Department of National Planning and Monitoring
Department of Works
The Independent State of Papua New Guinea
Autonomous Bougainville Government

No.

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR CONSTRUCTION OF BRIDGES ON BOUGAINVILLE COASTAL TRUNK ROAD

IN

THE INDEPENDENT STATE OF PAPUA NEW GUINEA

OCTORBER 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

Chodai Co., Ltd.

Japan Engineering Consultants Co., Ltd.

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PREFACE

In response to a request from the Government of the Independent State of Papua New Guinea, The Government of Japan decided to conduct a basic design study on the Project for Construction of Bridges on Bougainville Costal Trunk Road and entrusted the study to the Japan International Cooperation Agency (JICA)

JICA sent to Papua New Guinea a study team from February 27 to April 1, 2008, and conducted a field study at 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 the Independent State of Papua New Guinea for their close cooperation extended to the teams.

October, 2008

Masafumi Kuroki
Vice-President
Japan International Cooperation Agency

October 2008

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for construction of Bridges on Bougainville Coastal Trunk Road in the Independent State of Papua New Guinea.

This study was conducted by Chodai Co., Ltd.and Japan Engineering Consultants Co., Ltd. under a contract to JICA, during the period from February 2008 to October 2008. In conducting the study, we have examined the feasibility and rational 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,

Junji YASUI
Project Manager,
Basic design study team on the Project for
Construction Bridges on
Bougainville Coastal Trunk Road
In the Independent State of the Papua New Guinea
Chodai Co., Ltd.

Summary

Summary

1. Overview of Papua New Guinea

The Independent State of Papua New Guinea (hereafter called "PNG"), situated in the Southern Hemisphere just under the equator at south latitude 0~14° and east longitude 141~160°, is the largest of the Pacific island states (covering an area of 462,000 km^2) and has a population of 6,190,000 (2006). PNG is blessed with natural resources and, ever since gaining independence in 1975, has played a central role in the region. In terms of economy, the GNI in 2006 was US$4,559 million and the per capita GNI was US$770.

Bougainville, situated to the east of the main island of New Guinea, is a volcanic island covering an area of 10,000 km^2 and having a population of 210,000 (as of 2006). The main industries on the island are copra and cacao cultivation and copper mining. Trouble arising over the Bougainville copper mines led to militant landowners instigating a conflict, and this escalated into a movement for independence and eventual military clashes with forces of the PNG government. Following that, the Bougainville Peace Agreement comprising the three main components of 1) implementation of an arms collection program, 2) establishment of an autonomous government for Bougainville, and 3) creation of a referendum concerning the future political standing of Bougainville, was concluded between the central government and secessionists in August 2001. In May 2005, autonomous elections were held and the Autonomous Bougainville Government was established on June 15.

2. Background and Outline of the Requested Project

Concerning the transport sector in Bougainville, as the superior plan, the National Transport Development Plan (NTDP) (2001-2010) was compiled with the objective of providing safe and reliable transport services throughout the whole of PNG. However, in 2006, this was reviewed and revised as the National Transport Development Plan (2006-2010) giving priority to the allocation of budget to repair and maintenance rather than the new construction of infrastructure. Within this plan, 15 top priority highways have been designated, and one of these is the Bougainville Coastal Trunk Road.

Bougainville Coastal Trunk Road is an arterial state highway stretching for approximately 190 km between Kokopau across from Buka and the former capital of Arawa. Not only is this an important transport route for people and goods (farm products and daily necessities such as cacao and copra, etc.), but it is also the primary

artery for passage of ambulances and other emergency vehicles. However, at 15 points along the route, bridges or culverts (causeway) are damaged or are not supported, and people and vehicles have no choice but to cross river shallows. Such conditions impede the flow of traffic.

The Government of PNG sent a request to the Government of Japan in August 2006 asking for Grant Aid regarding the repair of 13 bridges on the section of Bougainville Coastal Trunk Road between Buka and Arawa. In response to this, the Government of Japan consigned JICA to implement the Preliminary Study from August to September 2007. During this, a further two bridges that had little prospect of repair were added to the list, and the Basic Study eventually came to target 15 bridges.

3. Outline of the Study Findings and Contents of the Project

Based on the results of the Preliminary Study, the Government of Japan decided to conduct the Basic Design Study on the Project for Construction of Bridges on Bougainville Coastal Trunk Road and entrusted the Study to JICA. JICA subsequently dispatched the Basic Design Study Team to Papua New Guinea from March to April 2008.

The Preliminary Study targeted six causeways and nine bridges, however, as a result of conducting comparative examination of economy, ease of execution, materials procurement, ease of transport and maintenance in the Basic Design Study, it was recommended that bridge structure be newly adopted at all 15 sites because this approach offered better economy, ease of execution and durability, etc. Table 1-1 shows the target structures and structural types that were recommended in the original request, the Preliminary Study and the Basic Design Study respectively.

Table 1-1 List of Structural Types in the Request, Preliminary Study and Basic Design Study

No	Name	Bed materials Gravel size	Requested Contents			Preliminary Study			This study			Difference
			Structural type	Bridge lenght (m)	Width (m)	Structural type	① Bridge length(m)	Width (m)	Structural type	② Bridge length(m)	width(m)	②-①
1	Bakanovi	Medium-small	Bridge	60	5.2	Bridge	70	5.2	Bridge	75	5.0	5
2	Bove	Medium-small	Bridge	60	5.2	Bridge	30	5.2	Bridge	20	5.0	-10
3	Pukarobi 1	Small	Causeway	20	4	Cawseway	25	5.2	Bridge	25	5.0	0
4	Pukarobi 2	Small	Causeway	30	4	Cawseway	20	5.2	Bridge	50	5.0	30
5	Creepers	Medium-small	Causeway	25	4	Cawseway	20	5.2	Bridge	20	5.0	0
6	Ratavi	Small	Bridge	60	5.2	Bridge	60	5.2	Bridge	50	5.0	-10
7	Iraka	Large-medium	Bridge	60	5.2	Bridge	60	5.2	Bridge	75	5.0	15
8	Korova	Small	Causeway	40	4	Cawseway	30	5.2	Bridge	20	5.0	-10
9	Malas	Small	Bridge	40	5.2	Bridge	30	5.2	Bridge	20	5.0	-10
10	Ururva	Small	Additional request	-	-	Bridge	30	5.2	Bridge	20	5.0	-10
11	Kaskrus	Large-medium	Additional request	-	-	Cawseway	30	5.2	Bridge/BC	25	5.0	-5
12	Rotaovei	Medium	Bridge	50	5.2	Bridge	36	5.2	Bridge	40	5.0	4
13	Warakapis	Medium	Bridge	60	5.2	Bridge	40	5.2	Bridge/BC	25	5.0	-15
14	Irung	Medium	birdge	60	5.2	Bridge	60	5.2	Bridge	40	5.0	-20
15	Rawa 1	Large-medium	Causeway	40	5.2	Cawseway	45	5.2	Bridge	40	5.0	-5
Total				605			586			545		-41

4. Project Implementation Period and Cost Estimation

In the Project, it is expected that it will take 7 months to conduct the detailed design and 30 months to construct the facilities. The Project cost required for fulfilling the undertakings by the Government of PNG is estimated at 5 million yen.

5. Examination of Project Validity

The Project will benefit the whole of Bougainville Island and the benefiting population is forecast to be 210,000 (as of 2006). The effects anticipated from implementation of the Project are as follows.

Direct Effects

- The whole route of 190 km between Kokopau and Arawa will be connected without the need for any river crossings, and travel time along the said section will be shortened by around 1 hour.
- Since the road will be permanently repaired, the current problem in which the road becomes impassable for 30 days a year due to flooding will be resolved.
- Construction of bridges will allow ordinary vehicles such as cars, motorbikes and bicycles to pass, thereby leading to diversification of transport means. Larger vehicles and greater numbers of vehicles can also be expected.

- Emergency vehicles such as ambulances will be able to pass at all times.
- Accidents involving the washing away of pedestrians and vehicles due to dangerous river crossings during flooding will be prevented.
- River pollution caused by vehicles crossing rivers will be avoided.
- Until now, the dilapidated sections of old causeways caused corrosion to riverbanks during flooding, however, this problem will be resolved and the river environment will be made safer.

Indirect Effects

- Since the island's sole lifeline will no longer be dictated by weather conditions and the reliability of the road will increase, this will contribute to the stabilization of the everyday movement of daily necessities, better access for roadside residents to medical care and education facilities, vitalization of local agriculture and forestry, and local development, etc.
- Since more diverse, larger capacity and more regular means of transport will become available, the currently expensive cost of transport between Arawa and Buka will be reduced for the local residents.
- Since vehicles will no longer cross rivers, the local residents will be able to cook and wash with clean water, thereby leading to a better standard of living.
- Since the risk of land runoff caused by residual causeways will disappear, land use by the local residents will become more stable.
- Through employing local residents in the construction works, this will lead to higher incomes and more stable livelihoods for the local population.

Moreover, the maintenance of bridges and access roads constructed in the Project will be undertaken by the Department of Works (DOW) and ABG. The Bougainville DOW and ABG are manned with engineers who possess the technical capacity for maintenance, so there is no problem regarding capability on the local side. Moreover, since the mean annual maintenance cost in the Project is equivalent to just 0.6% of the DOW annual budget in 2008, the cost should not be a problem either.

To sum up, the Project will enable the permanent north-south linkage of Bougainville Island by a single road through constructing permanent facilities at 15 current riverbed crossings. As a result, this will contribute to the stabilization of local lifestyles, improvement of access to medical care and education facilities and general improvement in everyday convenience for the roadside residents. Also, the permanent

accessibility of the coastal trunk road will enhance the reliability of goods transport and vitalize the local economy.

In consideration of these facts, since the Project can be expected to impart a major effect on the development of roadside areas and to contribute to the improvement of lifestyles for local residents and reduction of poverty, it is deemed to be valid as a Grant Aid undertaking of the Government of Japan.

However, in order to ensure the effective implementation of the Project, it will be necessary to pay attention to the following items.

- Security
  The security situation in PNG is extremely poor. Although Bougainville is safer than Port Moresby and Lae on the main island, it will still be necessary to secure cooperation from the police and to bind a contract with a local security company in order to prevent theft of equipment and materials and to secure safety of personnel from thieves as they commute to work and during working hours.

- Understanding and cooperation of roadside residents regarding the Project
  Obtain cooperation from the residents upon showing them that the Project will benefit their lifestyles.
  If necessary, have residents actively participate in the Project in order to promote a sense of unity. Also show care regarding the handling of boundary lines and personal property adjoining the road.

- Establishment of Community Coordination Committee
  In order to promptly resolve the above kinds of problems when they occur, it will be necessary to establish Community Coordination Committee (local residents, DOW, ABG and police officials) in order to ensure communication of accurate information and mutual understanding. Concerning this, among the conditions agreed with the Government of PNG in the Basic Design Study minutes, it is stipulated that letters of cooperative consent be secured from roadside residents and that Community Coordination Committees be established and operated when executing the works.

The Project for Construction of Bridges on Bougainville Coastal Trunk Road

In

The Independent State of Papua New Guinea

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Abbreviations

ABG:	**Autonomous Bougainville Government**
AP:	**Authorization to Pay**
AusAID :	**Australian Agency for International Development**
B/A:	**Banking Arrangement**
BMS :	**Bridge Management System**
DBST :	**Double Bituminous Surface Treatment**
DEC:	**Department of Environment and Conservation**
DLPP:	**Department of Lands and Physical Planning**
DNPM :	**Department of National Planning and Monitoring**
DOFA:	**Department of Foreign Affairs**
DOW:	**Department of Works**
DTS:	**Division of Technical Services**
EIA:	**Environmental Impact Assessment**
EL:	**Elevation**
EN:	**Exchange Note**
IRC:	**Internal Revenue Commission**
GDP:	**Gross Domestic Product**
GNI:	**Gross National Income**
HWL:	**High Water Level**
IRC:	**Internal Revenue Commission**
JICA:	**Japan International Cooperation Agency**
JPY:	**Japanese Yen**
MOA:	**Memorandum of Agreement**
M/D:	**Minutes of Discussion**
NTDP:	**National Transport Development Plan**
ODA:	**Official Development Assistance**
PC:	**Prestressed Concrete**
PNG:	**Papua New Guinea**
RAMS :	**Road Asset Management System**
ROW:	**Right of Way**
SHBJ:	**Specification for Highway Bridges in Japan**
SPT:	**Standard Penetration Test**

CHAPTER 1

Background of the Project

Chapter 1 Background of the Project

1-1 Background and Outline of the Grant Aid

Bougainville Coastal Trunk Road is an arterial state highway stretching for approximately 190 km between the capital Kokopau on the opposite shore from Buka and the former capital of Arawa. Not only is this an important transport route for people and goods (farm products and daily necessities such as cacao and copra, etc.), but it is also the primary artery for passage of ambulances and other emergency vehicles. However, at 15 points where the road crosses rivers along the route, there are no crossing facilities such as bridges, etc. At such points, residents walk across the rivers or use four-wheel-drive vehicles to cross, however, passage is frequently impeded by high water levels during and after rainfall.

The Government of PNG sent a request to the Government of Japan in August 2006 asking for Grant Aid regarding the repair of 13 bridges on the section between Buka and Arawa. In response to this, the Government of Japan consigned JICA to implement the Preliminary Study from August to September 2007. During this, a further two bridge plans that had little prospect of implementation were added to the list, and the Study targeted 15 sites.

Based on the results of the Preliminary Study, the Government of Japan decided to conduct the Basic Design Study on the Project for Construction of Bridges on Bougainville Coastal Trunk Road and entrusted the Study to JICA. JICA subsequently dispatched the Basic Design Study Team to Papua New Guinea from March to April 2008.

The Preliminary Study targeted six causeways and nine bridges, however, as a result of the Basic Design Study, it was recommended that bridge structure be newly adopted at all 15 sites in consideration of comparative examination of economy, ease of construction, durability of structures, materials procurement, ease of transport and maintenance. Table 1-1 shows the target structures and structural types that were included in the original request, the Preliminary Study and the Basic Design Study respectively.

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Total				605			586			545		-41

Based on the site surveys and analysis following return to Japan, the Study Team prepared the Basic Design Summary Document. JICA dispatched the Basic Design Explanation Team to PNG in October 2008. Upon holding discussions with the PNG government, both sides confirmed and reached agreement on primarily the scope of works of each side, and the M/D was signed by the parties on October 9, 2008.

1-2 Natural Conditions

(1) Climate

Papua New Guinea comprises the eastern half of New Guinea Island and surrounding islands surrounded by the Coral Sea and Pacific Ocean, and it is situated to the east of Indonesia. Except for limited mountain areas, almost all of PNG is affected by the tropical monsoon, and climate can broadly be divided into the northwest monsoon (rainy season from December to March) and the southeast monsoon (May to October).

The Study target area of Bougainville is located east of New Guinea and is the largest island (approximately 10,000 km^2) in the Solomon Islands. The climate of Bougainville is heavily influenced by the northwest monsoon in the north as typified by Buka, and the southeast monsoon and Pacific seasonal winds in the central and southern areas as typified by Kieta. The mean annual temperature is just under 27℃ with the maximum temperature reaching 32.5℃ (September) and the minimum falling to 20.5℃ (October and November), although there is not a great difference between monthly temperatures

throughout the year.

(2) Hydrology and Hydraulic Conditions

Rainfall data were obtained from the Buka observatory and Kieta observatory in order to get an idea of rainfall conditions around the Project route. According to the observation data, annual rainfall in the north as measured by Buka observatory is approximately 2,690 mm, with 1,572.1 mm falling in the six months between November and April (rainy season) and 1,117.5 mm falling in the six months from May to October (dry season). Meanwhile, annual rainfall in the south as measured by Kieta observatory is approximately 3,360 mm with monthly rainfall ranging from 223.2 mm (June) to 341.7 mm (September).

Incidentally, meteorological observations on Bougainville have not been carried out since observatories were destroyed and closed down during the conflict in 1989. The observatory in Buka was reopened in April 1993, however, it was closed again in September 1995 and has not conducted observations since.

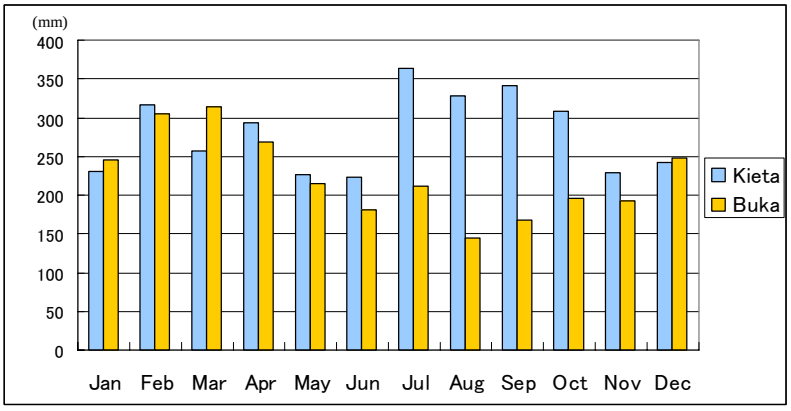


Figure 1-1 Rainfall Records at Buka and Kieta

(Note 1) Obtained from the National Weather Service, PNG
(Note 2) Recording period: Kieta observatory 1978~1989, Buka observatory 1982~1995

(3) Topography and Geological Conditions

The 15 bridge construction sites can be divided into two areas according to the geological conditions. One is the area between Bakanovi Bridge and Malas Bridge, which comprises alluvial with partial volcanic ash deposit and is made up of silt, sand and gravel. The ground here is loose with an N value of 10~15, and no clear supporting layer can be recognized down to a depth of 15~20 m. Meanwhile, the area from Ururva Bridge to Rawa1 Bridge comprises agglomerate with partial volcanic ash deposit, and the rock formation can be found close to the ground surface.

In the Study, topographical surveying and road surveying (width 80m, length: planned bridge length + 300m), river surveying (width: planned bridge length +100m), 11 sections), and geological investigations (boring, standard penetration testing, indoor testing) were carried out at the 15 bridge construction sites. The findings of these topographical surveys and geological investigations are reflected in the overall map of the area.

(4) Earthquakes

Being situated on the boundary of the Philippine Ocean Plate, the Australian Plate and the Pacific Plate, PNG experiences a lot of earthquakes. Figure 2-6 shows a distribution map of earthquakes in this area.

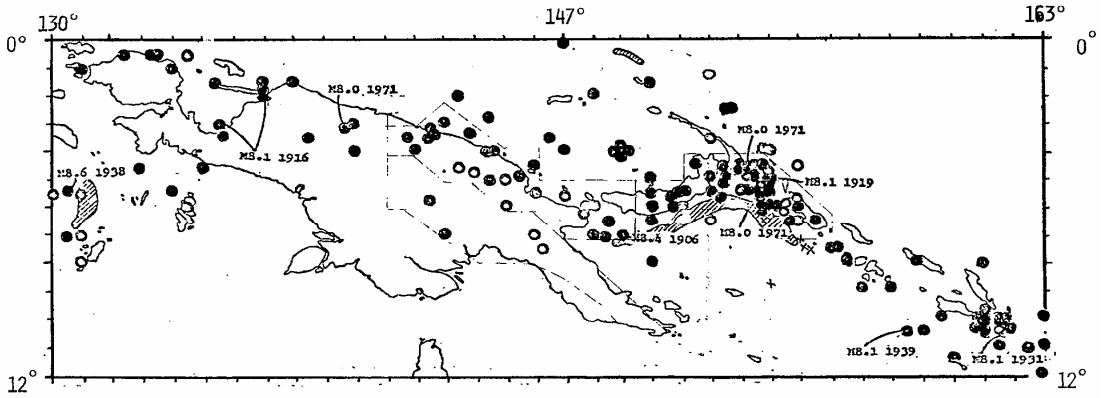


FIG. 2A.1. EARTHQUAKES OF MAGNITUDE 7.0 AND GREATER, 1900 - 1972

Solid circles - epicentres of shallow (≤60km) earthquakes.
Open circles - intermediate and deep (>60km) earthquakes.
Date and magnitude of earthquakes with M = 8.0 or greater is shown in the figure. Ref. 2 .7

Major earthquakes since 1972 are shown by a cross.
(Supplied by the Geophysical Observatory, Port Moresby.)

Dotted lines indicate region adopted for calculation of seismicity in section 2A.5.

Figure 1-2 Distribution of Earthquakes around PNG

Source: Earthquake Engineering for Bridges in PNG 1976

1-3 Environmental and Social Considerations

(1) Environmental Legislation in PNG

1) Procedure of Environmental Permit

Based on the PNG Environmental Act 2000/Environmental Regulation 2002, the Project was categorized as a Level 2 process by the Department of Environment and Conservation (hereinafter referred to as "DEC") on October 12, 2007. Generally, construction of bridges requires a detailed environmental impact assessment, however, since the reconstruction of already existing bridges does not entail major impacts, only an environmental management & monitoring plan (hereinafter referred to as "EMMP") is required here.

