Department of Works & Implementation
Papua New Guinea

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
RECONSTRUCTION OF
LERON BRIDGE AND BITIJA BRIDGE
ON THE HIGHLANDS HIGHWAY
IN
PAPUA NEW GUINEA

DECEMBER 2000

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

PREFACE

In response to a request from the Government of Papua New Guinea the Government of Japan decided to conduct a basic design study on the Project for Reconstruction of Leron Bridge and Bitija Bridge on the Highlands Highway and entrusted the study to the Japan International Cooperation Agency (JICA).

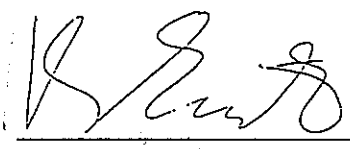
JICA sent to Papua New Guinea a study team from July 6 to August 12, 2000.

The team held discussions with the officials concerned of the Government of Papua New Guinea, 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 Papua New Guinea 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 Papua New Guinea for their close cooperation extended to the teams.

December 2000



Kunihiko Saito
President
Japan International
Cooperation Agency

December, 2000

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Reconstruction of Leron Bridge and Bitija Bridge on the Highlands Highway in Papua New Guinea.

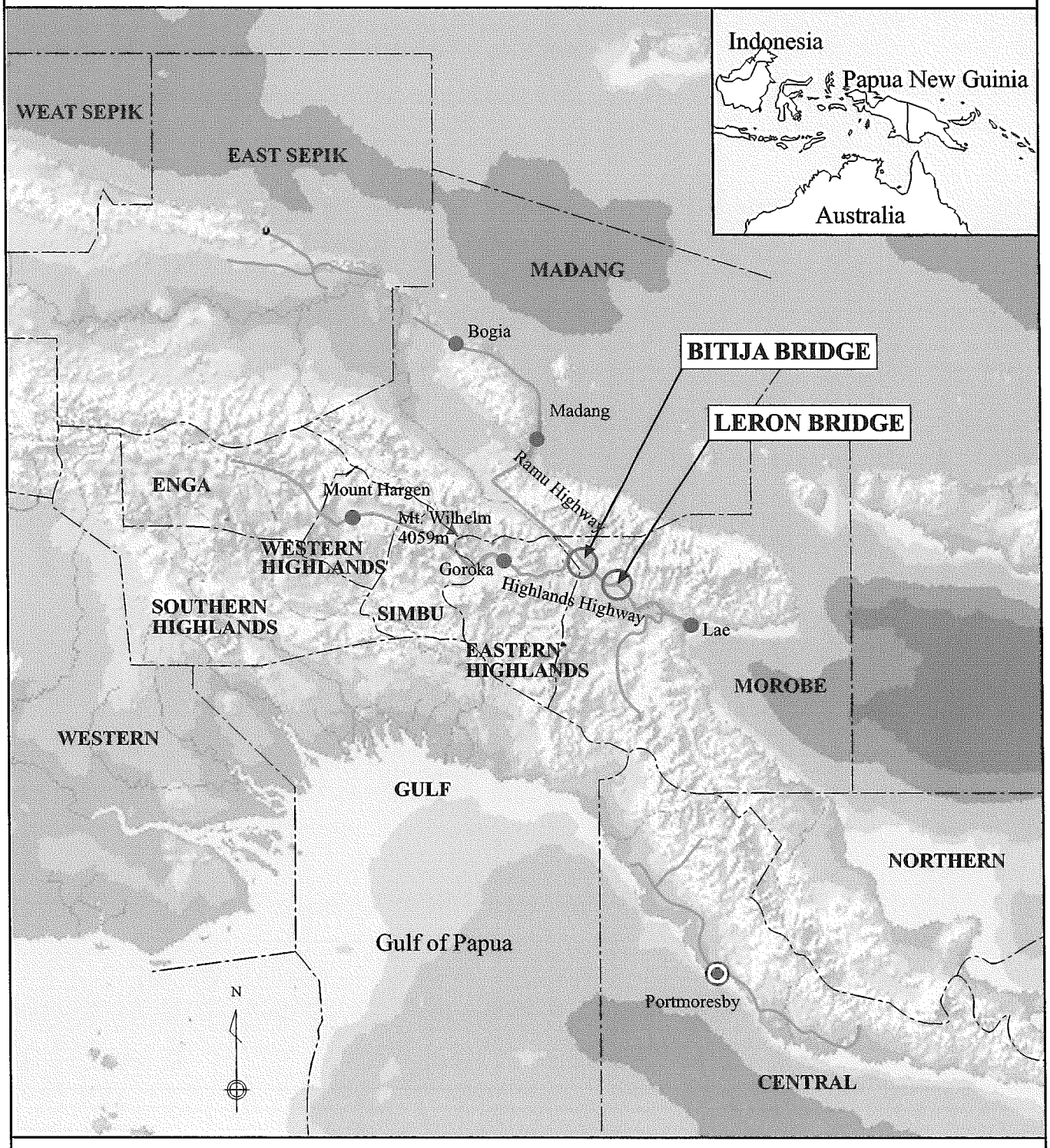
This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from June 30, 2000 to December 20, 2000. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Papua New Guinea and formulated 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,

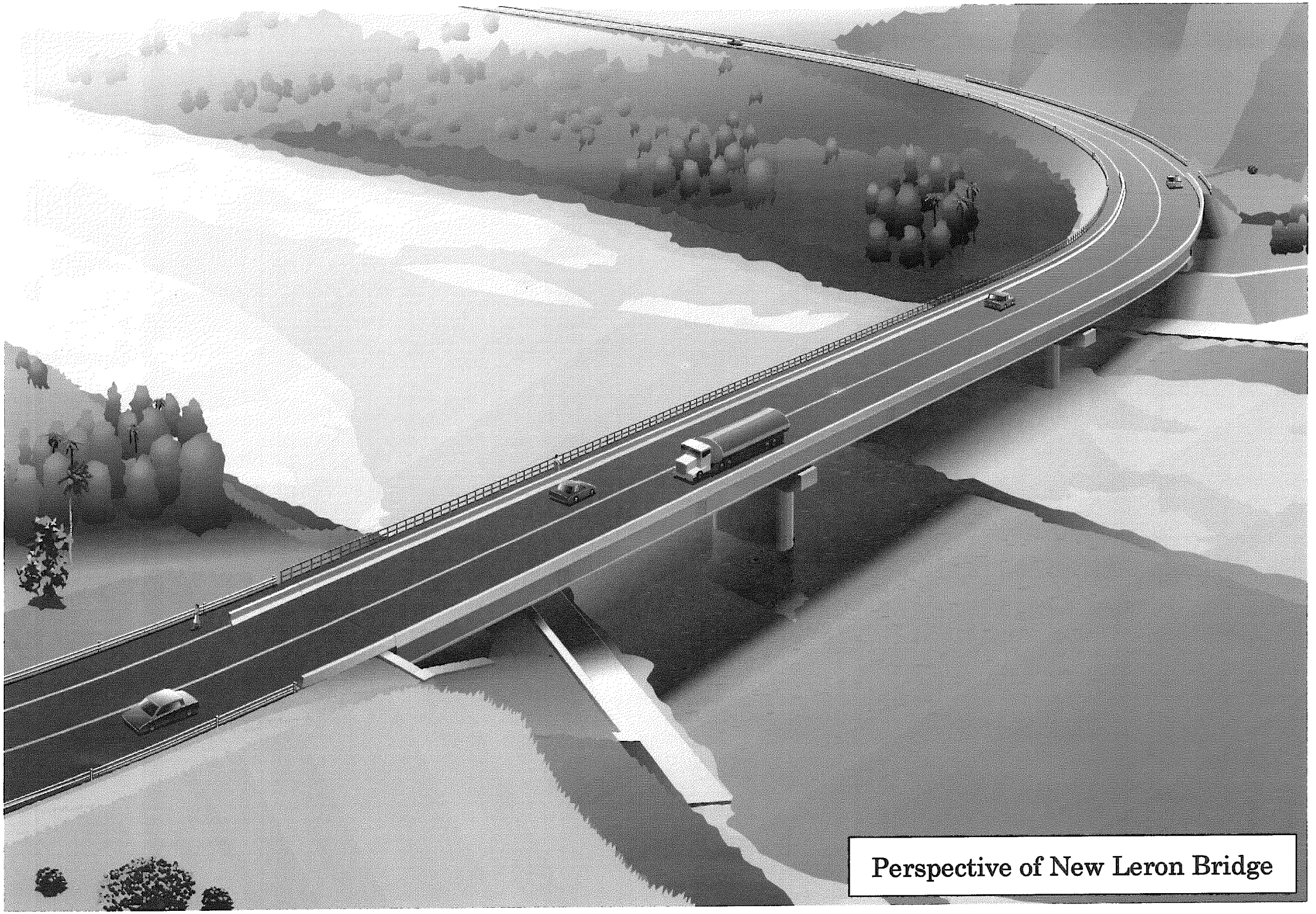
K. Matsumoto

Kiminori Matsumoto
Project Manager
Basic design study team on
the Project for Reconstruction of
Leron Bridge and Bitija Bridge
on the Highlands Highway
in Papua New Guinea
Nippon Koei Co., Ltd.

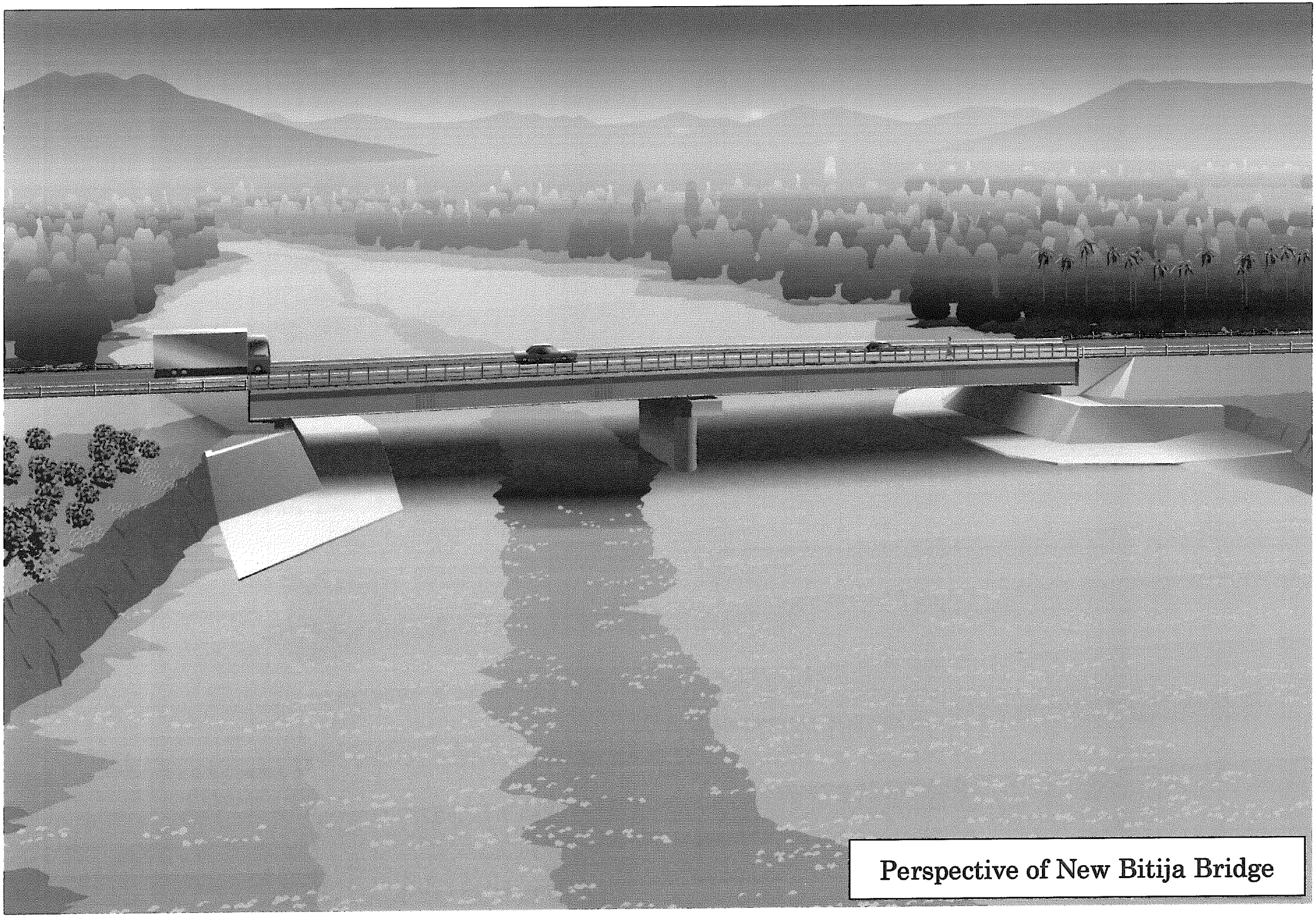


BASIC DESIGN STUDY ON THE PROJECT FOR RECONSTRUCTION OF LERON BRIDGE AND BITIJA BRIDGE ON THE HIGHLANDS HIGHWAY IN PAPUA NEW GUINEA

LOCATION MAP



Perspective of New Leron Bridge



Perspective of New Bitija Bridge

Abbreviations

ADB	:	Asian Development Bank
AusAid	:	Australian Aid
DA	:	Department of Agriculture
DEC	:	Department of Environment & Conservation
DNPM	:	Department of National Planning & Monitoring, Former DNPI
DOWI	:	Department of Works & Implementation, Former DOTW
EU	:	European Union
GDP	:	Gross Domestic Products
JICA	:	Japan International Cooperation Agency
KN	:	Kilo Newton
NMB	:	National Mapping Bureau
JBIC	:	Japan Bank of International Cooperation (Former OECF)
PC	:	Prestressed Concrete
PNG	:	Papua New Guine
POM	:	Port Moresby
ROW	:	Right of Way
WB	:	World Bank

BASIC DESIGN STUDY REPORT
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CONTENTS

Appendices

Chapter 1 BACKGROUND OF THE PROJECT

The Highlands Highway connecting Lae City and the Highlands region is the most vital trunk highway with the heaviest traffic volume in PNG. DOWI branch office has investigated the conditions of this highway continuously to find maintenance problems. Through these investigations, they found that two bridges at Lae to Watarais (a junction of the Highlands Highway and the Ramu Highway, 160km from Lae) section on this highway have aged and became traffic bottlenecks in terms of the load carrying capacity and the traffic flow capacity. These two bridges that are in critical condition are Leron Bridge (98.7 km from Lae City) and Bitija Bridge (156km from Lae City) on the Highlands Highway.

