Department of Works
The Independent State of Papua New Guinea

No.

THE PREPARATORY SURVEY REPORT
(OUTLINE DESIGN)

ON
THE PROJECT FOR RECONSTRUCTION OF BRIDGES
ON NEW BRITAIN HIGHWAY
IN
THE INDEPENDENT STATE OF PAPUA NEW GUINEA

JANUARY 2015

JAPAN INTERNATIONAL COOPERATION AGENCY
Chodai Co., Ltd.
INGEROSEC Corporation

EI
JR
15-008

Preface

Having made the decision to implement the preparatory survey on the Project for Reconstruction of Bridges on New Britain Highway in the Independent State of Papua New Guinea, Japan International Cooperation Agency has consigned implementation of the survey to the consortium of CHODAI CO., LTD. and INGEROSEC Corporation.

Between May 26, 2014 and October 18, 2014, the Survey Team held discussions with related officials of the Government of the Independent State of Papua New Guinea, implemented field survey in the Project target area, conducted work in Japan, gave explanations on the draft outline basic design in the recipient country, and completed the report in hand.

I hope that this report will contribute to the furtherance of the Project and prove useful in enhancing friendly relations between the two countries.

In closing, I would like to offer my heartfelt gratitude to all those persons who gave their cooperation and support to the survey.

January 2015

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Summary

1. Overview of Papua New Guinea

The Independent State of Papua New Guinea (Papua New Guinea), which has national land area equivalent to 1.25 times the area of Japan and a population of approximately 7,160,000, is a major country in Oceania, however, its domestic road network (total length approximately 30,000 kilometers) contains many unopened sections, leading to fractured links between cities. Moreover, due to fragile road structures, roads and bridges are rendered impassable by landslides, slope failures, river flooding, etc. due to torrential rain in the rainy season. Because such cases seriously impact the economy and citizen lifestyles, there is a pressing need to build a network of trunk roads that is more resistant to disasters.

New Britain Highway in West New Britain Province stretches for 203 kilometers (paved section of 133 kilometers, unpaved section 70 kilometers) from Palm Oil Junction close to the border with East New Britain Province to Mai Junction close to the provincial capital of Kimbe, and it has 38 bridges over major river crossings along the route.

In 2013, Papua New Guinea had nominal GDP of 15,970 million US dollars (April 2014 estimate of the IMF) and per capita GDP of 2,283 US dollars (ditto), ranking it 113th and 131st respectively out of 188 countries. The actual GDP growth rate since 2007 has been 7.1%, however, thanks to the economic boost created by export of liquefied natural gas (LNG) from May 2014, the GDP growth rate for 2015 is expected to exceed 20% (IMF, 2013).

2. Background of the Project

The Government of Papua New Guinea has compiled PAPUA NEW GUINEA VISION 2050, which depicts the long-term state vision up to 2050, the Papua New Guinea Development Strategic Plan 2010-2030 (DSP), which describes the concrete strategies for realizing this, and the Medium Term Development Plan 2011-2015 (MTDP), which describes the five-year plan for realizing DSP 2010~2030 and gives the clear basis for investment. As the goal for highways in the transport sector, based on the understanding that "the road network is a lifeline for citizens using markets and services," it is intended to "increase the length of national highways from 8,460 kilometers in 2010 to 25,000 kilometers by 2030 and to keep the entire network in good condition." In addition, targets have been set for every five years (the target for 2015 is to have 10,000 kilometers of highways with 65% of these in good condition). The strategy for building the road network comprises the following measures: 1) improvement and rebuilding of 16 priority national highways and repair of other national highways, 2) construction of missing links on the 16 national highways, 3) construction of eight economic corridors, 4) construction and repair of local roads, and 5) strengthening of traffic safety and education.

Major industries along New Britain Highway, which is one of the abovementioned 16

priority national highways, are the oil palm industry and forestry. These industries utilize New Britain Highway as the sole transportation route (lifeline) for exporting products overseas. The oil palm industry and forestry support the livelihoods of more than 180,000 people through both direct and indirect employment, and if the national highway becomes impassable due to bridge collapse and so on, not only does it impart huge losses to these industries, but it also threatens the livelihoods of roadside residents.

It was against such a background that the Government of Papua New Guinea, in March 2013, requested the Government of Japan to provide grant aid concerning the Project for Reconstruction of Bridges on New Britain Highway, which proposes to rebuild the damaged Kapiura Bridge and Aum Bridge, as part of the program to improve New Britain Highway. If this Project can be implemented in tandem with another bridge replacement project currently being implemented under ADB funding on the same highway, it will have major beneficial effects such as enabling faster movement of people and goods between regions, securing a route that is highly resistant to flood disasters, and realizing a safe national highway. Incidentally, Kapiura Bridge and Aum Bridge (the target bridges) were originally made in Japan and constructed by a company with strong links to Japan as part of a policy to construct a road for boosting timber production at the start of the 1980s.

3. Outline of the Survey Results and Contents of the Project

On receiving the request from the Government of Papua New Guinea, Japan International Cooperation Agency (JICA) made the decision to implement the preparatory survey for the Project for Reconstruction of Bridges on New Britain Highway and dispatched the survey team to Papua New Guinea from May to July 2014. As a result of the survey, necessity was confirmed regarding the reconstruction of the damaged and deteriorated Kapiura Bridge and Aum Bridge as requested, and also the removal of the existing bridges, which was requested during the survey.

As a result of conducting review of economy, structure, ease of execution, maintenance, materials procurement, etc. in the basic design study, it was recommended that the two requested bridges should undergo reconstruction based on the following contents.

Table 1- 1 Road and Bridge Particulars in the Preparatory Survey (Basic Design)

	Kapiura Bridge		Aum Bridge	
	Existing bridge	New bridge	Existing bridge	New bridge
Design velocity		60km/h		60km/h
Horizontal alignment		Straight bridge section		R=115m
Bridge type	Lower deck langer bridge	3-span continuous plate girders	Lower deck truss bridge	2-span continuous plate girders
Bridge length	116m(114.8m)	45.65+46.00+45.65	50.0m(49.0m)	38.0+38.0

(span arrangement)					
Effective width		5.8m	7.50 (motorway) + 1.2 (sidewalk)	5.8m	7.50 (motorway) + 1.2 (sidewalk)
Superstructure	Main girder height	Stiffening girder 1.8m Rise 16.0m	2.1m	Main structure height 7.0m	1.9m
	Number of main girders	-	4 main girders (3 x 2.5m)	-	5 主桁(4×1.8m～4×3.0m)
	RC floor slabs	160mm	220mm	Steel floor slabs	240mm
	Erection method	Removal: pier ＋ CC	Pier + vent＋CC	Removal: pier ＋CC	Pier + vent＋CC
Abutments	Type	Reverse T type 5.5m Reverse T type 4.0m	Reverse T type 13.0m Reverse T type 11.5m	Reverse T type 4.5m Reverse T type 6.0m	Reverse T type 7.5m Reverse T type 8.0m
	Foundations	Pile foundations	Steel pipe piles φ 800 L=37m, 37m	Pile foundations	Steel pipe piles φ 800 L=53m, 63.5m
Piers	Type	-	Overhanging piers H=17.5m (P1,P2)	-	Overhanging piers H=14m
	Foundations	-	Steel pipe piles φ 800 L=30m(P1, P2)	-	Steel pipe piles φ 800 L=43m

4. Project Works Period and Cost Estimation

The Project works period is scheduled to last seven months for the implementation design and 22 months for the facilities construction. The Project cost is estimated as billion yen (billion yen on the Japan side, and million yen on the Papua New Guinea side).

5. Project Evaluation

1) Project Validity

In development plans in Papua New Guinea, based on the understanding that the road network is a lifeline for citizens using markets and services, it is intended to increase the length of national highways from 8,460 kilometers in 2010 to 25,000 kilometers by

2030 and to keep the entire network in good condition.

Development plans in Papua New Guinea have designated 16 national highways for priority development, and one of these is New Britain Highway, on which the target bridges are located. Rebuilding Kapiura Bridge, which currently has traffic controls due to insufficient bearing capacity, and Aum Bridge, which has collapsed following collision by a vehicle and is currently replaced by a temporary log bridge, and thereby securing smooth, safe and disaster-resistant road traffic is consistent with the development plans.

Being large-scale bridges, Kapiura Bridge and Aum Bridge cannot be constructed with the technology that is available in Papua New Guinea; moreover, since sophisticated coffering technology is needed in order to safely build solid bridge piers in the rivers, it will be necessary to use Japanese technology.

2) Project effectiveness

The quantitative outputs that are anticipated from Project implementation are as described below.

- **Increase in bridge load bearing capacity:** The existing bridges were designed to bear load of T33 and special trailer load of 44 tons per lane. The new bridges will be able to withstand loads of T44 per lane on two lanes, i.e. loads of 88 tons in total.

- **Increase in average running speed:** The average running speed of vehicles over the detour route of Aum Bridge was measured as 11.0km/h, while the average running speed over the existing Kapiura Bridge, where vehicles need to stop once at the gate, was 18.4km/h. When the new bridges are finished, it will be possible for vehicles to cross them at design velocity of 60km/h.

- **Average daily traffic volume**: Daily traffic volume in the field survey of New Britain Highway was 493 vehicles per day. Assuming that the traffic volume increases in line with GDP, the daily traffic volume in 2020 that is three years after completion of construction project will be 772 vehicles per day.

The qualitative outputs of the Project will be as follows.

- **Improvement in bridge performance and safety**: With the new construction of Aum Bridge and Kapiura Bridge, the load bearing capacity will increase and, because upper deck structures whereby the main structure is located below the road surface will be adopted, there will be less chance of vehicles crashing into the bridges. Thus, safety will be improved.

- **Increased and smoother physical distribution**: Because a temporary wooden structure is used as a detour around the existing Aum Bridge, while vehicles need to stop at the gate on the existing Kapiura Bridge, vehicles cannot run smoothly over the bridges. With the new construction of Aum Bridge and Kapiura Bridge, vehicles will immediately pass over the bridges and this will contribute to the promotion of physical distribution over New Britain Highway.

- **Securing of traffic at times of disaster**: Because the detour for the existing Aum Bridge is located in a lower position than the existing bridge, there is a high risk of the bridge detour becoming inundated and impassable at times of flooding. Following completion of the new bridge, vehicles will be able to pass and traffic will be secured even when flooding occurs.

- **Safety of pedestrians**: There are no sidewalks on the Aum Bridge detour or on the existing Kapiura Bridge. However, because sidewalks will be included on the new bridges, the safety of pedestrians will be secured.

Report of the Preparatory Survey
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2. Study Schedule
3. List of parties Concerned in the Recipient Country
4. Minutes of Discussions
5. Other Relevant Data
   5.1 Minutes of Understanding
6. References

Project Location Maps

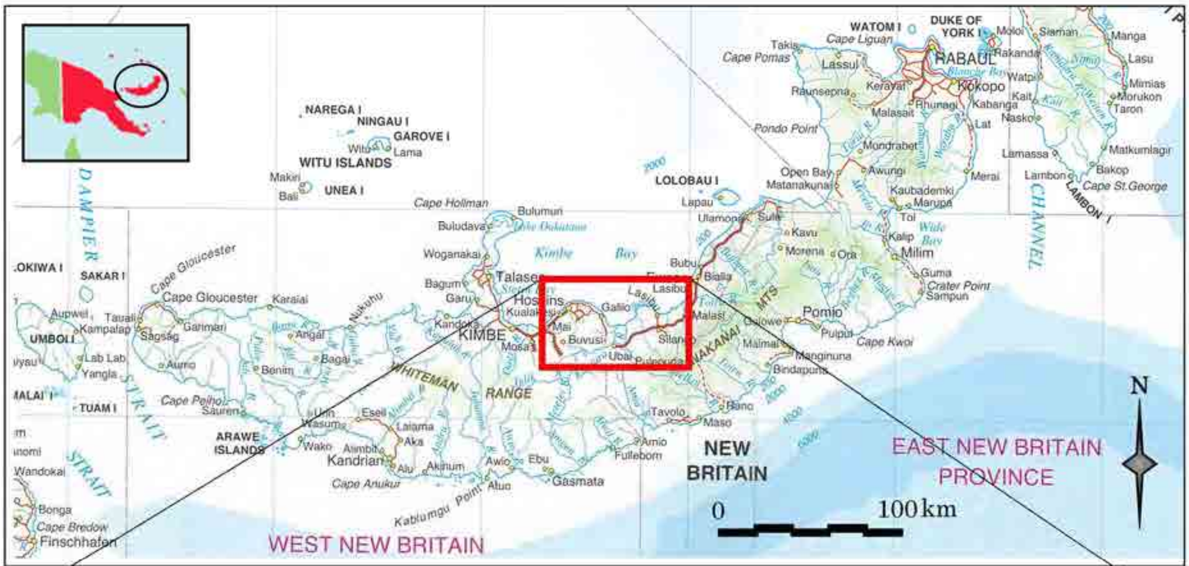
■ **Overall Location Map**

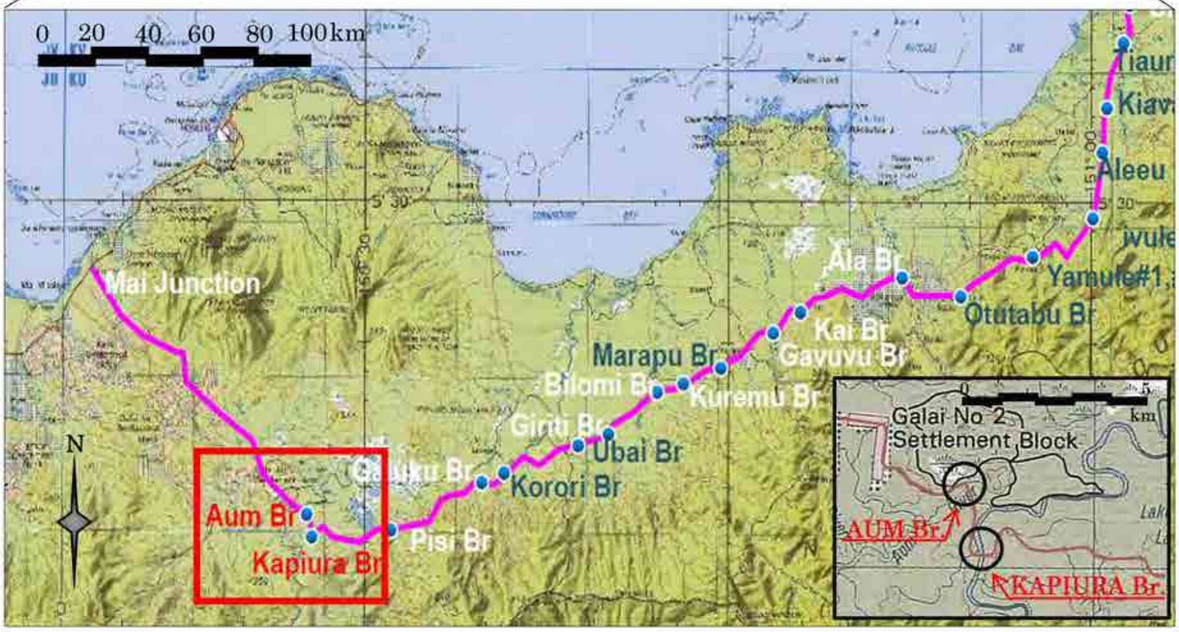
Independent State of Papua New Guinea

Capital: Port Moresbey (9°28'S・147°13'E)
(Population: 299,000)
Area: 463,000 km2
Population: 7,014,000
Geographical features: Situated to the north of Australia and just south of the Equator, Papua New Guinea comprises over 10,000 large and small islands including the eastern half of New Guinea Island, the Bismarck Islands, Bougainville Island, etc. The center of New Guinea Island is a mountain belt with peaks reaching up to 4,000 meters.

(Source: 2012 Data Book of the World)

■ **Project Area Location Map (New Britain Island)**





Perspective

(1) Aum Bridge

(2) Kapiura Bridge

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Abbreviations

ABG	Autonomous Bougainville Government
ADB	Asian Development Bank
A/P	Authorization to Pay
AUSAID	Australian Agency for International Development
BRIRAP	Bridge Replacement for Improved Rural Access Project
B/A	Banking Arrangement
CEMP	Contractor's Environmental Management Plan
CBR	California Bearing Ratio
DBST	Double Bitumineux Surface Treatment
DCPT	Dynamic Cone Penetration Test
DEC	Department of Environment and Conservation
DNPM	Department of National Planning and Monitoring
DOW	Department of Works
DSP	Development Strategic Plan
E/N	Exchange of Notes
EMP	Environmental Management Plan
GDP	Gross Domestic Product
HOPL	Hargy Oil Palms Limited
HMA	Hot Mix Asphalt
HWL	High Water Line
IEE	Initial Environmental Examination
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
LNG	Liquefied Natural Gas
M/D	Minutes of Discussions
MTDP	Medium Term Development Plan
NBPOL	New Britain Palm Oil Limited
NEXCO	Nippon Expressway Company Limited
PNG	Papua New Guinea
PMU	Project Management Unit
RAP	Resettlement Action Plan
SBLC	Stettin Bay Lumber Company Limited
TOR	Terms of Reference
UNDP	United Nations Development Programme
USGS	United States Geological Survey
WNB	West New Britain

Chapter 1 Background of the Project

1.1 Background of the Project

West New Britain Province produces 70% of palm oil in Papua New Guinea, which is the sixth largest producer in the world, and the palm plantations in this province are located mainly around New Britain Highway. Not only are all activities such as harvest, collection and transportation of palm to oil refining mills and ports conducted via New Britain Highway, but this road is the lifeline that supports the livelihoods of 200,000 residents in Talasea District, which constitutes half of the eastern side of the province. Since the government has the goal of building a "society that is knowledgeable, fair and free," the development of New Britain Highway, which is one of the country's 16 priority highways, is an important national policy. It was against such a background that the Government of Papua New Guinea, in March 2013, requested the Government of Japan to provide grant aid concerning the Project for Reconstruction of Bridges on New Britain Highway, which proposes to rebuild the damaged Kapiura Bridge and Aum Bridge.