Figure 1-3 shows the Level 2 procedure based on legislation.

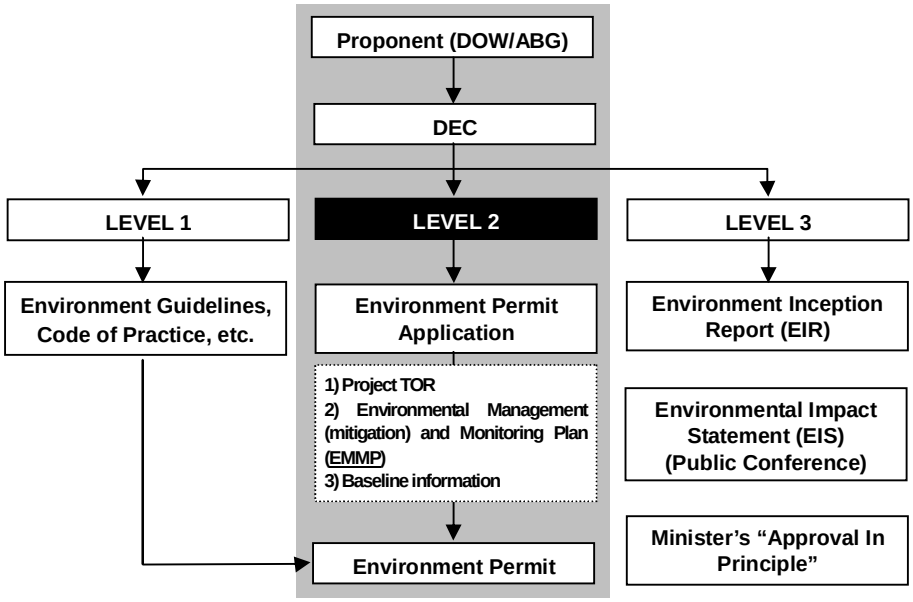


Figure 1-3 Procedure up to Issue of the Environmental Permit

2) Progress of the Environmental Permit Procedure

In the Basic Design Study, the environmental officials of the DOW and environmental assessment officials of the DEC held discussions and confirmed the necessary documents for Level 2 procedure. Based on the results, the Study Team assisted in preparation of the required documents, which were submitted by the DOW environmental officer in March 2008, and the environmental permit was issued on June 27 (see the Appendices for the permit). The submitted documents were as follows.

Table 1-2 Documents Submitted for the Level 2 Procedure

Item	Detailed Items
1 Document Cover	——
2 Environmental Management and Monitoring Plan (EMMP)	2-1 Scope of Works
	2-2 Baseline information
	2-3 Monitoring Plan
	2-4 Management Plan
	2-5 Format for discharge water and waste
3. Memorandum of Agreement with Stakeholders (MOA)	Consensus document for each construction site
4. Commission Fee (100K)	Already paid to the DOW

Source: Prepared by the Study Team based on interviews with environmental officials of the DOW and environmental assessment officials of the DEC

(2) Procedure of Land Expropriation and Compensation

1) Procedure of Land Expropriation

Generally speaking, 93% of land in Papua New Guinea belongs to private and customary owners, and the other 7% belongs to the government. Although the legal procedures for land expropriation take only 8 to 12 months, in reality the process drags on for anything up to around 10 years. Reasons for this are given as follows: 1) it is necessary to obtain documents from numerous agencies such as the DLPP (Department of Lands & Physical Planning), provincial authorities and the DOW, etc., 2) land assessment surveys can last anything from a month to a year, and 3) a long time is spent on negotiations with residents concerning the assessed value.

There are two types of land expropriation process in the land act, one is "Compensatory Process" and the other is "By Agreement with landowners." Generally, the compensatory process takes anything up to 10 years due to the above reasons. Hence, it is thought the second method entailing agreement (MOA) with landowners will be adopted in the Project. Moreover, ABG intends to prepare the statutory declaration giving legal status to the MOA for additional security. The following figure shows the legal procedures for acquiring land.

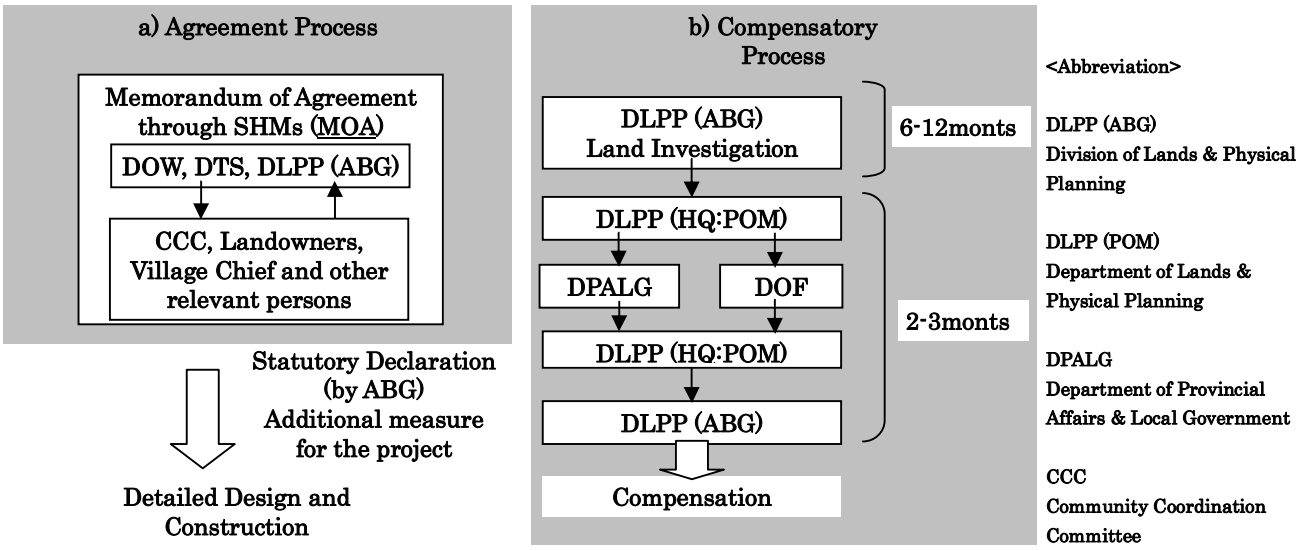


Figure 1-4 Legal land Expropriation Procedure and Project Policy

Source: Prepared by the Study Team based on hearings with the DLPP

Moreover, according to the DLPP, in cases where the government acquires land, an official document known as an NLD (Native Land Dealings) is issued and copies are retained by the provincial government, central government and landowner. However, in the Government of ABG, NLDs were lost during the civil conflict in the 1980s. Moreover,

since the central government NLD archives in Port Moresby are partially missing, it has not been possible to confirm the NLDs for the Study target sites.

2) Compensation Costs Outside of the ROW

Generally, property and agricultural products in the ROW are not compensated after land expropriation. Moreover, the landowners around the Study bridge sites understand that there will be no compensation within the ROW.

Meanwhile, the amount of compensation for customary or privately owned land in PNG is assessed and determined according to site surveys based on the land law. According to the DOW Land Bureau (Port Moresby), the price per hectare in Bougainville is approximately 3,000 PGK and negotiations are conducted based on this price. As for farm products, negotiations will be conducted based on the price list prescribed by the DLPP. As is shown below, farm products are classified into four categories A~D, and prices vary according to size.

Table 1-3 Base Prices for Farm Products Eligible for Compensation

Category		Most Expensive Items and Price on the list		Major Species / Items of the Category
A: Cash crops		Coconut Palm (Hybrid: Mature)	30K／tree	Citrus, Cocoa, Coffee, Coconuts, Rubber, Tea
B: Useful trees	B1 Single Plants and Trees	Mango (mature)	15K／tree	Avocado, Banana, Nuts, and other trees and grasses eaten by locals
	B2 Clump Plants and Trees	Sago (harvestable mature)	30K／tree	Bamboo (for building), Banana, Sugarcane, etc.
	B3 Plants and Trees by Area	Sago (1 ha or more) Cogon (1 ha or more) Watercress (1m2 or more)	30K／ha 30K／ha 2K／m2	Kunai Grass, Bamboo (for building), Sago, Watercress
C: Edible cultivated species	C1	Taro	5K／1 unit	Bean, Broccoli, Cabbage, Cucumber, etc.
	C2	Pepper vines	3K／1 unit	Cassava, ginger, passion fruit, pumpkin, water melon, etc.
	C3	Sweet potato	6K／1 unit	English potato and Sweet potato
D: Timber trees		Canoe tree	100K／tree	Pine and other timber trees
E: Others		Cemetery	800-1200K／ha	
		Sacred area	600K/ha	

Source: VALUE GENERAL Price schedule for expropriation of trees and plants all region March 2000/ Department of Lands

3) Current Status of Right of Way

① Awareness of ROW by landowners

The target road was registered as a provincial road in the 1970s, at which time land expropriation was carried out. The road was recently raised in status to a national highway, however, since the road width (ROW) stated in the letters and official materials (Survey Direction 1990) submitted by the DOW during the Preliminary Study is 30 m, an ROW of 30 m shall be adopted in the Project. Currently, there are no indicators of ROW on the road, however, the landowners around the bridge sites are aware of the ROW and displayed adequate understanding of it when explanation was given in the stakeholder meetings in the Study. The landowners also consented to the fact that the ABG will not provide any compensation for crops located inside the ROW.

② Statutory ROW expropriation documents

As was indicated under the section "Procedure of Land Expropriation and Compensation," the said Survey Direction 1990 has been ascertained as the basis of legislation and guidelines, etc. prescribing ROW in PNG. However, in future it is desirable to establish legal procedures for re-expropriation utilizing the MOA of the ABG government, and the Study Team requested the DOW to provide basic materials to the ABG government by the start of works.

4) Conclusion regarding land Acquisition

The planning affected area will be in the right of way, however private land and/or customary land may be affected by construction access road, detour and offices area during construction. ABG should conduct appropriate compensation based on relevant laws and compensation list such as table 1-3.

(3) Outline of Stakeholder Meetings

1) Objectives

The stakeholder meetings were held with the objective of obtaining a public consensus for the

Project through giving the following explanations and exchanging opinions.

- Explanation of the Project outline and expected schedule in the future
- Explanation of predicted positive and negative impacts and suitable mitigation measures
- Confirmation of the impacted scope of works and scope of ROW (explanation of scope at each bridge construction site)

- Exchange of opinions
- Signing of MOA (Memorandum of Agreement concerning project implementation, cooperation and response in the event of problems, etc.)

2) Implementation Status

The stakeholder meetings were scheduled at all 15 bridge construction sites, and the JICA Study Team attended the meetings in Rawal and Ururva. The meetings at the remaining 13 sites were successively staged by the ABG. The meetings were attended by around 15 landowners and village chiefs, and the MOAs were signed without any major opposition. During the meetings, it was also confirmed that the ABG would provide compensation in cases where land outside of the ROW is used.

Photograph 1-1 Stakeholders Meetings (June 2008, Rawal and Ururva)

(4) Environmental Impacts and Considerations in the Project

As was demonstrated in the Preliminary Study, concerns are raised over a number of undesirable impacts such as water turbidity, noise and land expropriation not entailing the relocation of residents, etc. However, almost all these effects are limited to during the works period and are thought to be avoidable (through altering water utilization sites, etc.). Moreover, since obstructions such as dilapidated causeways and so on will be removed in line with the Project, bank corrosion and soil runoff arising from such objects will be improved.

The DOW has guidelines for mitigating the general impacts of works (noise, water turbidity, etc.), and these will be implemented by the works contractors. Also, an environmental permit based on the EIA law was issued on June 27, 2008, and it will be necessary in future to implement and monitor the mitigation measures that are stipulated in the permit.

Environmental monitoring is generally implemented by works contractors under the supervision of the DOW.

Proposed mitigation measures based on JICA's environmental and social consideration guidelines are as follows;

Table 1-4 Primary Mitigation Measures and Monitoring Plan

Bridge Name (ID No.)	Key Items and Impacts	Mitigation Measures	Monitoring
Bakanovi (3), Bove (4), Malas (14) Korova (12)	**Local economy** Possible clearance of useful trees for construction of access road	-Minimization of affected area on design of access road alignment -Appropriate compensation by ABG (Out of the ROW)	No need monitoring
Ururva (19)	**Underground water and vibration** There are two spring points near target bridge. Earth work may affect to spring water's quantity and quality.	No need mitigation measures	Periodical check water quality and quantity with eyes
All bridges	**Water use** Use of the river water by local residents (for bathing, washing, drinking, cooking and fishing) may be affected. (Alteration of current utilization sites)	- Securing alternative water points upstream	Periodical check water quality and quantity with eyes
	Solid and Liquid Waste Existing structures, construction waste such as waste oil and general waste from the base-camp site may have an impact.	Planning of waste management by contractors (Construction waste and domestic waste from base camp)	Periodical check of management waste by taking photo
	Land use and local economy Privately owned land and customary land may be affected by access road construction, works diversion routes and installation of the base-camp.	Conduct construction activities inside of ROW	Appropriate compensation by ABG (Out of the ROW)
	Water turbidity caused by earth works Turbid water may have an impact on aquatic flora and fauna.	Contractor should conduct mitigation measures such as setting up grit chamber and/or mulching for prevention turbidity.	Periodical check water quality and quantity with eyes
	Accident Number of traffic accidents may increase on the diversion during construction, and new bridge due to speeding post construction	- Notification of the construction period and diversion routes to residents. - Traffic safety measures by contractors (adherence to safe speeds, safety of pedestrians, etc.) - Safety measures for children (setting up signs and guard rails, etc. on the bridges)	Recording of accident frequency and causes

Source: Modified based on the findings of the Preliminary Study (Monitoring Plan was added).

CHAPTER 2

Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Back Ground of the Project

Bougainville Coastal Trunk Road connecting Kokopau and Arawa is one of the most important national highway in Bougainville Island. The Department of National Planning and Monitoring (DNPM) of the Government of Papua New Guinea (PNG) put one of the highest priority to the road and the most important policy for the development of infrastructure in the Autonomous Bougainville Government (ABG) is to keep the road in good condition.

The traffic on the road is always disturbed at 15 locations where adequate structures to cross the rivers do not exist. The objective of the project is to construct infrastructure to cross the rivers on the Coastal Trunk Road for the stability and the revitalization of the regional economy in Bougainville Island by securing safe and stable traffic on the road.

2-1-2 Outline of the Project

Construction of 15 structures on the Coastal Trunk Road is requested by the Government of PNG to the Japanese Government and each location of the structures is shown in Figure 2-1. All structures, which had been constructed at the 15 locations were destroyed by scours in the foundation of the structures. Construction of cause ways and bridges are recommended in the Term of Reference from the Government of PNG, however these structures are quite fragile against the score and will easily collapsed within a short period. The structures type shall be carefully selected in these circumstances and it is essential to plan the structures which are well protected against the scour. Following benefit will be gained through the construction of these structures.

1) To reduce the transportation time
2) To decrease the transportation cost
3) To diverse mode of transportation (e.g. Bicycle, Motorcycle, Car, Truck, etc.)
4) To secure safe and stable traffic condition
5) To decrease the number of bathing fatalities during crossing river
6) To remove the obstacles for the activities of an ambulance.
7) To improve the transportation of goods
8) To develop the local community

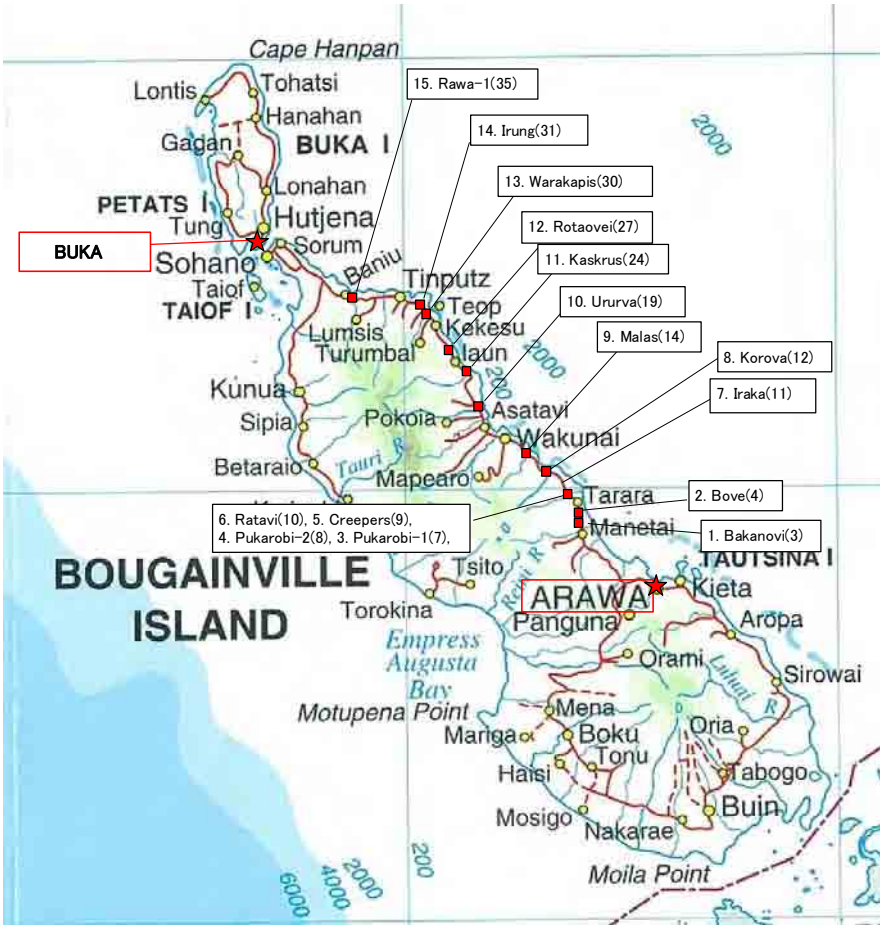


Figure 2-1 Bridge Location Map

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

(1) Basic Principle of the Project

It is confirmed that the structures at the 15 locations shall be reconstructed, after the field investigation by the basic design study team. At the 15 locations where the existing structures have been damaged or collapsed, the local residents have been forced to wade to cross a river. The study team also confirmed that the traffic on the road will be largely improved by the construction of 15 structures. Therefore, it was concluded that the improvement of the traffic on the Coastal Trunk Road could not be achieved without the construction of structures on the 15 locations requested by the Government of PNG.

(2) Basic Policy for the Natural Environment

1) Hydraulic Analysis

The analysis of the flood runoff in the river basin was carried out, based on the PNG Flood Estimation Manual provided by the Water Resources Bureau. The data of the

rainfall per day from 1978 to 1989 at the Kieta meteorological weather station and from 1986 to 1989 and from 1993 to 1995 at the rainfall observing station in Buka, are used for the analysis. Catchments areas of the river basin are calculated by using the regional contour map with a scale of 1 to 100,000. The high water level and the flow velocity at a flood were calculated based on the outcome of the longitudinal profile and the cross-section survey of a river. Considering the river size and the road standard, 50 year return period of the rain fall was adopted to determine a flood height.

2) Seismic Analysis

As PNG is located on the boundary between Philippine Sea Plate, Indian-Australian Plate and Pacific Plate, there are high possibilities of serious earthquake in PNG. Therefore, it is very important to adopt the seismic design for the public infrastructure including bridges. Following articles are prescribed in the Earthquake Engineering for Bridges in PNG revised in 1985 as the basic concept.

1. The service for the traffic shall be kept after the earthquake.
2. Parts of structural damages should be specified for urgent repair of a bridge.
3. A bridge must have enough durability against a medium scale earthquake throughout the life cycle of a bridge.

Life span of bridge is classified into following categories

a. Important bridges carrying high density traffic loading: 100 years
b. Permanent bridges other than those included above: 50 years
c. Temporary bridges i.e. Bailey: 20 years

The structures to be constructed in this project are classified into Category b. The acceleration response spectrum with 350 year return period stipulated by the manual in PNG was compared with the acceleration response spectrum prescribed in the Specifications for Highway Bridges in Japan (SHBJ) in this study,. As the result of the study, it is concluded that the acceleration response spectrum in SHBJ is greater than that of PNG. Therefore, the Specifications of seismic design for Highway Bridges in Japan are applied to this project for safety.

(3) Concept of the Social Environment

1) Procedure for environment permit

Based on "Environment Regulation 2002" of the Government of PNG, the Department of Works (DOW) and ABG submitted the notification letter to the Department of Environment and Conservation (DEC). After the evaluation, DEC determined this project as Level 2. The necessary documents to obtain the environment permit were discussed with the officers in charge of the environment issues in DOW and DEC. After the discussion, the documents required were prepared and submitted to DEC in March 2008, and the environment permit for the 15 bridges was issued on 27th June 2008.