1.1 Damages of Leron Bridge and Bitija Bridge

(1) Scouring of Foundations

The steel pile foundations of both Leron Bridge and Bitija Bridge are exposed due to scouring and are eroded moreover. Durability of those steel piles is in critical condition, so a flood or a strong earthquake may cause them to collapse.

(2) Damaged Concrete Slab Deck

Both bridges consist of a single lane concrete deck slab with steel girder. The slabs have many serious cracks and their surfaces are badly worn and have many dents and holes. In the near future, these decks may cave in. However, it is impossible to repair these decks completely because these bridges have only a single lane that would have to be shut to traffics for approximately one month during the repairs.

1.2 Social and Economical Importance

The Highlands region is the most populous region in PNG, with roughly half of the country's 4 million citizens residing there. The people are involved in a wide range of economic activities, including agricultural operations (vegetables, fruit, coffee, tea, etc.), mining operations (gold, copper, etc.), petroleum production, and various industrial and commercial businesses. The Highlands Highway is the only road link between this region and the major sea port which is located at Lae City. Consequently, the majority of goods produced in the region must travel down the highway to Lae for export via ocean freight, and conversely inputs to production must be imported to Lae via ocean freight and then trucked up the highway to the Highlands. In the same manner, the people of the region depend on the highway for the maintenance of social services. Medical, education, and clothing, (to name just a few items needed for everyday life) must all enter the region via the Highlands Highway. For these reasons, the Highway represents the lifeline for the economic and social activities carried out in the region, and the

highway becomes effectively useless if any of the vital bridges along its course should fail or otherwise become dangerous or unpassable.

Accordingly, the Government of PNG made a request for grant aid for the Project for Reconstruction of Leron Bridge and Bitija Bridge on the Highlands Highway (the Project) in September 1999 taking into account its urgency and priority.

Chapter 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

The establishment of this Project will provide an immediate replacement for the Leron Bridge and Bitija Bridge that are in critical conditions, thus eliminating the possibility of a failure of the bridges disrupting land transport to between the Highlands Region and Lae.

The overall goal of the Project is to ensure the continuous and uninterrupted operation of the Highlands Highway. This will contribute to the continuing development of the Highlands region and the nation as a whole.

2.2 Basic Concept of the Project

2.2.1 Outline of the PNG's Request

The Government of PNG requested the Japan's Grant Aid for the reconstruction of Leron Bridge and Bitija Bridge.

2.2.2 Principles to Formulate Scheme Outline

The principles applied in the Study for formulating the scheme outline are as follows:

- The scale of the new bridges will be just the same as the existing, however the new bridge will cope with various natural conditions at the bridge site.
- Load carrying capacity of the new bridge will be the same as those of standard existing bridges on the Highlands Highway.
- Approach roads and riverbank protection will be provided as the minimum requirements.
- Implementation of the Project will be in accordance with the Japan's Grant Aid system.

2.2.3 Location of New Bridge Site

<u>New Leron Bridge</u>

The new Leron Bridge will be located 15m upstream from the existing bridge.

The reasons for this location are as follows:

- After examination of topographic conditions of the site carried out in Japan, it was clarified that there was no necessity of mountain excavation for this site.

- If the existing bridge was to collapse due to a flood or an earthquake during construction, it would be harmless to the new bridge since it is upstream.

The ROW available at the bridge site is 30m wide on each side totaling 60m and it is enough for the upstream side construction.

New Bitija Bridge

The new Bitija Bridge will be located at the same place as existing one. It is very easy to construct a detour for the new bridge construction, because the difference of the height level of riverbed and access road is small.

2.2.4 Selection of Bridge Type

(1) Bridge Length

Required total bridge length and minimum span length are determined by using several empirical formulae as stipulated below based on the estimated flood peak discharge with a 50-year return period.

- Bridge Length

$L = 0.5^{/1} \sim 0.8^{/2} \cdot Q^{3/4}$ -------- (1) By Sabo Standard by MOC in Japan
$L = 3.3^{/1} \sim 4.9^{/2} \cdot Q^{1/2}$ ------- (2) Lacey's formula

Where: Q = Flood Peak Discharge
L = Desirable bridge length
/1: Applicable to a river with stable water flow
/2: Applicable to a river with unstable water flow
MOC : Ministry of Construction

- Minimum Span Length

$L = 30^{/1} + 0.005\ Q$ ------- (3)

Where: L = minimum span length
Q = peak discharge
/1 instead of 20 specified in Sabo Standard by MOC in Japan, 30 is applied taking the long logs deposited in the river into consideration.

For Leron Bridge

To accommodate the peak flood discharge of the Leron River at the bridge site, the desirable total bridge length is estimated at approximately 150m. The minimum span length is estimated at 35m by the formulae shown above to cope with the floating debris such as long and big logs.

For Bitija Bridge

For Bitija Bridge, total bridge length and minimum span length cannot be given by above formulas due to the small catchment area of Bitija(Beboi) River. The existing bridge length and span can be applied to the new bridge.

(2) Bridge Type Alternatives

Studying PNG situation of bridge construction, procurement of materials or aseismic design to be required, (Specifying Earthquake Engineering for Bridges in Papua New Guinea, 1985 Revision) the following four alternatives were recommended.

Leron Bridge

Alternative	Bridge Type	Total Bridge Length	Span Arrangement
A	3 span continuous triple steel girder bridge	150m	45m +60m + 45m
B	3 span continuous steel truss bridge	150m	45m +60m + 45m
C	3 span continuous PC box rigid frame bridge	150m	40m + 70m + 40m
D	4 span composite PC I girder bridge	150m	35m+2@40m+35m

Bitija Bridge

Alternative	Bridge Type	Total Bridge Length	Span Arrangement
A	2 span continuous triple steel girder bridge	50m	2 @ 25m
B	Single span triple steel girder bridge	50m	50m
C	2 span composite PC I girder bridge	50m	2 @ 25m
D	Single span PC box girder bridge	50m	50m

The evaluation of alternatives from various aspects are shown in Appendices 4, Technical Notes signed on August 11, 2000 Figure-2(1) and Figure-2(2).

(3) Selection of Bridge Type

For selection of the Optimum Bridge Alternative, the present situation of bridge planning and bridge construction activities in PNG were taken into account:

- The quality of cement in PNG has been much improved. However, locally produced cements cannot be applied to PC (Prestressed Concrete) bridge construction due to widely fluctuating quality. Furthermore, local contractors with PC bridge construction experience are not available.

- Most of the bridge types existing in PNG are steel girder bridge, which having been selected for easy quality control at job site and for earthquake proof aspects due to their light weight superstructure.

- The major bridge construction materials such as steel plate, reinforcing bars, PC cables and tendons are not available in PNG.

1) Selection of Superstructure

Based upon this construction situation in PNG and the evaluation results of the alternatives, alternative A (3 span triple continuous steel composite girder) is the most suitable for Leron Bridge. And for Bitija Bridge, alternative A is selected as the optimum bridge type.

Though the total bridge length of the new Leron Bridge was considered as 150m for the selection of the optimum bridge alternative, the bridge length for the basic design was changed as described at “2.2.3 Location of New Bridge Site” and was decided as 168m with bridge type alternative A, which is still optimum.

2) Selection of Deck Slab

Because the less number girder system makes deck slab span wider, thickness of the deck slab would be thicker. if the deck slab is made with RC. Thicker RC deck slab needs more reinforcing bars and it makes deck slab heavier. In this case, PC deck slab might be selected but no contractor is able to construct PC members in PNG. In this project, steel-concrete composite deck slab is selected as the optimum solution.

3) Selection of Foundation Type

Leron Bridge

For piers, an open caisson should be selected as the optimum foundation type based on the following site conditions:

- The subsoil is entirely dense sand and gravel include 10 – 40cm boulders. Therefore, it is difficult to drive piles or cast-in-site piles.

- Severe local scouring (Existing piles of H steel are exposed 1m due to scouring). Caisson type foundation is stable for scouring.

Bitija Bridge

At the Bitija Bridge site, the subsoil is loose sand with gravel. Driving steel piles is recommendable for Bitija Bridge due to the following site conditions:

- The subsoil is loose sand with gravel up to bearing strata (without boulders). So steel piles can be driven by hammer.

- Easy construction and construction period can be shortened.

2.2.5 Proposed Height of Bridge

Leron Bridge

After site investigation, longitudinal and cross section survey results of river bed of Leron River carried out in 1997 and 2000 were analyzed. This analysis shows that the riverbed settled down 1.5m. And this settling down of the riverbed is supposed to be continuous because the soil production of this area decreases year by year and scouring speed is high.

At the soil production area, collapsed soil volume (15 million m^3) due to earthquake excitation reduced the volume washed away is estimated 10 million m^3. This remaining soil will be washed away to downstream when a big rainfall happens at the soil productive area. Taking into account short time rainfall of 100-year return period (intensity: 132mm/day), sedimentation at the Leron Bridge location is estimated to average 1.29m depth.

Therefore, the proposed height of the new Leron Bridge must be decided considering estimated sedimentation, high water level and clearance from girder bottom. The existing bridge has clearance of 4m from the bottom of girder and the proposed height of the new Leron Bridge is intended to the same height as the existing bridge.

Bitija Bridge

The catchment area of the Bitija River is rather small and soil production due to earthquake in 1993 was only 60,000 m^3. Soil productive area is constant, therefore soil productive volume is also constant 35,000m^3 – 45,000m^3. Soil production volume of 60,000m^3 was washed out and soil sedimentation of this location is almost all by surface erosion.

Therefore, for short term rainfall of 100-year return period, average sedimentation depth is less than 7cm and the proposed new bridge height from the riverbed to the bottom of the girder is intended to apply the same height as the existing one.

2.2.6 Approach Roads

The approach roads of the new bridges have to be connected to the existing highway with the minimum requirement to meet the geometric standard specified in the Road Design Manual of DOWI. The pavement composition of the approach roads will be the same composition as of existing one.

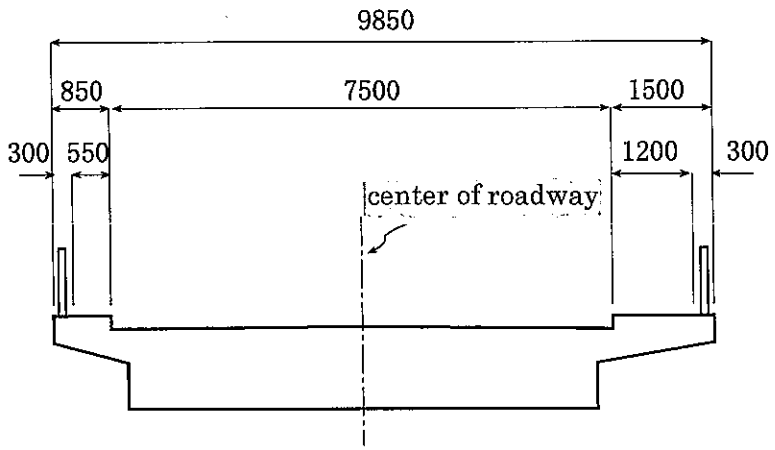
2.2.7 Proposed Width

(1) Roadway Width

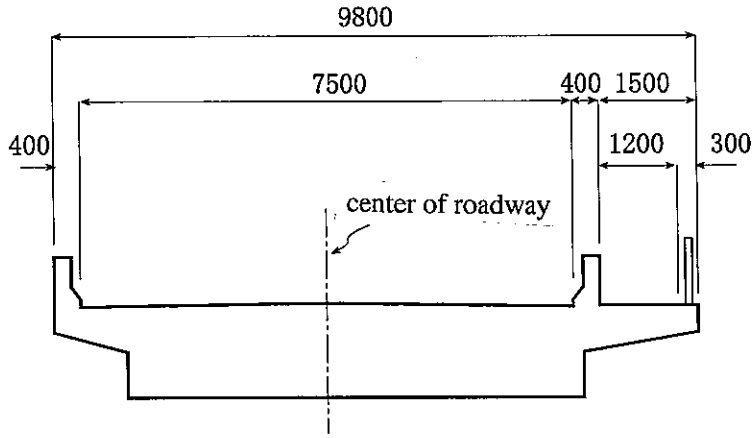
The standard road width of the Highlands Highway, before and after Leron Bridge and Bitija Bridge, is 6.5m of carriageway (2 lanes) and 2.0m shoulder on each side in average. Hence, these same widths as these are applied to the width of the approach roads.