If this Project can be implemented in tandem with another bridge replacement project currently being implemented under ADB funding on New Britain Highway, it will enhance the effects of development such as enabling faster movement of people and goods between regions, securing a route that is highly resistant to flood disasters, and realizing a safe national highway. Incidentally, Kapiura Bridge and Aum Bridge (the target bridges) were originally made in Japan and constructed by SBLC Co., Ltd., which has strong links with Japan, as part of a policy to construct a road for boosting timber production at the start of the 1980s.

1.2 Conditions in the Project Sites and Surrounding Areas

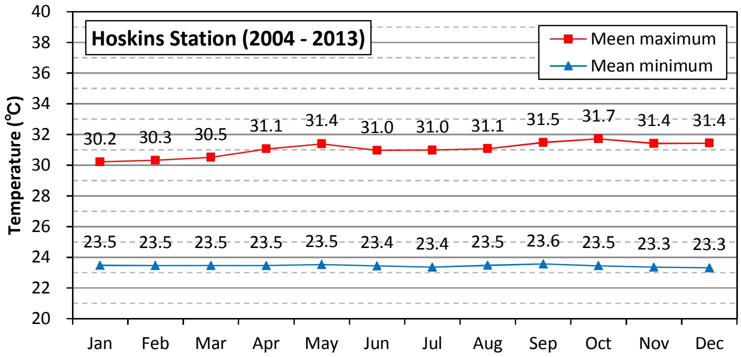
1.2.1 Natural Conditions

(1)Temperature

Except for limited mountain areas, almost all of Papua New Guinea 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).

On New Britain Island where the target bridges are located, the effects of the northwest monsoon are felt in the northern area, where Hoskins Airport is located, however, the south of the island feels the effects of the southeast monsoon, which gives rise to a different annual rainfall pattern.

Figure 1.2.1 shows the monthly mean maximum temperature and monthly mean minimum temperature at Hoskins Station over the past 10 years. The maximum temperature is around 31℃ throughout the year and the minimum is around 23℃, leading to a temperature differential of around 7℃. There is no great temperature difference between months throughout the year.

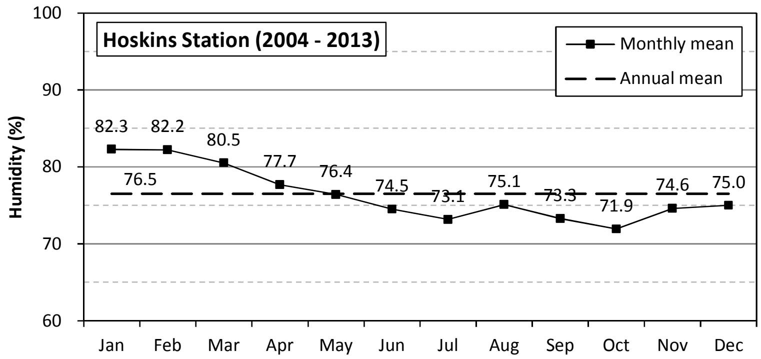


Source: National Weather Service

Figure 1.2.1 Monthly Mean Maximum Temperature and Minimum Temperature

(2)Humidity

Figure 1.2.2 shows monthly mean humidity at Hoskins Station over the past 10 years. Mean humidity is between 70%~85% throughout the year and the annual mean is 76.5%. Humidity is highest at more than 80% during the months of January to March due to the effects of the northwest monsoon.



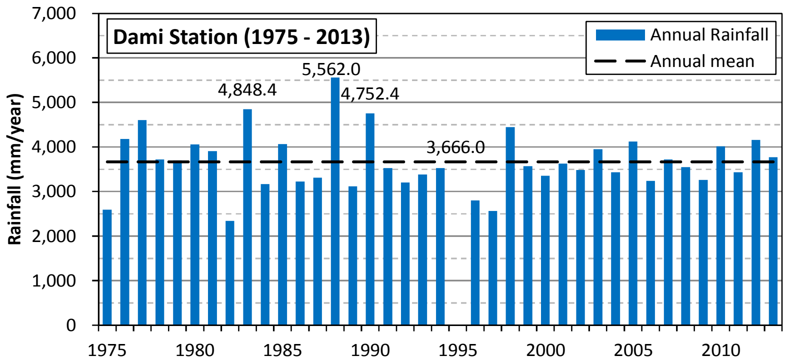
Source: National Weather Service

Figure 1.2.2 Monthly Mean Humidity

(3)Precipitation

1) Annual precipitation

Figure 1.2.3 shows annual precipitation at Dami Station for the past 39 years. The annual precipitation is approximately 3,670mm on average, reaching a maximum of 5,500mm and dropping to a minimum of 2,500mm.



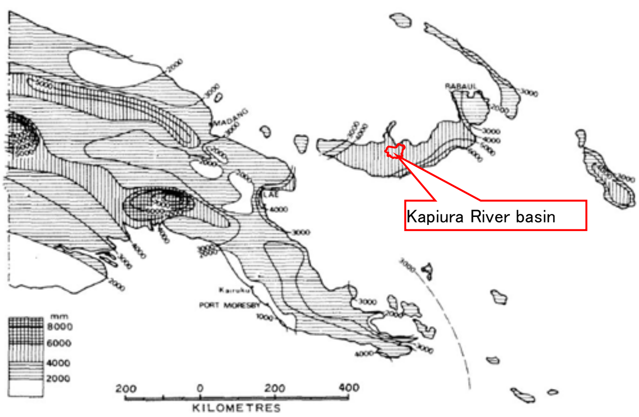
Source: National Weather Service

Figure 1.2.3 Annual Precipitation

2) Basin mean rainfall

① Kapiura River basin

Judging from the isohyetal map for New Britain Island shown in Figure 1.2.4, annual rainfall in Kapiura River basin is in the range of 4,000~5,000 mm and is 4,500 mm on average. The annual maximum daily rainfall in Kapiura River basin, which is used for calculating the design flow, is calculated through multiplying annual average rainfall at Dami Station of 3,670 mm by the ratio of basin annual mean rainfall derived from the isohyetal map divided by the annual mean rainfall observed at Dami Station, i.e. 1.23 (= 4,500mm /3,670mm).



Source: Hydrology in Tropical Australia and Papua New Guinea, A. J. Hall, 1984, with additions made by the Survey Team

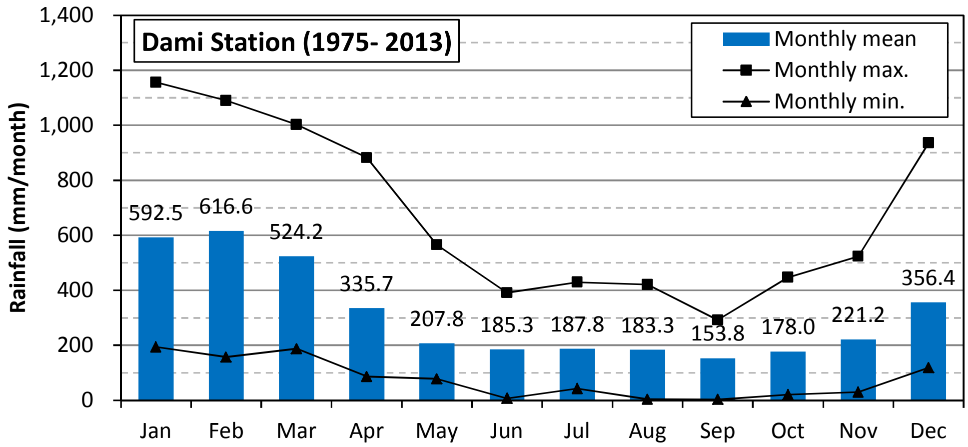
Figure 1.2.4 Papua New Guinea Isohyetal Map

② Aum River basin

Survey confirmed that the annual mean rainfall in Aum River basin is roughly in the same range as that observed at Dami Station. Therefore, there is no need to correct the annual maximum daily rainfall.

3) Monthly precipitation

Figure 1.2.5 shows the daily rainfall for each month observed at Dami Station. The rainy season in Hoskins is influenced by the northwest monsoon and lasts from December to April, while the dry season lasts from May to November. Monthly rainfall is highest at more than 500 mm between January and March, however, even during the dry season it reaches 150 mm or higher.

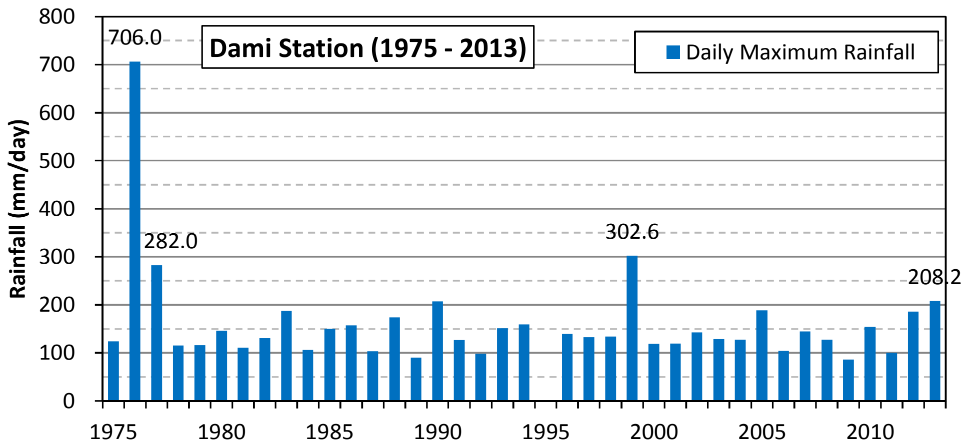


Source: National Weather Service

Figure 1.2.5 Monthly Precipitation

4) Annual maximum daily precipitation

Figure 1.2.6 shows the annual daily maximum precipitation at Dami Station. On average it is around 160 mm, however, rainfall equivalent to the scale of monthly precipitation sometimes occurs in a day. In recent years, 302.6 mm/day was recorded in February 1999, and 208.2mm/day was recorded in March 2013.

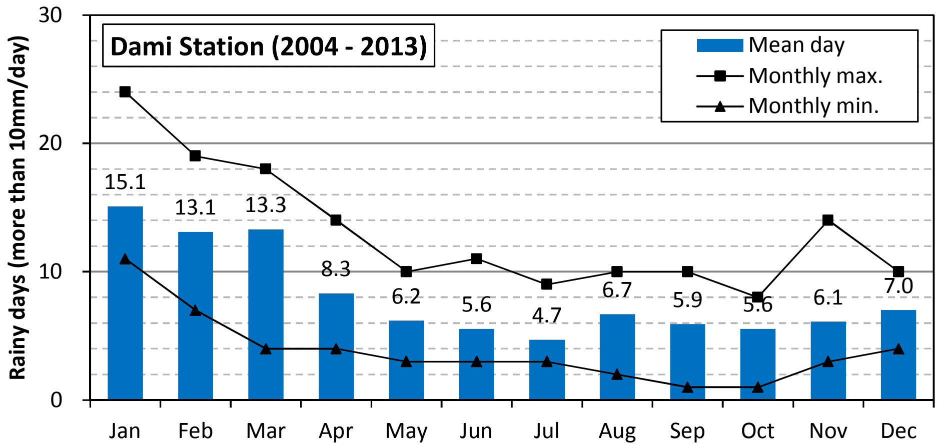


Source: National Weather Service

Figure 1.2.6 Annual Maximum Daily Precipitation

5) Number of days per month with precipitation of 10 mm or more

Figure 1.2.7 shows the number of days per month with precipitation of 10 mm or more over the past 10 years at Dami Station. During the rainy months of January and March, such days account for roughly half the month, however, even during the dry season, on average there are around five days per month that have precipitation of 10 mm or more. The annual number of days having precipitation of 10 mm or more is 96.4 days on average, corresponding to around 30% of the year.

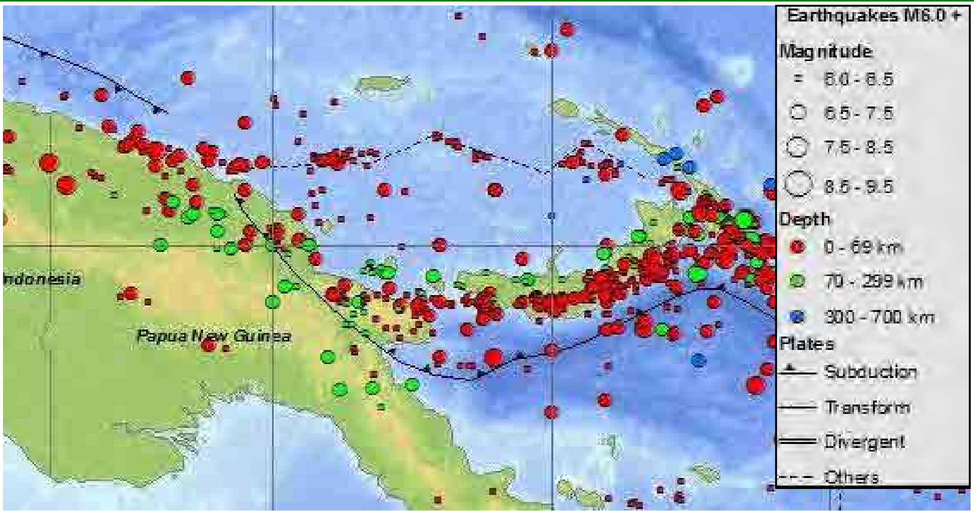


Source: National Weather Service

Figure 1.2.7 Days per Month with Precipitation of 10mm or More

(4) Seismic Survey

Papua New Guinea is one of the most seismically active countries in the world. The area stretching from the north of New Guinea Island including New Britain Island to Bougainville Island has a lot of seismic activity (see Figure 1.2.8). The Survey Team obtained the past seismic records of Papua New Guinea from the U.S. Geological Survey (USGS). Table 1.2.1 shows the record of recent earthquakes occurring around Papua New Guinea. On New Britain Island, seven earthquakes have occurred since 1998 and these are characterized by having shallow centers of less than 70 kilometers in depth.



Source: Seismicity Map of Papua New Guinea, USGS

Figure 1.2.8 Papua New Guinea Earthquake Distribution Map

Table 1.2.1 Recent Earthquake Record in Papua New Guinea

Date	Area	Epicenter Location		Depth of Center	Magnitude
		Latitude	Longitude		
17/July/1998	North Coast of New Guinea	2.960°S	141.920°E	10.0km	7.0
10/May/1999	**New Britain**	**5.150°S**	**150.880°E**	**103.0km**	**7.1**
16/May/1999	**New Britain**	**4.750°S**	**152.480°E**	**74.0km**	**7.1**
16/Nov/2000	New Ireland	3.980°S	152.160°E	33.0km	8.0
16/Nov/2000	New Ireland	5.230°S	153.100°E	30.0km	7.6
17/Nov/2000	**New Britain**	**5.490°S**	**151.780°E**	**33.0km**	**7.6**
8/Sep/2002	Coast of New Guinea	3.228°S	142.870°E	33.0km	7.6
10/Jan/2003	New Ireland	5.211°S	153.502°E	67.5km	6.7
11/Mar/2003	New Ireland	4.699°S	153.135°E	37.0km	6.6
7/Jun/2003	**New Britain**	**5.080°S**	**152.380°E**	**33.0km**	**6.6**
9/Sep/2005	New Ireland	4.539°S	153.445°E	91.3km	7.7
29/Sep/2005	**New Britain**	**5.437°S**	**151.816°E**	**25.0km**	**6.7**
11/Nov/2005	**New Britain**	**6.594°S**	**152.208°E**	**10.0km**	**6.6**
1/Sep.2006	Bougainville	6.822°S	155.535°E	45.7km	6.8
17/Oct/2006	**New Britain**	**5.846°S**	**151.010°E**	**32.0km**	**6.7**
28/Jun/2007	Bougainville	7.938°S	154.616°E	10.0km	6.7
26/Sep/2007	New Ireland	4.880°S	153.402°E	10.0km	6.8
22/Nov/2007	Eastern New Guinea	5.795°S	147.113°E	72.7km	6.8
23/Jun/2009	New Ireland	5.153°S	153.794°E	64.0km	6.7

Source: Historical Earthquakes in Papua New Guinea, USGS

(5)Topographical Survey, and Geological and Ground Survey

The topographical surveying and geological and ground survey were consigned to a local firm. Judging from projects conducted by the consortium in the past, since it was forecast that a local surveying firm in Papua New Guinea would be fairly expensive, consideration was given to economy through recruiting a third country operator and securing the necessary technical level for acquiring the information needed for planning and designing the target facilities.