2) Procurement of Construction Site and Compensation

The meetings with the local stakeholders were held at the 15 places where new structures will be constructed. All participants of the meetings agreed about the boundaries between the construction areas and their private areas which were indicated on the drawing by the study team. Moreover, all participants were agreed that no compensation for the land, trees or etc inside the construction area was provided and ABG is responsible for compensation to the asset of residence outside of the right of way when the asset influenced by the project.

3) Security Issues

The security situation in Bougainville seems to be better than that of other cities in Papua Newguinea. However, there are some risks in some area including the restricted zone in the south part of the island. Therefore, it is essential that security guards shall be operated for 24 hours at the construction sites.

(4) Environment for the project

1) Procurement of Construction Material and Equipment

The unit prices of the construction material and equipment in PNG needed for this project were investigated through this study. According to the investigation, the prices of most of the construction material and equipment were soared in the last couple of years. The cause of the soaring could be explained by the followings.

1. High demand of natural resources in the world
2. Soaring of fuel price
3. Construction boom in PNG
4. Few competition in the construction market in PNG

Therefore, the prices of construction material in PNG, JAPAN and other countries shall be examined and the most economical and reasonable material shall be selected for the project.

2) Assignment of Labours

Although construction workers are available in PNG, the wages for the workers have slightly risen in the past few years. High level of skill is not expected for the project and the skilled workers are available in the major cities in PNG including Port Moresby and Lae. The wages of worker and their skills in PNG, JAPAN and other countries are compared and the most reasonable staffs shall be assigned in the cost estimation.

(5) Situation of Local Subcontractor

There is no local contractor which has enough experience in bridge construction in Bougainville. On the other hand, there are some contractors with experience of bridge construction project in PNG.

(6) Management of Bridge Maintenance

The implementing agencies for this project are DOW of government of PNG and ABG which has responsibilities for the maintenance and improvement of the Bougainville Coastal Trunk Road in Bougainville. After the construction of bridges, the bridge inventory in ABG shall be updated and they shall be utilized for the bridge maintenance by the Agencies.

(7) Selection of Structure Type

The road condition of Bougainville Coastal Trunk Road is fine because of the good maintenance and improvement implemented by AusAID. However, all causeways for this project crossing the rivers have been damaged and destroyed by scouring in their foundation as shown in Photo2-1and Photo 2-2. Period between Preliminary Study and Basic Design study is 6 months and the RAWA1 was deteriorated rapidly in the short period.

Photo 2-1 Rawa1 at Preliminary Study

Photo 2-2 Rawa1 at Basic Design Study

Take into consider the severe geological, topographical and hydrological conditions, causeway constructed in the river would be collapsed in a short period of time. Therefore, bridge or culvert which has enough opening for the flood discharge of a river shall be adopted for this project. The construction cost of bridge and culvert is compared in this study and the bridge type is recommended for this project.

(8) Construction Method and Construction Schedule

The scale of bridge including bridge length and span length were determined to have enough opening of bridge to pass the flood discharge safely. As the bridge types recommended for this project, concrete bridge and steel bridge were compared and steel bridge is recommended taken into consider their construction cost and construction period. Same length and type of girder are adopted to each bridge in the project to make construction easy and to reduce the construction cost. The 15 bridges would be constructed by three parties and be completed within three years.

2-2-2 Basic Plan

2-2-2-1 Overall Plan of the Project

(1) Road Plan

1) Design Concept for Road

The construction sites are located on the Coastal Trunk Road runs along the coast on a flat landform. As the rivers run through such flat areas, the convex vertical alignment of the approach roads to a bridge shall be considered to secure enough clearance under the bridge deck for high water level as shown in Figure 2-2.

The maximum gradient of the approach roads is limited to 5 % because there are many outdated or ill-serviced heavy vehicles are still running in Bougainville. Moreover, the bridge sections were planned as flat roads and the approach roads shall be planed to be

connected smoothly to the bridges.

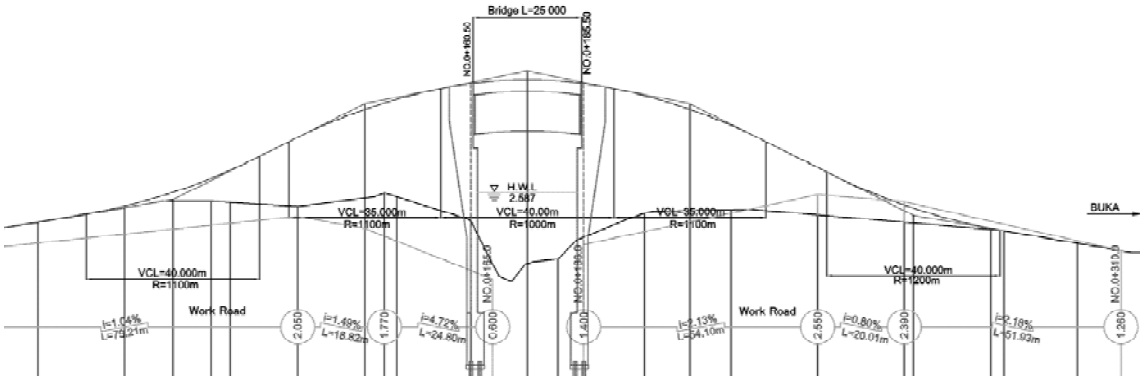


Figure 2-2 Vertical Alignment of a Bridge.

2) Design Criteria

"Road Design Manual (1994)" stipulated by the DOW was adopted as the main criteria for this project. In addition, "Explanation and Application about Road Structure Ordinance" utilized in Japan was adopted as a complementary manual.

3) Standard Road Width

Based on the "Road Design Manual (1994)", the standard road width in the road sections was planed as two-lane road with the width of 6 meter as shown in Figure 2-3.

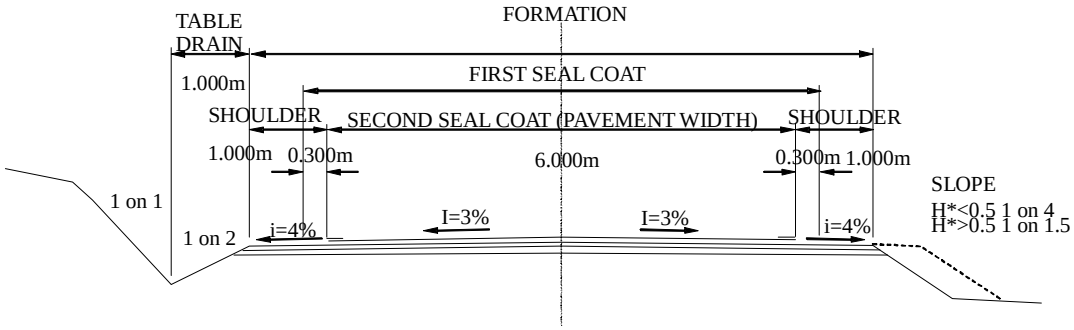
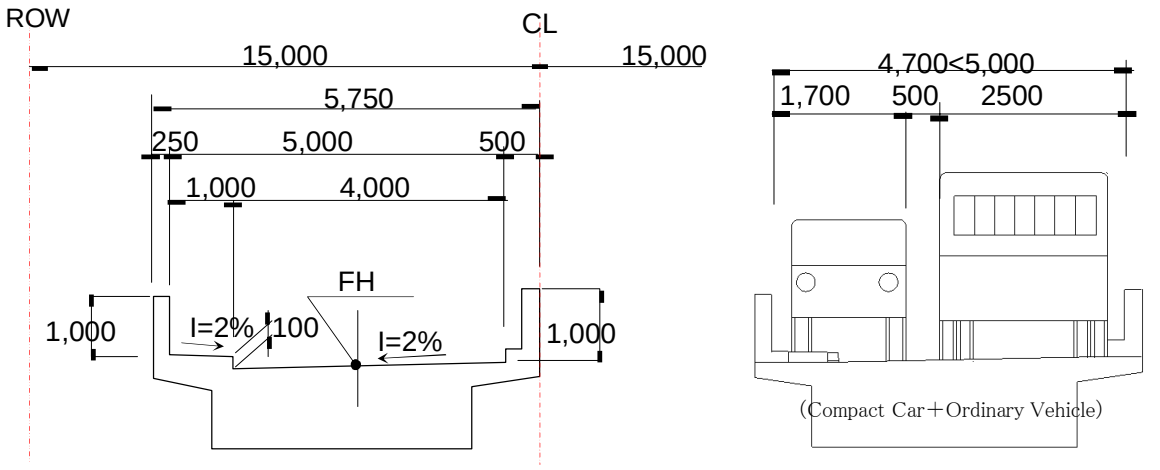


Figure 2-3 Standard Road Width

The standard carriage way on a bridge is 4 meter and foot way width is 1.meter wide. The width of bridge is determined taken into consider the local traffic condition that most of the local residents were expected to pass a bridge on foot. Guardrail will not be placed between carriageway and footway to pass each other car other Concrete handrails will be placed on both sides of the bridges as shown in Figure2-4.



＊ In case a broken-down car stops on the bridge

Figure 2-4　Standard Width on Bridge

4) Pavement

Most part of the existing roads on the Coastal Trunk Road have no asphalt pavement and the access roads to the bridge is also not paved. However, the 50 meter sections to a bridge will be paved with cold-mix asphalt for conservation of a bridge. Thickness of 20mm of concrete on the bridges deck will be placed as a wearing surface.

5) Drainage

L-Shaped side ditches and U-Shaped side ditches are placed at the top and the bottom of slopes respectively on the approach roads to protect against erosion by the rain as shown in Figure 2-5.

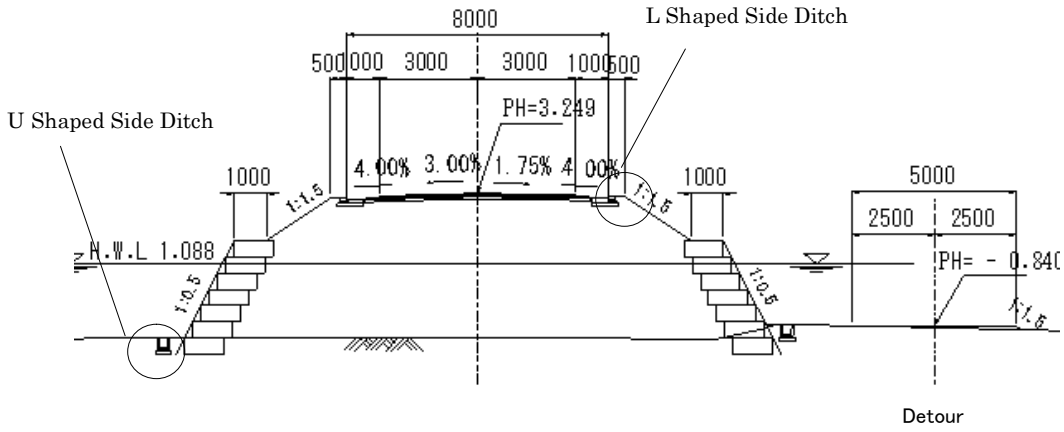


Figure 2-5 Drainage System

6) Revetment

The installation of gabion mat will be planned as a terrace of the slope of approach road to protect the slope from the river flow. The gabion terrace will be constructed up to high water level (HWL) with the gradient of 1 in 0.5 and the slope of embankments with the gradient of 1 in 1.5 will be constructed above the H.W.L as shown in Figure 2-6.

The gabions mat with 5 meter wide will be placed around the piers. as a river bed protection,

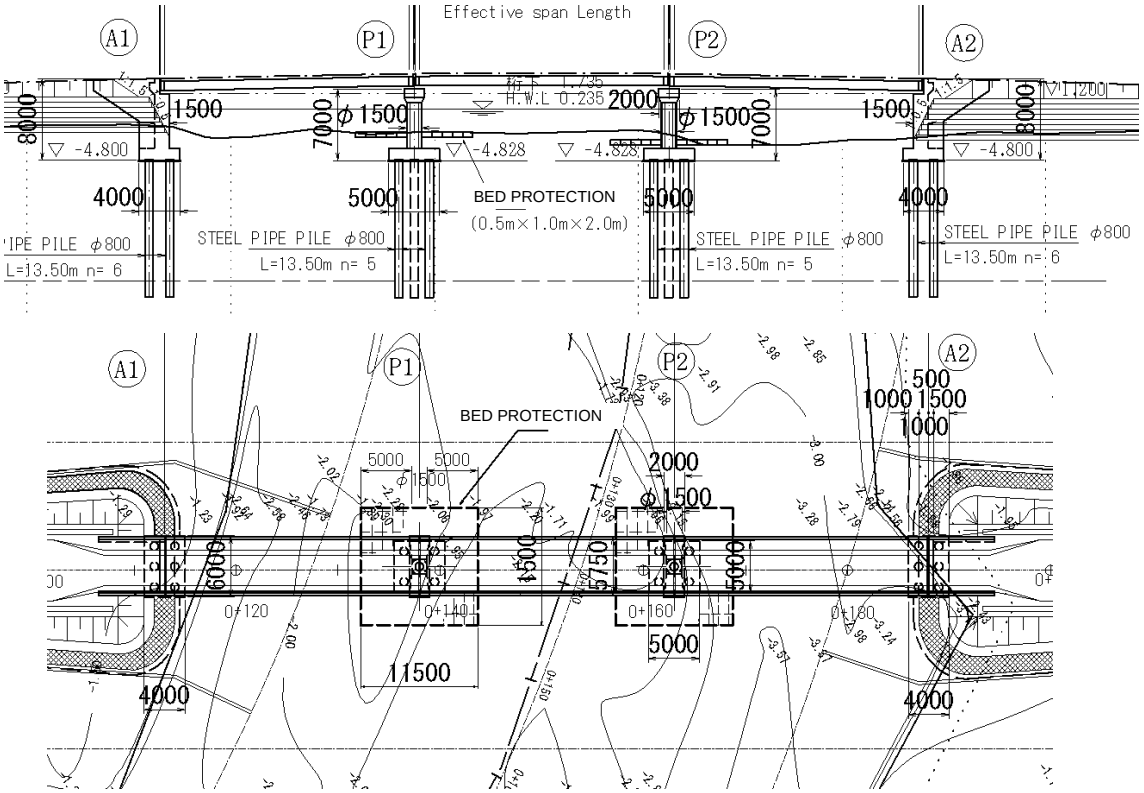


Figure 2-6 River Protection

(2) Bridge Design

1) Design Criteria

"Specifications for Highway Bridges" issued by Japan Road Association will be adopted as the basic bridge design criteria in this project and specification of ABG, PNG and Australia will be adopted if necessary.

2) Loading

A-Live Load (20-ton Truck Loading) stipulated in the Specifications for Highway Bridges will be applied as the Design Live Load for the design of bridges in this project.

3) Material Strength

The strength of the materials used in this project will be based on the Specifications for Highway Bridges in Japan as shown in Table 2-1.

Table 2-1 Strength of Material

Material	Strength
Concrete	Substructure : Abutment 24N/mm2、 Pier 30N/mm2 Superstructure : 30N/mm2
Reinforcement Bar	SD295 and SD345 Yield strength :295～440N/mm2
Structural Steel	SM490Y Yield Strength: more than 355N/mm2
Steel Pile	SKK490 Yield Strength: more than 315N/mm2

4) Bridge Location

The locations of the bridge were planned in order not to arise compensation for private land as much as possible.

5) Bridge Length

The bridge length has greatly influence to the project costs, and bridge length shall be minimized as much as possible to reduce the project cost. Therefore, the bridge lengths will be planned as short as possible by securing sufficient opening of bridge for the maximum discharge of a river calculated by hydrological analysis.

6) Standardization of Structures

The type of the structures and construction materials for structures were standardized by the following reasons.

- Limited resources for construction in Bougainville
- Reduction of Construction Cost
- Reduction of Construction Period
- Quality control by similar operation

(3) Hydrological and Hydraulic analysis

The velocity of river flow and the high water level of a river were analyzed to determine the sufficient clearances under the decks.

1) River Features

The river features are shown in Table 2-2.

Table 2-2 River Features

Bridge Name	River Name	Catchment Area (km^2)	Gradient of Riverbed	Average Gradient of Riverbed at Site	Remark
1.Bakanovi	Vito River	130.4	1/400	1/96	
2.Bove	Bove River	45.8	1/200	1/133	
3.Pukarobi 1	Pukarobi River	6.1	1/80	1/53	
4.Pukarobi 2	Creepers River	12.2	1/200	1/93	
5.Creepers	Mad Water	13.5	1/100	1/67	
6.Ratavi	Koreba River	11.9	1/500	1/50	
7.Iraka	Iraka River	39.9	1/300	1/57	
8.Korova	Korova River	18.1	1/300	1/400	
9.Malas	Malas River	28.6	1/300	1/286	
10.Ururva	Urunai River	37.7	1/200	1/200	
11.Kaskrus	Kaskas River	12.2	1/50	1/24	
12.Rotaovei	Arunai River	33.0	1/100	1/67	
13.Warakapis	Tinputz River	23.2	1/100	1/42	
14.Irung	Irung River	46.7	1/300	1/108	
15.Rawa 1	Rawa River	67.6	1/200	1/90	

2) Flood Discharge and Designed High Water Level

On the basis of PNG Flood Estimation Manual, the flood discharges on each return period were calculated as shown in Table 2-3.

Table 2-3 Flood Discharge (m^3/s)

Name	Catchment area (km2)	Flood Discharge		Remarks
		5-year (For construction period)	50-year (For designing of Bridges)	
1.Bakanovi	130.4	320.5	504.1	
2.Bove	45.8	157.0	251.4	
3.Pukarobi 1	6.1	44.9	75.3	
4.Pukarobi 2	12.2	73.5	124.3	
5.Creepers	13.5	77.8	129.9	
6.Ratavi	11.9	71.9	121.2	
7.Iraka	39.9	161.9	264.6	
8.Korova	18.1	92.8	151.3	
9.Malas	28.6	124.9	199.4	
10.Ururva	37.7	152.4	244.3	
11.Kaskrus	12.2	60.2	101.7	
12.Rotaovei	33.0	117.6	194,4	
13.Warakapis	23.2	91.0	149.2	
14.Irung	46.7	149.1	245.2	
15.Rawa 1	67.6	191.5	312.5	

The high water levels and the velocities of river flow at the flood discharge on return period of 50 year and 5 year at each bridge site are shown in Table 2-4 and Table2-5, respectively.

Table 2-4 Design Discharge, Water Level and Velocity

Name	Additional rate arising form sediment inflow	Design Discharge (m3/s)	Design Water Level (elevation)	Velocity (m/s)	Remarks
1.Bakanovi	Considered	554.5	0.235	3.538	Trapezoid-section Upper= 75m, Lower= 50m Design river bed level=present level
2.Bove	-	251.4	0.790	3.316	Rectangular-section Width=20m Design river bed level= -3.00m
3.Pukarobi 1	Considered	82.8	2.587	2.183	Trapezoid-section Upper = 25m, Lower= 20m Design river bed level=present level
4.Pukarobi 2	-ditto-	136.7	-5.327	2.465	Trapezoid-section Upper= 50m, Lower= 30m Design river bed level=present level
5.Creepers	-ditto-	142.9	-4.468	3.138	Trapezoid-section Upper= 20m, Lower= 12m Design river bed level=present level
6.Ratavi	-ditto-	133.3	-3.915	2.183	Trapezoid-section Upper= 50m, Lower= 30m Design river bed level=present level
7.Iraka	-ditto-	291.1	1.296	2.574	Trapezoid-section Upper= 75m, Lower= 50m Design river bed level=-0.55m
8.Korova	-	151.3	-1.098	3.224	Rectangular-section Width= 20m Design river bed level=present level
9.Malas	-	199.4	0.543	3.582	Rectangular-section Width= 20m Design river bed level=present level
10.Ururva	-	244.3	-0.019	3.059	Trapezoid-section Upper= 20m, Lower= 13m Design river bed level=-4.08m
11.Kaskrus	Considered	111.9	-1.007	2.805	Trapezoid-section Upper= 25m, Lower= 15m Design river bed level=present level
12.Rotaovei	-ditto-	213.8	0.423	3.056	Trapezoid-section Upper= 40m, Lower= 30m Design river bed level=present level
13.Warakapis	-ditto-	164.1	-0.066	3.180	Rectangular-section Width=25m Design river bed level=-2.13m
14.Irung	-ditto-	269.7	1.088	2.722	Trapezoid-section Upper= 40m, Lower= 25m Design river bed level=present level
15.Rawa 1	-ditto-	343.7	-0.700	3.347	Trapezoid-section Upper= 40m, Lower= 35m Design river bed level=-3.48m

Table 2-5 Discharge, High Water Level and Velocity during Construction

Name	Additional rate arising form sediment inflow	Design Discharge (m3/s)	Design Water Level m)	Velocity (m/s)
1.Bakanovi	Considered	352.6	-0.322	2.958
2.Bove	-	157.0	0.014	2.605
3.Pukarobi 1	Considered	49.4	2.150	1.785
4.Pukarobi 2	-ditto-	80.9	-5.775	2.006
5.Creepers	-ditto-	85.6	-5.098	2.511
6.Ratavi	-ditto-	79.1	-4.283	1.764
7.Iraka	-ditto-	178.1	0.910	2.071
8.Korova	-	92.8	-1.462	2.341
9.Malas	-	124.9	0.137	2.628
10.Ururva	-	152.4	-1.199	3.251
11.Kaskrus	Considered	66.2	-1.542	2.311
12.Rotaovei	-ditto-	129.4	-0.019	2.413
13.Warakapis	-ditto-	100.1	-0.505	2.464
14.Irung	-ditto-	164.0	0.484	2.136
15.Rawa 1	-ditto-	210.7	-1.244	2.580

3) Clearance under a Bridge

The clearances from the girder to the HWL will be determined in compliance with Japanese regulation because there is no regulation for the clearance in PNG. The clearances are stipulated by the Structure for River Management Facilities (Japanese River Association) and they are shown in Table 2-6. The clearances shall be increased with the 0.5 m, in case that the height of rivers bed anticipates to rise by sediment.