(2) Bridge Width

The standard width of the bridges on the Highlands Highway is shown in the following figure.



In addition to this, concrete barrier walls were considered to decide the new bridge width shown in the following figure to secure safety of pedestrian and protect vehicles at the lane edge and one side fence to protect pedestrian. This design was applied for Umi Bridge.



2.2.8 Protection of Abutment

Taking river flow velocity into account and scouring of pier inside the river, it is necessary to provide protection of abutments. Leaning type retaining walls suitable to provide for protection will be constructed.

2.3 Basic Design

2.3.1 Design Concept

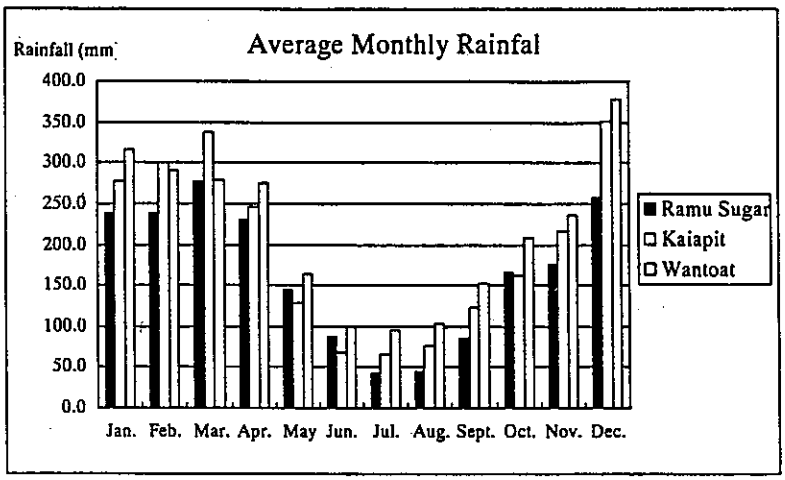
(1) Natural Conditions

1) Rainfall Pattern

There are three rainfall monitoring stations, Wantat, Kaiapit and Ramu Sugar Factory, in/near the Leron catchment area and Bitija catchment area. The daily rainfall data obtained from the NWS (National Weather Service) for the remote sensing analysis are as follows:

- Daily rainfall (1972 – 1980) at Wantoat (About 27km toward north from the Leron Bridge, elevation of 1,162m)
- Daily rainfall on 1974 at Kaiapit (About 20km toward north-west from the Leron Bridge, 27km toward south-east from the Bitija Bridge, elevation of 303m)

- Daily rainfall (1980 – 1999) at Ramu Sugar (About 30km toward north-west from the Bitija Bridge, elevation of 400m)



The above figure shows general rainfall pattern in these areas. According to this figure, the rainy season is a five-month period from December to April and the rest of the year goes under dry season.

2) River Bed Aggradation in Bridge Location

Leron Bridge

The aggradation of riverbed at the Leron Bridge location was estimated at 1.29m for maximum condition according to the following points of view.

a) According to the field survey and cross section survey (1997 and 2000), 1.5m riverbed degradation was observed in Leron bridge location.

b) The collapse soil volume, derived from the 1993 earthquake in Leron basin, was estimated at 15,880,000m^3. However, the estimated soil will not be discharged to the outlet of basin all at once. Some of the collapsed soil will be changed to colluvial soil as a secondary sediment and forms gentle slope. Some of the soil would be discharged to the lower stream. Because of that, mean annual sediment run-off is less than collapse soil volume.

c) The landslide/slope failure area increased (2.26km^2 to 5.02km^2) after an earthquake in 1993. However, since vegetation recover is much faster than newly occurred landslide/slope failure, the area of landslide/slope failure tending toward decreasing after earthquake. Consequently area of landslide/slope failure in 2002 is estimated as 2.77km^2 and 1.4% decreased from 1998.

d) In accordance with the decreased soil production area, sediment yield is also decreased from 1,290,000m^3 in 1994 to 600,000m^3 in 2000 (53% decrease). In addition, according to the a), it is reported that riverbed in Leron Bridge location is degraded. It means that the major influence factor to riverbed sedimentation is tend to decrease so that riverbed will be degraded in the Leron Bridge location even in the future.

e) The collapsing soil volumes derived from earthquake in 1993 were 15,880,000m^3 and 11,000,000m^3 of collapsing soil still deposited in soil production area. 4,700,000m^3 soils were flowing since 1993 because of the erosion. It can be said that these soils might be flowing down by the stream power from soil production area in case of the large scale rainfall. Therefore, sedimentation status at bridge location were predicted in case of 100-year probable rainfall (132mm/day). Consequently, the result of the estimation of riverbed aggradation was 1.29m at bridge location.

Bitija Bridge

The aggradation of riverbed at the Bitija Bridge location could not be determined. However, based on the bed load analysis, riverbed aggradation was estimated less than 0.07m in maximum condition according to the following points of view.

a) Due to missing cross section survey data, (8m difference was identified in existing cross section survey), riverbed deformation could not be examined.

b) The estimation of sediment yield from earthquake in 1993 was 60,000m^3.

c) There is no temporal change in landslide/slope failure area between 1994 to 1998 (0.02km^2, 0.03% of basin) so that it can be predicated that area of landslide/slope failure in 2002 will almost be the same.

d) According to the temporal analysis of landslide/slope failure area, there is no difference was observed so that temporal difference of sediment yield is less (3,500m^3 to 4,500m^3). 44,000m^3 sediment run-off was estimated at bridge location based on analysis.

e) The collapsed soil volumes derived from earthquake in 1993 were estimated as 60,000m^3 but these collapsed soil had already been missing so that the problems in sedimentation in this location could be understood as surface erosion. The result of the estimation of

riverbed aggradation was 0.07m at the bridge location in case of Return Period of 100 year Rainfall.

(2) Social Condition

The social conditions to be considered in the Study are 1) Land ownership system, and 2) Public security problem in PNG.

1) Land Ownership System

From the statistics, only 3% of the whole land in PNG belongs to private and the remaining 97% are under customary land tenure to each tribe, which in turn causes difficulty of land acquisition even for public projects.

Taking into account this situation, it is one of the concepts that the project facilities will be planned within the ROW limit of 30m each side, which had been newly acquired for this project.

2) Public Security Problem

It is difficult to say that the public security in PNG is in peace and good order. Hence, it is strongly requested to the Government of PNG to secure the safety of Japanese nationals engaged in the Project and to provide tight security against riot, insurrection, civil commotion and usurped power.

(3) Circumstances of Construction Conditions

1) Labor Conditions

In PNG, wage rate and other regulation have been stipulated in the Port Moresby Common Rule by the Department of Labor and Employment. For public servants, the General Order regulates those.

At the several construction job sites, it has been observed that local staffs are assigned as operators and common labors under supervision by Australian field foremen. This personnel assignment is likely standard.

2) Procurement of Construction Materials

- Steel Plates and Reinforcing Bars

Steel plates, reinforcing bars and secondary steel products such as steel pipes, wire meshes, corrugated metal pipes, angle bars, etc. are mostly imported from either Australia or New Zealand.

- Cements

  Only normal portland cement being produced by the Halla Cement Factory at Lae City is available locally for the Project. It is noted that importing cement is prohibited by the Government.

- Sand and Gravel, Plywood and Timber

  Sand and Gravel, Plywood and timber are all available at Lae City.

3) Procurement of Construction Equipment

   General construction equipments such as bulldozers, dump trucks, truck cranes, generators, etc. owned by local contractors (mainly Australian or New Zealander local subsidiary) are available in PNG. Hence, few construction equipments will be procured in Japan.

(4) Applicability of Local Contractor

Local contractors, which are mostly Australian or New Zealander subsidiaries, should participate in the Project as subcontractors of a Japanese contractor. It is important for Japanese technology, such as caisson and quality control, to be transferred through a joint operation.

(5) Capability of Executing Agency for Maintenance and Operation Works

The DOWI is responsible for maintenance and operation of the roads and bridges under the national highways and is the counterpart agency for the Study and the project implementation. DOWI faces a shortage of funds for the construction and maintenance of roads and bridges and also does not have enough experienced middle class engineer staff.

This Project gives good opportunity to recognize the necessity of periodical maintenance and to contribute to improving maintenance capabilities of engineer staff of the DOWI through implementation of the Project.

(6) Policy of Construction Schedule

Estimating construction schedule, the following items must be fully considered.

- Rainfall pattern

- Period to be required for procurement of material and machinery

- Workable items during rainy season

- Safety and security measures

At the site of Leron Bridge, river flow volume will be vast during rainy season, so it is necessary during planning of construction schedule to fully consider temporary detour, temporary bridge, and drainage system so they are not harmed through the rainy season. However, there will be less problem to the Bitija site for a little water flow of Bitija River.

2.3.2 Basic Design

(1) Overall Scheme

Overall scheme of the facility to be planned is shown in the following table.

a. Leron Bridge	b. Bitija Bridge
• Bridge Location The new bridge is located 15m upstream of the existing bridge for the following reasons:	The new bridge is located at the same position as the existing one for the following reasons:
• Bridge Length - 168.0m	- 50.0m
• Bridge Type - 3 span continuous composite steel girder + simple span composite steel girder	- 2 span continuous composite steel girder
• Combination of Span Arrangement - 51.4m + 52.0m + 39.45m, 23.10m	- 24.6m + 24.6m
• Type of Abutment - Inverted T Abutment (Spread Footing)	- Inverted T Abutment (Steel Pipe Pile)
• Type of Pier - Hammer Type Pier	- Hammer Type Pier
• Type of Foundation - Circular Open Caisson	- Steel Pipe Pile
• Bridge Width - Overall Width: 9.8m Carriage Way 7.5m Foot Way 1.2m	- Overall Width: 9.8m Carriage Way 7.5m Foot Way 1.2m
• Road Width - Overall Width: 10.5m Carriage Way 6.5m Foot Way 2.0m x 2	- Overall Width: 10.5m Carriage Way 6.5m Foot Way 2.0m x 2

(2) Design Criteria

1) Design Standard to be applied

For this Project, Specifications for Highway Bridge (published by Japan Road Association) is basically applied except local conditions of thermal effect and earthquake intensity for design.

2) Geometric Standard

Highway Design Manual (PART 2) established by DOWI is applied for Geometric Standard as shown by the following table in this Project.

Geometric Standard applied for the Project

Geometrical Elements	Applicable Criteria	Remarks
Road classification	National Highway	
Design speed	V=60km/h	Traffic category is heavy (400vpd)
Horizontal curves	Minimum R=150m	
Transition curve length	Minimum R=50m	
Gradient	General max 5% Absolute max 8%	
Crossfall	3%	
Superelevation	9%	R=150m
Superelevation transition	60m	When V=60km/h, Wn=6.5m, e=0.09
Number of lanes	One each way	Asphalt surface
Carriageway width	3.25m	Asphalt surface
Shoulder width	2.0m	As same as existing

3) Design Flood Level

Design Flood Level for design is estimated in the following table. Flow depth of 50-year return period are applied.

Design Flood Level

Name of river	**50-year return period**	**Flow depth**	100-year return period	Flow depth
Leron River	**830m^3/s**	**4.0m**	910m^3/s	4.4m
Bitija River	**190m3/s**	**2.5m**	210m^3/s	2.7m

4) Live load to be applied

In PNG for live load, Austroads “TL-44” is applied. However, may heavier trucks weighing 60t are travelling along the Highlands Highway.

B-live load specified in the Japanese Criteria can cover this heavy load and is recommendable to apply in this Project.

5) Earthquake Load

Design Criteria for seismic effect in PNG is applied "Earthquake Engineering for Bridges in Papua New Guinea, 1995 Revision".

Using the following equation specified in the above criteria, earthquake coefficient V is estimated at 0.25 ~ 0.30 in this Project.

V = C • I • M • Wt
C : Basic Seismic Coefficient
I : Important Factor
M : Material Factor
Wt : Dead Load

6) Local Souring Depth

The local scouring depth of 3.2 m is considered in the stability analysis of substructure of the Study.

7) Thermal Effect

The effective temperature gradient will be ±10°C in the Study.

8) Log Impact

The forces due to log impact will be calculated in accordance with Article 2.10.6 of the AusRoads Bridge Code.

9) Unit Weight of Materials

The unit weight of materials applied in the Study is as follows:

Steel	:	77 KN/ m^3 (7,850 kgf/m^3)
Reinforced Concrete	:	27 KN/ m^3 (2,500 kgf/ m^3)
Concrete	:	27 KN/ m^3 (2,500 kgf/ m^3)
Asphalt Concrete	:	22 KN/ m^3 (2,300 kgf/ m^3)

10) Material Strength

- Superstructure

• Structural Steel		Mini. Yield Point	Mini. Tensile Strength
SS400	(t < 16 mm)	245 N/mm^2	400 ~ 510 N/ mm^2
SS400	(16 < t < 40 mm)	235 N/ mm^2	400 ~ 510 N/ mm^2
SM490Y	(t < 16 mm)	365 N/ mm^2	490 ~ 610 N/ mm^2
SM490Y	(16 < t < 40 mm)	355 N/ mm^2	490 ~ 610 N/ mm^2
SM520	(t < 16 mm)	365 N/ mm^2	520 ~ 640 N/ mm^2
SM520	(16 < t < 40 mm)	355 N/ mm^2	520 ~ 640 N/ mm^2
• Reinforcing bar (SD295A)		295 N/ mm^2	440 ~ 600 N/ mm^2
• Concrete (28 days)		23,500 KN/ cm^2 (240 kgf/cm^2)	

- Substructure

• Concrete (28 days)	20,600 KN/cm^2 (210 kgf/cm^2)	
	Mini. Yield Point	Mini. Tensile Strength
• Reinforcing bar		
For column (SD345)	345 ~ 400 N/ mm^2	490 N/ mm^2
For others (SD295A)	295 N/ mm^2	440 ~ 600 N/ mm^2

(3) Outline of Basic Design

Based on the overall scheme, basic design for superstructure, substructure, approach road and protection of abutment was carried out.