1) Topographical surveying

In order to secure the necessary accuracy for implementing the preparatory survey, topographical surveying was implemented round the target bridge sites. The findings were utilized in accurately grasping topographical conditions around the Project sites, determining the structure and scale of the target facilities, and providing data for the design, facilities planning and calculations.

Table 1.2.2 shows the contents of the surveying investigations. Moreover, the plan views of Aum Bridge and Kapiura Bridge are shown in Figure 1.2.9 and Figure 1.2.10.

The detailed results of the topographical surveying are shown in the appendices.

Table 1.2.2 Contents of Surveying

Type	Scale and Specifications	Unit	Quantity
Topographical surveying	Plane table surveying ・Aum Bridge : L 300m x W 200m×2 (river right bank and left bank) =120,000 m^2 ・Kapiura Bridge: L 300m x W 200m×2 (river right bank and left bank) =120,000 m^2	m^2	240,000
	Longitudinal topographical surveying ・Aum Bridge : L=500m ・Kapiura Bridge: L=782m	m	1,282
	Cross-sectional topographical surveying ・Aum Bridge : 20m intervals on the road center line, 26 cross sections ・Kapiura Bridge: 20m intervals on the road center line, 41 cross sections	Cross section	67
River surveying	Plane table surveying ・Aum Bridge : L 400m x W 90m =36,000 m^2 ・Kapiura Bridge: L 400m x W 156m = 62,400 m^2	m	98,400
	River longitudinal surveying ・Aum Bridge : L=500m ・Kapiura Bridge: L=400m	m^2	900
	River cross-sectional surveying ・Aum Bridge : 50m intervals on the river center line, 11 cross sections ・Kapiura Bridge: 50m intervals on the river center line, 9 cross sections	Cross section	20

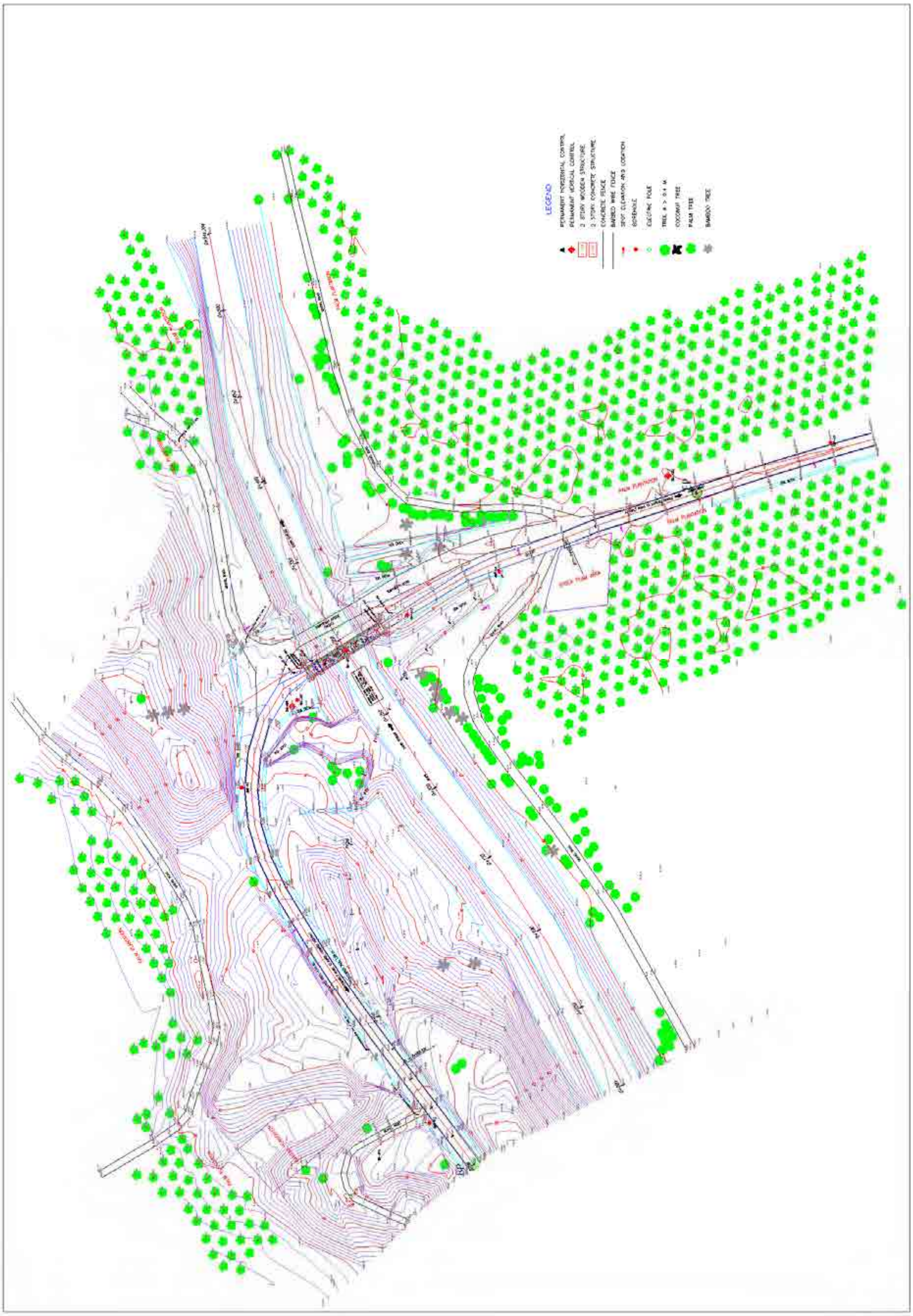


Figure 1.2.9 Aum Bridge Topographical Map

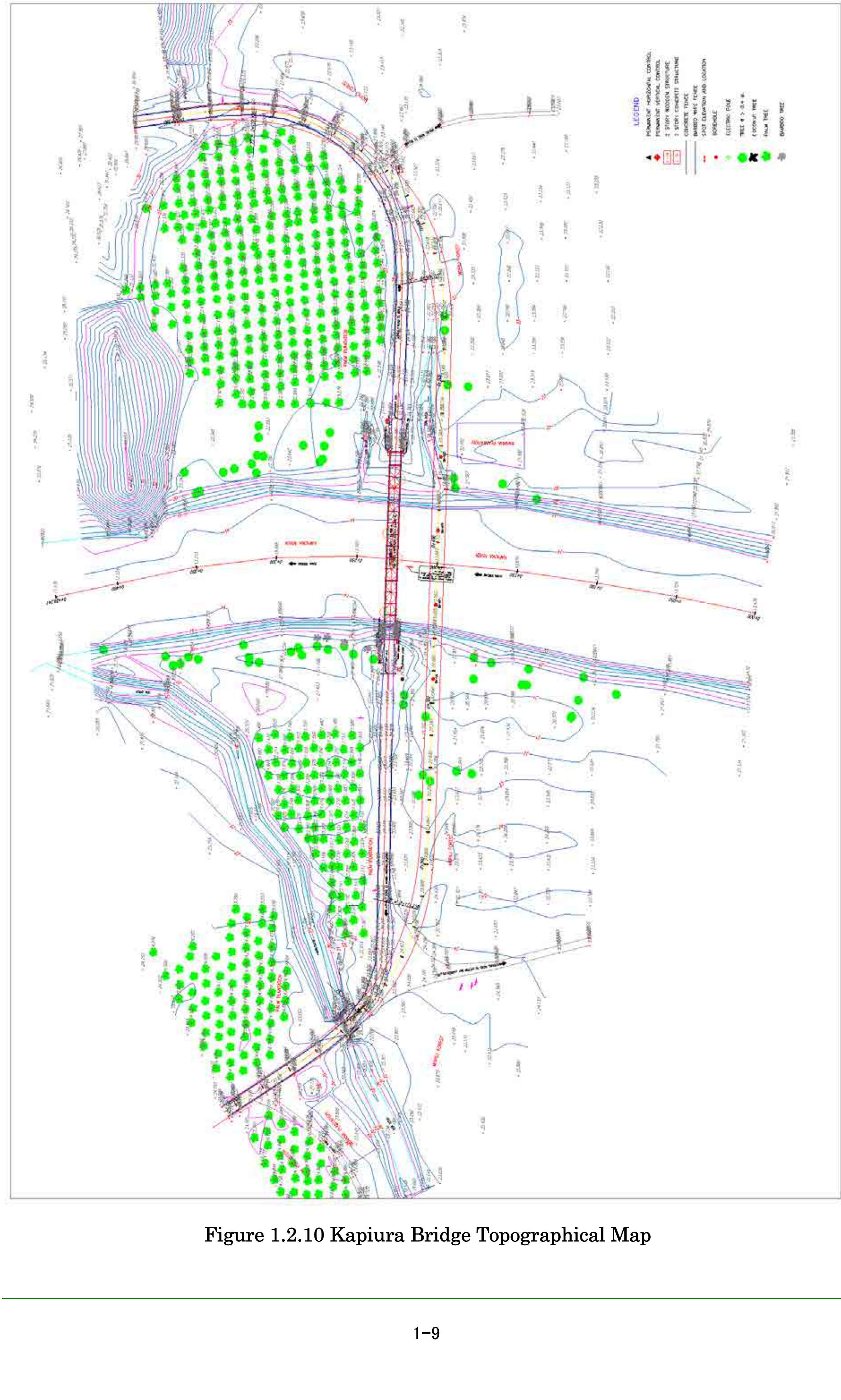


Figure 1.2.10 Kapiura Bridge Topographical Map

2) Geological survey

① Outline of survey

The geological survey was implemented in the abutment and pier positions at the reconstruction sites for Aum Bridge and Kapiura Bridge. Table 1.2.3 shows the implemented contents of the geological survey.

Table 1.2.3 Contents of Geological Survey

Survey	Item	Contents	Objective
Geological survey (subcontracted)	Geological reconnaissance	• Area around the 2 existing bridges (Aum Bridge and Kapiura Bridge)	• Determination of survey positions • Estimation of facilities construction positions • Estimation of ground conditions
	Boring	• Aboveground part: 4 positions (Aum Bridge 2, Kapiura Bridge 2) • Underwater: 3 positions (Aum Bridge 1, Kapiura Bridge 2)	• Preparation of column diagrams and geological maps • Acquisition of samples for indoor testing • Determination of facilities construction positions • Confirmation of bearing layer position →Review of type of foundations
	Standard penetration test	• Implement at 1m intervals in the sedimentary layer using boring holes.	• Acquisition of N values • Preparation of column diagrams and geological maps
	Indoor test	• Specific gravity, liquid limit, particle size, water content, etc.	• Acquisition of soil parameters • Preparation of column diagrams and geological maps

Photograph 1.2.1 Kapiura Left Bank Boring

Photograph 1.2.2 Kapiura Right Bank Boring

② Results of boring survey

Detailed results of the boring survey are given in the appendices under the title "Geological Survey Results: Boring Column Diagrams." The Project area has thick covering of river sediments. In particular, because the river flow becomes extremely large at Kapiura Bridge, a lot of sediments are carried down. Boring was conducted down to GL-60m, however, it still wasn't possible to confirm a clear bearing layer. A stratum where the mean N value is continuously over 30 was selected as the bridge bearing layer.

Figure 1.2.11 and Figure 1.2.12 show the projected strata cross sections for Aum Bridge and Kapiura Bridge.

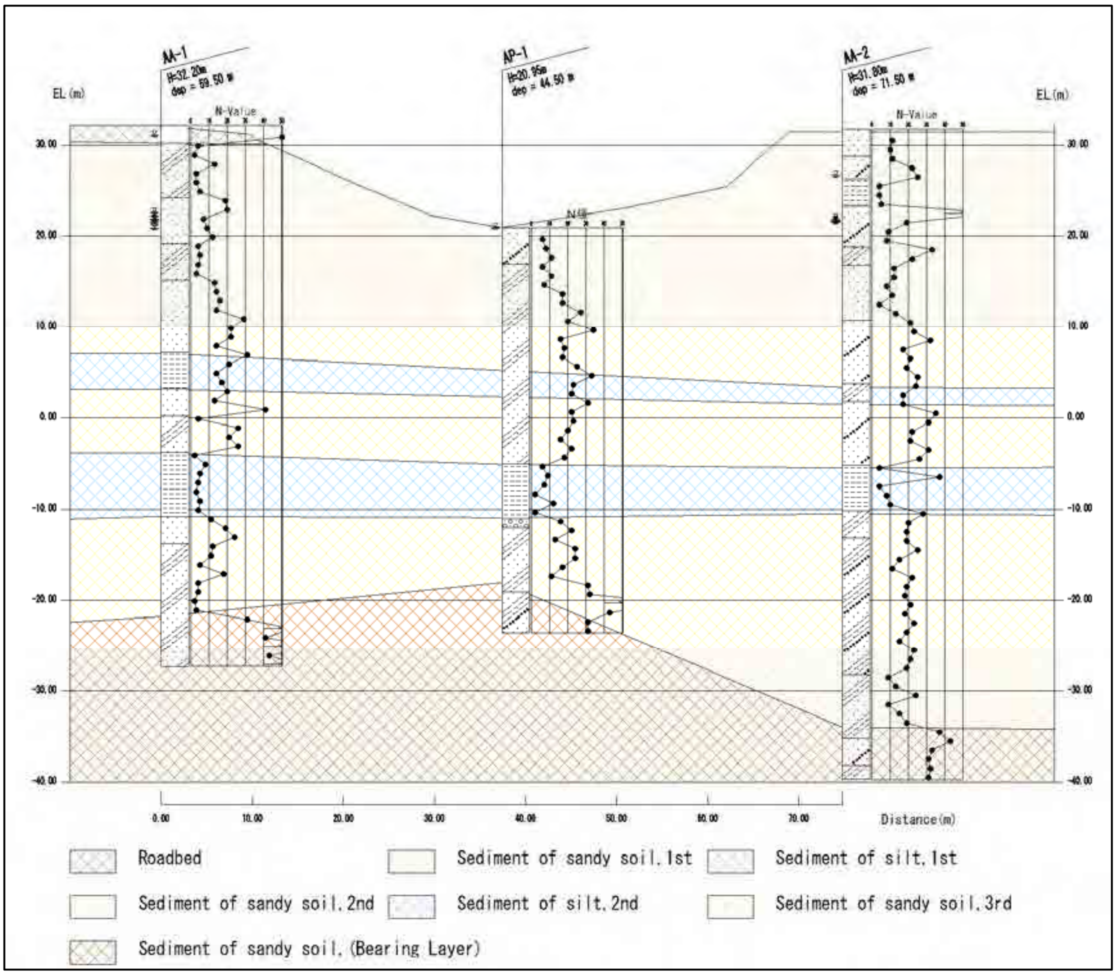


Figure 1.2.11 Projected Strata Cross Section - Aum Bridge

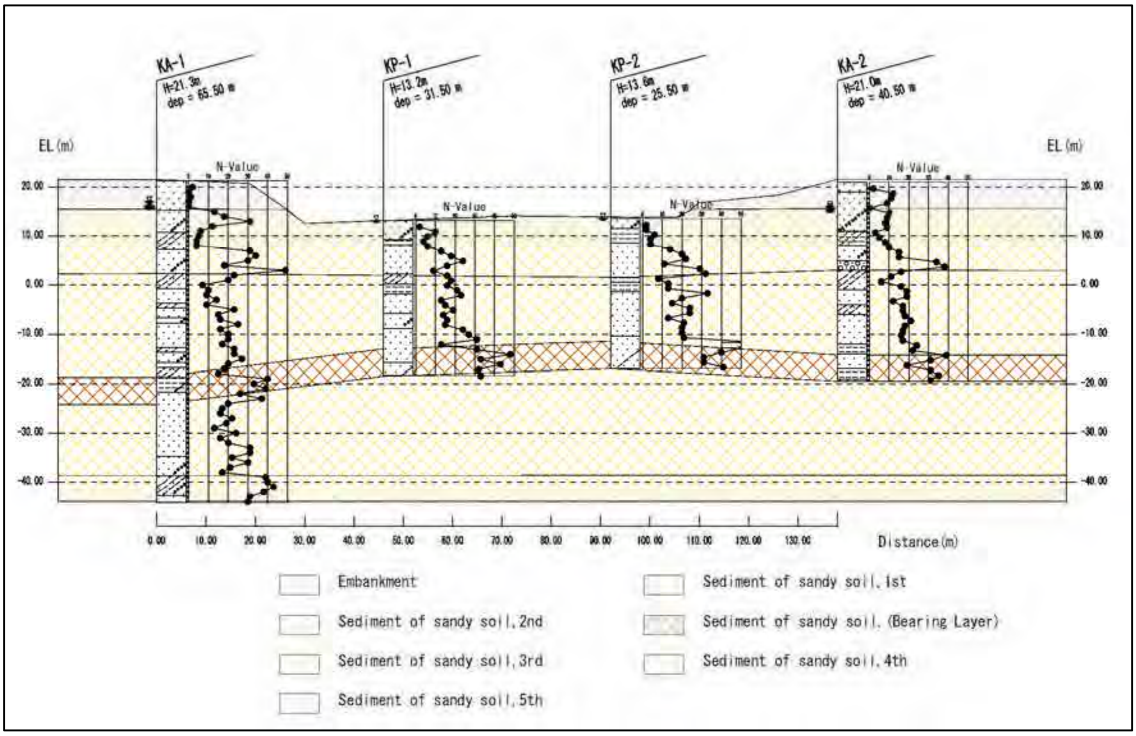


Figure 1.2.12 Projected Strata Cross Section - Kapiura Bridge

3) Ground survey

Ground survey was implemented with the aims of gauging the paving composition, bearing power, and banking material characteristics of existing roads, and the findings were used as data for examining the road body, roadbed, and subgrade. Table 1.2.4 shows the contents of the ground survey.

