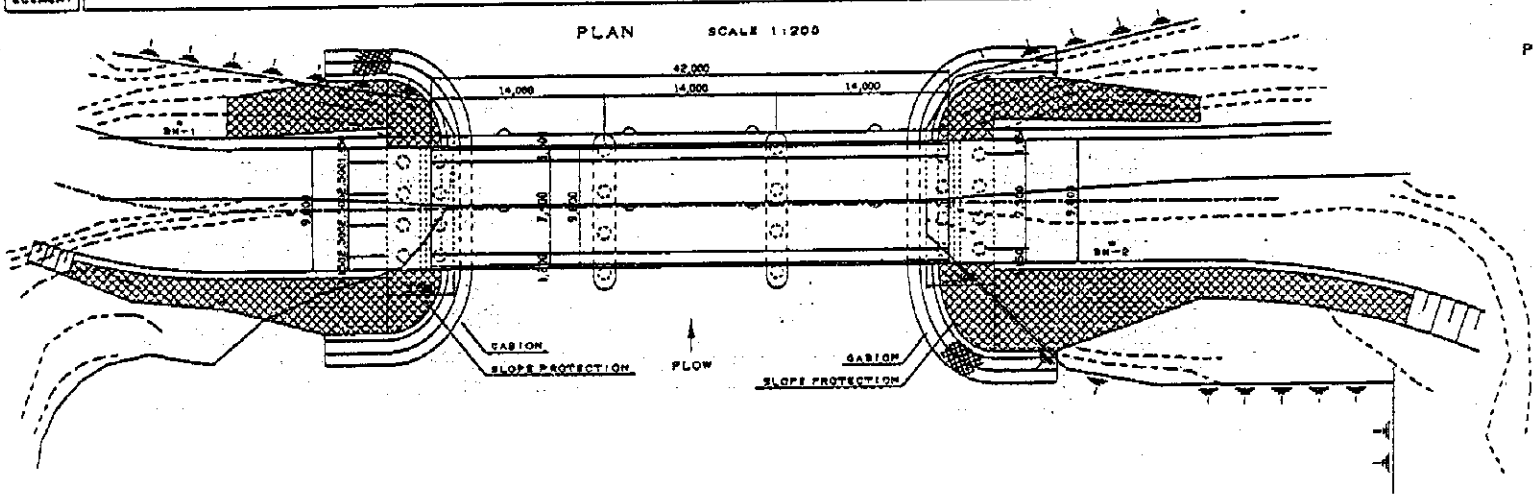
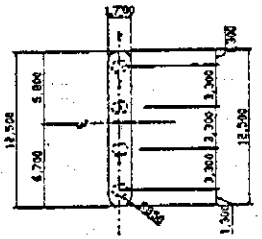


PIER PLAN SCALE 1:200



THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	
THE PROJECT FOR RECONSTRUCTION OF BRIDGES	
DRAWING TITLE	GENERAL VIEW KOSPALANA BRIDGE (No. 70)
SCALE	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY ORIENTAL CONSULTANTS CO., LTD	