Table 2-6 Clearance under a bridge

Discharge (m3/s)	Clearance under girder (m)
200 Under	0.6
200 to 500	0.8

2-2-2-2 Bridge and Span Length

(1) Method to Determine the Bridge Component

Standardized span length of 20m or 25m has been studied for this project to secure the quality of the structure and reduce the construction cost. Bridge and span lengths are determined considering the following factors.

1) Keep the clearance under the bridge above the high water level.
2) Standardized bridges span of 20m or 25m shall take into considered and the bridge length should be multiple of the span length

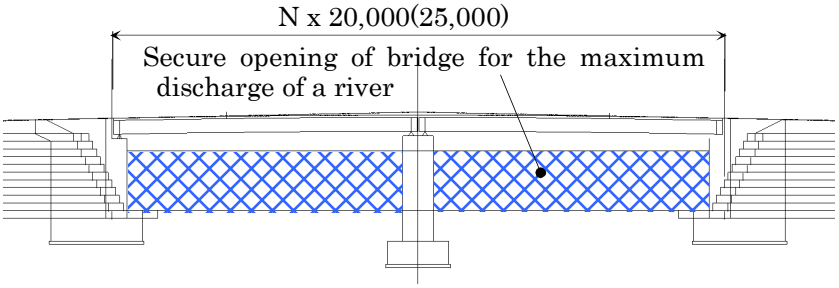


Figure 2-7 Concept of the Bridge Opening

(2) Flow chart for the selection of bridge and span lengths

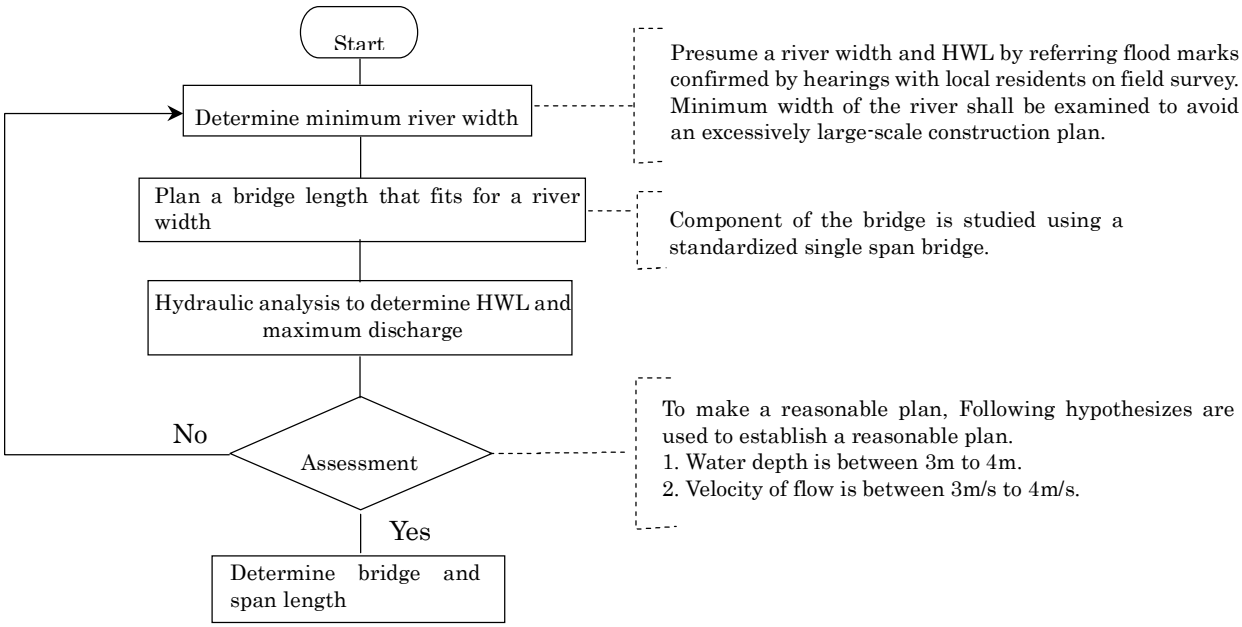


Figure 2-8 Flow chart for the selection of bridge and span lengths

(3) Bridge and span length of the 15 Bridges

Bridge and span length of the 15 bridges in the project are listed in Table 2-7. The maximum water depth at the time of a flood is h=4.0m at Ururuva bridge, and the maximum velocity of flow is V=3.6m/s at Malas Bridge.

Table 2-7 River Conditions and Scale of the Bridges

No	Name	Structural type	Discharge (m^3/S)	HWL (altitude)	Water depth (m)	Roughness coefficient (n)	Flow rate (m/s)	Bridge clearance hight (M)	Bridge length (m)	Selection of span length
1	Bakanovi	bridge	554.5*	0.235	3.8	0,05	3.5	1.5**	75	=3x25
2	Bove	bridge	251.4	0.790	3.8	0.035	3.3	0.8	20	
3	Pukarobi 1	bridge	82.8*	2.587	2.0	0.05	2.2	1.1**	25	
4	Pukarobi 2	bridge	136.7*	-5.327	2.0	0.05	2.5	1.1**	50	=2x25
5	Creepers	bridge	142.9*	-4.468	3.0	0.06	3.1	1.1**	20	
6	Ratavi	bridge	133.3*	-3.915	1.9	0.06	2.2	1.1**	50	=2x25
7	Iraka	bridge	291.1*	1.296	1.8	0.06	2.6	1.3**	75	=3x25
8	Korova	bridge	151.3	-1.098	2.5	0.035	3.2	0.6	20	
9	Malas	bridge	199.4	0.543	2.8	0.035	3.6	0.6	20	
10	Ururva	bridge	244.3	-0.019	4.0	0.035	3.1	0.8	20	
11	Kaskrus	bridge	111.9*	-1.007	2.3	0.05	2.8	1.1**	25	
12	Rotaovei	bridge	213.8*	0.423	2.1	0.05	3.1	0.8	40	=2x20
13	Warakapis	bridge	164.1	-0.066	2.1	0.05	3.2	1.1**	25	
14	Irung	bridge	269.7*	1.088	3.4	0.05	2.7	1.3**	40	=2x20
15	Rawa 1	bridge	343.0*	-0.701	2.8	0.035	3.3	1.3	40	=2x20
Total									545	

Note 1: The * mark indicates that 10% of additional discharge has been added considering the earth and sand are mixed into flood flow.

Note 2: Return period of a flood is 50 years.

Note 3: The ** mark indicates that 500 mm of bridge clearance has been added where the slope of river bed around the bridge area is steep, and the bridge opening become small caused by a blockage of driftwood at the time of a flood.

2-2-2-3 Selection of bridge type

(1) Selection of Substructure and Foundation Types

1) Substructure

To minimize damage from scouring by a flood, the basement of an abutment shall be extended to 2 m in depth under the river bed. In that case, the height of abutment becomes 6.0m to 8.0m. For the bridge piers, circular column bridge piers are adopted to accord a possible future change of direction of flow of a river.

2) Foundation

According to the geological survey, there are thick sand layer at 10 locations of Arawa side (Bakanobi ~ Ururuva). Bearing stratums having N value 50 and above are confirmed in 4

locations, and clear bearing stratum could not confirmed in the depth of 25m at 6 locations. On the other hand, there are very hard stratum on the surface of the ground and SPT test could not be carried out at 5 locations of Buka side (Kaskrus ~ Rawa1). Consideration of the above geological conditions, spread foundation for the 5 locations in Buka side and pile foundation for Arawa side will be adopted.

(2) Selection of Superstructure Type

Following factors are considered in selecting superstructure type:

1) Bridge lengths between 20m to 75m are nominated considering the natural condition of the rivers.
2) Required bridge span length is about 20m to 25m when the maximum discharge of a river is under Q_{max}<1,000m^3/s. Bridge types under the range are studied.
3) Majority of bridge constructed in PNG are steel bridges. Pre-stressed concrete bridge is hardly confirmed in PNG. within the scope of our survey.
4) Types of existing bridges in the Bougainville Island include bailey bridges, pony truss steel section girder bridges, and large truss bridges.

Based on the above, premises, following bridge type are nominated for the selection.

Table 2-8 Superstructure type for the Selection

Category	Type	Description
Steel bridge	Simple composite H shape steel bridge	Simple composite girder that can be applied to a span length of less than 25m and below. H shaped steel is used as a main girder, the simple structure contributes to the efficiency of construction, and low construction cost. This type of bridge is nominated to the bridge adopted to the Project by the above reasons. (Type 1)
	Pony truss	Pony truss assembly mode bridge (a panel system bridge as represented by Bailey bridges). Since there are many this type of bridge in Bougainville Island and contractor has much experiences of this type of bridge and nominated as bridge type for the Project (Type 3)
Concrete bridge	Post-tensioning T girder	A pre-stressed concrete bridge used for 20m to 40m span length. The bridge girders are fabricated on site in a construction yard. This type is nominated as a representative of concrete bridges to adopt for the project. (Type2)

Based on the above consideration, the following bridge types are compared to adopt to this project.

Type 1: Simple composite H shape steel bridge

Type 2: Simple PC post-tensioning T girder

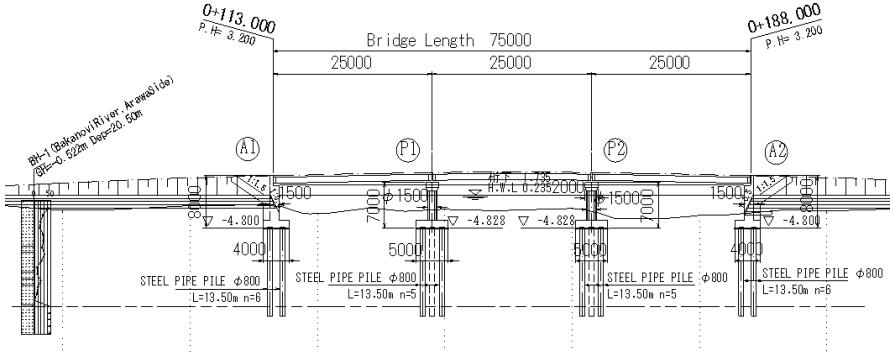
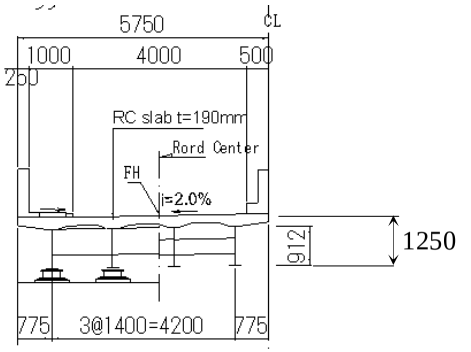
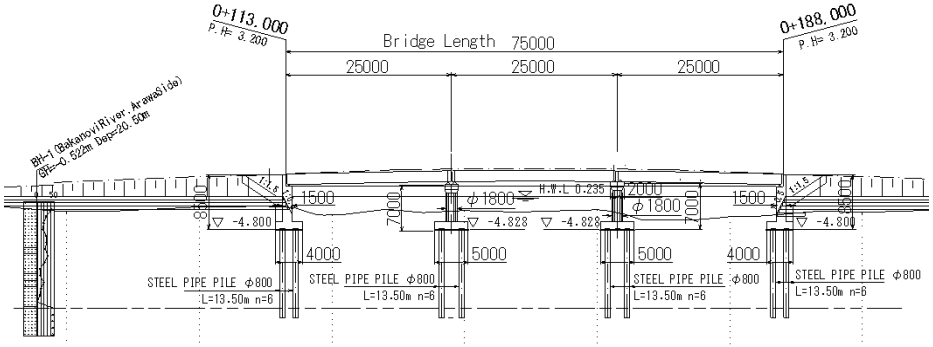
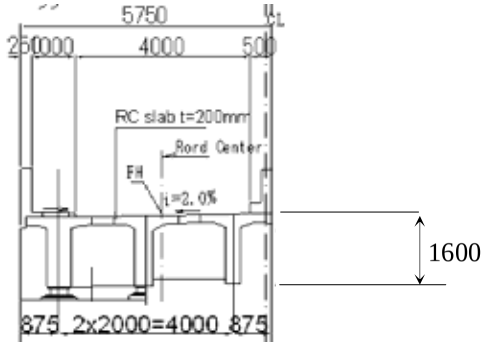
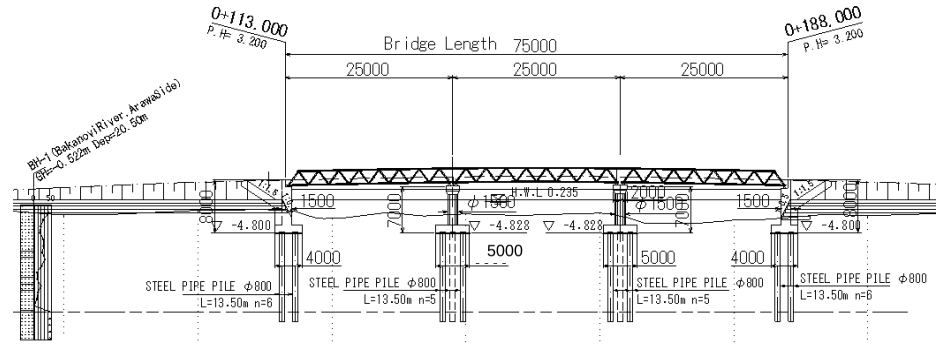
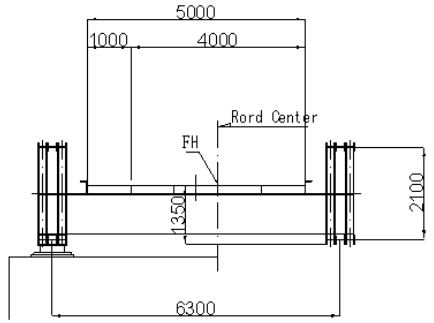
Type 3: Steel Pony truss

These 3 type of bridge were studied and compared on Bakanovi Bridge as an example and the results of the study are shown in Table 2-9.

(3) Conclusion

As a result of the comparison and consideration, Type 1 simple composite H shape steel bridge, which is superior in economic efficiency as well as in structural performance and construction efficiency, will be adopted for this project.

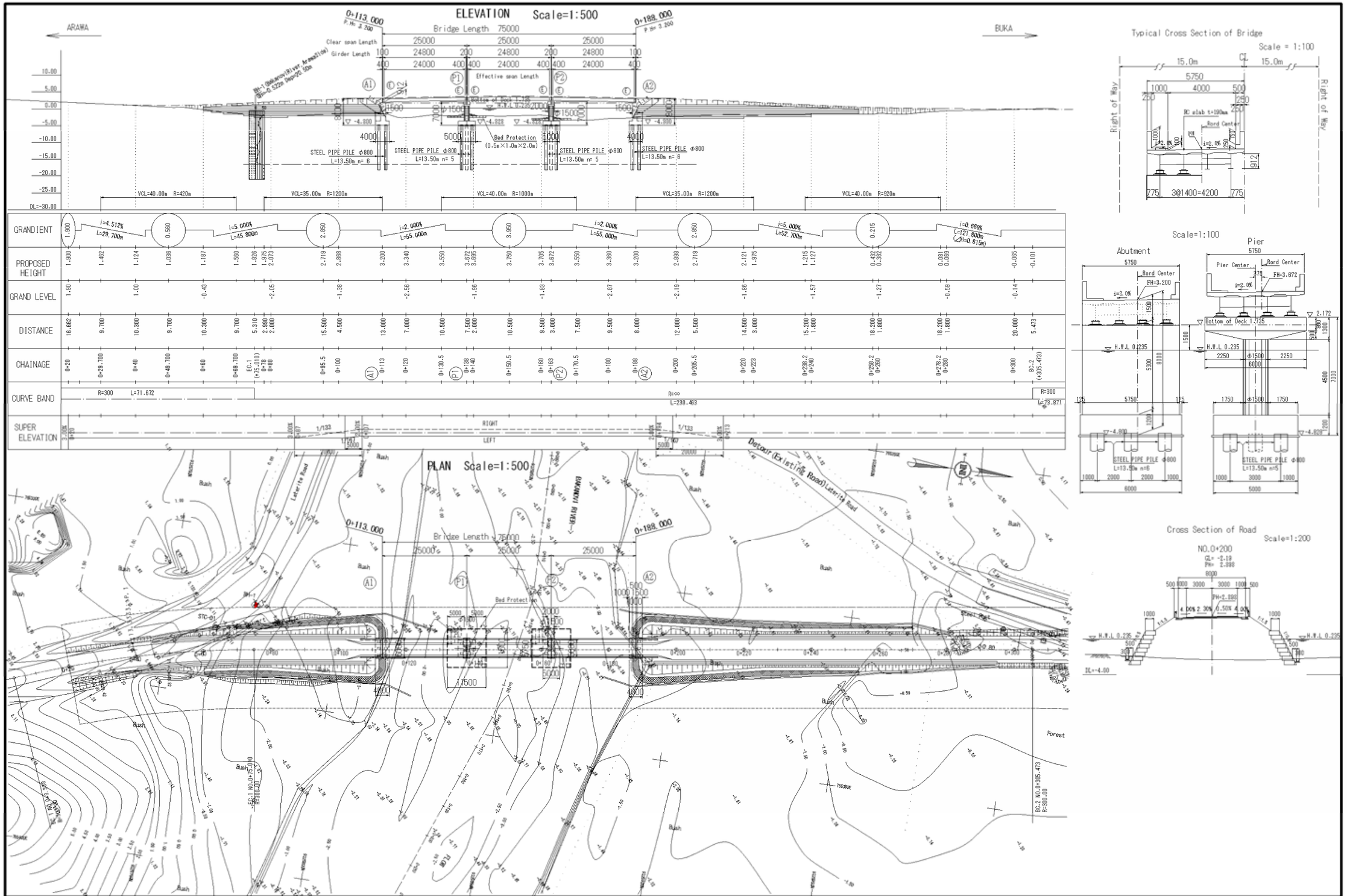
Table 2-9 Study of Bridge Type
Plan and Elevation of Each Type of Bridge

Type1 Simple Composite H Steel Bridge		
Type 2 Simple Post-Tension T Girder		
Type 3 Pony Truss (Assembly Mode Bridge)		