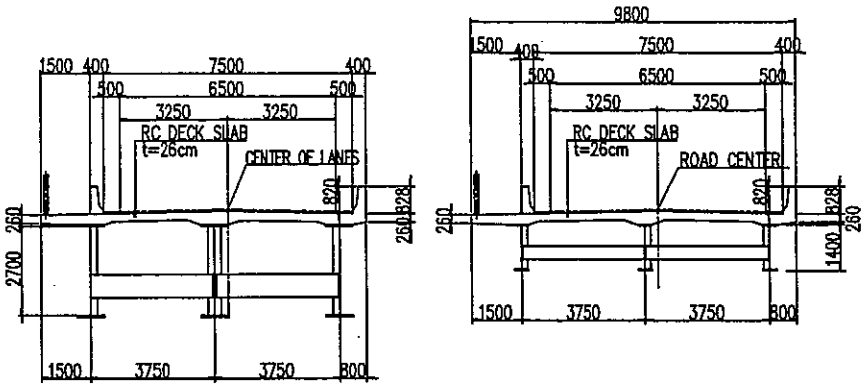
The outline of outputs are shown below.

Leron Bridge

1) Superstructure

In order to eliminate construction cost of superstructure (saving amount of steel), simplified construction and shortening construction period, less numbers of steel girder system is applied for superstructure in this Project.

This system is rational and economical steel composite girder and 3 girders are applied for stability of overturning due to earthquake. Typical cross section is shown in the following figure.



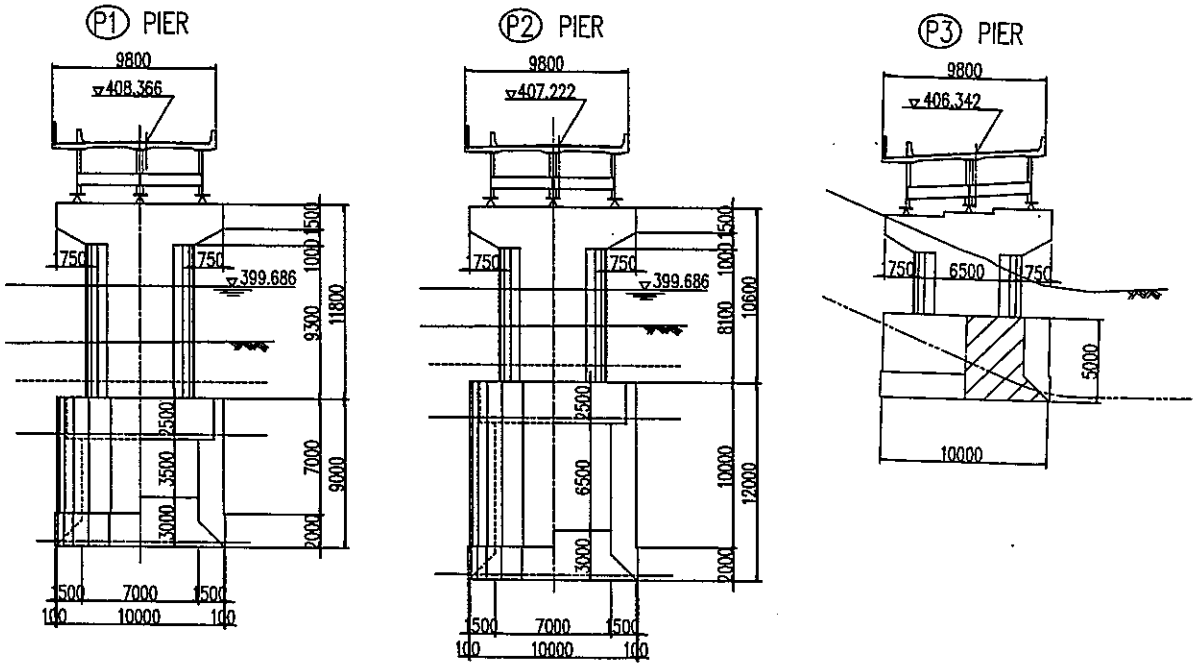
2) Substructure

- Design of Pier

Profile of piers based on basic design are shown in the following figure.

Open Caisson is applied for stability of variable waterbed and can be constructed in the subsoil with sand, gravel, and boulder.

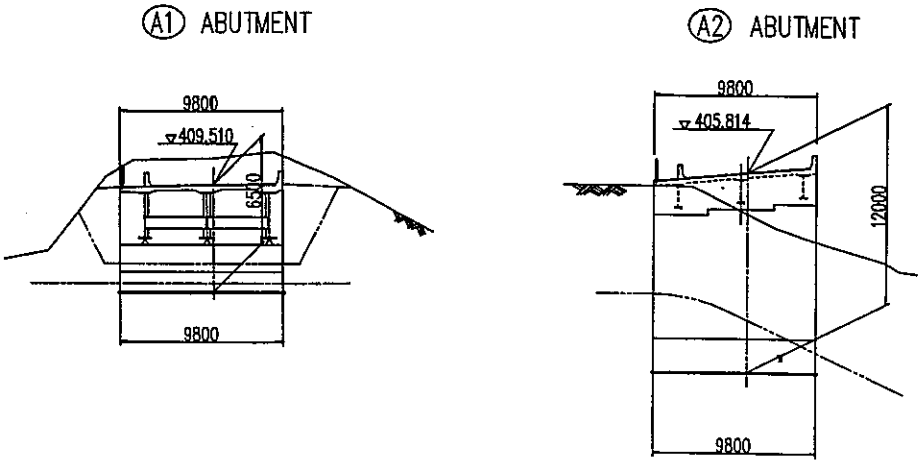
Stability of caisson is checked assuming design ground level to be 3.2m (scoring depth) below stable riverbed.



- Profile of Abutment

  Inverted T type with spread footing is applied for abutment because from boring results, bearing strata (mud stone) appears in shallow depth from surface layer.

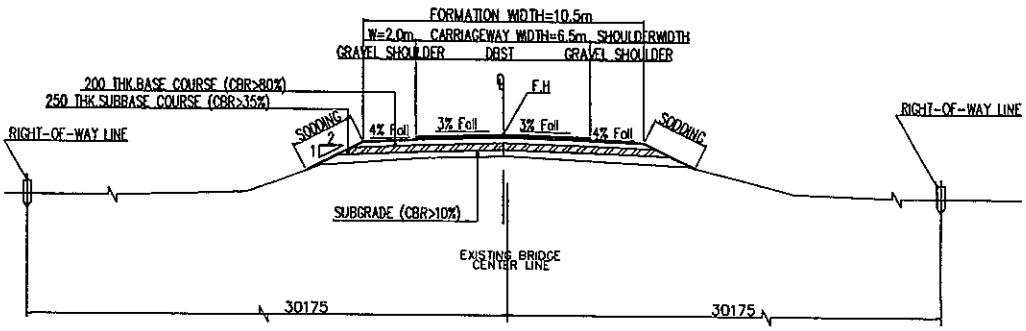
  The profile of abutments are shown in the following figure.



3) Approach Road

Width and composition of pavement for approach road in this Project is basically the same as the existing highway.

Curve of horizontal alignment applied in this Project satisfies the minimum curve length of L=140m because interval between centerlines of the new and the existing is small and 15m.