Table 1.2.4 Contents of Ground Survey

Survey	Item	Contents	Objective
Ground survey (subcontracted)	Soil bearing test	• DCP test: 8 locations (Aum Bridge 4 locations, Kapiura Bridge 4 locations)	• Acquisition of CBR values necessary for examining the road paving composition (type, thickness) and sections, etc.
	Indoor test	• Soil testing at DCP test locations (classification, water content, consistency limit, specific gravity, particle distribution, optimum water content, CBR, etc.)	• Acquisition of characteristics as local banking materials →Examination of road body, roadbed, and subgrade, etc.

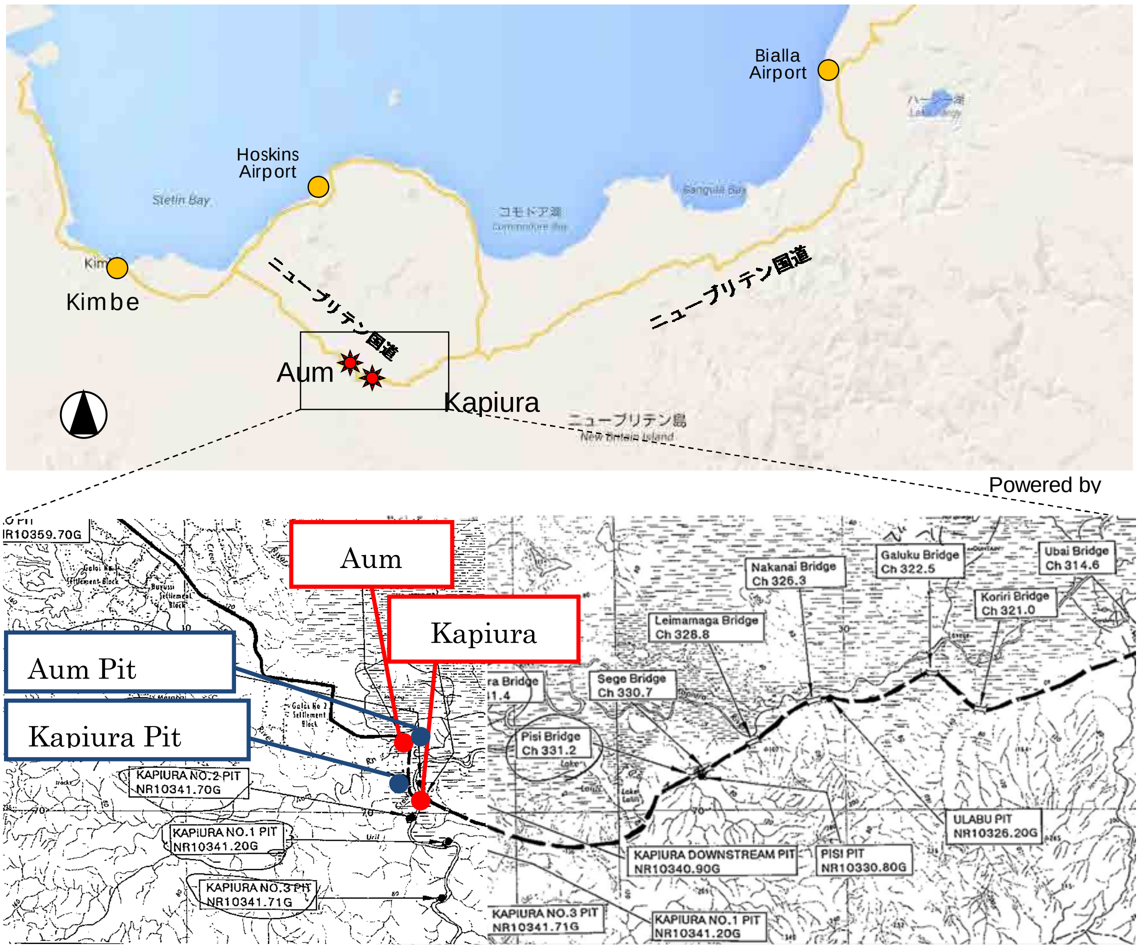


Figure 1.2.13 Map of Sampling Locations

Photograph 1.2.3 Sampling Situation and Samples (Aum Pit)

Photograph 1.2.4 Sampling Situation and Samples (Kapiura Pit)

① Paving composition and bearing capacity of existing road

In order to grasp the paving composition and bearing capacity of existing road, dynamic cone penetration test (DCPT) was implemented at eight locations, comprising four locations each at Aum Bridge and Kapiura Bridge. Photograph 1.2.5 and Photograph 1.2.6 show the used equipment and conditions during the survey.

The results of DCPT at each location are shown in Table 1.2.5. The CBR value of the existing road is about 38 on average around Aum Bridge and 21 on average around Kapiura Bridge.

Photograph 1.2.5 Used Equipment (Dynamic Cone Penetration)

Photograph 1.2.6 Survey Implementation Situation

Table 1.2.5 DCPT Results

Pit No.	Moisture content %	Atterberg Limits				CBR soaked	Specific Gravity
		LL	PL	PI	LS		
AMP-K1	33.3	40	36	4	2	50	2.39
AMP-K2	40.2	42	33	9	5	15	2.28
AMP-U1	30.6	36	33	3	2	40	2.45
AMP-U2	21.0	38	34	5	2	50	2.38
KPP-K1	27.5	42	38	3	1	18	2.19
KPP-K2	23.6	41	33	9	5	17	2.59
KPP-U1	35.0	54	36	17	7	20	2.52
KPP-U2	23.0	49	43	6	3	30	2.54

1.2.2 Environmental and Social Consideration

(1)Systems for Environmental and Social Consideration in the Recipient Country

1) Environmental Act Requirements in Papua New Guinea (2000)

Environmental impact evaluation in Papua New Guinea is implemented according to the Environment Act (2000) and related legislation and guidelines that have been enacted by the Department of Environment. The Environment Act stipulates sustainable operation of the national land in terms of biological and physical aspects such as water, air and so on.

Other related legislation includes the Fauna Act (1966), Protected Area Act (1978), Convention on International Trade in Endangered Species of Wild Fauna and Flora (1978) Washington Convention), Crocodile Trade and Protection Act (1978), and National Parks Act (1984).

The Environment Regulation of 2002 stipulates projects according to their degree of impact. According to this, infrastructure development projects are treated as Level 2, and this is further divided into Level 2B for cases of relatively large impact and Level 2A for cases of small impact.

Infrastructure works treated as Level 2B include river damming and discharge, construction of residential facilities over 5 hectares or more, construction of airfields, construction of new national highways and so on. As for Level 2 infrastructure projects, the project operator needs to apply to the DEC with its intention to implement and undergo review of the application, however, there is no need to advertise the application contents or stage public hearings. The period for conducting procedures for Level 2A projects in the DEC is no greater than 30 days. Accordingly, since the bridge reconstruction works in the Project are classified as Level 2A, there is no need to take environmental approval procedures.

According to environmental legislation, the DEC has jurisdiction over projects for the construction of new national highways, however, matters pertaining to the maintenance of roads and bridges are handled by the DOW. New national highway construction works are classed as Level 2B, making it necessary for an IEE to be submitted to the environment department of the DOW and a review and copy to be sent to the DEC. Since bridge reconstruction works are classed as Level 2A, there is no need to prepare and submit an IEE.

The DEC is responsible for Environment Act (2000) and related legislation. As the government agency for environmental management, its mission is to preserve the natural resources of PNG and enhance the comfortable lifestyles and standard of living of citizens. The Department of Environment and Conservation is composed of three departments, i.e. environmental protection, sustainable environmental management, and policy formulation. Currently 170 personnel have been appointed for 200 positions.

The DEC has issued the following guidelines:

・Guideline for submission of an application for an environmental permit to discharge waste. *GL-Env/03/2004*.

o Noise discharges. *IB-ENV/03/2004*

o Air discharges. *IB-ENV/02/2004*

o Water and Land Discharges. *IB-ENV/04/2004*

2) The Department of Works (DOW)

In line with implementation of a World Bank project, the DOW was required to establish an environmental section in its contracting department. The environment manager and two monitoring staffs have compiled environmental guidelines for road and bridge construction, and they offer guidance on preparation of environmental impact evaluation documents and operation of environmental management plans.

3) Other legislation

The following laws in Papua New Guinea are applicable to implementation of the Project:

(i) The Employment Act, 1978.

(ii) The National Cultural Property (Preservation) Act 1965.

(iii) The Public Health Act (1978)

(iv) Drinking water quality standards for raw (untreated) water

(2) Base Environmental and Social Conditions

Source concerning current environmental conditions: West New Britain Integrated Provincial Development Plan 2012-2015 (West New Britain Provincial Administration)

1) Social environment

① Land acquisition

Land around Aum Bridge and Kapiura Bridge comprises palm and eucalyptus plantations, and there are no general inhabited houses, private cultivated land or buildings in the area. In field survey hearings, it was found that a worker's compound for plantation managers is located a few kilometers from Aum Bridge (1 kilometer as the crow flies), and there is an SBLC employees' dormitory around 600 meters as the crow flies from Kapiura Bridge, however, the closest residents are those living in Evisohul and Nakisi clans some 5 kilometers from Kapiura Bridge.

New Britain Highway around the target bridges has an ROW of 40 meters in width, and the roadside areas around Aum Bridge and Kapiura Bridge comprise leased land used by New Britain Palm Oil Ltd. (NBPOL) and Stettin Bay Lumber Company (SBLC). Moreover, within the leased land, areas stretching approximately 50 meters from the rivers (Aum River, Kapiura River) are protected as buffer zones under the Logging Code of Practice, so no plantations are cultivated here. Figure 1.2.14 shows the landowners around Aum River and Kapiura River.

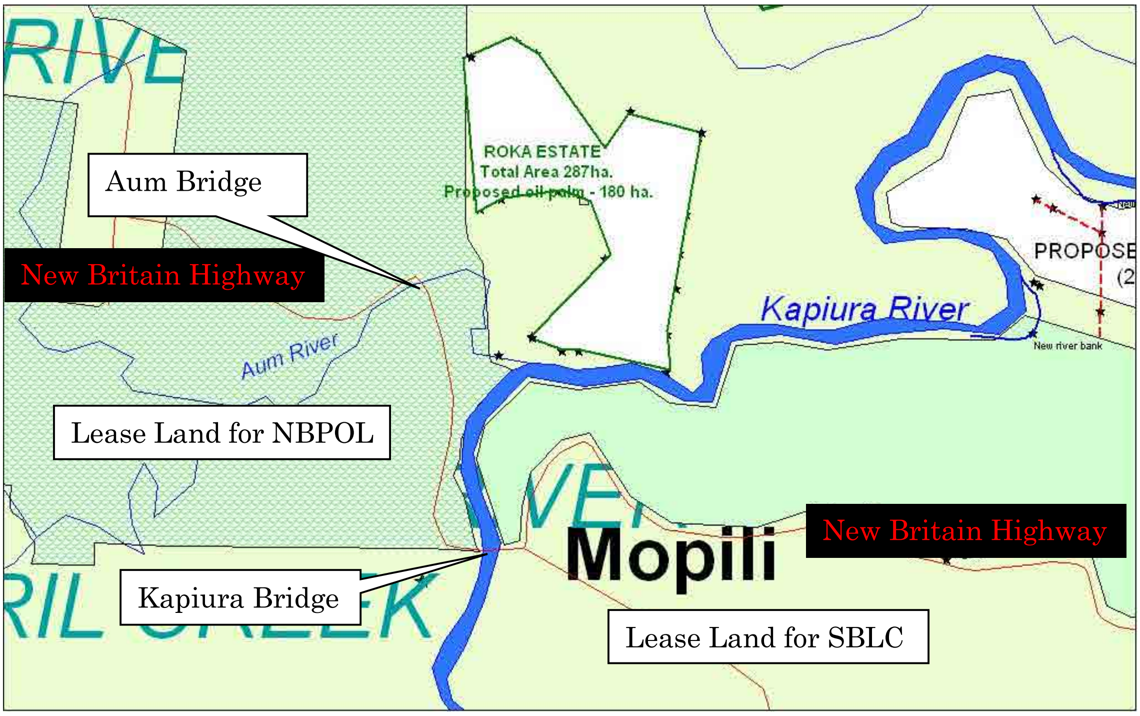


Figure 1.2.14 Land Ownership around the Project Sites (Source: NBPOL, SBLC)

2) Natural environment

① Wide area vegetation classifications and vegetation

Wide area vegetation in West New Britain Province is classified into lowland floodplain forest, hilly rain forest, Montana forest, swamp forest, grassland, and secondary forest.

Large-trunk forests have the diversity of many lowland rainforest species characterized by lowland flood plain and hill forest types. The canopy in such forests reaches heights of

30~40 meters. Homalium foetidum, pommetia pinnata, calophyllum spp, Canarium spp, Manifera minor, planchonell spp, Octomeles sumatrana, and Amberoii spp trees, which have high commodity value, reach heights of 50 meters with breast height diameter of 80 centimeters on average and a maximum of 120 centimeters.

These two types of forest can be easily distinguished. An estimated 85% of these forests are located on flatland, while the remainder is located in the foothills of Nakanai and Whiteman mountains. Highland forests are characterized by stunted vegetation and moss on the forest floor.

Swamp forests are largely composed of mangroves and pandanus (Pandanus boninensis) which can be observed in water in coastal areas.

Secondary forests are found within the perimeters of the village and they occur as a result of shifting cultivation and subsequently oil palm planting by the villagers. Secondary forest generally comprises Macaranga, Tetrameles nudiflora and Trema orientalis, which are not used as commodities. In formerly cultivated forest, the species of Antocepalus chinensis and Octomeles sumatrana and Albizia procera can be seen.

Much of the province was previously covered by lowland forest and tropical rainforest. However, as a result of population growth and conversion of land along the northern coastline to farmland, the tropical rainforest today can only be found along the southern coastline. Grasslands cannot generally be seen except in a small area of Gloucester.

② Soil

The fertile soil nourished by volcanic ash drives the prosperity of the palm oil business. In areas not influenced by volcanic activity, the soil is influenced by the base material before erosion. Influenced by young alluvial deposits, soil in the tropical belt is predominantly silty clay loam with a black surface layer. This is fine particle soil with good water drainage.

③ Fauna

According to the research findings of Bishop and Broome (1980) and Mercer (1989) in various fields, the density and distribution of fauna depend on the degree of infiltration of human activities into habitats. Oil palm forests, road construction, mine development, harvesting of timber and cash crops, and hunting activities have impacted the density and distribution of fauna including endemic species. However, because animals have migrated to undeveloped forests in line with these intrusions into the natural world, their density has increased in inland areas. Even so, many of these species are dwindling in numbers due to the rapid disintegration of habitats.

④ Land use

Land use in the province can be broadly classified into the categories of Oil palm

Plantations, Forest Plantations, Settlements and the natural vegetation. These broad classifications are subjected to many factors such as topography, drainage, geology and soils. Land utilization is generically determined by the type of soil and its fertility and the accessibility to markets. Figure 1.2.15 shows the estimated land use situation.

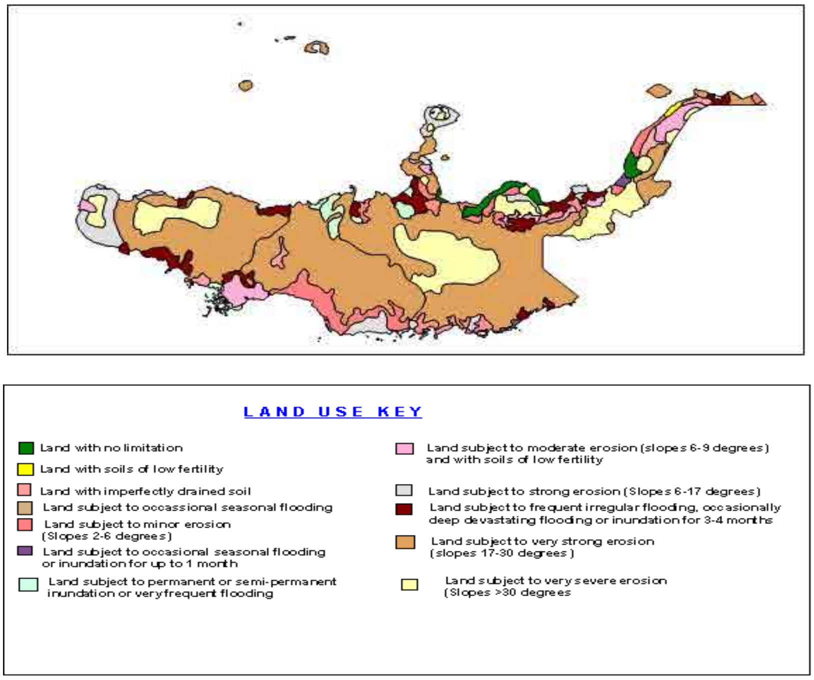


Figure 1.2.15 Presumed Land Use Situation

Table 1.2.6 Cash Crop Suitability and Level of Performance

Area	Cash Crops	Compatibility
Talasea District Bialla, Hoskins, Kimbe, Talasea, Bali/Vitu	Cocoa, coconuts, palm oil	High
Kandrian Gloucester District Gloucester, Gasmata, Kandrian Coastal, Kandrian Inland Kalia-Kove	Cocoa, coconuts	High
	Spices, coffee	Medium

⑤ Wildlife management areas

West New Britain has the following four wildlife management areas, however, the Project sites do not infringe on any of these.

a) Pokili WMA - Hoskins LLG 9,840 Ha
b) Garu WMA - Talasea LLG 8,700 Ha
c) Kurtavele Bird Century - Gloucester LLG
d) Loroko National Park - Hoskins 100 Ha

⑥ Reefs and islands

West New Britain is dominated with fringing and offshore reefs making it hazardous for navigation. It has 125 islands in 130,000 square kilometers of sea, 869 kilometers of coastlines and 1,370 square kilometers of shallow reef.