	Type 1: Simple composite H shape steel bridge	Type 2: Simple PC post-tensioning T girder	Type 2: Simple pony truss
Description	・Simple composite girder with H shape steel as the main girder. ・The deck is made by reinforced concrete with wearing surface of 2 cm is added	・Simple T girder of the post-tensioning system.	・Simple assembly truss using for temporally bridge ・Abutment width and beam of pier will be wider. ・Deck is steel decking panel.
Economic efficiency	Superstructure: JPY 117 million Substructure: 73 Total: 190 million (1.00) The most economically efficient among the 3 candidates.	Superstructure: JPY 38 million Substructure: 77 Total: 215 million (1.13) The most expensive among the 3 candidates.	Superstructure: JPY 133 million Substructure: 75 Total: 208 million (1.09) The 2nd place among the 3 candidates.
Structural performance	・Simple structure using H shape steel, which is easy to manufacture. ・Much experience has been accumulated in construction of this structure, which is considered highly reliable. ・The height of the structure is low and the length of access road can be made the shortest among the 3 candidates. ◎	・High strength of concrete is required for the main girder. Supply of such high quality concrete at the local sites is not easy. ・Many of this type of bridge has been constructed in the world and this structure is considered reliable. △	・Method of building truss structure is assembling section steel. ・Manufacturing of girder is complicate and time consuming ・Not much used as a permanent bridge (suitable for a temporary bridge). △
Construction efficiency	・The weight of the members are comparably light, and construction efficiency is superior. ◎	・Since the girder is very heavy, a large size of heavy machine is required. ・Since the girder shall be manufactured at site, many engineers and skilled workers required at the sites. ・The construction period is long. △	・Bridge component are assembled by manual .and election of girder is easy. ・Number of bridge component is not a few and need lot of work. △
Serviceability for Maintenance	・Requires repainting coating once every 20 to 30 years (fluorocarbon polymer coating). ○	・Since the bridge is made of concrete, less maintenance is required for the main girder. ◎	・Requires repainting every 20 to 30 years ・The bridge members are complicated and painting area. Ia also large. Painting at the corner of steel members tend to corrode .. ・The deck is not water tight ・.The main structure are exposed to rain and long term durability is not enough. △
Evaluation	Recommended bridge type in all aspects of economic efficiency, structural performance, construction efficiency and maintenance management. ◎		

2-2-3 Basic Design Drawing

Drawings of the Basic design are shown as follows;



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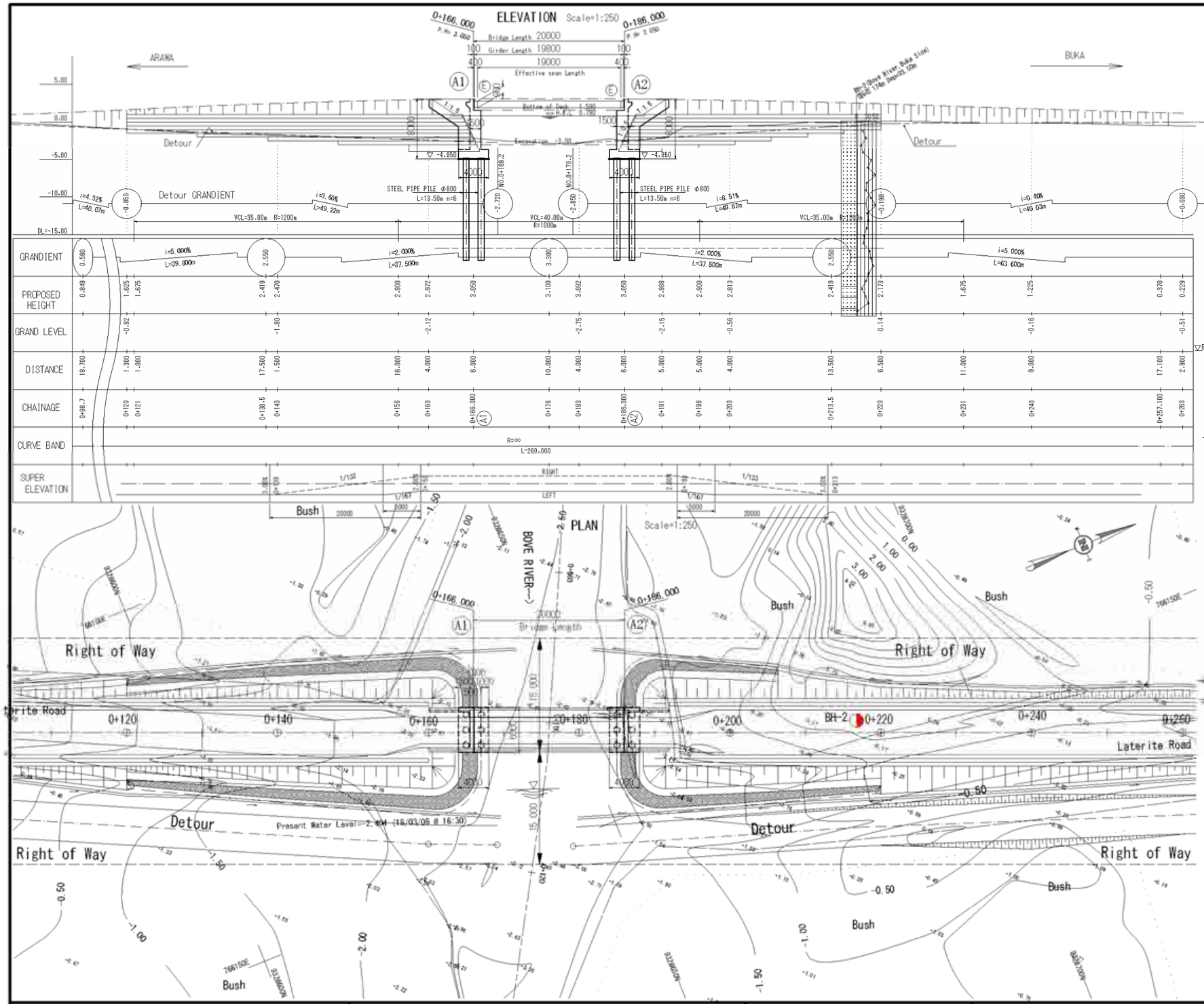
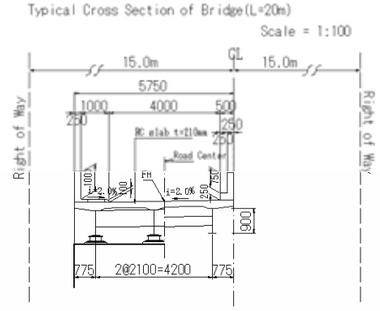
			GENERAL VIEW OF THE BAKANOVI BRIDGE	1:500		

ELEVATION Scale=1:250



Typical Cross Section of Bridge(L=20m)

Scale = 1:100



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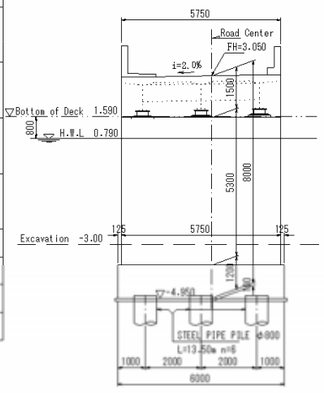
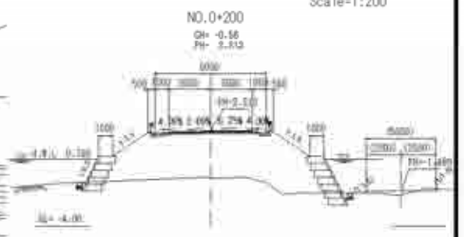
Scale=1:100



Cross Section of Road

Scale=1:200



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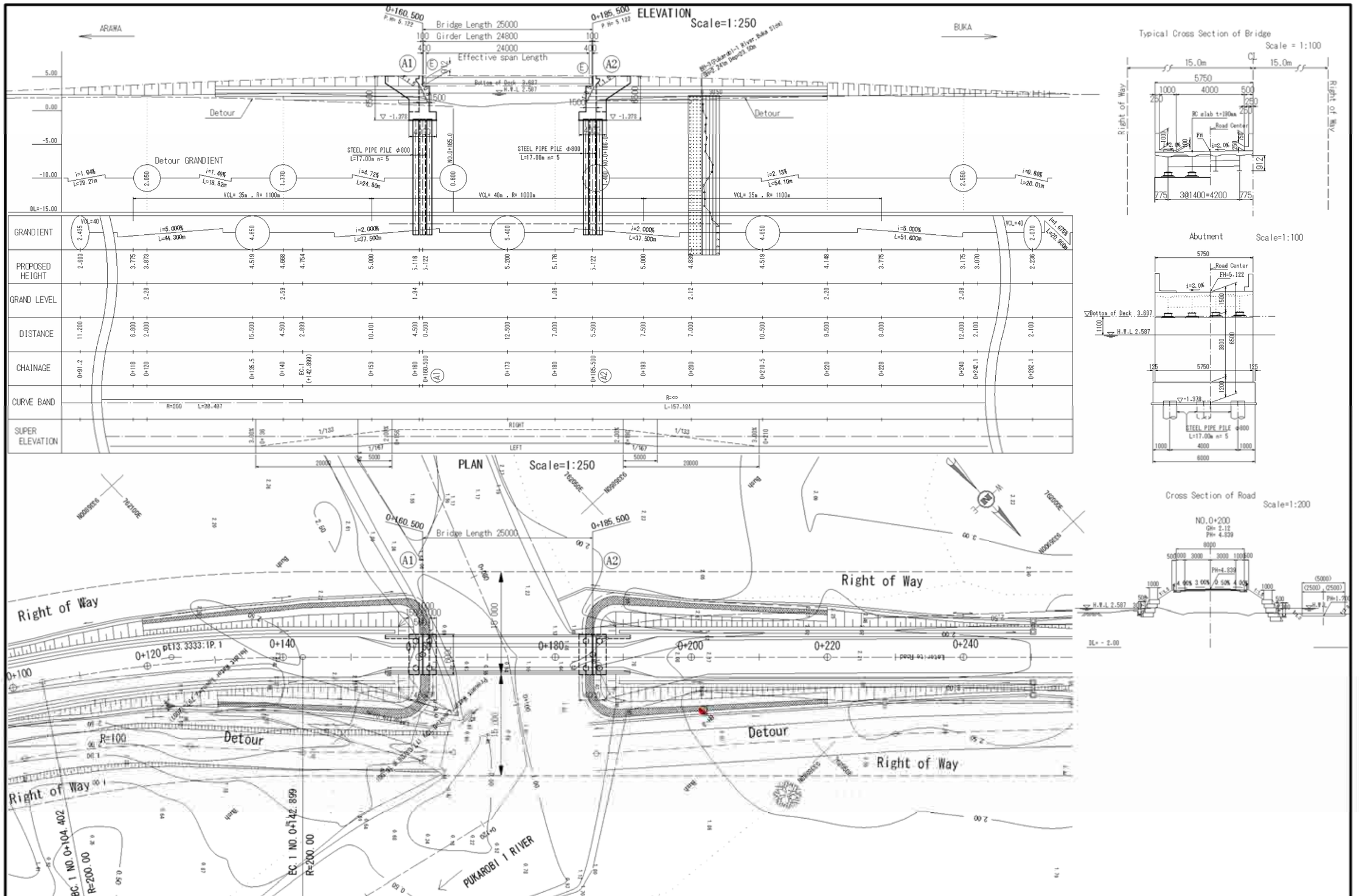
			GENERAL VIEW OF THE BOVE BRIDGE	1:250		



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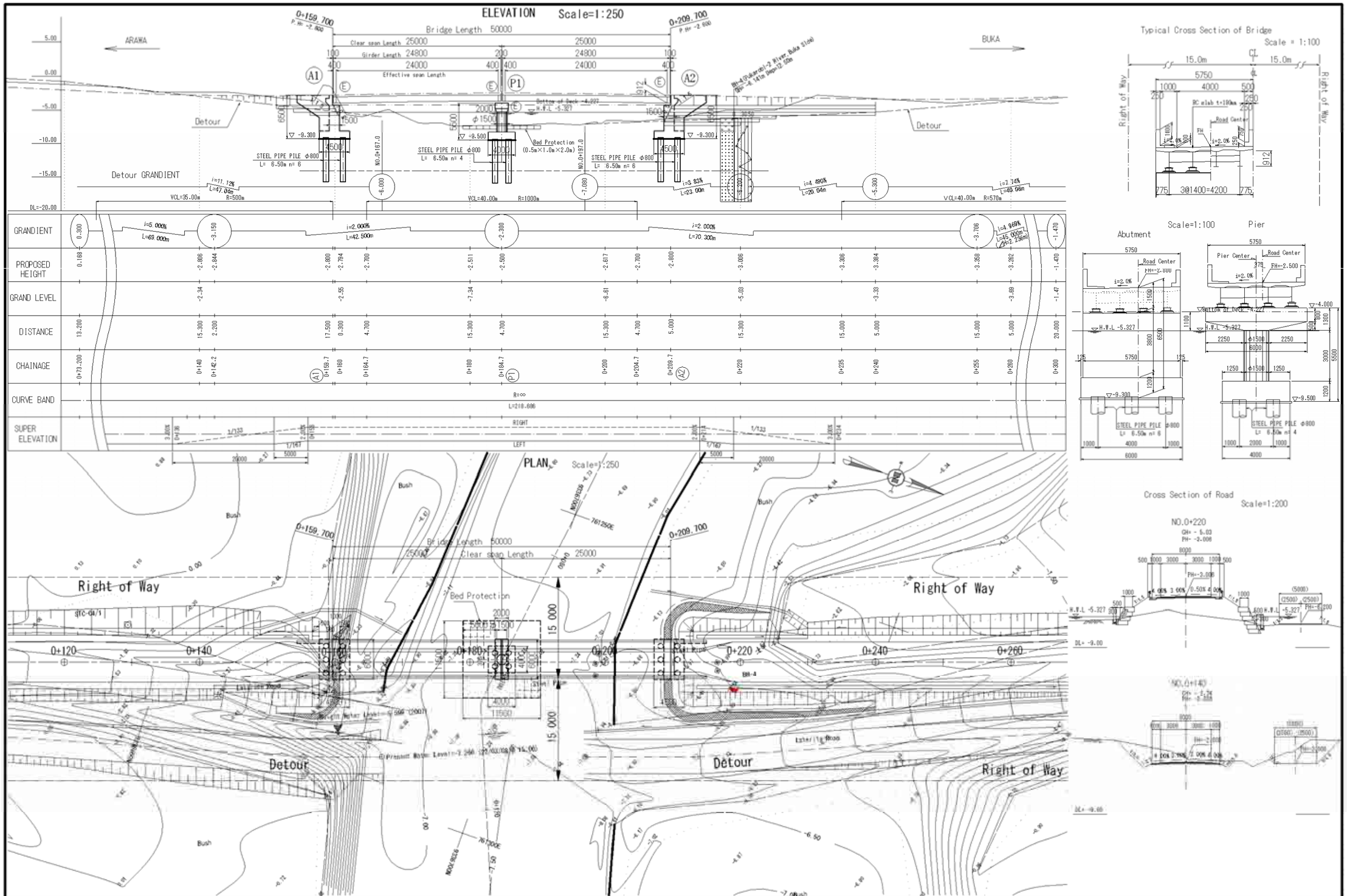
			GENERAL VIEW OF THE PUKAROBI-1 BRIDGE	1:250		



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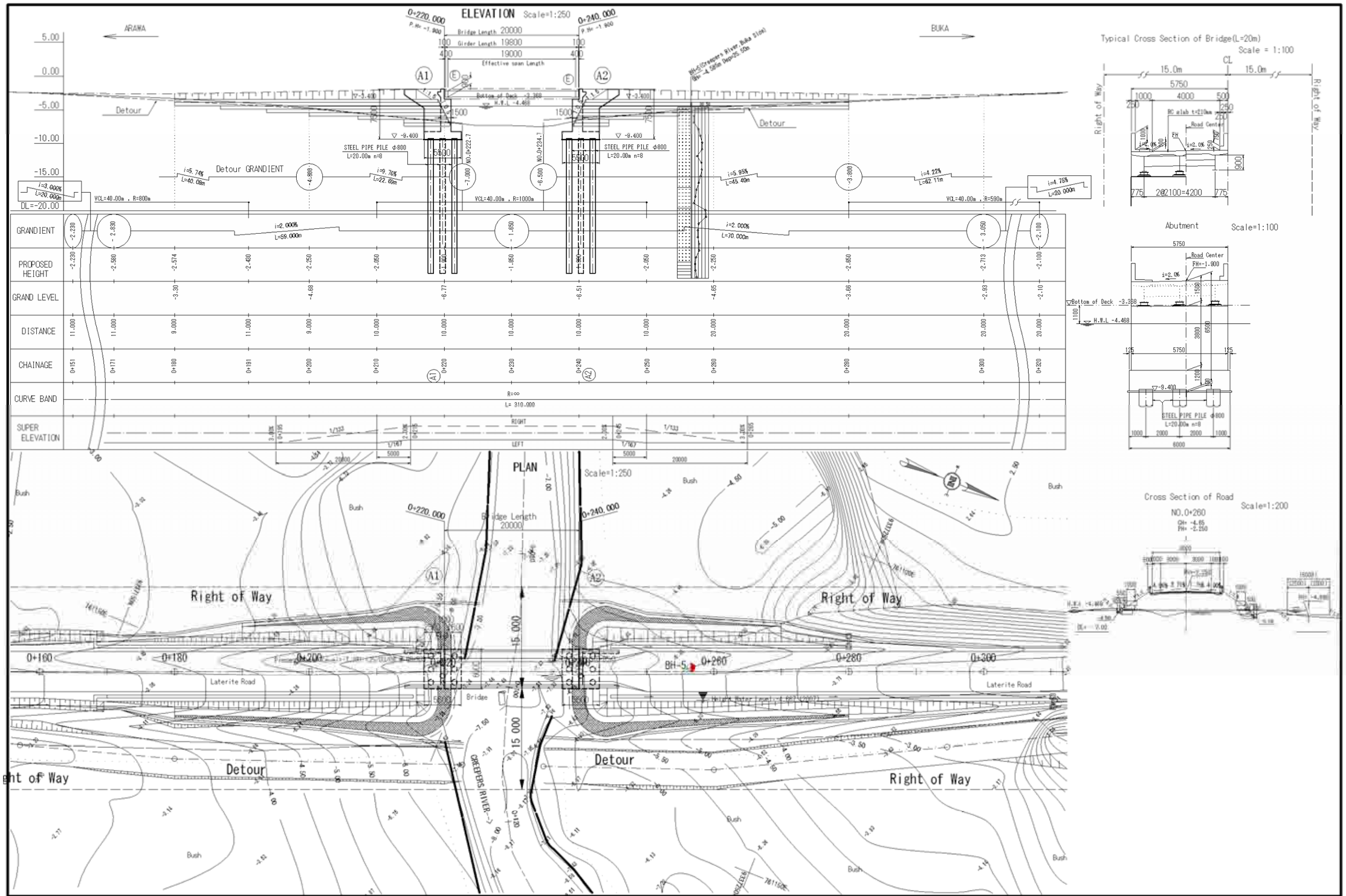
			GENERAL VIEW OF THE PUKAROBI-2 BRIDGE	1:250		