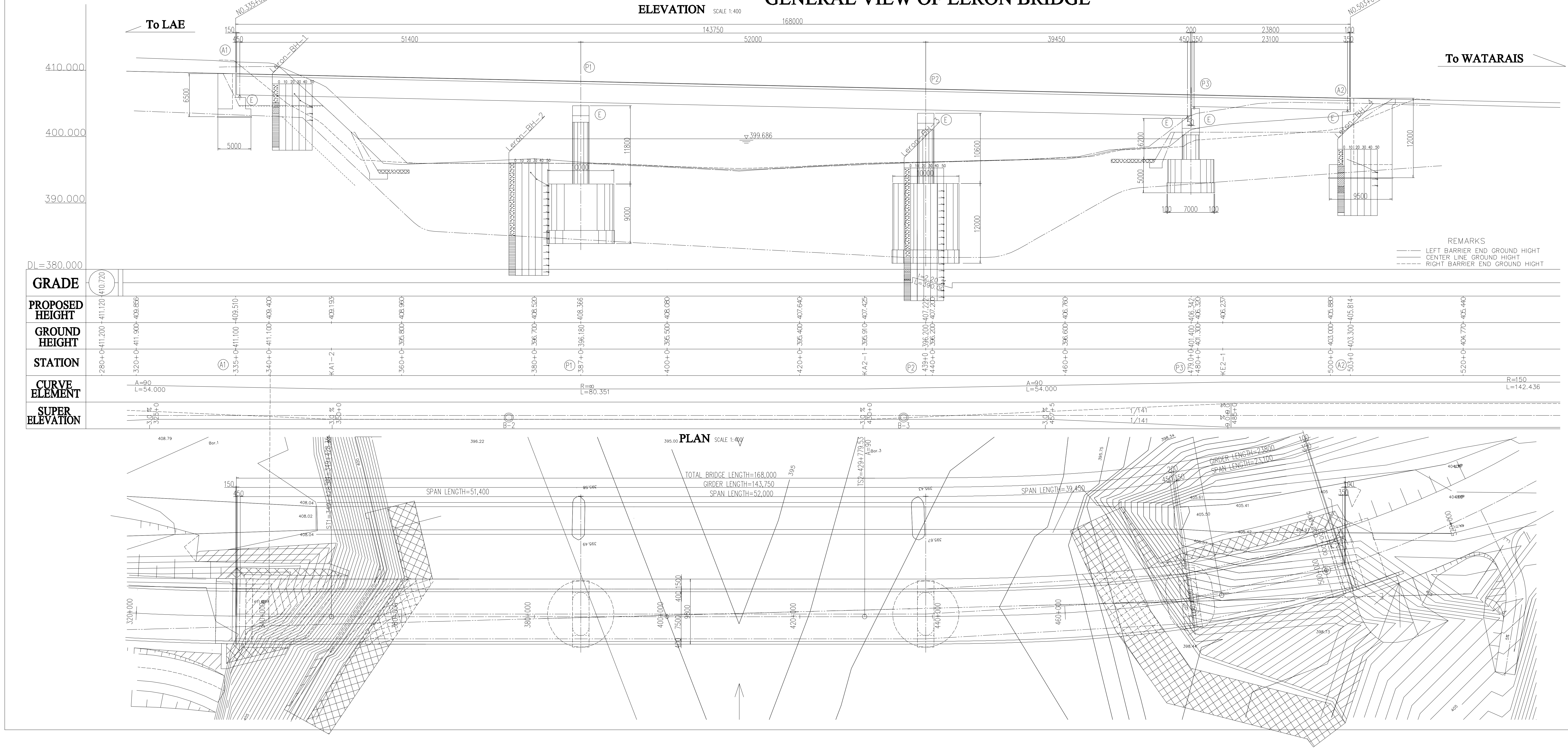
4) Protection of Abutment

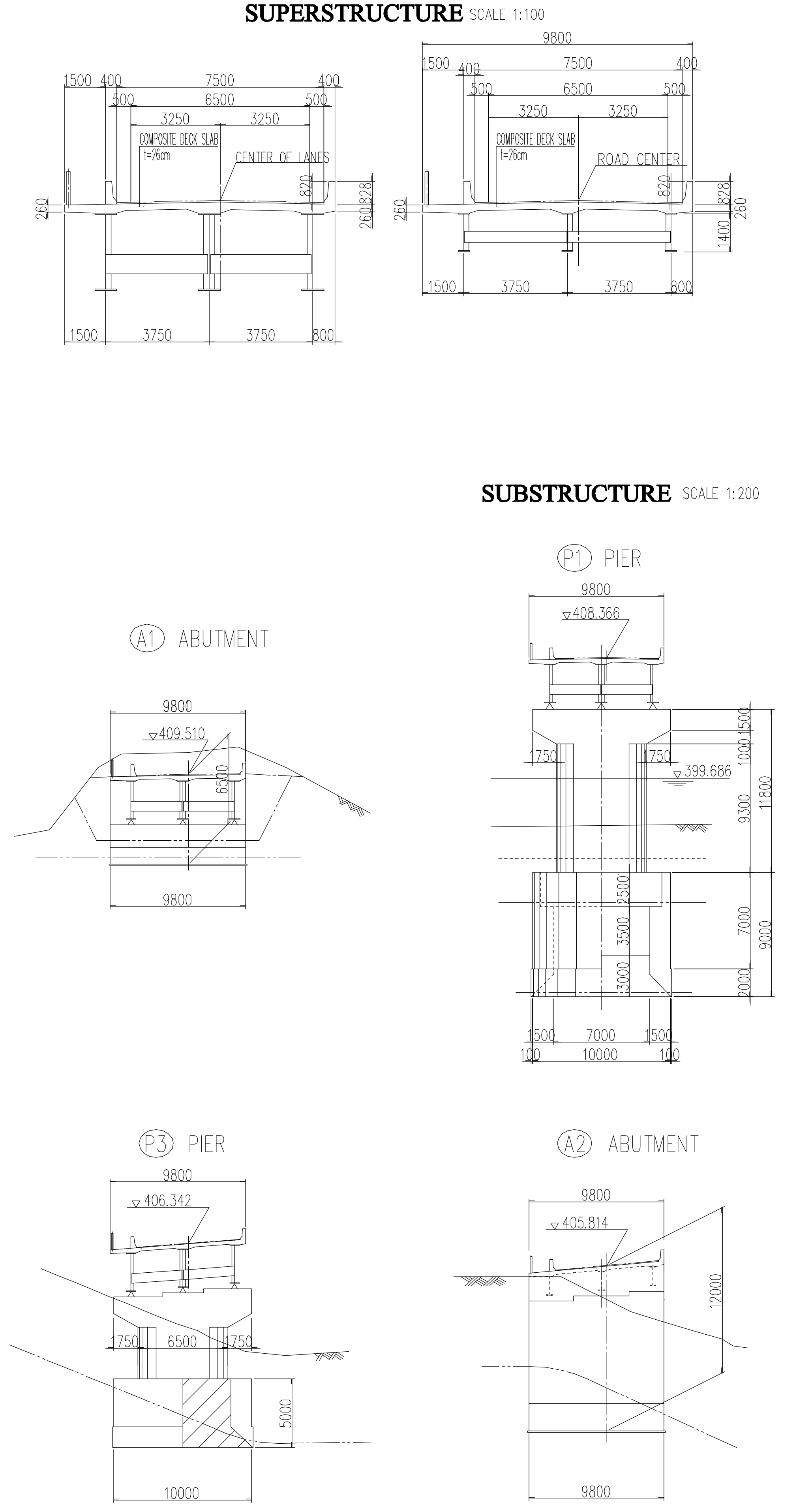
Minimum provision for protection around abutment is required. In this project, leaning type retaining wall is applied. This structure is strong for impact force and easy to construct.

Bitija Bridge

The basic design profile of Bitija Bridge is shown in the figure of Basic Design.

GENERAL VIEW OF LERON BRIDGE





DESIGN CRITERIA

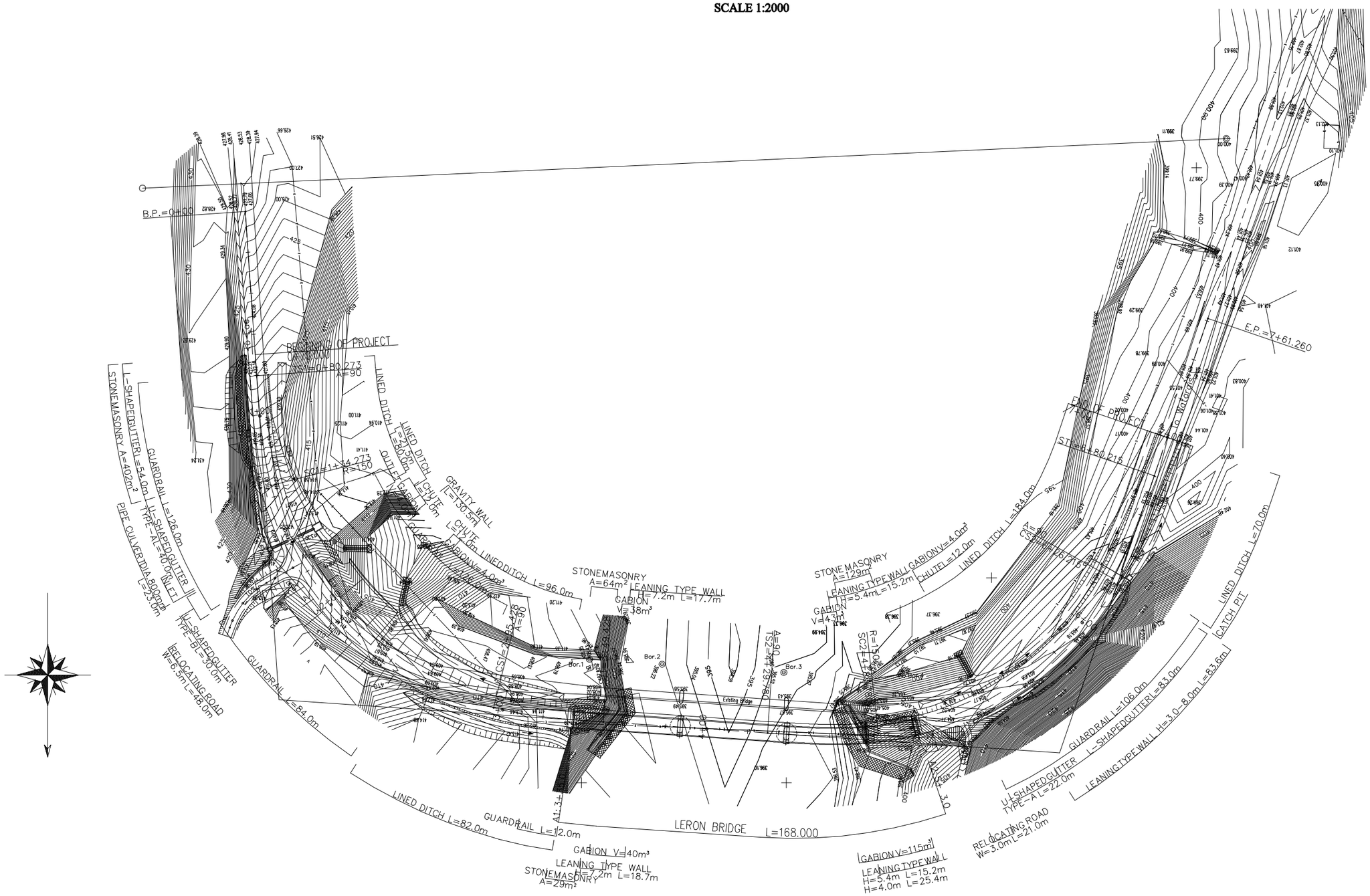
TYPE OF BRIDGE	3-SPAN CONTINUOUS I SECTION GIRDER
	SINGLE SPAN I SECTION GIRDER
TOTAL BRIDGE LENGTH	L=168.000m
GIRDER LENGTH	L=143.700m , 23.800m
SPAN	51.40m+52.00m+39.50m , 23.10m
WIDTH	CARRIAGE WAY WIDTH=7.50m SIDEWALK WIDTH=1.50m
LIVE LOAD	B LIVE LOAD
IMPACT COEFFICIENT	i=20/(50+L)
SEISMIC COEFFICIENT	Kh=0.30
ANGLE OF SKEW	90° 00'00"
RADIUS OF CURVATURE	R=∞~ A=90
LONGITUDINAL SLOPE	i=2.200%

MATERIALS

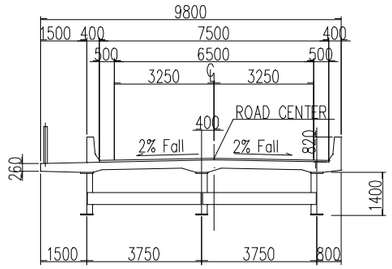
CONCRETE	SLAB	σck=24N/m㎡
	SUBSTRUCTURE	σck=21N/m㎡
	FOUNDATION	σck=21N/m㎡
STEEL	GIRDER	SS400,SM400,SM490Y
	REINFORCEMENT	410Y

GENERAL PLAN OF LERON BRIDGE

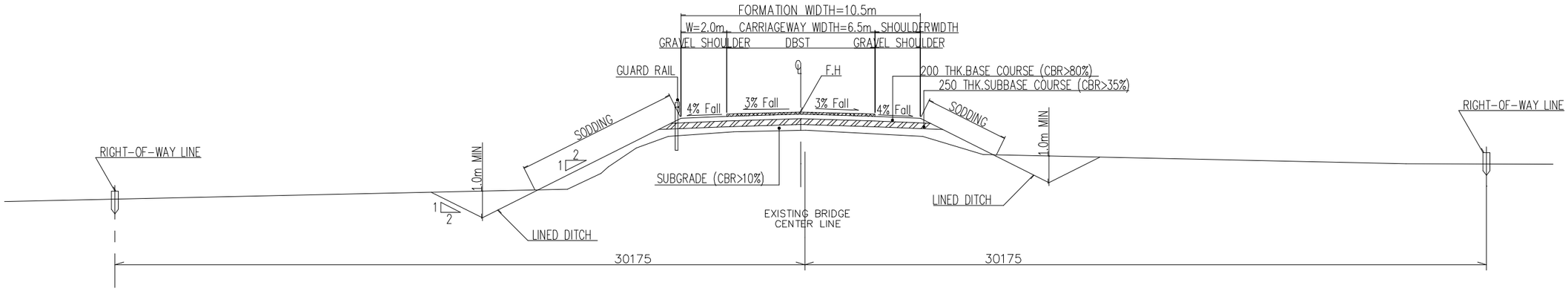
SCALE 1:2000



DEPARTMENT OF TRANSPORT & WORKS PAPUA NEW GUINEA	CONSULTANT NIPPON KOEI CO.,LTD. TOKYO,JAPAN
THE PROJECT FOR RECONSTRUCTION OF LERON BRIDGE ALONG THE HIGHLANDS HIGHWAY	
DRAWING TITLE	SCALE
GENERAL PLAN OF LERON BRIDGE	1: 2000
PREPARED BY / APPROVED BY	DWG.NO.
	C-1



BRIDGE SECTION



ROAD SECTION

TYPICAL CROSS SECTION OF ROADS

SCALE 1:200

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THE PROJECT FOR RECONSTRUCTION OF LERON BRIDGE ALONG THE HIGHLANDS HIGHWAY	
DRAWING TITLE	SCALE
TYPICAL CROSS SECTION OF ROADS	1:200
PREPARED BY / APPROVED BY	DWG.NO.
	C-3