⑦ Volcanoes

West New Britain has 40 volcanoes, of which 11 are live volcanoes, five are dormant, and 24 are extinct. Mt. Witori in Hoskins erupted 3,500 years ago spreading volcanic ash over thousands of square kilometers, whereas Mt. Pago erupted in August 2002. The eruption of Mt. Witori was one of the largest eruptions in human history. The active volcanoes in West New Britain are Mt. Ulawun, Mt Lolobau, Hulu Crater, Giwu Peak, Mt. Hargy, Sulu Range and Mt. Ruckenberg in Biala, and Mt. Langla in Gloucester and Mt. Pago in Hoskins, and Mt. Gabuna, Mt. Malala and Mt. Gulu in Talasea. There is also a submarine volcano off the west coast of Lolobau Island, while geysers, which are indicative of volcanic activity, can be found in Hoskins, Talasea and Nakanai. Earthquakes also occur frequently along this section of the Bismark archipelago.

West New Britain has well-known lakes such as Dakataua Lake in Williamez Peninsula, Hargy Lake in Bialla, Humbuli Lake in Talasea, Lalili Lake and Namor Lake in Bialla. Also, hot springs can be found along the coast running from Talasea to Cape Hoskins and Bialla. Sulfur ejections can be seen in the skies around the mountain area of Gabuna, and the distinctive odor of sulfur is noticeable on the coast along Talasea Highway around Pataga and in the coastal village of Garu.

Source concerning current environmental conditions: WEST NEW BRITAIN INTEGRATED PROVINCIAL DEVELOPMENT PLAN 2012-2015 (WEST NEW BRITAIN PROVINCIAL ADMINISTRATION 2011)

(3) Environmental Impact Evaluation

1) Scoping

Table 1.2.7 shows the results of scoping.

Table 1.2.7 Scoping Results

Category		Impact Item	Evaluation		Reason for Evaluation
			Before works During works	In service	
Pollution countermeasures	1	Air pollution	B	C	During works: Temporary deterioration of air quality is forecast in line with operation of construction machinery, etc. In service: Negative impacts of exhaust gases from running vehicles on air quality are expected depending on the level of increase in traffic volume. On the other hand, since unpaved road will be paved, the effects of dust, etc. will be mitigated.
	2	Water pollution	B	B	During works: There is a possibility of water pollution occurring as a result of wastewater from

Category		Impact Item	Evaluation		Reason for Evaluation
			Before works During works	In service	
					the works sites, heavy machinery, vehicles and works dormitories, etc. In service: Runoff of dust and oil from the road surface at times of rain is forecast.
	3	Solid wastes	B	D	During works: It is forecast that construction leftover earth and waste materials will be generated. In service: There is not expected to be generation of wastes that will have an impact on the local environment.
	4	Soil pollution	B	D	During works: There may be a possibility of soil pollution due to runoff of construction oil, etc.
	5	Noise and vibration	D	D	During works and in service: There are no residences, schools, medical facilities, etc. that are prone to effects around the target road.
	6	Land subsidence	D	D	There is not expected to be any work, etc. that could trigger land subsidence.
	7	Bad odor	D	D	There is not expected to be any work, etc. that could trigger bad odor.
	8	Bottom sediment	D	D	There is not expected to be any work, etc. that could have an impact on bottom sediment.
Natural environment	9	Protected areas	B	D	There are no national parks or protected districts located around the Project target area. Aum Bridge and Kapiura Bridge are surrounded by palm and eucalyptus plantations, however, in buffer zones that are established 50 meters either side of the rivers, natural forests are preserved and harvesting of flora and fauna is controlled for the purpose of river protection.
	10	Ecosystem	D	D	Because the Project entails the repair and replacement of existing road and bridges and there are no rare species of flora and fauna in the target area, it is thought that there will be hardly any impact on the ecosystem.
	11	Hydrological phenomena	D	C	During works: There is not expected to be any work, etc. that could trigger changes in the flow or beds of rivers, etc. In service: When building piers in water for going over lakes and rivers, it is possible that the structures could trigger change in the flow regime.
	12	Topography and geology	D	D	Since the Project aims to replace existing bridges and will not entail large-scale cutting or banking works, it is thought there will be hardly any impacts on topography and geology.
Social environment	13	Resettlement of residents	D	D	Before works: The area around the bridges comprises plantations so there will be no resettlement of residents.
	14	Impoverished classes	D	D	Before works: It is possible that impoverished people will be included among those requiring resettlement.

Category		Impact Item	Evaluation		Reason for Evaluation
			Before works During works	In service	
					In service: Thanks to the paving of currently unpaved road, impoverished people will also enjoy benefits such as better access to social services such as schools and hospitals and markets.
	15	Minorities and indigenous population	D	D	There are no minorities or indigenous population in the Project target sites and surrounding area.
	16	Local economy (employment and means of livelihood, etc.)	D	D	Since the Project entails repair of existing road, the impact on the local economy is expected to be minimal.
	17	Land use and use of local resources	D	D	Since the Project entails replacement of existing bridges, the impact on the local economy is expected to be minimal.
	18	Water use	D	D	During works: Water from Aum River and Kapiura River is not used for drinking. The only uses are fishing and recreational bathing.
	19	Existing social infrastructure and social services	D	D	During works: A detour will be provided so there will be no impact. In service: There are no residences or public facilities around the bridges, and there is little risk of accidents occurring due to increased traffic volume or faster speeds.
	20	Social infrastructure and social organizations such as local decision making agencies, etc.	D	D	Since the Project entails replacement of existing bridges, the impact on the social infrastructure and local decision making agencies, etc. is expected to be minimal.
	21	Maldistribution of damage and benefits	D	D	Since the Project entails replacement of existing bridges, it is expected that it will impart hardly any maldistribution of damage and benefits.
	22	Clash of interests in the area	D	D	Since the Project entails replacement of existing bridges, it is expected that it will not trigger any clashes of interests in the local area.
	23	Cultural heritage	D	D	There is no cultural heritage located in the Project target sites and surrounding area.
	24	Landscape	D	D	Since the Project entails replacement of existing bridges, the impact on landscape is expected to be minimal.
	25	Gender	D	D	As there are no residences, etc. around the bridges, there are not expected to be any particular negative impacts on gender, however, consideration will be given through establishing sidewalks, etc. upon confirming local conditions in hearings with the implementing agencies during the field survey.
	26	Rights of children	D	D	As there are no residences, etc. around the bridges, there are not expected to be any particular negative impacts on children's rights.
	27	HIV/AIDS and	B	D	During works: Although it is not expected to

Category		Impact Item	Evaluation		Reason for Evaluation
			Before works During works	In service	
		other infections			conduct large-scale works, it is possible that infections could spread due to the influx of workers.
	28	Working environment (including labor safety)	B	D	During works: It will be necessary to consider the working environment of construction workers. In service: When the bridges go into service, there will be no work that imparts negative impacts on workers.
Others	29	Accidents	B	B	During works: It will be necessary to display consideration regarding accidents during the works. In service: There is concern that more road accidents will occur as a result of increased traffic volume and faster running speeds.
	30	Trans-boundary impacts and climate change	D	D	Since the Project entails replacement of existing bridges and does not have very large scale, there are expected to be hardly any trans-boundary impacts or impact on climate change, etc.

A: Significant negative impact is expected.
B: Negative impact is expected to some extent.
C: Extent of negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

① Environmental and Social Consideration TOR

Table 1.2.8 shows the environmental and social consideration TOR based on the results of scoping.

Table 1.2.8 Environmental and Social Consideration TOR

Environmental Item	Survey Item	Survey Method
Examination of alternative plans	① Examination of alignment ② Examination of work methods	① Minimization of land acquisition in the buffer zones along rivers, and examination of alignment for smooth traffic ② Examination of works methods for mitigating environmental impacts and traffic congestion, etc. during works
Air quality	① Confirmation of environmental standards, etc. (Japanese environmental standards, WHO standards, etc.) ② Grasping of current air quality ③ Gauging of the level of increase in traffic volume based on traffic demand projection ④ Confirmation of homes, schools, hospitals, etc. around the target sites ⑤ Impact during the works	① Survey of existing materials ② Forecast of impacts based on the results of traffic demand projection ③ Site reconnaissance and hearings ④ Confirmation of the works contents, methods, period, positions, and scope, types of construction machinery, operating positions, operating periods, number of running works vehicles, their running periods, traffic lines, etc.
Water quality	① River water quality	① Survey of existing materials,

Environmental Item	Survey Item	Survey Method
	② Use of river water in daily life	information collection at related agencies ② Site reconnaissance and hearings in the local area
Solid wastes	① Method for treating construction wastes	① Hearings at related agencies, survey of similar projects
Soil pollution	① Measures to prevent oil leaks during works	① Confirmation of the works contents, methods, period, types of construction machinery and equipment, operating and storage positions, etc.
Noise and vibration	① Confirmation of environmental standards, etc. (Japanese environmental standards, WHO standards, etc.) ② Distance from sources to residential areas, hospitals and schools ③ Impact during the works	① Survey of existing materials ② Site reconnaissance and hearings ③ Confirmation of the works contents, methods, period, positions, and scope, types of construction machinery, operating positions, operating periods, number of running works vehicles, their running periods, traffic lines, etc.
Land acquisition and resettlement of residents	① Confirmation of scale of land acquisition	① Related legal systems and instances, etc. ② Satellite photographs of the target area ③ Confirmation of buildings around the target road (homes, schools, medical facilities, etc.) ④ Confirmation of land use conditions around the target road based on land use maps and interviews during the site reconnaissance ⑤ Preparation of a resident resettlement plan (summary) based on the Papua New Guinea Lands Act, JICA Environmental and Social Consideration Guidelines, World Bank Operational Policy 4.12, etc.
Existing social infrastructure and social services	① Existence of homes, schools, medical facilities, etc. around the project target sites	① Survey of existing materials, hearings at related agencies, site reconnaissance
HIV/AIDS and other infections	① HIV/AIDS prevalence rate around the Project sites ② Agencies conducting related activities	① Survey of existing materials, hearings at related agencies ② Hearings at related agencies
Working environment (including labor safety)	① Labor safety measures	① Survey of similar project cases (contents of contracts with works subcontractors, etc. in similar projects)
Accidents	① Increased accidents when the bridges go into service (distribution of homes and various facilities, human moving distances, positional relationship with expected transport facilities)	① Survey of existing materials, site reconnaissance
Stakeholder discussions (SHM)	Two-stage implementation: ① Scoping plan stage	① Door to door visits, group interviews Period: around May~June 2014 Targets: Kimbe municipal employees,

Environmental Item	Survey Item	Survey Method
		MOW, NBPOL, SBLC and other major road users Contents of discussions: Purpose of survey, schedule, explanation of scoping plan

Table 1.2.9 shows the results of the environmental and social consideration survey based on the site reconnaissance, hearings at related agencies, and collection of materials.

Table 1.2.9 Environmental and Social Consideration Results

		Impact Item	Impact Evaluation in Scoping		Impact Evaluation based on Survey Results		Reason for Evaluation
			Before works During works	In service	Before works During works	In service	
	1	Air pollution	B	C	B	C	Air environment was good during the site reconnaissance; however, operation by construction machinery during the works will have an impact. Change caused by increased traffic volume after going into service will be small.
	2	Water pollution	B	B	C	N/A	According to hearings with officials of Kimbe provincial administration, there are no residents around the Project sites, however, local residents depend on nearby wells and rain-fed water for their water requirements, and the rivers are only used for fishing. On implementing a basic quality investigation of river water under the bridges using a pack test, etc., generally good measurements were obtained. Moreover, because coffering will be conducted when excavating for the bridge substructure works, there will be no major water pollution or deterioration in water quality as a result of the Project.
	3	Solid wastes	B	D	C	N/A	It will be necessary to appropriately dispose of the solid wastes generated in the Project.
	4	Soil pollution	B	D	B	N/A	Adequate control methods will be required to prevent runoff of oil, etc. from construction machinery during the works.
	5	Noise and vibration	D	D	N/A	N/A	There are no residents or buildings that are sensitive to noise and vibration around the bridges.
	6	Land subsidence	D	D	N/A	N/A	
	7	Bad odor	D	D	N/A	N/A	

		Impact Item	Impact Evaluation in Scoping		Impact Evaluation based on Survey Results		Reason for Evaluation
			Before works During works	In service	Before works During works	In service	
	8	Bottom sediment	D	D	N/A	N/A	
	9	Protected areas	B	D	C	C	Impacts on buffer zones due to construction works and change in road alignment will be limited, and impacts on river protection and animal habitats will also be small.
	10	Ecosystem	D	D	N/A	N/A	
	11	Hydrological phenomena	D	C	N/A	C	Since the bridge piers will be designed in consideration of the results of hydrological analysis, it is forecast there will be no impacts in terms of changed flow, etc.
	12	Topography and geology	D	D	N/A	N/A	
	13	Resettlement of residents	D	D	N/A	N/A	Since land around the Project sites consists of plantations and there are no residences, there will be no need for resettlement of residents.
	14	Impoverished classes	D	D	N/A	N/A	
	15	Minorities and indigenous population	D	D	N/A	N/A	
	16	Local economy (employment and means of livelihood, etc.)	D	D	N/A	N/A	
	17	Land use and use of local resources	D	D	N/A	N/A	
	18	Water use	D	D	N/A	N/A	
	19	Existing social infrastructure and social services	D	D	N/A	N/A	There are no residents or social infrastructure around the Project sites.
	20	Social capital and social organizations such as local decision making agencies, etc.	D	D	N/A	N/A	
	21	Maldistribution of damage and benefits	D	D	N/A	N/A	
	22	Clash of interests in the area	D	D	N/A	N/A	
	23	Cultural heritage	D	D	N/A	N/A	
	24	Scenery	D	D	N/A	N/A	
	25	Gender	D	D	N/A	N/A	
	26	Rights of children	D	D	N/A	N/A	
	27	HIV/AIDS and other infections	B	D	B	N/A	It will be necessary to formulate measures for preventing impacts from the influx of

		Impact Item	Impact Evaluation in Scoping		Impact Evaluation based on Survey Results		Reason for Evaluation
			Before works During works	In service	Before works During works	In service	
							workers during the works in the EMP.
	28	Working environment (including labor safety)	B	D	B	N/A	
	29	Accidents	B	B	B	B	EMP during the works and traffic safety education after the bridges go into service will be needed.
	30	Trans-boundary impacts and climate change	D	D	N/A	N/A	

A+/-: Significant negative impact is expected.
B+/-: Negative impact is expected to some extent.
C+/-: Extent of negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

2) Mitigation measures

Table 1.2.10 shows the detailed environmental impacts of Project implementation and the measures for mitigating them.