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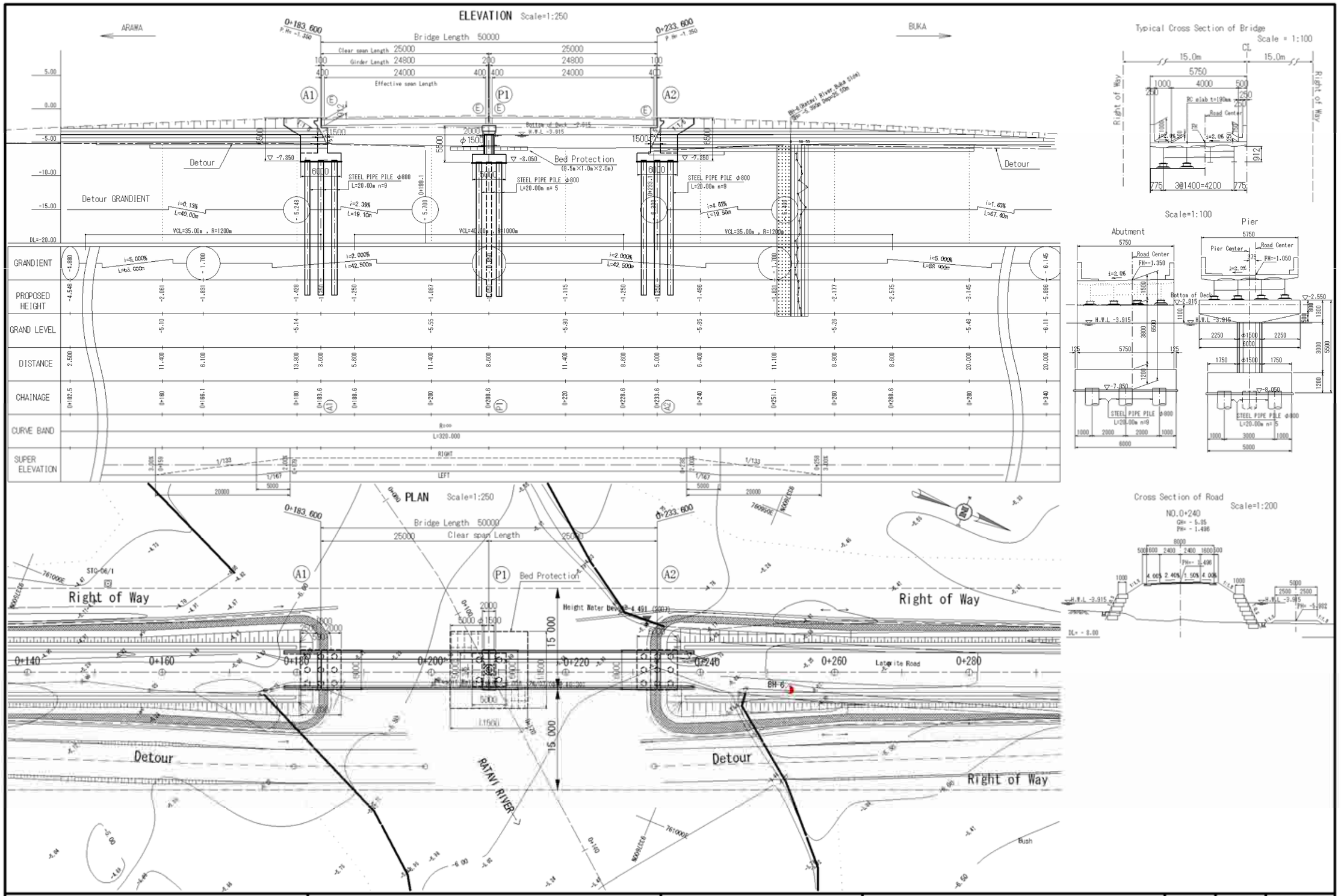
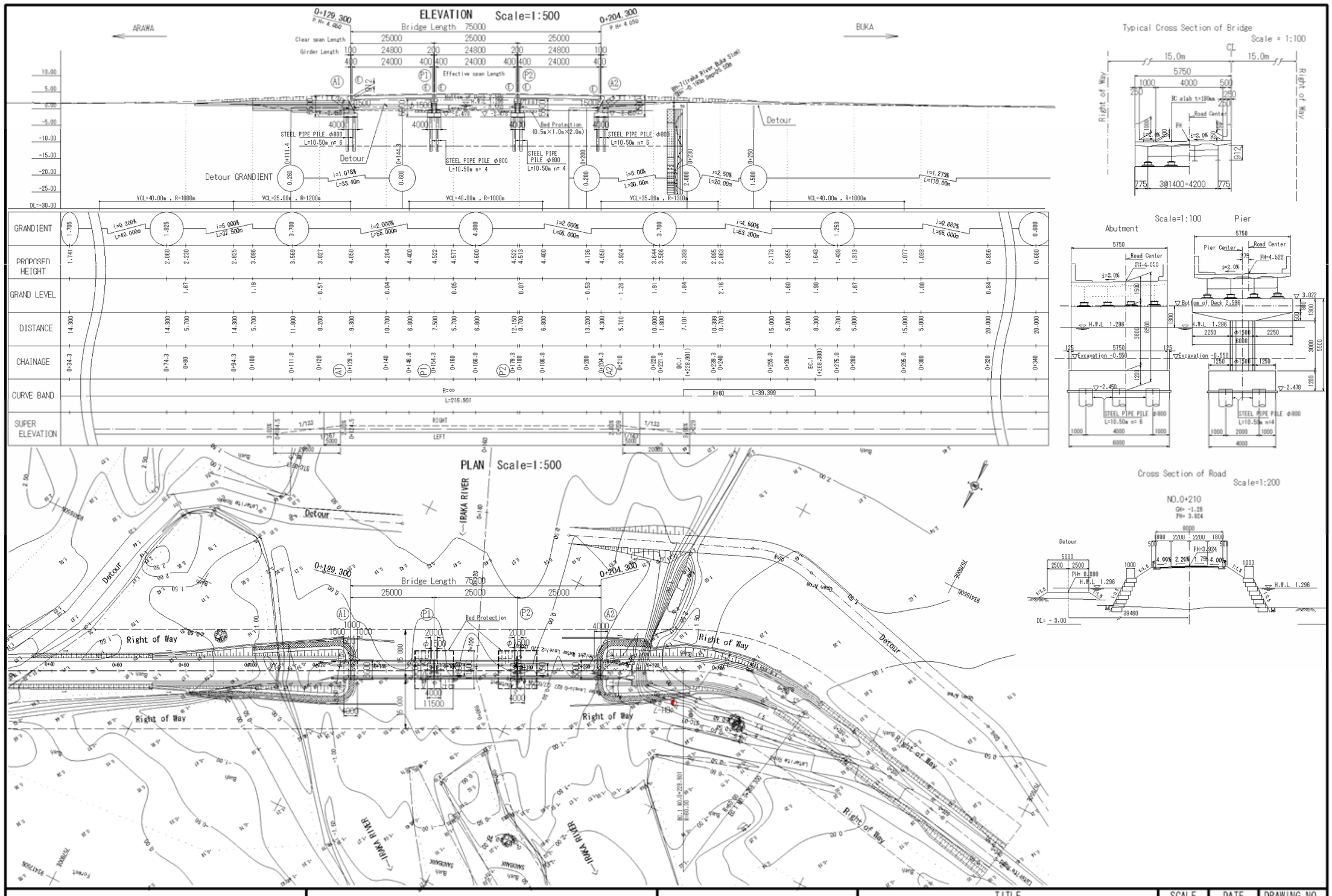
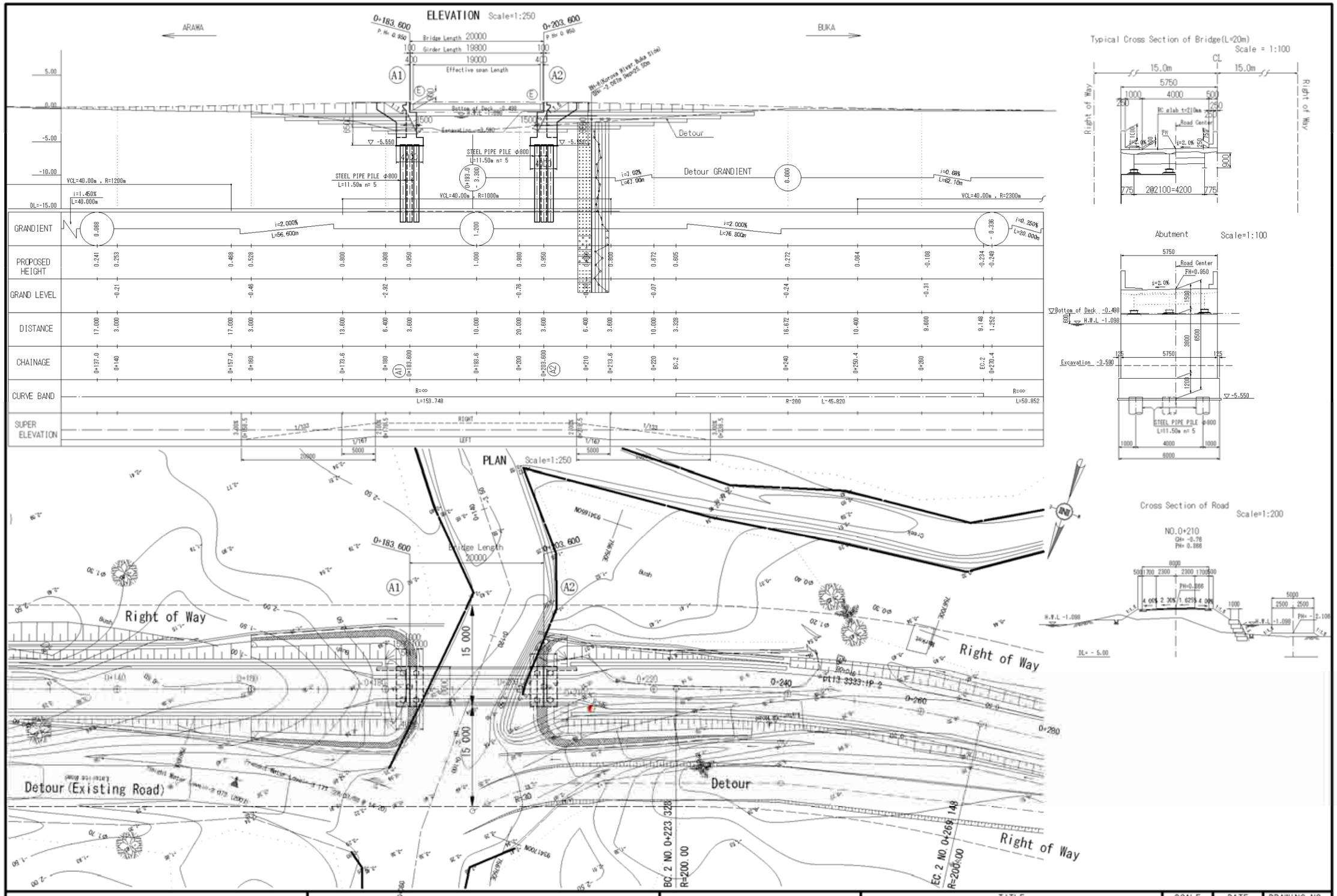
			GENERAL VIEW OF THE CREEPERS BRIDGE	1:250		



DEPARTMENT OF WORKS	THE PROJECT FOR CONSTRUCTION OF BRIDGES ON BOUGAINVILLE COASTAL TRUNK ROAD IN THE INDEPENDENT STATE OF PAPUA NEW GUINEA	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO.
			GENERAL VIEW OF THE RATAVI BRIDGE	1:250		



DEPARTMENT OF WORKS	THE PROJECT FOR CONSTRUCTION OF BRIDGES ON BOUGAINVILLE COASTAL TRUNK ROAD IN THE INDEPENDENT STATE OF PAPUA NEW GUINEA	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO.
			GENERAL VIEW OF THE IRAKA BRIDGE	1:500		



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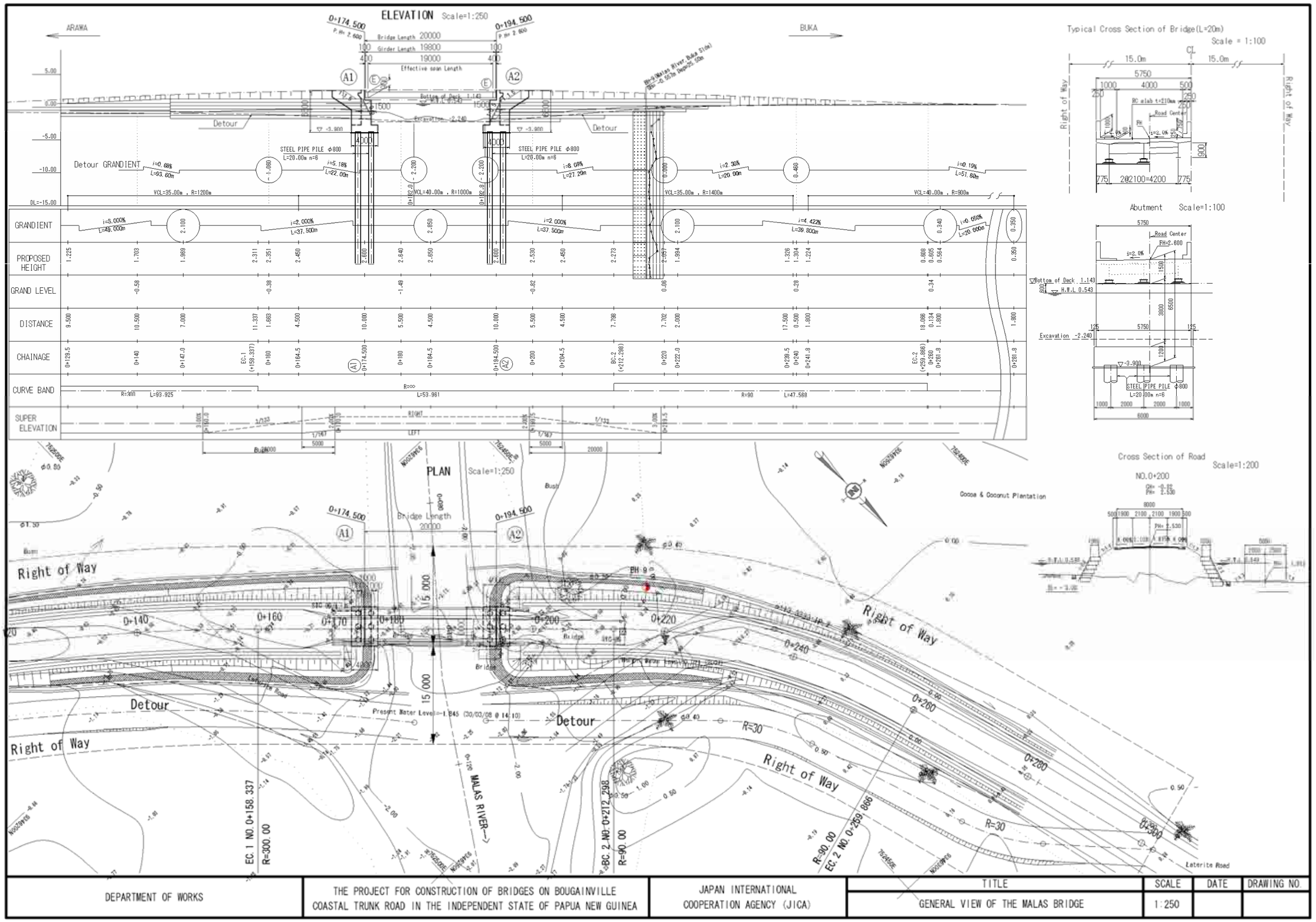
			GENERAL VIEW OF THE KOROVA BRIDGE	1:250		



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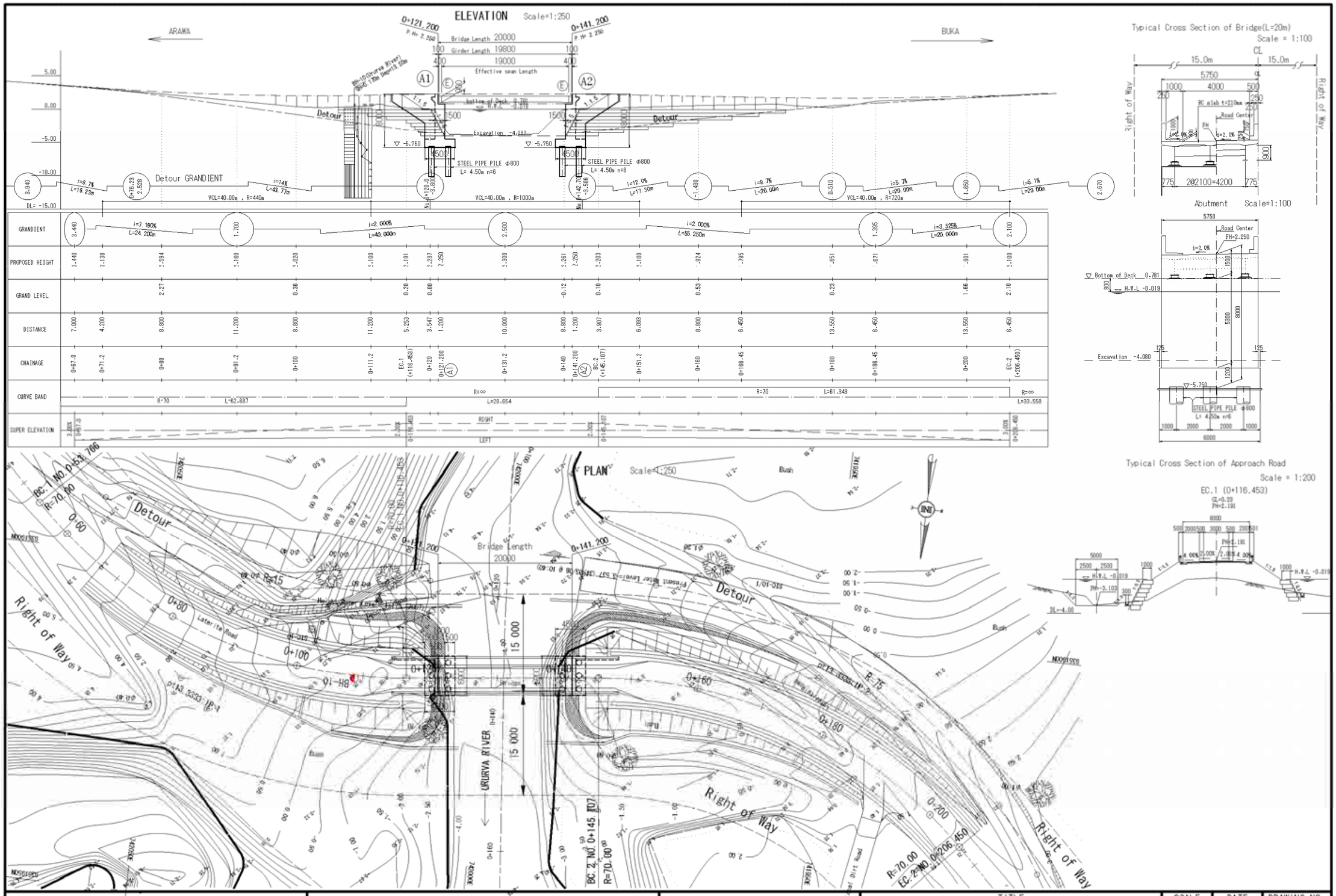
			GENERAL VIEW OF THE MALAS BRIDGE	1:250		


ELEVATION Scale=1:250
ARAWA
BUKA
0+121.200
0+141.200
Bridge Length 20000
Girder Length 19800
Effective span Length 19000
A1
A2
Detour
Detour GRANDIENT
STEEL PIPE PILE φ800
L= 4.50m n=6
Excavation -4.080
▽ -5.750
VCL=40.00m , R=440m
VCL=40.00m , R=1000m
VCL=40.00m , R=720m
GRANDIENT
PROPOSED HEIGHT
GRAND LEVEL
DISTANCE
CHAINAGE
CURVE BAND
SUPER ELEVATION
PLAN Scale=1:250
Typical Cross Section of Bridge(L=20m)
Scale = 1:100
15.0m
CL
Right of Way
RC slab t=210mm
Road Center
FH=2.250
i=2.0%
Abutment Scale=1:100
Bottom of Deck 0.781
H.W.L -0.019
Typical Cross Section of Approach Road
Scale = 1:200
EC.1 (0+116.453)
EC.2 (0+206.450)
BC.1 NO.0+53.766
BC.2 NO.0+145.707
Bridge Length 20000
URURVA RIVER
Laterite Road
Local Dirt Road
Bush
BH-10
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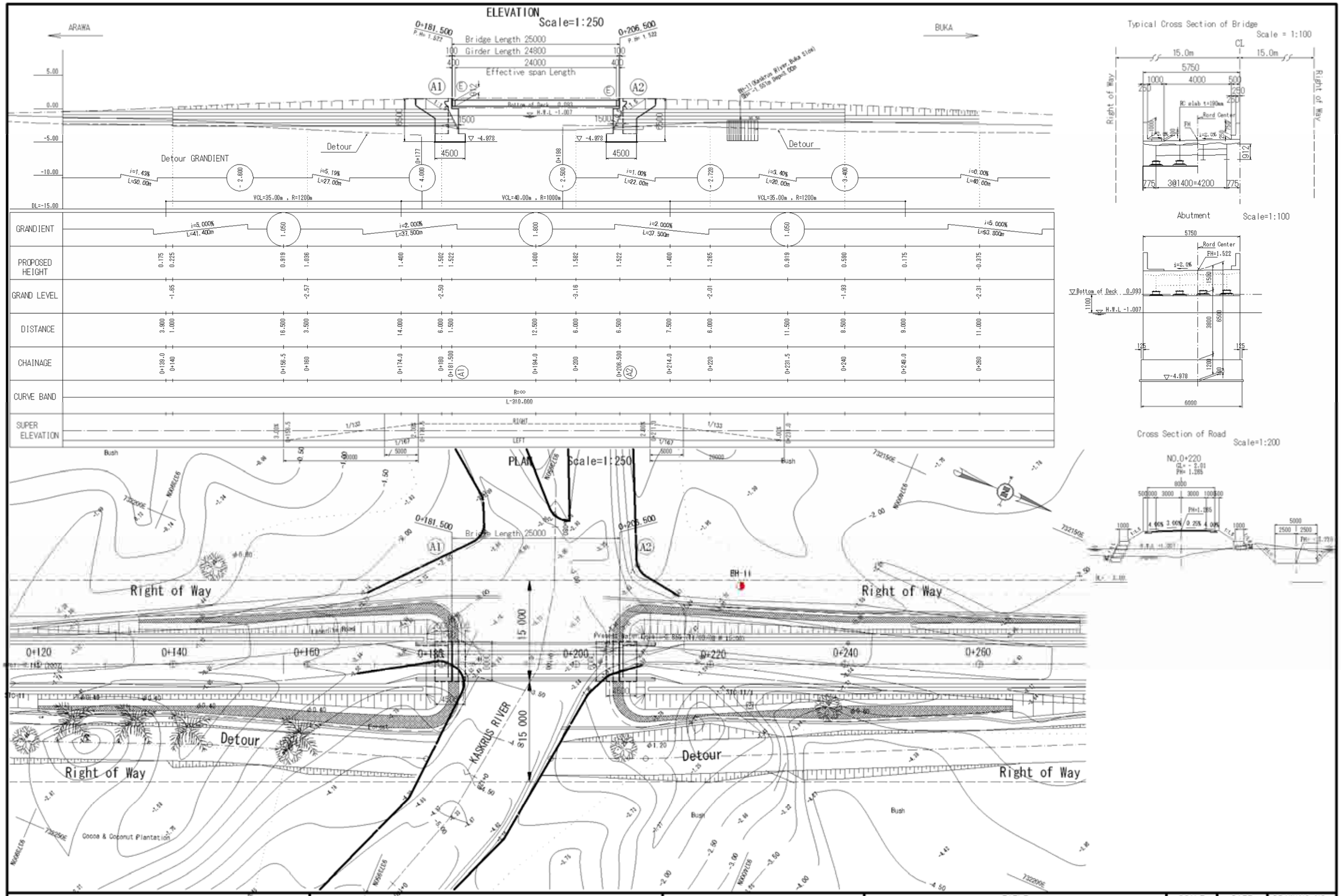
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
TITLE
GENERAL VIEW OF THE URURVA BRIDGE
SCALE
1:250
DATE
DRAWING NO.