PROFILE OF LERON BRIDGE

VERTICAL SCALE 1:400
HORIZONTAL SCALE 1:2000

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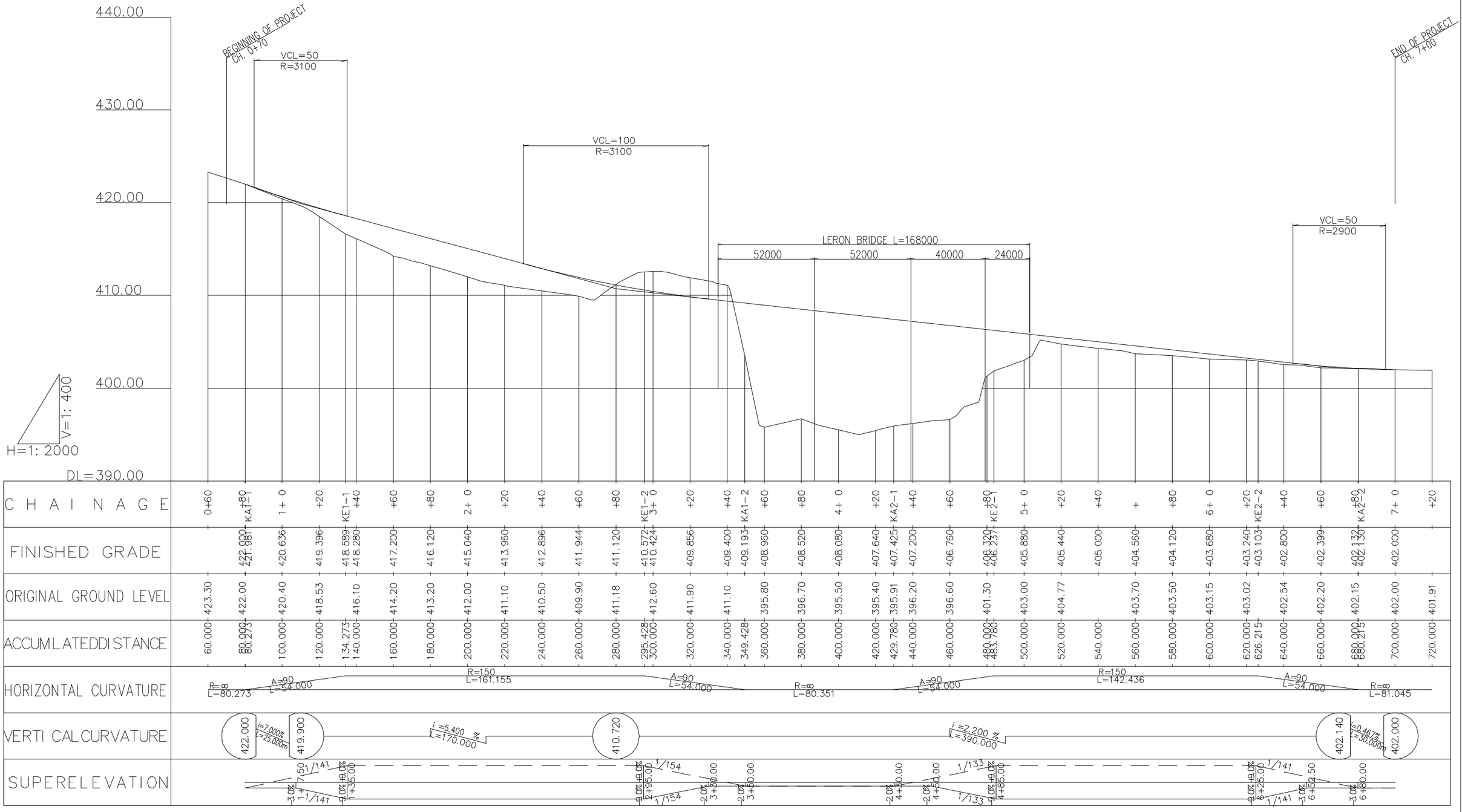
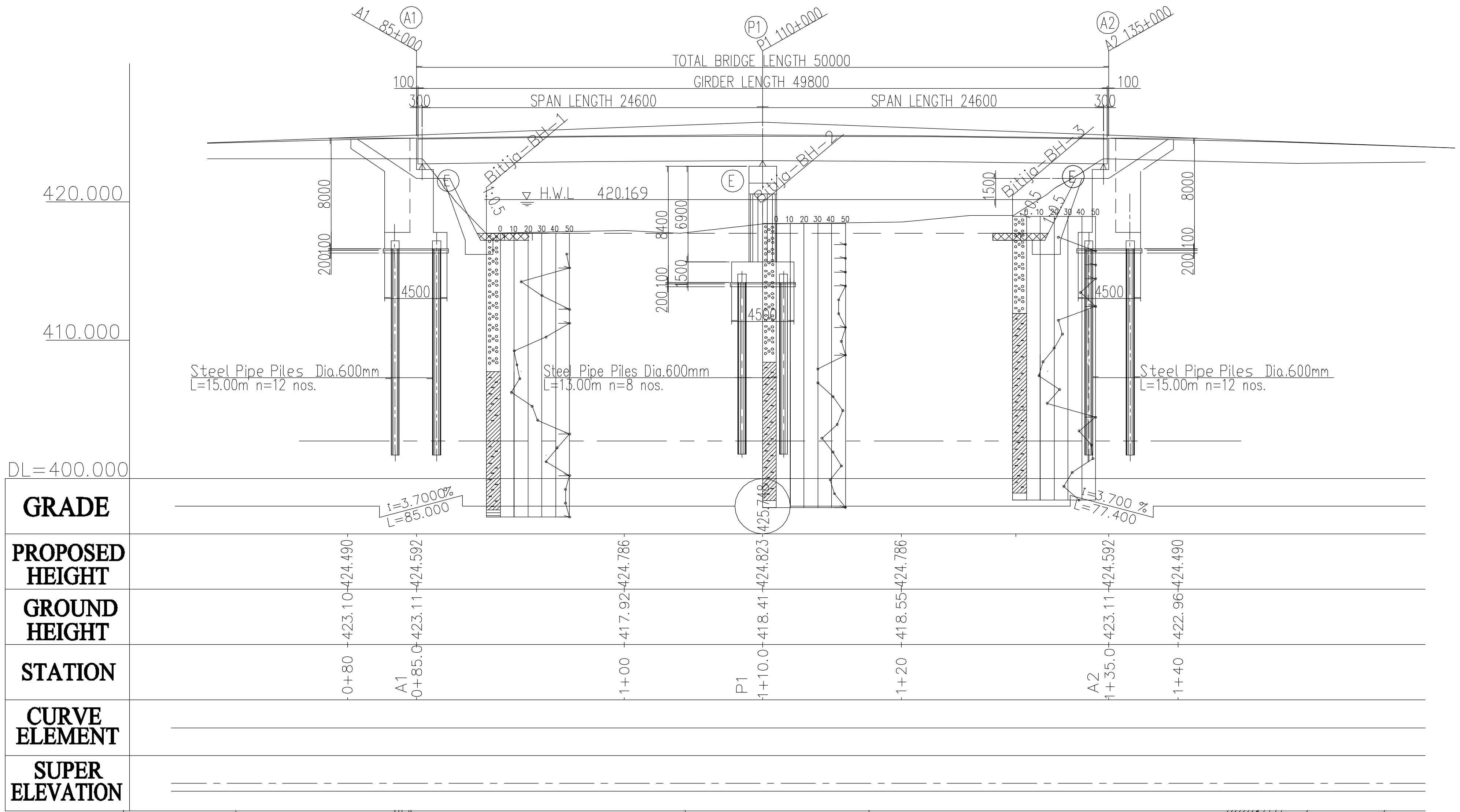
THE PROJECT FOR RECONSTRUCTION OF LERON BRIDGE ALONG THE HIGHLANDS HIGHWAY		
DRAWING TITLE		SCALE
PROFILE OF ROADS		AS SHOWN
PREPARED BY	APPROVED BY	DWG.NO.
		C-2



GENERAL VIEW OF BATIJA BRIDGE

ELEVATION SCALE 1:200



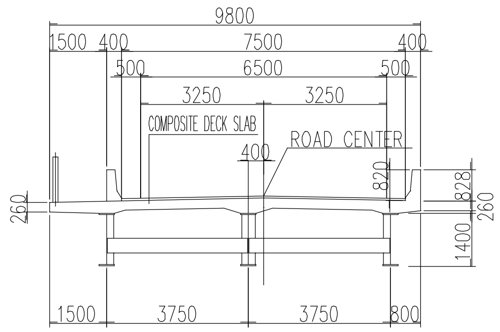
DESIGN CRITERIA

TYPE	2-SPANS CONTINUOUS I SECTION GIRDER
TOTAL BRIDGE LENGTH	L=50.000m
GIRDER LENGTH	L=49.800m
SPAN	2 x 24.600
WIDTH	CARRIAGE WAY WIDTH=7.50m SIDEWALK WIDTH=1.50m
LIVE LOAD	B-LIVE LOAD
IMPACT COEFFICIENT	i=20/(50+L)
SEISMIC COEFFICIENT	Kh=0.30
ANGLE OF SKEW	90° 00'00"
RADIUS OF CURVATURE	R=∞
LONGITUDINAL SLOPE	i=3.700%

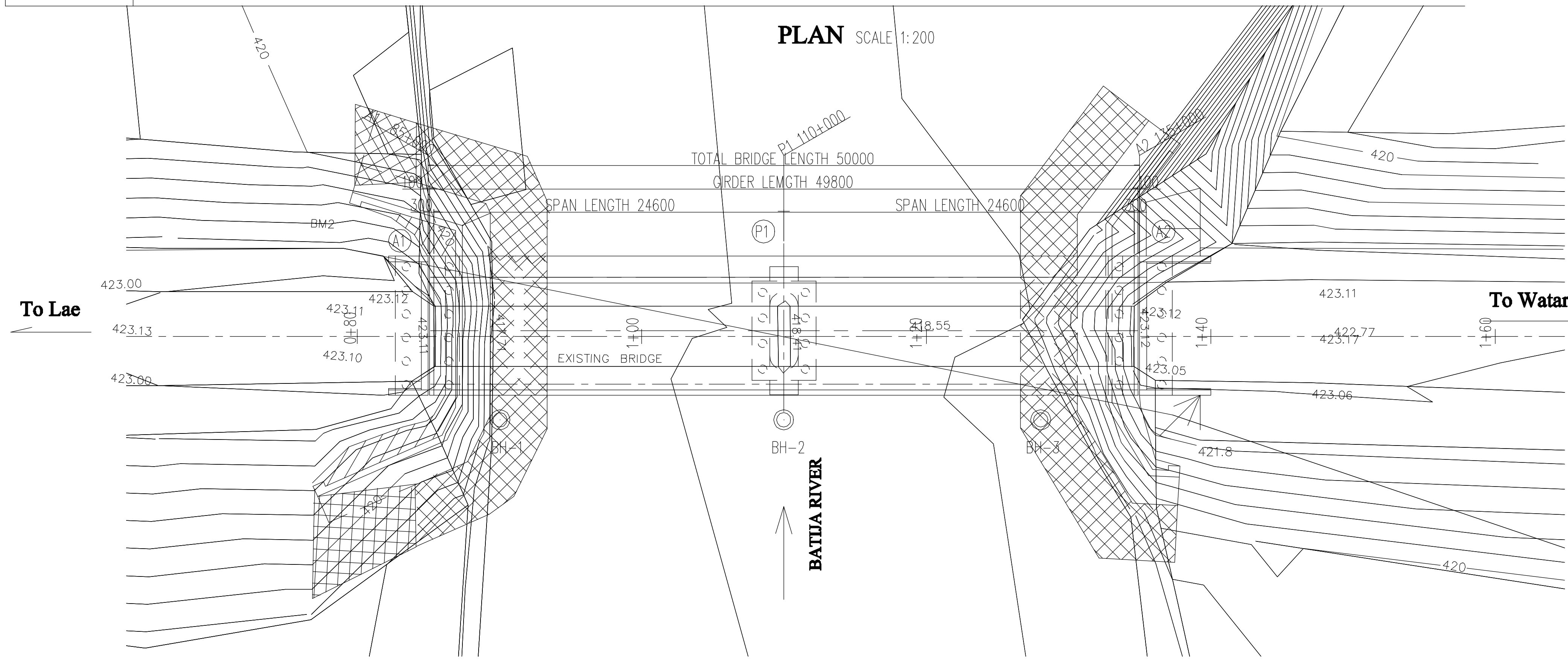
MATERIALS

CONCRETE	SLAB	$\sigma ck=24N/mm^2$
	SUBSTRUCTURE	$\sigma ck=21N/mm^2$
STEEL	GIRDER	SS400,SM400,SM490Y
	PILE	SKK400
	REINFORCEMENT	410Y