Table 1.2.10 Summary of Environmental Impact and Mitigation Measures by Work

Impact Element	Environmental Impact	Environmental Mitigation Measures
Land acquisition, clearance inside ROW, resettlement of residents, and social issues	• Loss of property and means of livelihood • Disturbances on part of affected community • Impacts from construction activities • Safety problems • Disturbance of cultural and archaeological areas	Community consultation and participation; early surveys; use of the Land Acquisition and Resettlement Framework as applicable
Bridge construction works Foundation works Superstructure works	• Sediment runoff caused by excavation in foundation works • Water pollution • Noise and vibration	a. Adoption of coffering b. Establishment of sand basins c. Introduction of low-noise and low-vibration machines
1. Civil works a. Cutting and banking on flat land b. Earth movements close to settlements/villages c. Borrow pits d. Dust and noise	• Loss of trees and grass due to slope failure and landslides; removal of topsoil, destruction of natural drainage systems • Pollution of surface water and increased sedimentation • Soil erosion caused by destruction of terrain and vegetation, destruction of	d. Prohibition of piling and measures to prevent piled materials from collapsing in sensitive areas e. Prevention of soil erosion through using of standard civil engineering materials and installation of drainage channels f. Planting of vegetation on bare land based on

Impact Element	Environmental Impact	Environmental Mitigation Measures
control e. Stone quarries and stone crushing plants f. Extraction of river gravel	natural drainage systems, accumulation of wastewater, ponds, water pollution, destruction of flora • Generation of noise, vibration and dust • Impacts on road safety, traffic congestion, and roadside vegetation • Soil erosion and accumulation due to impacts on the natural terrain, landslides and slope failure, noise, vibration and road accidents • Impacts on aquatic life due to alteration of river courses and settlement of sediments	discussions with local cooperative organizations g. Sediment runoff prevention works based on sandbags and fencing h. Establishment of drainage channels on completion of works, stabilization of ground, and scenic improvement and planting of vegetation based on community consultations i. Appropriate water sprinkling on the road and in quarries, installation of silencers, limitation of work times around inhabited areas j. River training geared to securing safety in the event of flooding
2. Paving works (roadbed, subgrade works)	• Noise and vibration • Generation of dust • Traffic accidents and safety • Impacts on roadside vegetation	a. Prevention of runoff to rivers based on appropriate management of materials (covering, appropriate stockpile management based on process planning)
3. Drainage works	• Scouring of valley slopes resulting in landslide • Disruption to natural drainage systems caused by removal of trees, vegetation and topsoil • Surface water pollution and increased sedimentation	a. Installation of appropriate drainage facilities
4. Paving works (asphalt) a. Asphalt plants b. Bitumen overlay	• Release of asphalt (bitumen) into the environment and runoff of bitumen into surface water causing water pollution • Deforestation resulting from the use of fuel wood to heat bitumen • Air pollution and bad odor • Adverse health impacts from improper use of bitumen drums e.g. as drinking water storage containers	a. Proper siting of plants away from settlements or villages, use of asphalt only on fine days; storing of bitumen drums in bunded areas; clean-up of areas after activities b. Preparation of appropriate particle sizes and application based on asphalt management c. Education for users of old bitumen drums about the dangers of using these as drinking water storage drums d.
5. Natural protection area, etc. works	• Destruction of vegetation and permanent settlement due to urbanization • Uncontrolled exploitation of natural resources in the Project areas • Increased traffic speeds along the road with likely accidents	a. Grasping of the scope of protected areas and living conditions of flora and fauna, and planning of Project contents with a view to minimizing impacts.

Impact Element	Environmental Impact	Environmental Mitigation Measures
6. Campsite Management a. Equipment mobilisation b. Labour force mobilisation c. Labour camps d. Base (construction) camps e. Materials transportation f. Increased traffic and operating speeds g. Explosives, combustibles and toxic material	• Vibrations, noise and dust generation, traffic and safety problems and damage to roadside vegetation • HIV/AIDS and other infections brought about by influx of construction workers, deforestation due to use of timber fuel, competition for scarce natural resources; pollution of surface and ground water from unsanitary waste disposal practices; illegal hunting and fishing by workers • Unplanned settlement and communities along the road • Exploitation of unmanaged natural resources in the Project area • Increased traffic speeds along the road with likely accidents • Fire and explosive hazard; ground and surface water pollution from pollution runoff; infiltration from spills and/or leaks; improperly discarded oils and lubricants	a. Minimizing the loads caused by transporting aggregate, fill materials, etc. on local residents and environment. b. Maximising local labour; providing ppropriate training and familiarization for outsiders; enforcement of rules and regulations c. Distancing of camps away from villages; and maintenance of good waste management practices so as not to impact local drinking water. d. Construction of appropriate storage areas, implementation of good waste management, removal of solid wastes and restoration of sites to their original state on completion of works e. Limiting of aggregate, chemicals and other construction materials to items that have no negative impact on the environment. f. Shortening of travel times due to road improvement, and installation of appropriate signs and speed humps during construction phase. g. Management of hazardous materials storage in marked areas to avoid possible impacts within the camp and to humans. h. Provision of proper sanitation facilities

(4) Environmental Management Plan

1) Environmental impact and mitigation measures

① Environmental countermeasures during works

i) Air pollution

In areas around aggregate (crushed stone and sand, etc.) storage yards and areas where dust is generated by the operation of large trucks and construction machines, it will be necessary to install sheet covers, spray water, comply with running speed limits, implement appropriate maintenance of construction machines, periodically spray water on roads and open spaces and so on.

Concrete plants and asphalt plants should be located over 1 kilometer away from residential and sensitive areas.

Efforts will be made to comply with environmental standards for air quality near residential areas through installing temporary enclosures and dust-protection barriers as required. During works, air quality will be regularly monitored and consideration will be given to the appropriate management of environmental countermeasures.

ii) Water pollution

Excavation work in the river may contaminate water due to effluent from excavation. Effluent from excavation will be treated through installing sand basins, and if effluent water quality exceeds the wastewater standard of PNG, necessary measures such as inserting coagulant will be implemented in order to comply with standards. Effluent from concrete plants will also need to undergo the necessary treatment.

Human wastes from offices and dormitories used by the clients, engineers and contractors should be treated by installing septic tanks so that effluents comply with wastewater standards before being discharged.

Chemical agents such as fuel and coagulant should be stored away from flood outflow with care taken to prevent ignition as a result of fire.

iii) Disposal of surplus soil and construction waste

Construction wastes will be recycled as much as possible. The contractor should organize sanitary teams to collect garbage from the work dormitories and treat it properly in cooperation with the local government.

iv) Noise and vibration

In the construction stage, noise and vibration will be very severe as a result of excavating work, large trucks, and operation of construction machines. It will be necessary to implement proper maintenance of construction machines and vehicles in order to prevent noise and vibration.

Concrete plant crushing work should be conducted at least 1 kilometer from hospitals, schools or other facilities that are sensitive to noise and vibration. Work will be limited to daytime. In case of night working, it will be necessary to give advance notifications to residents upon securing permission from the local government.

Vibrations will be periodically monitored to make sure that excavation and hammering work do not cause damage to homes and property.

Around residential areas, temporary barriers for noise reduction will be installed if necessary to uphold environmental standards. Environmental monitoring for noise will also be implemented in order to ensure proper environmental standards.

The construction contract with the contractor will include mitigation measures in the construction stage such as working time limit, safety measures for transportation, speed limit of vehicles, allocation of traffic guards and so on.

After completion of construction work, borrow pits and quarries can sometimes become deep ponds and cause accidents involving children and farm animals if left unattended. In the Project, effort will be made to ensure management responsibility and return conditions to normal in the works contract.

The contractor should assign an environmental manager and implement appropriate environmental management before the commencement of construction. The environmental management plan will include the following items.

Proper allocation of borrow pits, quarries, construction material stock yards, and asphalt plants, etc.

Transportation plan of construction materials (routes, time zones)

Allocation of surplus soil and waste treatment sites

Erosion control and stabilization in surplus soil

Wastewater collection and treatment facilities

Control of worker’s camps

Traffic control and traffic management

Noise mitigation measures such as temporary noise barriers

Dust control

Management and stock of hazardous substances such as fuel

Human waste collection and treatment

Restoration of public facilities such as drainage channels

Restoration of borrow pits and quarries

2) Environmental Monitoring

① Objective

Environmental monitoring patrols will be implemented in order to confirm existing environmental conditions around the Project sites and ensure compliance of the activities with legislation as described in the EMP.

② Organization

The supervising engineer under the Project Manager will organize an environmental patrol team comprising the environmental officer, consultant engineer, contractor's manager and environmental officer, etc.

③ Implementation method

In the environmental patrols, environmental conditions and the situation regarding implementation of mitigation measures will be confirmed according to each item based on the environmental checklist. Table 1.2.11 shows the environmental patrol checklist.

Table 1.2.11 Monitoring Plan

Environmental Item	Item (Measurement or Judgment Method)	Location	Frequency (also state the continued period when in service)	Responsible Agency
[During works]				
Air quality	Visual check	Area around works sites	Once/month	Works contractor
Noise	Basic noise meter Condition of use of designated construction machinery	Area around works sites	Once/month	Works contractor
Water quality, topography, and geology	pH, turbidity (visual measurement or basic gauge), changes in water flow based on visual check, sediment erosion and runoff conditions, etc.	Upstream and downstream of the bridge sites	Once/month	Works contractor
Changes in the local vegetation and biota	Checking for any changes in local vegetation and biota (visual check based on patrols)	Area around works sites	Once/month	Works contractor
Checking of complaints	Checking for any complaints from passers-by and local residents	Area around works sites Camp yards Areas around borrow pit works facilities	Once/month	Works contractor
[After works]				
Water quality	pH, turbidity, water temperature	Upstream and downstream of the bridge sites	Once/month	DoW

Table 1.2.12 shows the environmental monitoring form.

Table 1.2.12 Environmental Monitoring Form

Environmental Monitoring Form

Monitoring will be stated in and implemented according to the CEMP (Contractor's Environmental Management Plan) that is prepared by the contractor based on the contract documents.

1. Pollution Countermeasures

— Air quality (exhaust gas measurements and ambient air environmental measurements)

Item (unit)	Measurement (Mean value)	Measurement (Maximum value)	Local Standard	Reference International Standard	Remarks (Measurement location, frequency, method, etc.)
Dust	-	-	-	-	Areas around works sites, every day, check by visual inspection. (Where necessary, confirm the implementation of water sprinkling and other measures).

—Water quality (wastewater measurements and environmental measurements in surrounding water bodies)

Item (unit)	Measurement (Mean value)	Measurement (Maximum value)	Local Standard	Reference International Standard	Remarks (Measurement location, frequency, method, etc.)
pH		-	Difference between upstream and downstream	-	Every day during substructure works
Turbidity	-	-	There must be no difference of 25 NTU or more between the upstream and downstream.	-	50 meters upstream and downstream of the bridge works sites, every day during the substructure works, confirm by means of basic turbidity

Item (unit)	Measurement (Mean value)	Measurement (Maximum value)	Local Standard	Reference International Standard	Remarks (Measurement location, frequency, method, etc.)
					meter that uses electric conductivity.
Water temperature	-	-	Difference of 2℃ or more between upstream and downstream	-	When measuring turbidity

－Solid wastes

Monitoring Item	Conditions during the Report Period
Situation regarding treatment of construction wastes around works sites and living wastes around camps	During the works period, as a rule, conduct daily observations, give monthly reports, and ensure thorough mitigation measures where necessary.

－Noise and vibration

Item (unit)	Measurement (Mean value)	Measurement (Maximum value)	Local Standard	Reference International Standard	Remarks (Measurement location, frequency, method, etc.)
Noise level					During works that generate noise, measure noise around the works sites every day using a basic level gauge.

2. Natural Environment

－Ecosystem

Monitoring Item	Conditions during the Report Period
Conditions of vegetation and biota around the works sites	During the works period, as a rule, conduct daily visual observations, record any changes and report as necessary.

3. Social Environment

－Lifestyle, livelihood, others

Monitoring Item	Conditions during the Report Period
Contents of complaints from passers-by and other stakeholders in line with works implementation	Report to the client via the supervising consultant according to necessity.

Monitoring after construction of work shall be conducted by the DOW based on sampling and visual inspection for roughly 1 year. The monitoring result will be reported to JICA.

1. Pollution Countermeasures

－Water quality (wastewater measurements and environmental measurements in surrounding water bodies)

Item (unit)	Measurement (Mean value)	Measurement (Maximum value)	Local Standard	Reference International Standard	Remarks (Measurement location, frequency, method, etc.)
pH		-	Difference between upstream and downstream	-	Every month
Turbidity	-	-	There must be no difference of 25 NTU or more between the upstream and downstream.	-	Every month, Confirm by means of basic turbidity meter that uses electric conductivity.
Water temperature	-	-	Difference of 2°C or more between upstream and downstream	-	When measuring turbidity

2. Natural Environment

－Ecosystem

Monitoring Item	Conditions during the Report Period
Conditions of vegetation and biota around the sites	Monthly visual observations, record any changes and report as necessary.

3. Social Environment

－Traffic accidents, others

Monitoring Item	Conditions during the Report Period
Traffic accidents, Damage of facilities such as cracks of asphalt pavement or concrete structures, erosion of embankment etc. Contents of complaints from passers-by and other stakeholders.	Report to JICA according to necessity.

Table 1.2.13 shows the environemntal monitoring checklist that is given in the DOW guidelines.

Table 1.2.13 Environmental Monitoring Checklist

ENVIRONMENTAL MONITERING PATROL CHECKLIST			
(The engineer shall monitor the following parameters)		DATE & TIME:	
		Weather Condition	
		Observer and Name of Responsibility Person	
ISSUE	Parameters	Indicator	Check Result
EMG 1: LAND ACQUISITION, CLEARING OF RIGHT OF WAY, RESETTLEMENT AND SOCIAL ISSUES (The engineer in liaison with the DOW PMU and the Provincial Lands Office shall monitor)	The process of land acquisition and compensation:	Ensure that affected parties are satisfied and receive payments promptly (before commencement of works)	
	Legal requirements:	Ensure that legal requirements are being fulfilled.	
	Grievances	Ensure grievances are dealt with promptly.	
EMG 2: EARTH MOVEMENTS RELATING TO CUT AND FILL ACTIVITIES IN FLAT AREA	Stability of spoil area	Presence of slides, scouring, erosion or destruction of property in valleys, disruption of water supply systems and irrigation systems, complaints from local residents	
	Vegetative cover is maintained.	Survival rate of plants. Watchman on site.	
EMG 3: EARTH MOVEMENTS RELATING TO CUT AND FILL ACTIVITIES IN STEEP, HILLY OR UNSTABLE AREAS	Vegetative cover is maintained:	Survival rate of plants	
	Slope is stable	No evidence of mass earth movement	
EMG 4: EARTH MOVEMENTS IN THE VICINITY OF SETTLEMENTS ALONG THE ROADSIDE (SEE EMG2)	Site location:	Review location to ensure that the quarry is properly located and that material removal is being removed from approved areas only.	
EMG 5: BORROW PITS	Site is closed and stabilized:	Site landscaped, drainage lines reinstated, site re-vegetated and any compaction in access roads removed.	
	Implementation of erosion control:	No presence of fresh gullies or increased turbidity, no other evidence of erosion	
	Proper site closure:	Natural contours and	

		vegetation restored.	
EMG 6: DUST NOISE AND VIBRATION CONTROL	Compliance with requirements:	Noise, dust and vibration control procedures implemented. No visible dust generation during construction phase. Dust is acceptable within communities where contractor's vehicles are required to pass through. Noise is acceptable at the work site and within surrounding communities. Heavy compactor rollers not being used close to communities. Use is not permitted inside assessed vibration zone.	
EMG 7: OPERATION OF EXISTING QUARRY SITES (TERRESTRIAL AND RIVER)	Proper site location:	Review location to ensure that the quarry is properly located and that material removal is being done in approved areas only	
	Implementation of erosion control:	No presence of fresh gullies or increased turbidity, no other evidence of erosion.	
	Proper site closure:	Natural contours and vegetation restored.	
	Safety:	During blasting, ensure that adequate warning is given to the workers and surrounding communities.	
EMG 8: ESTABLISHMENT AND OPERATION OF STONE CRUSHING PLANTS (refer to EMG 6 & 7)			
EMG 9: CONSTRUCTION OF BASE OR SUB – BASE COURSE, REGRAVELLING (refer to EMG 6)			
EMG 10: DRAINAGE WORKS (refer to EMG 2)			
EMG 11: ESTABLISHMENT AND OPERATION OF ASPHALT PLANTS OR ASPHALT PREPARATION AREAS	Compliance with requirements:	No use of fuel wood, proper management of site.	
EMG 12: Bitumen Overlay (refer to EMG 11)			
EMG 13: PROTECTION OF NATURAL AREAS AND SENSITIVE	Compliance with requirements:	Sensitive areas avoided or measures taken to avoid impacts	

ECOLOGICAL SITES	Water Quality:	Baseline water quality to be established prior to commencement of works. This will be undertaken in all major rivers and tributary crossings to ensure that there is no compensation claim for water impacts from the project.	
CAMPSITE MANAGEMENT			
EMG 14: EQUIPMENT MOBILISATION (refer to EMG 6) EMG 15: MOBILISATION OF THE LABOUR FORCE (refer to EMG 16) EMG 16: ESTABLISHMENT AND OPERATIONS OF LABOUR CAMPS	Camp is self-sufficient in food, water and fuel:	No complaints from residents, local prices remain stable	
	Provision of water and sanitation facilities:	Latrines constructed no disruption in local water supplies.	
	Waste disposal:	Upon completion, camp site is neat and clean and no rubbish and materials remain.	
MG 17: ESTABLISHMENT AND OPERATIONS OF BASE (CONSTRUCTION) CAMPS	Provision of water and sanitation facilities:	Latrines constructed, no disruptions in local water supplies	
	Proper site closure:	Natural contours and site appearances restored. Engineer's report testifying to the restoration of the site.	
EMG 18: MATERIAL TRANSPORT (REFER TO EMG 6) EMG 19: INCREASED TRAFFIC AND OPERATING SPEEDS (refer to EMG 13) EMG 20: EXPLOSIVES, COMBUSTIBLES AND TOXIC MATERIAL MANAGEMENT	Compliance with requirements:	Hazardous materials management procedures implemented. No visible puddles of oil or oil contaminated soil.	

Source: Edited from the Guidelines for the Environmental Evaluation of Road and Bridge Infrastructure Projects (Department of Works, September 2013)

④ Report

Environmental patrol reports will be prepared by the contractor and given to the client following confirmation by the managing consultant.

3) Implementation Setup

① DoW

The DOW (PMU), i.e. the Project proponent, must assume responsibility for managing the Project and establishing the organization to satisfy the environmental requirements of the EMP. The PMU will employ the Engineer to implement the EMP under the Project Manager and assign an Environmental and Social Officer and Community Liaison Officer to the contractor's organization.