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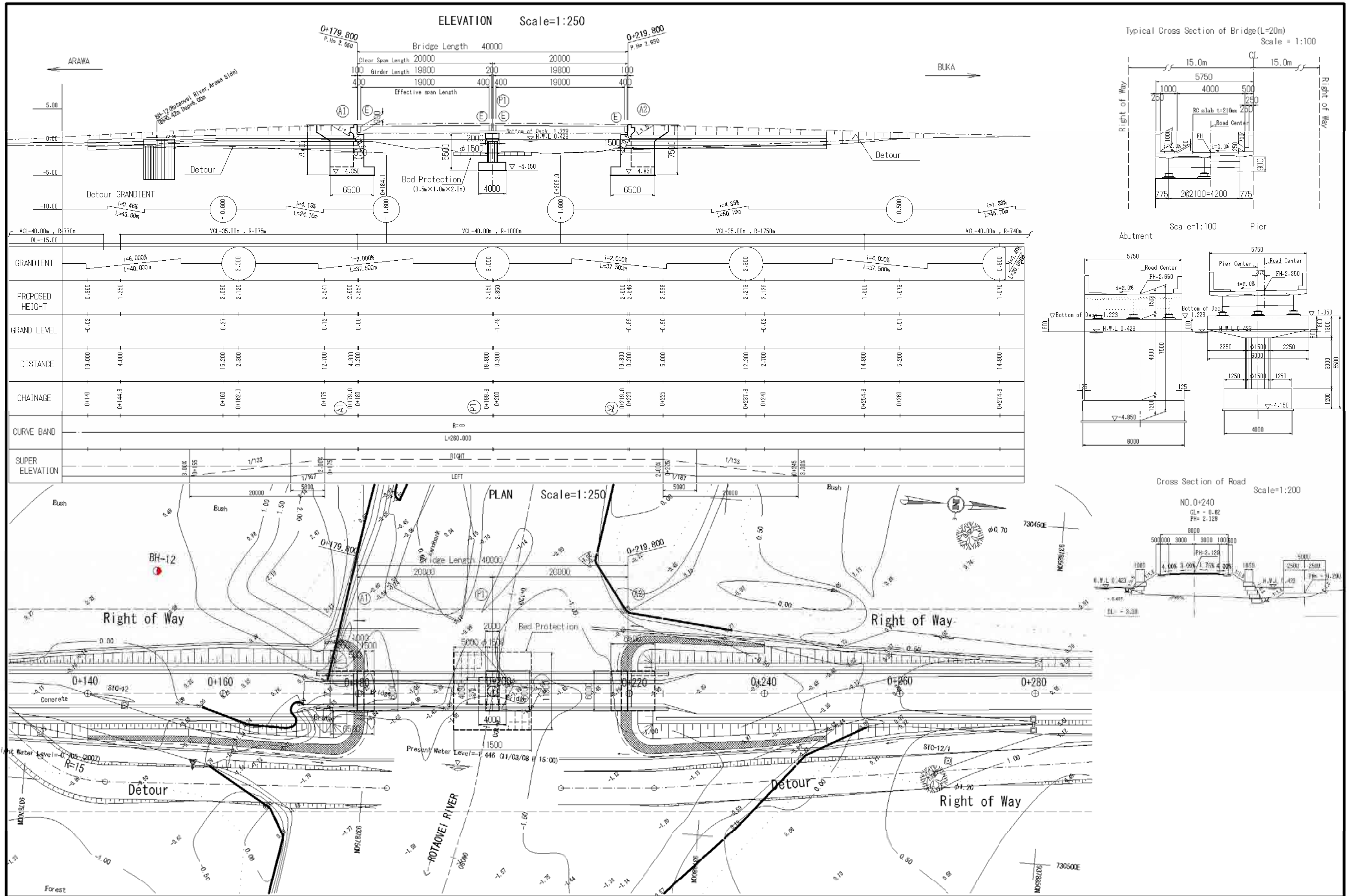
			GENERAL VIEW OF THE KASKRUS BRIDGE	1:250		



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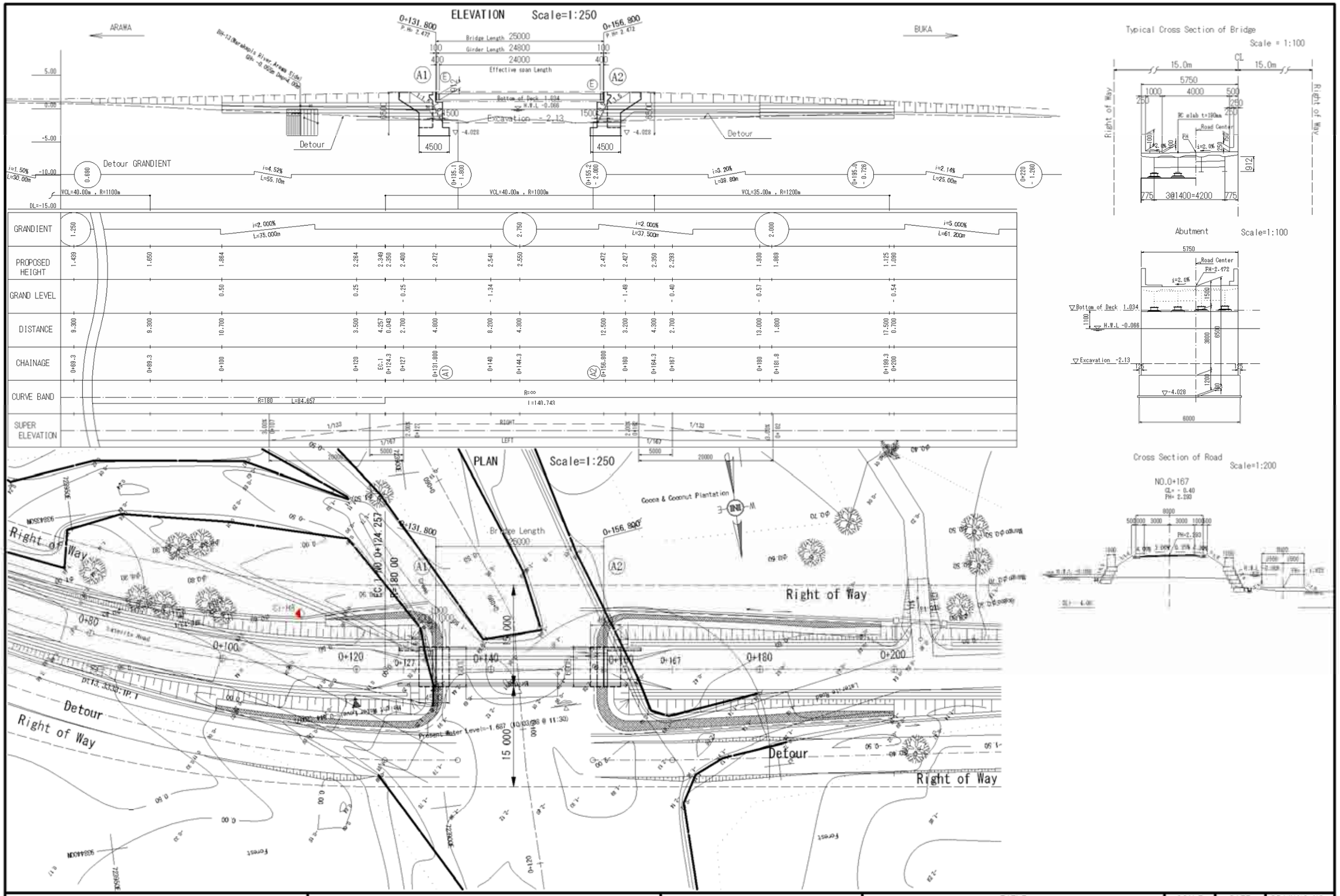
			GENERAL VIEW OF THE ROTAOVEI BRIDGE	1:250		



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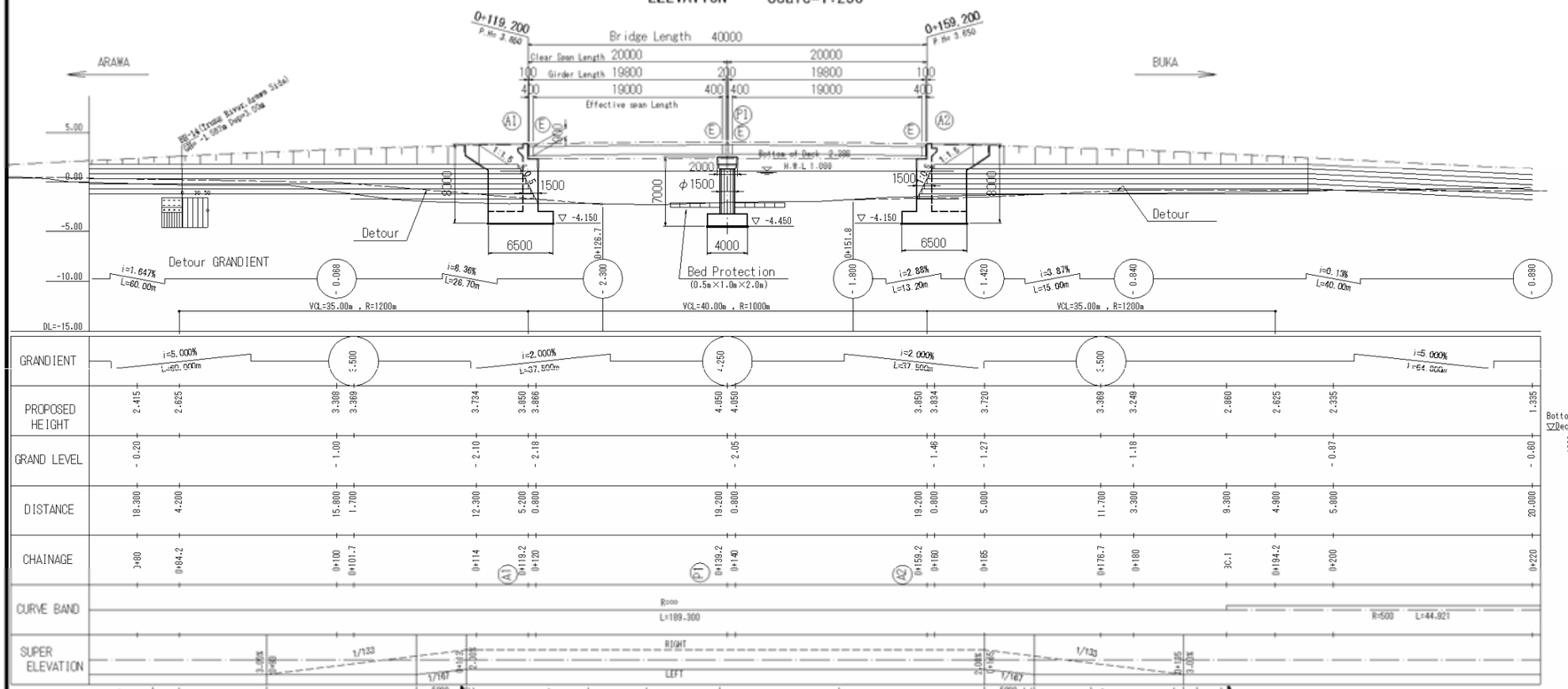
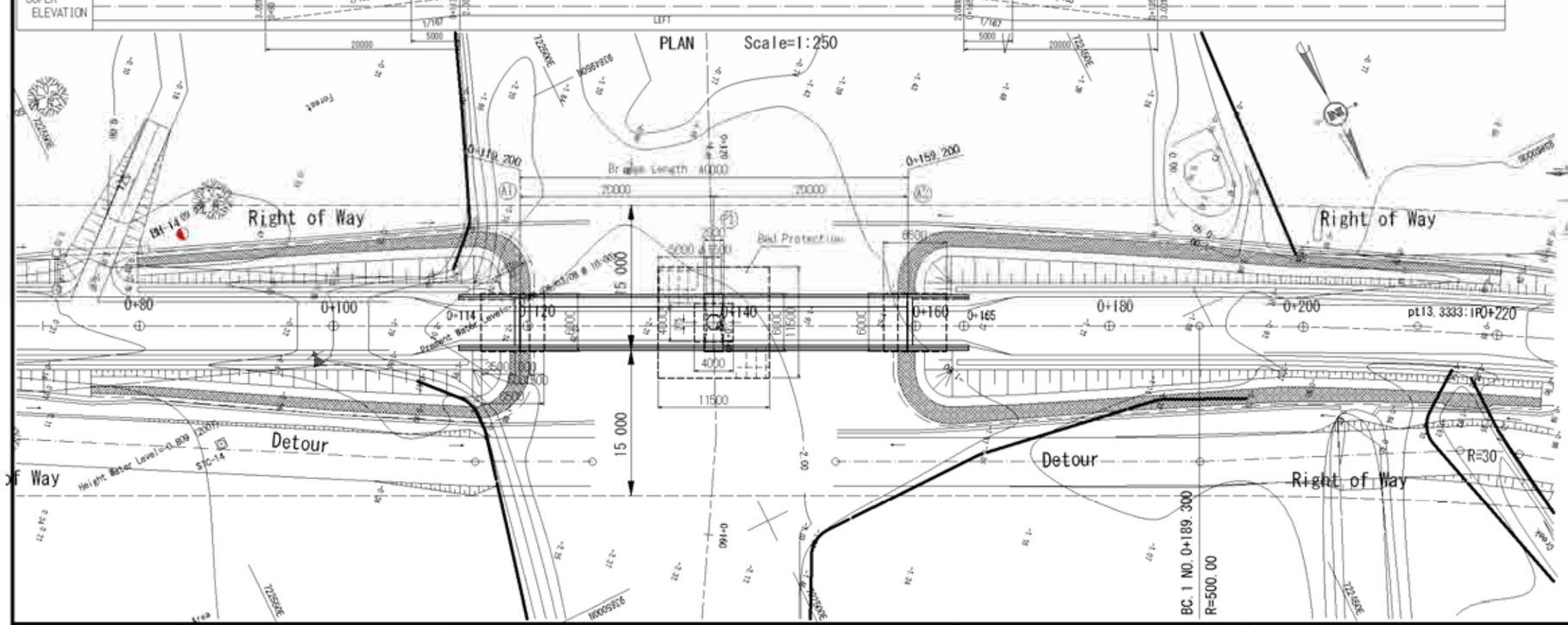
			GENERAL VIEW OF THE WARAKAPI BRIDGE	1:250		

ELEVATION Scale=1:250

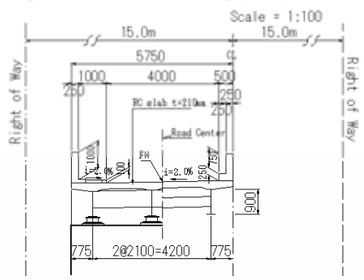


PLAN Scale=1:250



Typical Cross Section of Bridge(L=20m)

Scale = 1:100



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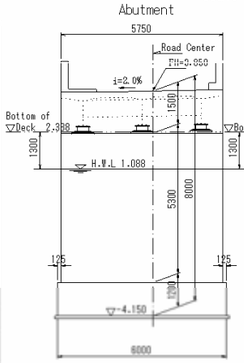
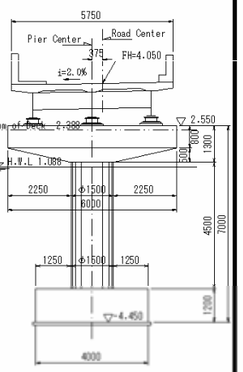
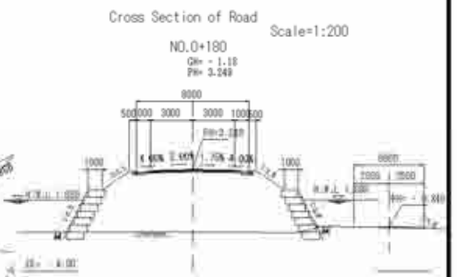


Pier



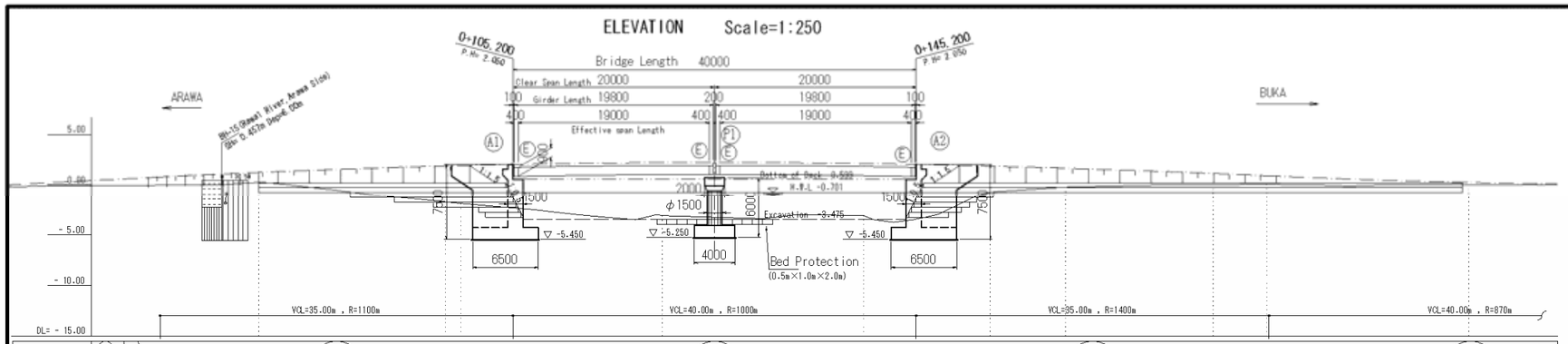
Cross Section of Road

Scale=1:200



DEPARTMENT OF WORKS	THE PROJECT FOR CONSTRUCTION OF BRIDGES ON BOUGAINVILLE COASTAL TRUNK ROAD IN THE INDEPENDENT STATE OF PAPUA NEW GUINEA	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE / DRAWING NO.
			GENERAL VIEW OF THE IRUNG BRIDGE	1:250	

ELEVATION Scale=1:250



Typical Cross Section of Bridge(L=20m)