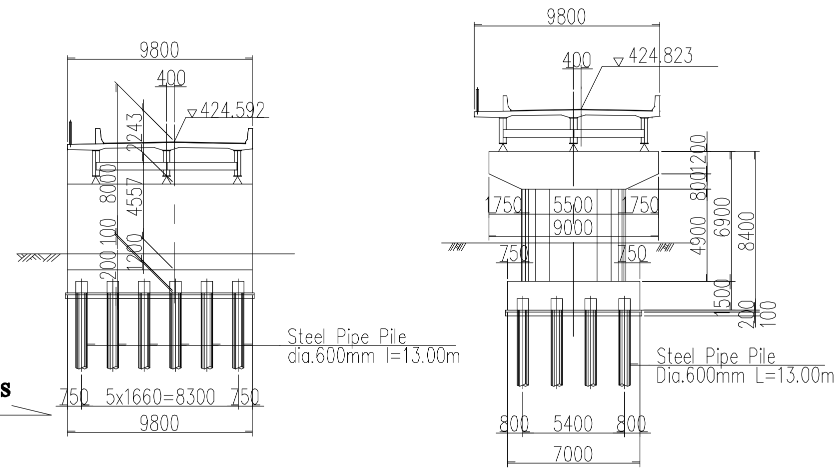
SUPERSTRUCTURE SCALE 1:100



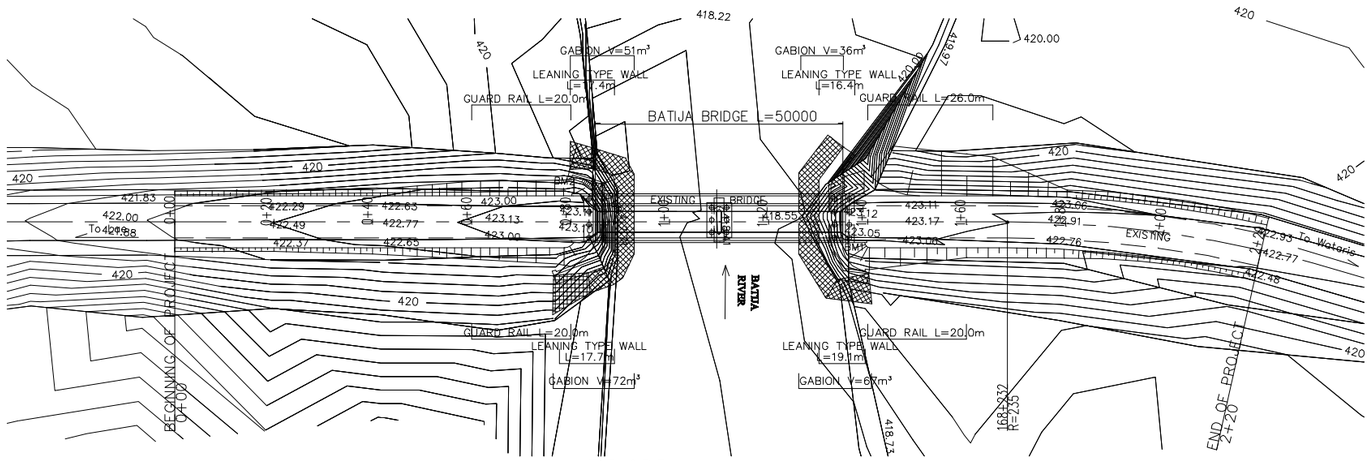
PLAN SCALE 1:200



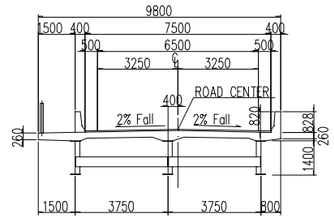
SUB-STRUCTURE SCALE 1:200



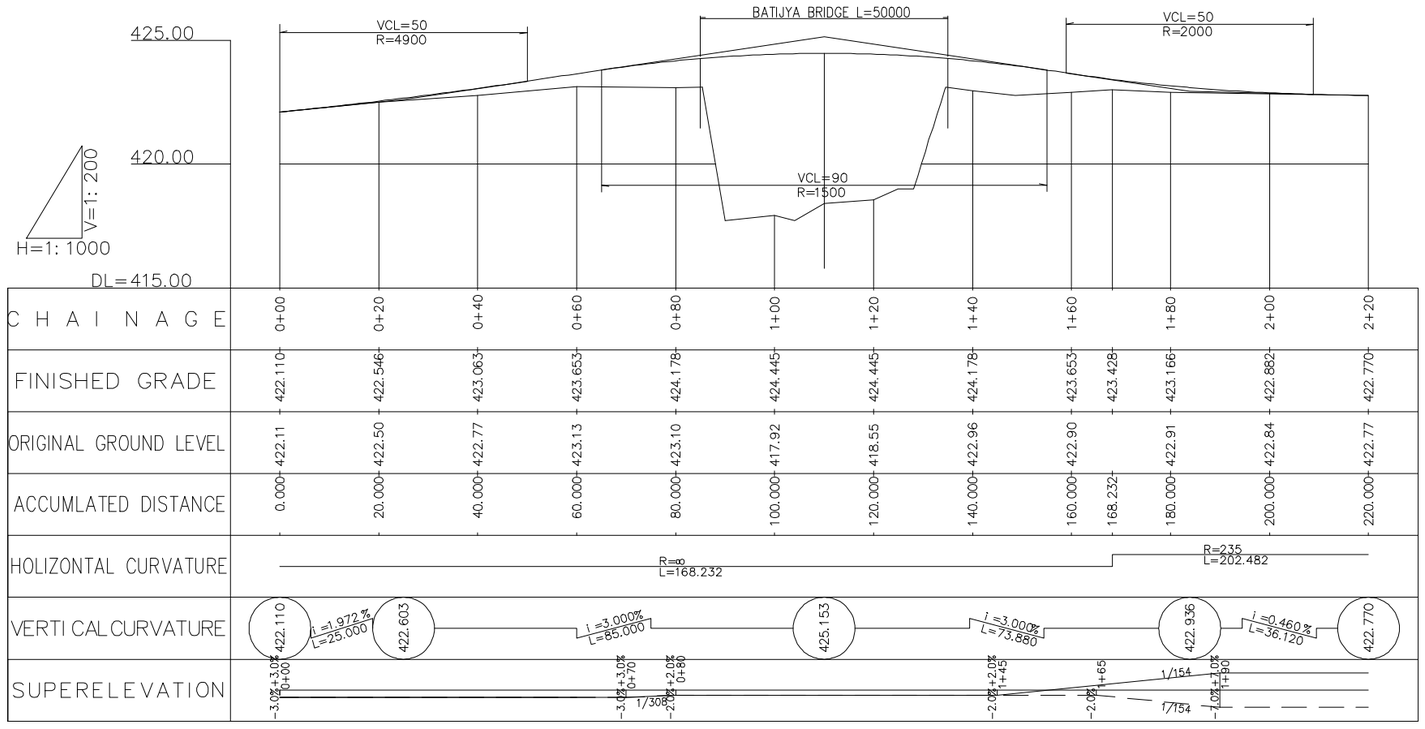
PLAN AND PROFILE OF ROADS



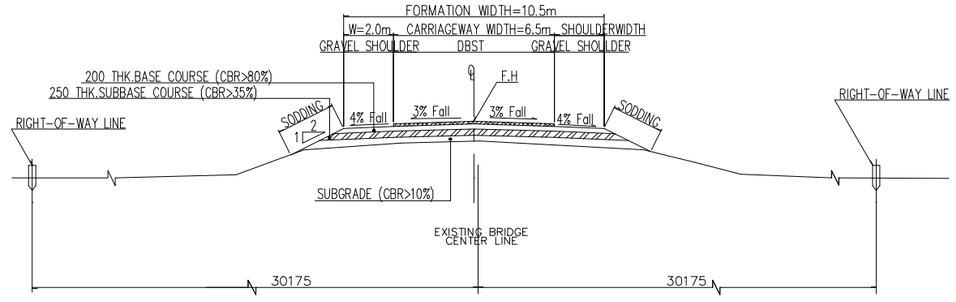
PLAN SCALE 1:1000



BRIDGE SECTION



PROFILE VERTICAL SCALE 1:400
HORIZONTAL SCALE 1:2000



ROAD SECTION

TYPICAL CROSS SECTIONS SCALE 1:200

DEPARTMENT OF TRANSPORT & WORKS PAPUA NEW GUINEA	CONSULTANT NIPPON KOEI CO.,LTD. TOKYO,JAPAN
THE PROJECT FOR RECONSTRUCTION OF BATIJA BRIDGE ALONG THE HIGHLANDS HIGHWAY	
DRAWING TITLE	SCALE
PLAN AND PROFILE OF ROADS	AS SHOWN
PREPARED BY / APPROVED BY	DWG.NO. C-1

Chapter 3 IMPLEMENTATION PLAN

3.1 Implementation Plan

The Department of National Planning and Monitoring (DNPM) is responsible for the administrative matters of the project implementation and the Department of Works and Implementation (DOWI) is responsible for the technical matters of the project implementation. Hence, DNPM will engage in the coordination, adjustment, preparation, etc. of the administrative matters on the Grant Aid and technical cooperation agreed between the two countries. While DOWI will be responsible for management, supervision, and maintenance of the Project.

A Japanese consultant will be involved in the following services as the Engineer on behalf of the Government of PNG.

- Detailed engineering design including preparation of the tender documents,
- Pre-construction activities for the prequalification and tendering, and
- Construction supervision

A Japanese contractor to be selected by open tender according to the Japan's Grant Aid system will undertake the construction in accordance with the work program and schedule of the Project.

The contractor should be responsible for maintenance of the completed works until the final acceptance.

3.1.1 Implementation Concept

Taking into account that the Project will be implemented under the Japan's Grant Aid Scheme, the implementation concepts are established as follows:

- Maximize the procurement of local labors, materials and equipment in PNG so as to increase employment opportunities, to facilitate technology transfer and to provide positive impact to the local economy.
- Establish good communication among the Government of PNG, the consultant, and the contractor to implement the Project as smoothy as possible.
- Prepare a practical construction plan taking into account the local rainfall pattern, period required for materials and equipment procurement, application of appropriate construction methods.
- Establish safe camp and plant yard, and program secured the operation plan considering the present public security in PNG.

3.1.2 Implementation Conditions

Special considerations for the project implementation are as follows:

- Labor Law

  The contractor should administer labors properly under adequate safety control and prevent conflict with local labors in accordance with the prevailing government laws in PNG.

- Tight Security at Job Site

  Special security measures to be provided by the Government agency concerned should be requisite to secure the project personnel and properties.

- Religious and Local Restriction

  Besides national and public holidays, there are religious or local traditional holidays in PNG. These activities should be taken into consideration in estimation of the workable days.

- Custom Clearance

  All the project equipment and materials imported from Japan and the third countries will be unloaded at Lae port which is the most important part accounting for about 37% of the total cargo handling in PNG. Thus, close cooperation and assistance from the Lae Harbor Boards is necessary in the unloading and custom clearance in order to complete the mobilization in a timely manner.

- Caisson Excavation

  The most difficult field work which possibly causes delay is caisson excavation under the water in the dense sand and gravel with boulders. The contractor should mobilize enough equipment and drain facilities such as hydraulic clam shells, submersible pumps, backhoe with long arm and drain pits to ensure the construction schedule.

3.1.3 Scope of Works

The scope of works for which the Japanese Government and the Government of PNG are respectively responsible are as follows:

(1) Works and Facilities to be Provided by Japanese Government

- Construction of the new Leron Bridge and Bitija Bridge with the incidental facilities such as drainage, expansion joints, railings and concrete barriers,

- Construction of the approach roads with miscellaneous facilities such as traffic sign boards, lane markers and drainage,

- Construction of the river bank protections by concrete gravity type retaining wall,

- The temporary construction facilities such as camp & plant yard, and temporary road, and

- Others such as transportation of the construction materials and equipment from Japan and the third countries to PNG and the consulting services.

(2) Works and Facilities to be Provided by the Government of PNG

- Removal of the existing Leron Bridge and Bitija Bridge. After the completion of temporary detour for the Bitija Bridge site, Government of PNG must remove the existing Bitija Bridge immediately. Otherwise, the completion of new Bitija Bridge will be delayed. The removal of the existing Leron Bridge must be accomplished immediately after the completion of the Leron Bridge construction.

- Relocation of electric power line at the Leron Bridge site. This must be accomplished before the beginning of the construction.

- Installation of traffic sign boards of load and speed limitation, and grantry barrier for vehicular clearance in order to ensure the safety of the existing bridge until the completion of the new bridge.

- Provision of tight security in and around the construction camp and plant yard, and during transportation of the materials and equipment.

- Payment for banking services

- Land legalization and compensation

3.1.4 Consultant Supervision

(1) Schedule of the Consulting Services

The Project will commence after signing an Exchange of Notes (E/N) pertaining to the engineering services for the detailed design between the Governments of Japan and PNG. The contract for the detailed design will be concluded between DOWI and the Japanese Consultant who will provide the following engineering services within the limits of the Grant Aid.

1) Detailed Design Phase

The consultant will carry out the detailed engineering design of the bridge and approach roads in compliance with specifications and concepts in the basic design.

2) Pre-Construction Phase

After signing an Exchange of Notes (E/N) pertaining to the engineering service for the constructions supervision and the construction, DOWI will initiate to select a Japanese contractor who will implement the project through an open tender. The consultant will assist DOWI on the following tasks:

- Bid announcement
- Prequalification of contractors
- Pre-bid conference and site inspection
- Tender and the tender evaluation
- Contract negotiation

3) Construction Supervision Phase

The engineering services for construction supervision will begin after issuance of the Notice of Proceed to the contractor by the DOWI.

The consultant will perform his duties in accordance with criteria and standards applicable to the construction works and will exercise the powers vested in him as the Engineer under the contract to supervise the filed works by the contractor.

The consultant within his capacity as the Engineer will directly report to DOWI about the field activities and will issue field memo or letters to the contractor regarding the various matters in terms of the progress, quality, safety and payment of the project.

(2) Staffing

1) Staffing for the Detailed Design

In the preparation of the detailed design including the tender documents, Japanese staff of the following expertise are needed:

- Project Manager
- Bridge Engineer (Superstructure)
- Bridge Engineer (Substructure)
- Highway Engineer
- Construction Planner/Cost Estimator
- Specification Writer

2) Staffing for Construction Supervision

With reference to the major field works required for close supervision during the construction period, following consulting staff are considered during the construction supervision stage:

- Project Manager
- Resident Engineer
- Open Caisson/Foundation Engineer
- Steel Bridge Engineer

(3) Construction Plan

1) Temporary Work

- Camp and plant yard

Immediately after issuance of the Notice to Proceed to the contractor by DOWI, the contractor will mobilize the project equipment, materials and staff. At the beginning, the contractor will establish camp and plant yard at the Leron Bridge site and Bitija Bridge site.

• Power supply

Power supply required in the field work and camp is provided with generators.

• Water supply

Water for drinking and mixing and curing of the concrete in the construction is obtained from a new well to be provided.

- Temporary Bridge for the Leron Bridge Site

6m wide steel temporary bridge will be constructed at the Leron Bridge site for the construction of the piers and the superstructure.

- The detour for the Bitija Bridge site

New Bitija Bridge will be constructed at the same place as the existing one. After the construction of the detour by the Japanese contractor, the existing Bitija Bridge will be removed by the Government of PNG. The detour will be provided using embankment fill, concrete pipe and gabion.

2) Construction of Substructure

- Caisson construction for Leron Bridge

The caisson which is the foundation of the P1 and P2 pier of Leron Bridge will be constructed applying a segmental method. One lot (segment) length is about 2.5 ~ 3 m and the work sequence of the lot is as follows:

Leveling of casting bed → Installation of forms → Setting rebars → Pouring concrete → Curing concrete → Excavation of inside caisson by backhoe, clamshell with drainage facility → Sinking caisson

In the caisson excavation, it is assumed that the soil can be excavated inside the caisson under dry condition with enough drainage facilities.

After completely sinking the whole caisson, the seal concrete is poured and subsequently sand and gravel with compaction is provided inside the caisson.

- Construction of wall pier shaft and abutment shaft

On the top slab of the caisson, supporting and scaffolding will be provided with the forms for the shaft. Meantime, the reinforcing bars which have been cut and bent will be installed. After these works have been completed, the concrete (210kgf/cm^2) is poured by pump with application of vibrators, and curing the concrete by watering will follow.

After confirmation of the concrete strength reaching 70% of 210kgf/cm^2, about 7 days after the pouring, the scaffolding, supporting and forms will be dismantled.

3) Construction of Superstructure

- Procurement of steel plates

  After approval of the shop drawing by the consultant, the contractor can order the steel plates and shaped steels specified in the approved drawing.

- Fabrication of Steel Bridge

  Based on the full scale drawings of the steel bridge, the contractor initiate to fabricate the structural members such as girders, sway bracing, lateral bracing by cutting and welding to be done by licensed welders. After completion of the fabrication, the contractor should carry out the shop assembly for the Engineer's inspection. After acceptance of the shop assembly, the contractor can pack the structural members, of which maximum length is 12 m, for the transportation.

- Transportation of Steel Bridge

  The route all the way to the job site has acceptable horizontal alignment to accommodate the trailer carrying the 12 m long bridge members except at two sites, before and after Leron Bridge, where sharp curves are located. At these sites, shifting the rear axles by a crane will solve the problem

- Erection of Steel Bridge

  Erection of steel girder will be conducted by a crawler crane moving on the temporary bridge.