② Contractor's role

The contractor will have a major role in implementing the EMP during construction.

i. At the time of tender the contractor is required to review the EMP.

ii. The contractor is also required to include in the tender documents the role of EMP implementation manager according to the work management experience and scale of the project.

iii.Before construction commences, the contractor will review and re-submit the CEMP, which will address the works implementation plan and environmental mitigation measures stated in the EMP. It will establish the organization for implementing mitigation measures and implement the environmental monitoring. The CEMP will be submitted by the contractor to the DoW prior to starting work. The contractor can only commence work following the approval of the CEMP. A copy of the CEMP will also be sent to DEC.

iv. During construction the contractor will have the primary role of monitoring and supervising the CEMP.

v. The contractor will be required to submit monthly reports to the DoW showing how the CEMP is being implemented and monitored.

③ Reporting and Review

The contractor will submit monthly reports to DoW showing the results of CEMP implementation and monitoring. The DoW will aggregate the contractor's monthly reports into a quarterly report and together with its comments forward these as required to JICA and DEC.

4) Stakeholder consultations

Table 1.2.14 shows the results of the stakehodler meetings.

Table 1.2.14 Summary of Consultation Explanation of the Project & Hearing of Opinions at Kapiura, Aum Bridge

Data and Venue	Attendees & Designation	Request and Collected Information	Concerns/Issues
May 26, 2014	DOW: Mr. Peko, Mr. Keith	Concerning removal of the existing bridges, the local side requests the Japanese side to implement due to lack of personnel in West New Britain Provincial Office. This is stated in the M/D.	

Data and Venue	Attendees & Designation	Request and Collected Information	Concerns/Issues
May 27, 2014 DOW West New Britain Division	Mr. John Sitapai (Provincial Works Acting Manager)	West Britain Highway is the only community road, and residents will lose access to hospitals, schools and markets if the bridges are impassable.	
May 28, 2014 NBPOL SBLC	Mr. Ashiey Barnes(Head of Mini Estates) Mr. PeterS C Yiu(GeneralManager/Director), Mr. Reginald Ovasui(AdminManager)	Land in both the upstream and downstream of Aum Bridge is leased by NBPOL from the state. Land in the downstream of Kapiura Bridge is leased by NBPOL from the state, while land in the upstream is leased by SBLC, which is willing to cooperate.	Buffer Zone refers to land over 50 meters on both sides of the river, where private use is prohibited. However, public use is allowed.
May 28, 2014 JICA Office at POM	DOW: Mr. Sikam	Concerning removal of existing bridges, this can be performed with Bailey bridges, however, the local side does not have the engineering experience or equipment to remove such large-scale bridges as in the Project. It therefore requests the Japanese side to remove the bridges.	
June 30, 2014 Provincial Office Planning Division	Mr. Bill Michael Kiangua (Head of Planning Division)	General statistical data in WNB. Future planning book of WNB. Usually river water is used only for washing, bathing and recreation activities such as swimming and fishing, but not use for drinking.	Consistency of connection is necessary for the people.
June 30, 2014 Statin Bay Lumber Company	Mr. Reginald Ovasul (Admini. Manager)	Cadastral map of the plantation The bridges are very important to transport timber.	Flooding often causes driftwood, scouring and inundation around local markets. Great flood occurred in 1999 & March 2013 in Kapiura. Flood waters reached to the market near junction and water flowed over the temporary bridge at Aum. To avoid erosion harm, timber industry areas are set back 50 meters from the river. Sand gravel is not taken from the upstream of Kapiura, but sometimes is used for borrow pit.
June 30, 2014 July 2 New Britain Palm Oil Limited	Mr. Ashley Barnes (Head of Mini Estate)	Cadastral map Location of the nearest water fall observation station The bridges are absolutely necessary for transportation of gathered fruits, refined oil and workers.	Water level at Kapiura river sometimes overflows the bridge around once a year. Sometimes earthquakes occur because of volcanoes in WNB.

Data and Venue	Attendees & Designation	Request and Collected Information	Concerns/Issues
Site reconnaissance July 1	Mr. Dagwin (Dow Provincial civil Engineer) Kiangua (Head of Planning Division) Local guard man of Kapiura Bridge Local people	There is no customary land and private land around both bridges. Nearest resident areas are 5-6 km from Kapiura Bridge.	Not using successive traffic Highest water level Location of nearest residence

Source: Study Team

5) Project Implementation Schedule

Table 1.2.15 shows the Project implementation schedule.

Table 1.2.15 Project Schedule and Environmental and Social Consideration Procedure

item		Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Remarks
	Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Project Planning																
(Object, Project sites, Component, Proponent, Organization, Fundation and etc.)																
Application of the Project to DEC																
Basic Design																
IEE if necessary																
Enviromental Certificate																
Grant Aid Agreement																
Detaile Design																
Land Acquisition Procedure																
Contractor's Bidding																
Land Clearance																
Commencement of Contract																to be continued
Contractor's EMP																

Attachment

Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have assessment reports (EIA reports) been already prepared? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N (c) Y (d) N	(a) When the Project contents have been finalized, the Project proposal will be submitted from the DoW (Project proponent) to DEC. (b) (c) The bridge reconstruction Project corresponds to Category 2A in the Environmental Guidelines; thus its implementation will be approved. The DEC branch in the DOW requires preparation of the CEMP. (d)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the Project and the potential impacts been adequately explained to the local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the local stakeholders? (b) Have the comments from the stakeholders (such as local residents) been reflected to the Project design?	(a) Y (b) Y	(a) Direct hearings have been held with the stakeholders comprising WNB Province Office and bridge users NBPOL and SBLC in order to provide explanations and listen to requests. (b) The outline design results, etc. will be announced to the stakeholders as necessary. Clearance of Bridge girder during High water Level was considered in design based on user's information and request.
	(3) Examination of Alternatives	(a) Have multiple alternative plans of the Project been examined with social and environmental considerations?	(a) Y	(a) Zero option of reconstruction bridges is impossible because of no alternative road network. Road alignment and river management plans that entail changing the positions of the existing Aum Bridge and Kapiura Bridge are not feasible because they would entail acquisition of plantation and customary land and large-scale alteration of the riverside buffer zones. Reconstruction of Bridges on existing position is feasible.
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that air pollutants emitted from the Project related sources, such as vehicle traffic, will affect ambient air quality? Does ambient air quality comply with the country' s air quality standards? (b) If air quality already exceeds environmental standards near the route, is there a possibility that the Project will make air pollution worse? Are any mitigating measures for air quality taken?	(a) Y (b) N	(a) The generation of atmospheric polluting substances from passing vehicles is predicted to lead to air pollution, but the amount of DUST or other pollution substances generation over WNB is almost same with Project than without Project. (b) The emission gases will diffuse on the bridges, therefore, this Project will not lead to deterioration of air quality around the route.
	(2) Water Quality	(a) Is there a possibility that soil runoff from the bare land resulting from earth banking and cutting, etc. will cause water quality degradation in downstream water areas? (b) Is there a possibility that the Project will contaminate water sources, such as well water?	(a) N (b) N	(a) The planned approach roads are planned to be banked structures higher than the existing road due to flood water line constraints, etc. The case using banking structure for some part of the road also will be forcasted not cause water quality degradation(pH, Turbidity) with preventive measures against soil runoff such as early slope ,greening. (b) When performing excavation for bridge foundations, use of the cofferdam method can minimize the impacts.
	(3) Noise and Vi	(a) Do noise and vibrations from the vehicle and train traffic comply with the country' s standards? (b) Do low frequency sounds from the vehicle and train traffic comply with the country' s standards?	(a) Y (b) Y	(a) The noise on the bridges will be lower than noise on the flat road. If noise levels exceed the standard, There are no facilities that require protection in the local areas. (b) There are no houses near the bridges, so there will be little impact from low frequency vibration.
3 Natural Environment	(1) Protected Ar	(a) Is the Project site located in protected areas designated by the country' s laws or international treaties and conventions? Is there a possibility that the Project will affect the protected areas?	(a) N	(a) The riverside band is designated as a buffer zone based on Logging Code Practice in the Project sites and surrounding area. Taking plants and hunting are prohibited in this area, however, the impact to ecological scheme will be negligible because the
	(2) Ecosystem	(a) Does the Project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the Project site encompass the protected habitats of endangered species designated by the country' s laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate protection measures taken to prevent impacts, such as disruption of migration routes, habitat fragmentation, and traffic accident of wildlife and livestock? (e) Is there a possibility that installation of bridges and access roads will cause impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystems due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered?	(a) Y (b) N (c) N (d) N (e) N	(a) Aum Bridge and Kapiura Bridge are situated in an area of palm and eucalyptus plantations, but riverside bands of 50 meters on both sides are designated as buffer zone, where the hunting of flora and fauna is controlled in line with the objectives of river protection. (b) No valuable and protected habitats have been confirmed on the proposed route. (c) As the Project entails bridge replacement, it is expected that the impact to ecosystem will be small. (d) No large-size wildlife or farm animals have been confirmed in the Project area. (e) The Project is not expected to cause loss of existing swamp, however, when greening slopes and so on, indigenous species will be planted to ensure there is no influx of foreign species or pests.
	(3) Hydrology	(a) Is there a possibility that hydrologic changes due to the installation of structures will adversely affect surface water and groundwater flows?	(a) N	(a) Aum Bridge is planned with two spans and Kapiura Bridge with three spans. Increase in HWL due to installation of piers will be limited to 100mm, and since the cross section of piers will be negligible compared to the river cross sections, there will be hardly any increase in water line that affects upstream areas.
	(4) Topography a	(a) Is there any soft ground on the route that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there a possibility that civil works, such as banking and cutting will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? (c) Is there a possibility that soil runoff will result from bank and cut areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(a) N (b) N (c) N	(a) The Project area has such terrain that slope failures or landslides are not likely to be induced. Moreover, excavation works of the type that cause major topographical transformation will not be implemented. (b) The bridge approaches will basically be banked structures, which will be designed and constructed with steps to ensure that slope failures or landslides do not occur. Specifically, banking will be designed based on application of PNG's earthwork standards while also referring to Japanese standards. Up to the 100-year flood water line (HWL), banking will either comprise gabion (retaining wall) or be covered by gabion for slope protection. On surfaces above the HWL, slope protection will be provided by planting indigenous species (grass). (c) For the establishing and running the waste soil disposal sites

4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by Project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is compensation going to be paid prior to the resettlement? (e) Is the compensation policy prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) N (b) N (c) N (d) N (e) N (f) N (g) N (h) N (i) N (j) N	(a) Aum and Kapiura bridges are located around land leased from the state and used for plantations, so there are no residents or inhabited buildings for a few kilometers in the surrounding area. (b) (c) (d) (e) (f) (g) (h) (i) (j)
	(2) Living and L	(a) Where bridges and access roads are newly installed, is there a possibility that the Project will affect the existing means of transportation and the associated workers? Is there a possibility that the Project will cause significant impacts, such as extensive alteration of existing land uses, changes in sources of livelihood, or unCEMPloyment? Are adequate measures considered for preventing these impacts? (b) Is there any possibility that the Project will adversely affect the living conditions of the inhabitants other than the target population? Are adequate measures considered to reduce the impacts, if necessary? (c) Is there any possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the Project? Are adequate considerations given to public health, if necessary? (d) Is there any possibility that the Project will adversely affect road traffic in the surrounding areas (e.g., increase of traffic congestion and traffic accidents)? (e) Is there any possibility that Project will impede the movement of inhabitants? (f) Is there any possibility that bridges will cause a sun shading and radio interference?	(a) N (b) N (c) Y (d) N (e) N (f) N	(a) The works will create CEMPloyment opportunities for local residents living over a few kilometers from the sites. (b) There are no inhabitants. (c) To prevent the immigration of infectious diseases such as HIV in line with the immigration of workers, measures will be planned and implemented through lectures, etc. at the phase of CEMP during construction. (d) During construction, there will basically be no impact on local traffic because the existing road will be secured, however, measures to counter congestion caused by the work and works vehicles will be examined and implemented in the CEMP. (e) (f)
	(3) Heritage	(a) Is there a possibility that the Project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) There are no valuable heritage or historical sites of the archaeological, historical, cultural, or religious variety in the Project area, and no areas that are protected under domestic law.
	(4) Landscape	(a) Is there a possibility that the Project will adversely affect the local landscape? If that is the case, are necessary measures taken?	(a) N	(a) Both Aum Bridge and Kapiura Bridge will be designed to blend with the surrounding landscape through adopting appropriate color coating for girders and so on.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) Y	(a) There are no residential areas of ethnic minorities and indigenous peoples in and around the Project area. (b) The rights of ethnic minorities and indigenous peoples are respected based on law, etc.
	(6) Working Conditions	(a) Is the Project proponent not violating any laws and ordinances associated with the working conditions of the country which the Project proponent should observe in the Project? (b) Are tangible safety considerations in place for individuals involved in the Project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the Project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the Project not violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) The environment for workers will be upheld based on labor law ordinances concerning work times, break times, and worker health and safety. (b) In the works CEMP that is prepared in the D/D phase, safety measures will be considered. (c) In the works contract, it will be required to prepare a safety plan containing safety management measures such as appointment of a safety manager, and implementation will be thoroughly enforced. (d) In implementing the Project, stakeholder consultations will be frequently held, and the works contract will require appointments of an Environmental, Health and Safety Officer and Community Liaison Officer, etc. according to the PNG environmental guidelines.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) N (c) N	(a) In the D/D phase, adequate pollution mitigation measures to reduce impact during the construction based on both national and international standards will be examined and stated in the CEMP and their implementation will be guaranteed. (b) In the case where tree cutting arises in the buffer zone in the upper reaches of Kapiura River, reforestation, etc. will be implemented as necessary. (c) In the D/D phase, the possibility of traffic congestion or maldistribution of benefits will be examined and countermeasures will be stated in the RAP or CEMP and their implementation will be guaranteed.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) Y	(a) Monitoring of the natural environment comprising air quality, noise, water quality, etc. during works will be planned in the CEMP and implemented. (b) The CEMP/MD will stipulate that the existence of variations in the natural environment comprising air quality, noise, surface water, groundwater, plant ecology, etc., should be grasped by sampling and visual inspection during and after construction for roughly 1 year. (c) The monitoring framework will be drafted in the CEMP and incorporated into the construction contract. (d) The CEMP/MD will stipulate that, except in emergencies,

6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Roads, Railways and Forestry Projects checklist should also be checked (e.g., Projects including large areas of deforestation). (b) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., Projects including installation of power transmission lines and/or electric distribution facilities).	(a) N (b) N	(a) Because new bridges replacing the existing ones will be constructed on land adjoining the existing road, there will be no major deforestation. (b)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to trans-boundary or global issues should be confirmed (e.g., the Project includes factors that may cause problems, such as trans-boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) Being a small-scale Project, it will not have much of an impact.

Note 1) Regarding the term "Country' s Standards" mentioned in the above table, in the event that environmental standards in the country where the Project is located diverge significantly from international standards, appropriate environmental considerations need to be made. In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

Note 2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the Project and the particular circumstances of the country and locality in which the Project is located.

1.2.3 Traffic Volume Survey and Future Traffic Volume Estimation

(1)Traffic Volume Survey

Traffic volume survey was implemented with the aims of grasping current traffic conditions around the Project sites, estimating the future traffic volume necessary for deciding the bridge design and road specifications, and setting the design traffic volume and design load.