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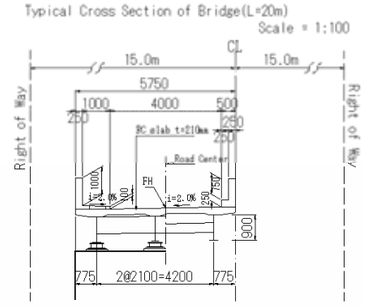
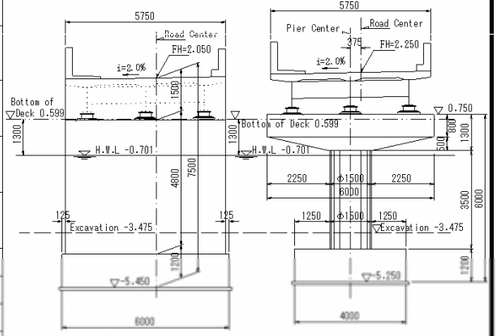
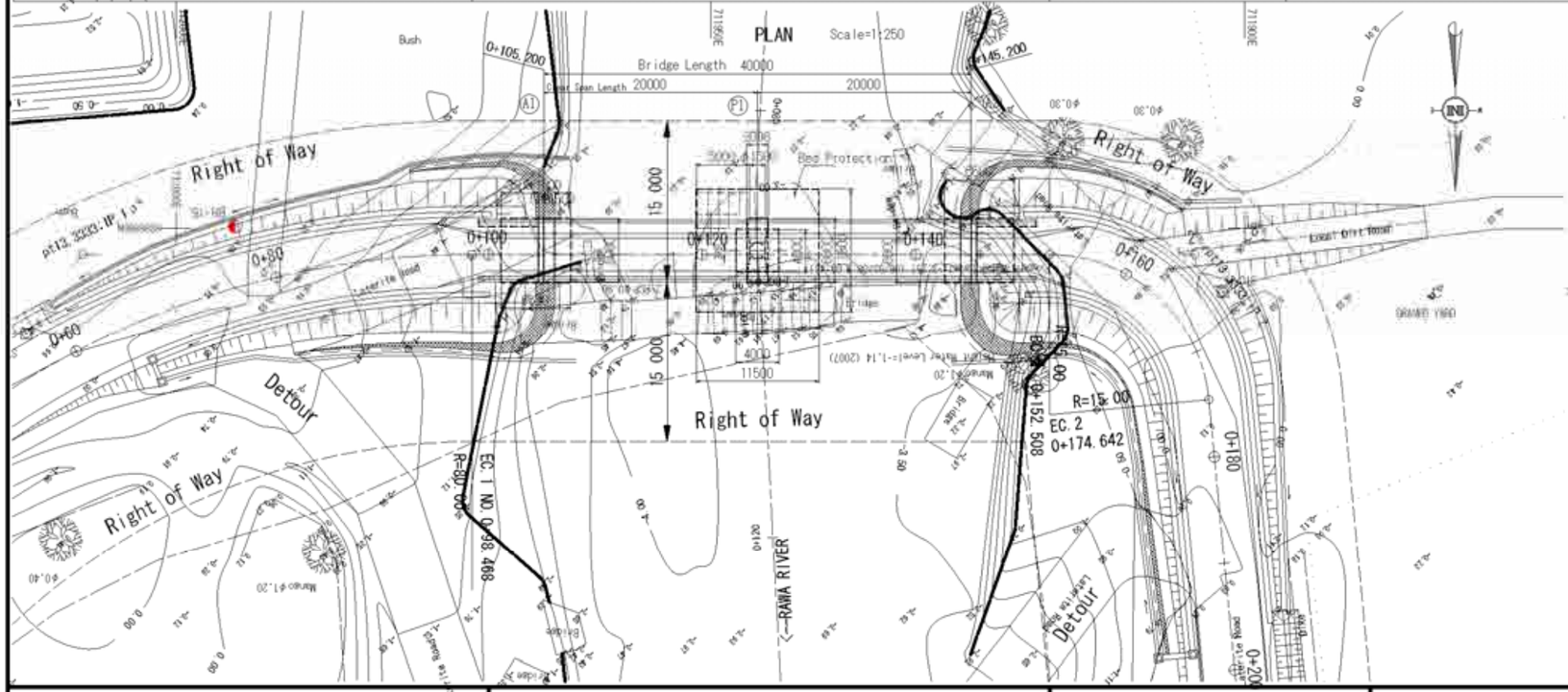


Abutment Scale=1:100 Pier

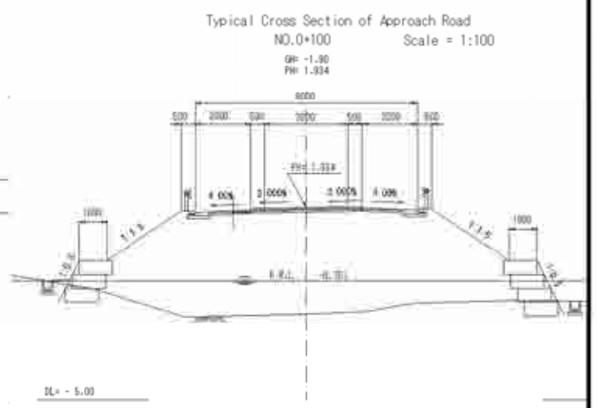


PLAN Scale=1:250



Typical Cross Section of Approach Road

NO.0+100 Scale = 1:100



DEPARTMENT OF WORKS	THE PROJECT FOR CONSTRUCTION OF BRIDGES ON BOUGAINVILLE COASTAL TRUNK ROAD IN THE INDEPENDENT STATE OF PAPUA NEW GUINEA	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO.
			TOPOGRAPHIC MAP OF THE RAWA BRIDGE	1:250		

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

In case, the project will be implemented under the grant aid following items shall be taken into considered.

1. ABG shall finish land acquisition and compensation before the start of the construction, in the case that land acquisition is necessary,
2. Establish a tight liaison between DNPM, DOW, AGB, the consultants and the contractors for smooth implementation of the project.
3. Utilize the local labors and materials adequately to activate the local economy, to promote technical transfer and to increase the opportunity for employment in the cost estimation.
4. Plan a construction schedule taking the island's precipitation into consideration.
5. Safety precaution corresponding to the security conditions in PNG shall be considered

2-2-4-2 Implementation Conditions

(1) Construction Yard

It is necessary to use government land for the construction offices during construction period, as there are lands belongs to the Government of PNG around the construction sites.

(2) High Water Level during the Construction Term

The water level of each river is usually low enough to cross on foots, but in case of heavy rain it will increase rapidly because of the mountainous island, and traffic will be blocked by the rivers. Therefore the contractor shall establish a safe construction plan taking into the river situation.

(3) Safety Measures

An elaborate safety precaution is important to implement the project because the security in the land occasionally gets poor. Therefore the construction offices have to be protected by guard fences and 24-hours security system by security guards shall be established to ensure the safety of project personnel and materials.

2-2-4-3 Scope of Works

The scope of works for each party is indicated in Table 2-10

Table 2-10 The scope of works

Japanese Government	PNG Government
-Construction of the 15 bridges, access roads and revetments	-Land acquisition for the 15
-Improvement of river beds around the sites	-Removal of the existing bridges
-Construction and removal of the construction offices	-Formulation and approval of environmental management & monitoring plan
-Safety measures for a general traffic during the construction	-Maintenance of the bridge and access road on this project
-Transportation of construction materials and machines to/from the sites	-Bank charge for the opening a Bank Account and issuing the Authorization to Pay
-Detail design, preparation of tender documents, tender assistance and construction supervision	-Tax exemption and refund from a custom duties, internal taxes and other fiscal levies imposed in PNG.
	- Land acquisition for construction offices
	-Maintenance and repair of the existing structure such as Rawa1 or Uruavi2.

2-2-4-4 Consultant Supervision

Construction supervision includes management of quality, time schedules and safety at the construction site. Quality Management will include a monitoring the quality of construction materials and a maintaining the accuracy of the structures. Mill sheets from manufacturers, material tests at the construction sites and piece work shall be monitored and examined throughout the supervision. Time schedule control will include a reviewing the progress of the works through weekly progress meeting and by identifying the critical path of the work items, which must be completed on the scheduled dates specified in the contract which accord to the grant aid system. If problems arise during the construction, the problem will be presented to the responsible parties and they will be required to take the necessary counter measures to solve the problems. And the consultants will report the progress of the construction to DOW, ABG and JICA PNG office. Safety management will include a monitoring to ensure that the contractor provides continuing safety education to the workers and the contractor performs routine inspection to verify safety on site.

2-2-4-5 Quality Control Plan

The quality control plan for materials and testing frequency are shown in Table2-11

Table 2-11 Quality Control Plan

	Item	Contents	Frequency
Material Inspection	Aggregates	Particles, specific gravity, hardness stability	One test report for every 250m^3 at each quarry site
	Cement	Particle, specific gravity, strength	One test report for every 30 tone for each supplier
	H Steel	Strength	One test report from each lot
	Steel Pipe Pile	Strength	One test report from each lot
	Reinforcement Bar	Strength, bending	One test report from each lot
	Asphalt	Needle penetration, viscosity, softening	One test report from each lot
	Embankment Soil	Particle, specific gravity, consolidation , moisture content, plastic/liquid limit, CBR	One test report for every 500m^3 from each pit
Product Inspection	Fresh Concrete	Temperature, slump	One test report for every 5 m^3, at site
	Hardened Concrete	Strength, unit weight	Two test reports for every 30m^3, specimen tests at 7 & 28days
	Asphalt Mix	Asphalt content	One test report for every 30 tones, at site
	Pavement Base Layer	Site density	One test for every 25m^2, at site
	Bearing Stratum for Pile	Location, bearing capacity	Confirmed by rebound test
	H Steel	Dimension, straightness	Each steel
	Steel Pipe Pile	Dimension, straightness	Each pipe
	Foundation and Substructure	Location, Dimension ,elevation	Each structure
	Superstructure	Location, dimension ,elevation	Every 5m along the bridge
	Painting	Thickness, workmanship	One report for every 200-500m^2
	Asphalt pavement	Thickness, flatness, elevation	Thickness recorded every 100m^2, flatness & elevation recorded every 5m along the bridge

2-2-4-6 Procurement Plan

Most of the materials for bridge constructions are imported from Australia, New Zealand and other countries in general, and they are available from the market in PNG. However, some of them are more expensive than in Japan. Therefore that kind of materials and machines are planned to transport to the site from Japan. Source of the materials are shown in Table2-12.

Table 2-12 Sources of the Major Construction Materials

	Item	Source	Remarks
Construction Material	Aggregates	PNG	Bougainville
	Cement	PNG	Lae
	H Steel	Japan	
	Steel Pile Pipe	Japan	
	Reinforced Bar	Japan	
	Plywood	PNG	Port Moresby
	Asphalt	PNG	Port Moresby
	Fuel Oil	PNG	Bougainville
	Bearings, Expansion Joint	Japan	
	Handrail Guard Rail	Japan	
Construction Equipment	Road Equipment	Japan	
	Excavation Equipment	Japan	
	Cranes	Japan	
	Pile Drivers	Japan	
	Generators	Japan	
	Vehicles	PNG	Port Moresby
Furniture, office & test equipment	Office Equipment	PNG	Port Moresby
	Telecommunication	PNG	Port Moresby
	Furniture	PNG	Port Moresby
	Test Equipment	PNG, Third country	Australia

2-2-4-7 Implementation Schedule

The Project implementation schedule is shown in Table2-13

Table 2-13 Implementation Schedule

The Poject for the Construction of Bridges on Bougainville Coastal Trunk Road

Accumulative Month	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	28	29	30	31
E/N Conclusion	△																														
Contract with Consultant	△																														
Site Survey	▬																														
Detailed Design	▬	▬																													
Execution of Tender Documents	▬	▬																													
Approval of Tender Documents		▬																													
Contract with Consultant for Supervisio		▬																													
Announcement for Prequalification		△																													
Submission of Drawings		△																													
Tender		▲																													
Evaluation of Tender		▬																													
Contract with Contractor		△																													
Mobilization	▬	▬																													
Establish of Office, Accomodation etc	▬	▬	▬																												
1 Bakanovi	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬															
2 Bove						▬					▬	▬	▬	▬	▬	▬	▬	▬													
3 Pukarobi1							▬								▬	▬	▬	▬	▬	▬	▬	▬									
4 Pukarobi2									▬	▬								▬	▬	▬	▬	▬	▬	▬	▬	▬					
5 Creepers											▬	▬											▬	▬	▬	▬	▬	▬			
6 Ratavi			▬	▬	▬	▬	▬	▬	▬	▬	▬	▬																			
7 Iraka						▬	▬								▬	▬	▬	▬	▬	▬	▬	▬									
8 Korova								▬	▬					▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬					
9 Malas										▬	▬																				
10 Ururva												▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬			
11 Kaskrus		▬	▬	▬	▬	▬	▬	▬	▬	▬																					
12 Rotaovei						▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬														
13 Warakapis											▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬			
14 Irung														▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬			
15 Rawa1																					▬	▬	▬	▬	▬	▬	▬	▬			

Total 30.0 months

2-3 Obligations of Recipient Country

2-3-1 Common Items in Japan's Grant Aid Scheme

- To secure land necessary for the sites of the project.
- To open a bank account in the name of the Government of the recipient country in Japan (B/A) and issue the authorization to pay (A/P)
- To ensure all the expenses and prompt execution for unloading, custom clearance.
- To exempt Japanese nationals from custom duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the goods and services under the project.
- To ensure proper maintenance, management and preservation of the facilities constructed by Japan's Grant Aid.

2-3-2 Special Items for the project

- Cost to remove the existing bridges. (Ururva Bridge)
- To establish the steering committee for a smooth implementation of the project.
- To secure the security around the sites and ports.
- To set up fences and gates around the sites.
- To obtain a environment permit

2-4 Project Operation Plan

The maintenance works needed for the approach roads and bridges after the completion of the project are shown in Table 2-14

Table 2-14 Maintenance Works for the Facilities

Work item	Frequency	Location	Content of work
Road and bridge maintenance	Continuous	Whole Facility	Maintenance work based on the RAMS、BMS DOW system Update the ABG's bridges inventory
Bridge maintenance	Twice per annum	Expansion Joints	Cleaning of expansion joints, if damage is detected take photos and record the date
		Drain	Cleaning drainage pipes, if damage is detected take photos and record the date
		Bearings	Cleaning the periphery of bearings. Confirm the movement and deterioration of elastomeric bearings.
		Handrails Guard Rails	Confirm the degree of deterioration if damage is detected take photos and record the date
		Steel Girder	Confirm the paint condition and rust. If problems are detected , take photos and record the date
	After flooding	Abutment, Pier	Confirm local scour and subsidence of the structure.
Approach road	Twice per annum	Pavement	Repair potholes
		Shoulder	Weed and level shoulder
		Slope	Repair slope erosion
		Drain	Removal of deposits
Bank protection	Twice per annum and after a flood	Concrete Block	Confirm movement due to erosion. Repair protection if problems are detected
Periodical bridge repair	Every 30 years	Steel Member	Prepare budget and repaint

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation by the Government of PNG

The cost required for fulfilling the undertakings by the Government of PNG is estimated at 1.08 million Japanese Yen as shown in Table 2-15.

Table 2-15 Project Cost to be borne by Government of PNG

Items	Amount (Kina)	Yen Equivalent (Million Yen)
Removal of the existing bridges	26,000	1.08
Maintenance of the existing structures	17,000	0.71
Payment of bank services charges for banking arrangement (B/A) and authorization to pay (AP)	76,905	3.20

This cost estimate is provisional and would be further examinated by the Government of Japan for the approval of the Grant.

2-5-2 Operation and Maintenance Cost

Using the DOW maintenance system, the periodical maintenance is carried out twice per annum. And according to the National Transport Development Plan 2006-2010, a prioritized allocation of budget will be conducted for maintenance of the existing infrastructures such as roads and bridges. Provisional costs for the maintenance work to be borne by the government of PNG are shown in Table 2-16.

Table 2-16　Costs for the Maintenance Work to be borne by the Government of PNG

Work item	Frequency	Cost（Kina）
Inspection and maintenance of bridges	Twice per annum	10,000
Repaint of steel structure	Every thirty years	1,132,000
Periodical repair of pavement	Every three years	30,000
Maintenance of drainages	Twice per annum	20,000
Inspection and maintenance of revetments	Twice per annum	37,000
Average cost per annum		232,000

CHAPTER 3

Project Evaluation and Recommendations

Chapter 3 Project Evaluation and Recommendations

3-1 Project Effect

The following effects can be anticipated as a result of Project implementation.

Table 3-1 Project Effects

Current Conditions and Problems	Project Countermeasures	Direct Effects and Level of Improvement	Indirect Effects and Level of Improvement
- People and vehicles cross over riverbeds - Delays are caused by flooding	- Construct bridges at all 15 points where people and vehicles have to cross riverbeds.	- The whole route of 190 km between Kokopau and Arawa will be connected without the need for any river crossings, and travel time along the said section will be shortened by around 1 hour. - The current problem in which the road becomes impassable (travel is delayed) for 30 days a year due to flooding will be resolved.	- Access to medical care and education facilities will improve, transport of everyday necessities will stabilize, and the lifestyles of local residents will be enhanced. - This will contribute to the vitalization of local industry and local development, which was delayed by the prolonged struggle for independence.
- Roadside residents need to pay high transport costs to reach the only banks and hospitals in Buka.		- Only vehicles with high vehicle height can cross rivers, however, all vehicles will be able to pass when bridges are built. - Means of transport will diversify to include bicycles and motorbikes, etc.	- Due to the diversification of transport means, the numbers of types of vehicles will increase and transport costs will come down.
- River accidents are occurring.		- Emergency vehicles will be able to pass at all times. - The washing away of vehicles and accidents arising from dangerous river crossings will be prevented.	- Making the road constantly passable will stabilize everyday life for approximately 210,000 residents.
- Due to the poor road situation, shipments of farm products such as coconuts and cacao, etc. are static.		- Construction of bridges and elimination of river crossings will enable larger and greater numbers of vehicles to pass, and thus lead to increased shipments of farm products.	- Roadside agriculture will be vitalized and the living standard of local residents will be improved.
- River crossings by vehicles cause turbidity of river water.		- River pollution caused by vehicles crossing rivers will be avoided.	- Since the local residents will be able to cook and wash with clean water from rivers, this will contribute to improvement in the standard of living.
- Dilapidated causeways lead to renewed collapse of riverbanks and environmental destruction during flooding.	- Conduct improvements inside river areas.	- Riverbank collapse will be controlled and the environment will settle down.	- Since soil runoff around rivers will be stopped, this will contribute to stabilization of lifestyles for local residents.
- Local residents have limited employment opportunities.	- Implement construction works.	- Employment of local residents in the works will lead to higher incomes.	- This will contribute to stabilization of lifestyles for local residents.

The Project effects can be confirmed through conducting hearings and monitoring surveys to gauge the level of satisfaction of residents. Also, changes in the quality and quantity of transport will be verified through measuring travel speeds and conducting traffic volume surveys.

The general contents and results of the traffic volume survey conducted during the site survey part of the Basic Design Study were as follows.

Date implemented: March 20, 2008 (Thursday)
Place: Rawal Bridge on the Buka side
Implementation time: 06:00~18:00 (12 hours)
Weather: Cloudy later fine

Table 3-2 Traffic Volume Survey Results (Both Directions))

Type	06:00 -08:00	08:00 -10:00	10:00 -12:00	12:00 -14:00	14:00 -16:00	16:00 -18:00	Total
4WD	11	9	8	7	6	7	48
Truck	16	25	12	19	24	14	110
Total vehicles	27	34	20	26	30	21	158
Passengers	364	573	217	355	632	276	2417
Pedestrians	14	10	21	2	2	1	50

Since March 20 was the day before the Easter break from the 21st to the 24th, traffic volume was relatively high at 158 vehicles (12 hours), and the figure of 2,417 passengers indicates that vehicles were filled with passengers. Regarding the types of freight being carried, there were numerous vehicles carrying bags of copra and cacao to Buka, while there were a lot of vehicles carrying food, daily necessities and fuel in the opposite direction to Arawa.

3-2 Recommendations

3-2-1 Issues to be Tackled by the PNG Side

In order to ensure the effects of Project implementation, it will be necessary to resolve the following issues.

(1) Repair and maintenance of road including the target bridges

The target bridges comprise nothing more than 15 isolated points along 190 km of the Bougainville Coastal Trunk Road between Kokopau and Arawa. It is also important to improve the road as a continuous line in order to realize a safe and pleasant highway. In particular, the securing of stable traffic at times of rain on unpaved sections is an issue. Moreover, in order to secure a favorable transport environment, it is important to conduct road maintenance that includes the bridges.

(2) River improvements and maintenance at river crossing points

River flow over this section tends to be fast even during the dry season, while boulders and driftwood can be seen carried down by torrents during the rainy season. Such objects occasionally block river sections and can greatly alter river courses. The bridge plans aim to realize safe structures through including bed protection works around bridge piers and bank protection works at the front of abutments. However, changes in the upstream river course can lead to unforeseen disasters and problems. Moreover, since boulders and driftwood flowing down rivers can block river sections and lead to flooding, it will be necessary to remove such objects in maintenance work.

(3) Construction of public information and rest facilities and implementation of transport safety education

As a result of the improvement of Bougainville Coastal Trunk Road, it is forecast that traffic volume will increase and it will be necessary to introduce public means of transport such as buses, etc. Moreover, due to the improved running conditions, there is concern over the occurrence of major road accidents. For this reason, it will be necessary to construct auxiliary facilities such as “road stations” that incorporate bus stops, rest facilities and safety facilities. It will be important to raise the safety awareness of residents through conducting car safety education at such auxiliary facilities.

3-2-2 Linkage with Technical Cooperation and Other Donors

Maintenance of Bougainville Coastal Trunk Road is carried out by AusAID, which possesses information on the road and technical data concerning repair and maintenance works. Considering that the bridge works in the Project will be executed while making use of the trunk road, from the viewpoint of smoothly advancing the works, it will be essential to exchange works information and technical data.