- Deck Slab Work

Concrete and steel composite deck slab is applied to Leron Bridge and Bitija Bridge. This type of deck slab, which its steel form itself function as a structural member, makes deck slab stronger and it can shorten construction period.

- Field Painting

  The filed painting will be done in two layers after completely cleaning the steel surface, especially of the splicing part. The 2nd layer should be painted after the first layer is completely dry.

- Incidental facilities

  After completion of the deck slab work, expansion joints, concrete wall barriers, handrails, drainage pipes will be installed at the same time.

4) Abutment Protection Works

During the construction of the abutment when the river flow has been diverted and the bed is in dry condition, excavation and installation of the gravity type retaining wall will be executed with draining the subsurface water by submersible pumps.

5) Approach Roads

Proper blended materials for each base and subbase courses, and proper sized and crushed aggregates for the surface treatment will be transported from Lae.

3.1.5 Procurement Plan

(1) Construction Materials

Sand and gravel for the concrete, crushed aggregate for DBST pavement and plywood for the form work and lumber of the supporting and form work are available locally. However, other construction materials, except bearing pads, and laboratory equipment will be procured from Japan.

A list of construction materials are where they procured from is shown in Table 2.1.

Table 2.1 Procurement of Major Construction Materials

Item	Procured in PNG	Procured in third Country	Procured in Japan
Cement	O		
Reinforcing bar	O		
Structural Steel		O (New Zealand)	
Gas pipe	O		
Shaped steel	O		
Paint	O		
Straight asphalt	O		
Concrete admixture	O		
Bearing pad			O
Welding lot	O		
Gabion wire	O		
Sand & Gravel	O		
Timber	O		
Plywood	O		
Gasoline	O		

(2) Construction Equipment

There are few rental companies of the construction equipment in PNG. However, the general equipments are owned by the local contractors and DOWI which can be lent to the Japanese contractor. Hence, only a few equipment such as earth auger and clam shell need to be procured from Japan.

The procurement of the construction equipment is shown in Table 2.2.

Table 2.2 Procurement for Major Construction Equipment

Item	Capacity	Procured in PNG	Procured in Japan
Bulldozer	21 t	O	
Pay Loader	1.4 m^3	O	
Dump Truck	10t	O	
Back Hoe w/long arm	0.6 m^3	O	
Vibrating Roller	3 - 4 t	O	
Road Roller	10 t	O	
Motor Grader	3.1 m	O	
Clamshell	0.6 m^3		O
Asphalt Distributor	4,000 lit	O	
Crawler Crane	80 t, etc.	O	
Truck Crane	80 t, etc.	O	
Truck Mixer	4.5 m^3	O	
Diesel Pile Hammer	4.5 t, etc.	O	
Cargo Truck	8 t	O	
Generator	125 kVA, etc.	O	
Air Compressor	10m^3/min, etc.	O	
Welding Machine	300 A	O	
Hydraulic Jack	100 t	O	
Tamper	60 - 100 kg	O	
Water Pump	8" dia., 30 m	O	
Vibrator	45 mm	O	
Lane Marker	2 lit/min.	O	
Vibro-Hammer	50 kW	O	
Earth Auger	45kW, 40t		O
Concrete Batching Plant	20 m^3/h	O	

3.1.6 Implementation Schedule

After signing the Exchange of Note for the detailed design, the project implementation will officially commence. The detailed design will take 3.5 months including a one month site survey. After the detailed design is completed, the Notes for the construction and the engineering services for construction supervision are exchanged by the two Governments, and preconstruction activities such as prequalification of the contractors, selection of the contractors, contract award, etc. will follow and take about 3.5 months.

Following those, the construction will commence and takes 19.5 months to complete the Project. The total implementation period is therefore estimated at 26.5 months as shown in Table 2.3.

Table 2.3 Implementation Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1)Detailed Design Stage																											
Site Survey																											
Detailed Design																											
Site Survey and Approval by DOWI																											
2)Preconstruction Stage																											
Prequalification																											
Tender Issue																											
Tender Opening																											
Signing Contract/Verification																											
3)Construction (Leron)																											
Preparations																											
Detour																											
Temporary Bridge																											
Temporary Island P_1、P_2																											
Foundation P_1、P_2																											
Pier Wall P_1、P_2																											
Abut A_1、A_2、Pier P_3																											
Fabrication of Steel Bridge																											
Transportation of Steel Bridge																											
Construction of Superstructure																											
Deck Slab Work																											
Incident Facilities																											
Riverbank Protection																											
Access Road																											
Demobilization																											
Relocation of Power Line																											
4)Construction (Bitija)																											
Preparation																											
Detour																											
Foundation A_1,A_2、Pier P_1																											
Abutment A_1,A_2、Pier P_1																											
Fabrication of Steel Bridge																											
Transportation of Steel Bridge																											
Construction of Superstructure																											
Deck Slab Work																											
Incidental Facilities																											
Riverbank Protection																											
Access Road																											
Demobilization																											
Removal of Existing Bridge (PNG)																											

■：in PNG
□：in Japan

3.1.7 Obligations of Recipient Country

The following necessary measures should be undertaken by the Government of PNG on condition that the Grant Aid by the Government of Japan is extended to the Project:

1. Remove of the existing Leron Bridge and Bitija Bridge.
2. Relocation of a power line at the Leron Bridge site.
3. To provide data and information necessary for the Project.
4. To secure the land for the execution of the Project, such as land for approach road, bridge construction, working areas, storage yard, etc.
5. To clear the sites prior to the commencement of the construction.
6. To bear commissions to the Japanese foreign exchange bank for its banking services based upon the Banking Arrangement, namely the advising commission of the "Authorization to Pay" and payment commission.
7. To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation in PNG and prompt international transportation therein of the materials and equipment for the Project purchased under the Grant Aid.
8. To exempt Japanese juridical and physical nationals engaged in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in PNG with respect to the supply of the products and services under the verified contracts.
9. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into PNG and stay therein for the performance of their work.
10. To provide necessary permissions, licenses and other authorizations for implementing the Project, if necessary.
11. To maintain and use properly and effectively the facilities constructed under the Project.
12. To bear all the expenses other than those to be borne by the Japan's Grant Aid within the scope of the Project.

13. To coordinate and solve any issues related to the Project which may be raised from third parties or inhabitants in the Project area during implementation of the Project.

14. To secure the safety of Japanese nationals including the other personnel engaged in the Project and to provide tight security against riot, insurrection, civil commotion, rebellion, and usurped power

3.2 Project Cost Estimation

Cost estimation for the part of the Project that will be implemented by PNG is as follows:

(1)	Removal of the existing Bitija Bridge	K.	250,000
(2)	Removal of the existing Leorn Bridge	K.	300,000
(3)	Land lease for the construction yard	K.	75,000
(4)	Construction sign boards and security measures	K.	5,000
(5)	Relocation of the power line	K.	160,000
(6)	Payment for banking services	K.	5,000
(7)	Site survey	K.	5,000
	Toatal	K.	800,000

3.3 Operation and Maintenance Plan

3.3.1 Operation and Maintenance Plan

After the completion of the Project, following operation and maintenance with the corresponding frequency are required to keep the structures in sound conditions.

Category	Frequency	Items to be Inspected	Scope of Works
Inspection/ Maintenance for the Bridge	Once a year	Expansion Joint	Cleaning of expansion joints, photographing a damage if any.
		Drainage	Cleaning of drainage pipes, photographing a damage if any.
		Bearing	Cleaning of the bridge seats especially around the bearings.
		Handrail/Concrete Barrier	Detect a damage if any and recording and the repair work
Inspection/ Maintenance for the River Structure	Once a year after heavy flood	River bed fluctuation	River cross section survey and recording
		Local scouring and river bank structure	Detect any excessive local scouring and settlement of the bank protection
Inspection/Maintenance for the Road	Once a year	Pavement	Patching work if there are potholes
		Shoulder	Grass cutting and leveling
		Embankment Slope	Detect any surface erosion and repair
		Ditch	Removal of sediments
Periodical Maintenance for the River Structure	Every 5 years or less when requires	Local scouring and river bank structure	Installation of river bed protection around piers if required and rehabilitation of the bank protection.
Periodical Maintenance for the Bridge	Every 10 years	Steel Members	Repainting and minor repair

3.3.2 Maintenance Cost

Based on the maintenance works mentioned in the above, the periodical maintenance cost for DOWI is estimated at PNG K.129,468 /year on average.

The following are a breakdown of these costs.

Maintenance Cost in Kina

Category	Frequency	Approx. Estimated Cost
Inspection/Maintenance for the Bridge	Once a year	K. 3,500
Inspection/Maintenance for the River Structure	Once a year	K. 1,200
Inspection/Maintenance for the Road	Once a year	K. 590,000
Periodical Maintenance for the River Structure	Every 5 year or less when required	K. 518,800
Periodical Maintenance for the Bridge	Every 10 year	K. 181,180

3.3.3 Need of Technical Cooperation

In general, the number of local government staff at a middle class are very limited in PNG and this situation is not exceptional to DOWI, especially to the Technical Division that is one of the key functional divisions as mentioned earlier.

Under this situation, it is a suitable opportunity to transfer various technology to the local government staff at a middle class on the occasion of the project implementation. The transfer of technology will be carried out in the following manners.

(1) Overseas Training in Japan for one trainee for the Road and Bridge Branch

- Bridge engineering technology
- Bridge planning
- Bridge design
- Construction and management of bridge projects

  Quality control

  Progress control

  Safety control
- Bridge inspection and maintenance

  Bridge inspection technique

  Bridge maintenance technique

(2) On-the-job Training for two trainees from the Provincial Works Department

- Construction management of the bridge project

  Quality control

  Progress control

  Safety control
- Bridge inspection and maintenance

  Bridge inspection technique

  Bridge maintenance technique

Chapter 4 PROJECT EVALUATION AND RECOMMENDATION

4.1 Project Effect

As a result of the socioeconomic and field survey and the basic design carried out in the Study, the direct and indirect impact and effects of the Project are as follows:

1) Direct Impact and Effects

Present Condition and Problems	Countermeasures taken in the Study	Direct Impact and Effects
1. Concrete slab deck of Leron Bridge and Bitija Bridge are severely deteriorated due to aging and heavy traffic loads. And due to the riverbed scouring, foundations of the existing bridges were exposed and stained. These inadequate foundations are possible to be a cause of a collapse of the bridges.	The existing Leron Bridge and Bitija Bridge are replaced by a new modern bridge with application of B-Loading in the Japanese Bridge Design Specification, and also deck slabs will be paved. The bridge opening of new bridge is designed to cope with severe scoring condition.	- The maintenance cost saving derived from balance of maintenance cost for between the existing and new bridges. - Decreasing the bridge collapse probability generates socio-economic stability in the Highland regions.
2. Leron Bridge and Bitija Bridge with 3.4 m of lane width are a traffic bottleneck since the Highlands Highway and most of the existing bridges on the Highway have been in 2 lanes (7.5m).	It is applied in the basic design that the new Leron bridge and Bitija Bridge have a dual lane of 7.5 m width which is the same width as the standard bridges on the Highlands Highway.	- Both time and operation cost saving are generated. - It is also expected to decrease traffic accident, to increase driving comfort, and to reduce drivers' physical fatigue.
3. Sharp curve of access road before and after Leron Bridge caused of bad drivability and car accidents.	Alignment of the access road is improved to be possible to run through by 60km/hr	- Drivers can run smoothly - Decrease of car accidents with better alignment
4. In the absence of the enough sidewalk, the pedestrians suffer danger in crossing the bridge.	Provision of a sidewalk of 1.2m width at one side is incorporated in the basic design.	- It is expected to reduce accidents resulting in injury or death.

2) Indirect Effects and Impact

The indirect effects and impact derived from the project implementation are likely acceleration of the agricultural and mining development in the Highland regions, improvement of the stability of production and transportation schedule, correction of regional disparties, and expansion of market spheres. Furthermore, it is expected to improve the stabilization of people's livelihood and national consciousness in the area where the public security is being aggravated.

(3) Verification of Effects and Impact

The effects and impact mentioned above are verified or measured by traffic volume and beneficiary population.

- Traffic Volume

The daily traffic volume counted in the Study in August 2000 was 857 vehicles at Leron Bridge. Based on this data, the future traffic volume is projected to be 1,534 AADT in year 2010 and 2,748 AADT in year 2020, using 6% of the annual growth rate.

- Beneficiary Population

The total beneficiary population based on 1990 census data is estimated at about 1.7 million and the breakdown is as follows:

Name of Province	Population in 1990
Morobe	380,117
Madang	253,195
Eastern Highlands	300,648
Chinbu	183,849
Western Highlans	336,178
Enga	235,561
Total	1,689,548

4.2 Recommendation

As the existing Leron Bridge and Bitija Bridge are traffic bottlenecks and in a very severe and dangerous condition in the Highlands Highway, it should be replaced urgently by a new one. This Project coincides with the Government's objectives and strategies in the current National Development Plan. Moreover, it is presumed that the Project would be implemented without any special problems in Japan's Grant Aid system and will be maintained properly by the DOWI after completion of the project. Considering the project scheme and the enumerated impact and effects derived from the project implementation, it is concluded that the project implementation through the cooperation of the Japan's Grant Aid Program would be very meaningful and thus its early implementation is most desirable.