1) Outline of survey

① Implementation dates

- June 15, 2014 (Sunday) 6: 00~18: 00: Traffic volume survey and OD survey (Holiday, 12 hours)
- June 16, 2014 (Monday) 6: 00~18: 00: Traffic volume survey and OD survey (Weekday, 12 hours)
- June 17, 2014 (Tuesday) 8: 00~16: 00: Axle load survey

② Survey location

- Traffic volume survey - 2 locations: Mai JCT, Shilanga Town
- OD survey – 2 locations: Mai JCT, Shilanga Town
- Axle load survey – 3 locations: Kimbe Port, Kumbango Mill (NEBOL), SBLC headquarters (front road)

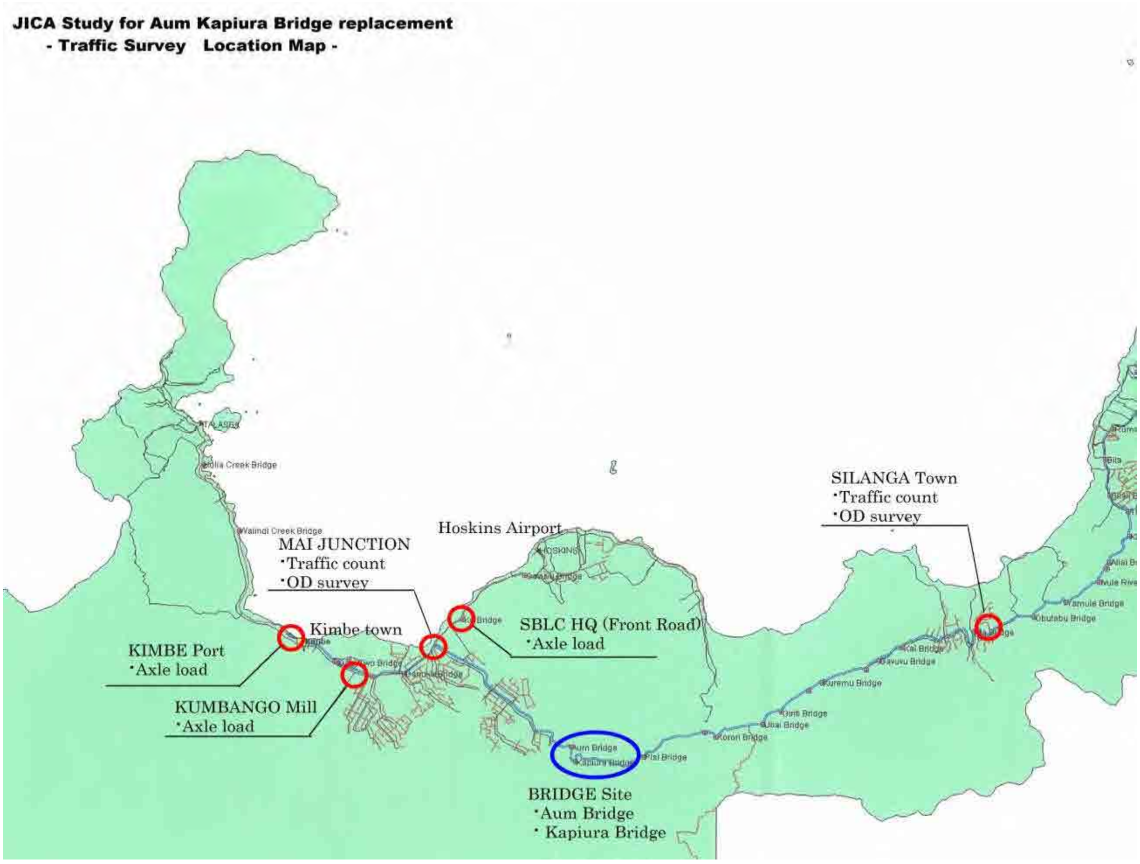


Figure 1.2.16 Map of Surveyed Locations

2) Contents of survey

① Traffic volume survey / OD survey

In the traffic volume survey, the number of running vehicles was measured at each location according to vehicle type, time zone, and direction. Together with the traffic volume survey, an OD survey was also implemented based on direct interviews with the drivers of all the surveyed vehicles.

Questions in the interview targeted vehicle type, type of ownership (personal or business), address of origin and facility of departure (classification), address of destination and intended facility (classification), purpose of travel, number of passengers, and contents of freight (in cases of freight vehicles), etc.

The surveys were continuously implemented for 12 hours between 06:00 and 18:00.

② Axle load survey

In order to avoid road accidents and congestion, survey was implemented at the following three locations with cooperation from NBPOL and SBLC.

- Kimbe Port
- Kumbango Mill (NBPOL)
- SBLC headquarters (front road)

3) Implementation results

① Traffic volume survey

i) Mai JCT

- Weekday (June 16, 2014)

Weekday traffic volume excluding two-wheel vehicles was heaviest between Hoskins－Kimbe with 920 vehicles traveling in both directions. In the direction of Vidija via Kapiura Bridge and Aum Bridge, there were 483 vehicles traveling in both directions to and from Kimbe, and 83 vehicles traveling to and from Hoskins. These two values represent only approximately 53% and 10% respectively of traffic volume between Kimbe and Hoskins.

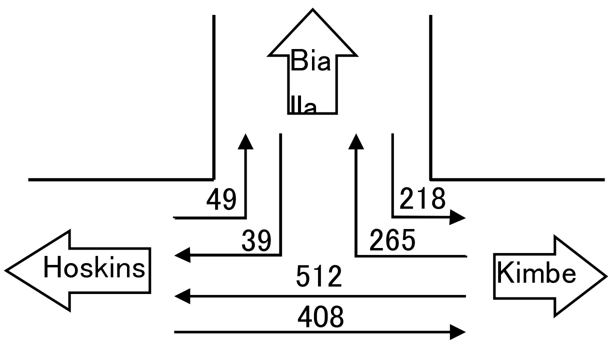


Figure 1.2.17 Traffic Volume in Each Direction (Weekday 12 hours, excluding two-wheel vehicles)

- Holiday (June 15, 2014)

Holiday traffic volume excluding two-wheel vehicles was 731 vehicles overall, corresponding to roughly 49% of the weekday volume. In terms of route, as on the weekday, traffic was heaviest between Hoskins－Kimbe with 433 vehicles traveling in both directions. In the direction of Vidija via Kapiura Bridge and Aum Bridge, there were 183 vehicles traveling in both directions to and from Kimbe, and 116 vehicles traveling to and from Hoskins. These two values represent only approximately 42% and 27% respectively of traffic volume between Kimbe and Hoskins.

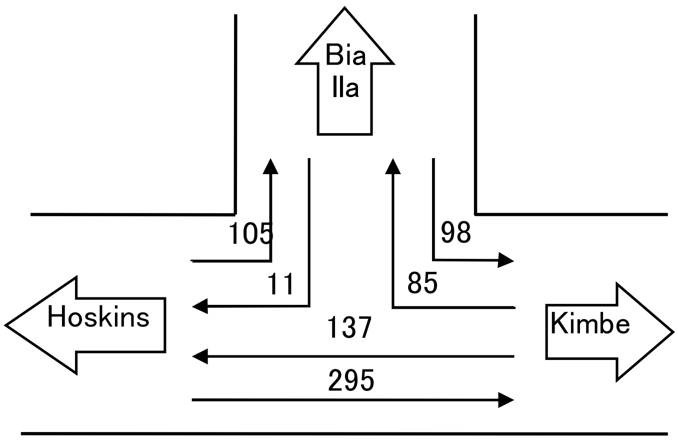


Figure 1.2.18 Traffic Volume in Each Direction (Holiday 12 hours, excluding two-wheel vehicles)

ii) Silanga

- Weekday (June 16, 2014)

Traffic volume in both directions excluding two-wheel traffic was extremely light at 142 vehicles over 12 hours.

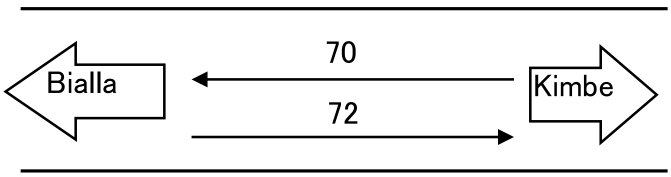


Figure 1.2.19 Traffic Volume by Direction (Weekday 12 hours, excluding two-wheel vehicles)

➢ Holiday (June 15, 2014)

Traffic volume in both directions excluding two-wheel traffic was extremely light at 86 vehicles over 12 hours, corresponding to 61% of the volume on the weekday.

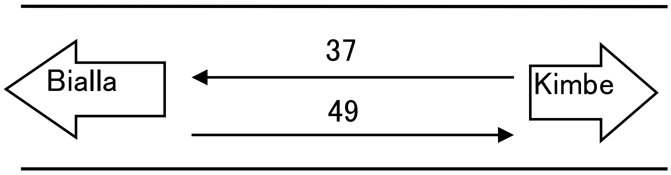


Figure 1.2.20 Traffic Volume by Direction
(Holiday 12 hours, excluding two-wheel vehicles)

② OD survey

The OD survey, like the traffic volume survey, was implemented at the two locations of Mai JCT and Silanga. Using the OD survey sheet that was prepared in advance, drivers were directly asked about their origin, destination, purpose of travel, number of passengers, type of freight, load weight and so on.

According to the findings, on the weekday, travel for business purposes accounted for more than 90% of traffic at both Mai JCT and Silanga, while this figure dropped to 70% with travel for private reasons rising to approximately 30% on the holiday.

③ Axle load survey

The heaviest axle load was found to be 14.97 tons on the timber carrying trucks (5 axle) of SBLC. In terms of maximum vehicle weight, a truck of the same variety weighing 60.58 tons was confirmed.

Meanwhile, vehicles owned by NBPOL were palm oil-carrying trucks (6-axle tank lorries) with maximum axle weight of 10.4 tons and maximum total weight of 51.99 tons. The same company’s fruit-carrying trucks (3-axle and 4-axle) had maximum axle weights of 11.92 tons (3-axle) and 11.36 tons (4-axle), and maximum total weights of 31.50 tons (3-axle) and 35.44 tons (4-axle).

The results of the axle load survey and traffic volume survey have been converted to “standard axle weight or wheel load” for use in design of road paving thickness. Specifically, when calculating DBST paving thickness according to Road Note 31, it is converted to the equivalent standard axle load (8.16 tons) traffic volume (esa) and impacts calculation of paving thickness. Moreover, concerning the heated asphalt paving thickness, it is converted to the N49 wheel load in the TA method and thus again has an impact on determination of the paving thickness.

Also, in bridge design, T44 and T66 (overload) are regarded as design live loads in Papua New Guinea, so passage by 66-ton vehicles is already taken into account. In the survey here, the maximum axle load was 14.97 tons (≒T66 axle load 14.7 tons) and maximum weight was 60.58 tons (<T66 vehicle weight 66 tons), confirming the validity of these load settings.

(2)Future Traffic Volume Estimation

1) Registered number of vehicles

In estimating the future traffic volume, survey was also conducted on the registered number of vehicles.

Upon confirming vehicle statistics obtained with cooperation from West New Britain provincial administration, the number of registered vehicles over the most recent 10 years (2004~2013) increased steadily between 2004 and 2011, reaching a peak of 3,145 vehicles in 2011, but it has declined slightly in recent years and was 2,832 vehicles in 2013 (see Figure 1.2.21)

VEHICLE STATISTICS FOR 10 YEARS										
Province	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WEST NEW BRITIAN	2028	2081	2231	2330	2700	2892	2989	3,145	2,885	2,832
	2028	2081	2231	2330	2700	2892	2989	3,145	2,885	2,832

Figure 1.2.21 Number of Vehicles in WNB Province
(Source: Motor Vehicle Insurance Limited)

Looking at the trend of registered new vehicles for the past five years (2009~2013) obtained in the same way as above, the number has declined slightly over this period, indicating that the demand for vehicles is not growing (see Figure 1.2.22).

The data provider suggested the following two reasons for the decline in vehicle registrations:

- Current owners are choosing not to renew vehicles.
- Imports of vehicles have declined following the imposition of an 80% import tariff by the PNG customs authorities in 2013.

New Vehicles Growth for 5 years					
Province	2009	2010	2011	2012	2013
WEST NEW BRITIAN	2,071	997	753	610	469
	2,071	997	753	610	469

Figure 1.2.22 Number of New Registered Vehicles in WNB Province
(Source: Motor Vehicle Insurance Limited)

2) Future traffic volume estimation

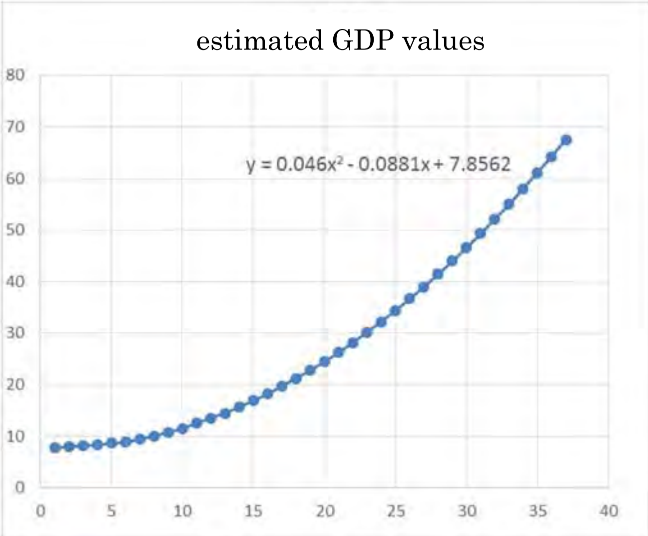
From the results of the survey of the number of registered vehicles, no increase in future traffic volume can be recognized at present. However, the target road is the only trunk road in the Project area and improvement projects are being advanced under direct jurisdiction of the Government of Papua New Guinea.

Therefor, in this project, as well as the BRIRAP project that precedes the same route, assuming an increase in traffic volume that was used as an index to the country's economic growth rate, it is assumed to use the traffic volume after 20 years as planned traffic volume.

Tsble 1.2.16 Actual GDP

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Kina (×10^6)	7.75	7.91	8.25	8.30	8.63	8.82	9.45	10.08	10.70	11.51	12.53	13.49

※ created based on BRIRAP project report



Year	GDP Kina (×10^6)	Vs 2014	Year	GDP Kina (×10^6)	Vs 2014
2014	15.6402	1.0000	2024	32.2402	2.0614
2015	16.8862	1.0797	2025	34.4062	2.1999
2016	18.2242	1.1652	2026	36.6642	2.3442
2017	19.6542	1.2566	2027	39.0142	2.4945
2018	21.1762	1.3540	2028	41.4562	2.6506
2019	22.7902	1.4572	2029	43.9902	2.8126
2020	24.4962	1.5662	2030	46.6162	2.9805
2021	26.2942	1.6812	2031	49.3342	3.1543
2022	28.1842	1.8020	2032	52.1442	3.3340
2023	30.1662	1.9288	2033	55.0462	3.5195
			2034	58.0402	3.7110

※ created based on BRIRAP project report

Figure 1.2.23 Future Estimated values of GDP

Result of traffic volume survey and field survey, roadside area of the target line has not been urbanization. Night of traffic volume is in the extremely low situation. Therefor, Day 12 hours traffic volume in MAI JCT (BIALLA cross section) can be regarded as a daily traffic volume.

Table 1.2.17 shows the future traffic volume (2034) calculated from the 12-hour traffic volume at Mai JCT (Bialla cross section) in the traffic volume survey.

Table 1.2.17 Estimated Traffic Volume

Type	Traffic Volume: Weekday	Traffic Volume: Holiday	Remarks
Result of traffic volume survey	571	299	
Total traffic volume of weekdays and holidays	148,868	31,181	Weekday：365*5/7 Holiday：365*2/7
Total annual traffic volume	180,049		
Annual average daily traffic volume (2014)	493		180,049 / 365
Future traffic volume (2034)	1,830		GDP growth rate (versus 2014)＝3.7111

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Superior Objectives and Project Goals

The Government of Papua New Guinea has compiled PAPUA NEW GUINEA VISION 2050, which depicts the state vision for 2050, the Papua New Guinea Development Strategic Plan 2010-2030 (DSP), which describes the concrete goals for realizing this, and the Medium Term Development Plan 2011-2015 (MTDP), which links directly to measures for the coming five years consistent with the DSP. As the goal for highways in the transport sector, the MTDP aims to increase the length of national highways from 8,460 kilometers (of which 29% comprises roads in good condition) in 2010 to 10,000 kilometers (65% in good condition) by 2015. Roads in good condition here refer to roads that are paved, are equipped with drainage facilities that protect the road structure, and have bridges in sound condition. The strategy for achieving this goal comprises the following measures: 1) improvement and rebuilding of 16 priority national highways and repair of other national highways, 2) construction of missing links on the 16 national highways, 3) construction of eight economic corridors, 4) construction and repair of local roads, and 5) strengthening of traffic safety and education.

New Britain Highway, which is one of the abovementioned 16 priority national highways, is a trunk road of 229 kilometers (paved section of 106 kilometers, unpaved section 123 kilometers) linking Kimbe, the capital city of West New Britain Province, with Rabaul close to the border with East New Britain Province, and it has 38 major bridges along the route. This road passes through wide expanses of oil palm plantations, which are regarded as key industrial infrastructure together with the timber industry, which is another key sector. Currently on New Britain Highway, the Bridge Replacement for Improved Rural Access Project (BRIRAP), which entails replacing single-lane deteriorated Bailey bridges with two-lane new bridges in 12 locations, is in progress. When this is finished, resulting in improvement of load bearing capacity, elimination of single-lane sections, and shortening of travel times, the functions of New Britain Highway will be greatly improved.

The Project aims to conduct rebuilding, improvement of load bearing capacity, and shortening of travel times through adoption of two lanes on Kapiura Bridge and Aum Bridge, which are two large bridges not targeted by BRIRAP and where traffic delays are occurring. In doing so, the Project intends to improve accessibility to markets and contribute to economic development not only in West New Britain Province but all of Papua New Guinea.

2.1.2 Outline of the Project

The Project, which constitutes part of the program to improve New Britain Highway, entails the rebuilding of Kapiura Bridge, which has become damaged due to flooding and deterioration, and Aum Bridge, which has collapsed following a collision with a large vehicle.

The following benefits will be obtained through rebuilding these bridges.

a) Safe passage of large vehicles (improvement in bridge load bearing capacity: T33→T44)

b) Shortening of transportation times (increase of travel speeds through resolution of single-lane traffic)

c) Mitigation of risks arising from flood disasters (abolition of the Aum temporary bridge)

d) Mitigation of risks arising from traffic accidents (improvement of alignment and adoption of dual lanes on Aum Bridge)

e) Mitigation of traffic control work (abolition of the gate on Kapiura Bridge)

f) Promotion of river utilization (establishment of steps leading to rivers)

g) Increase of physical distribution

Source: JICA Study Team

Note) The bridges indicated in red are the bridges targeted in the Project; and those in blue are targeted by BRIRAP and the Major Bridge Survey (ADB).

Figure 2.1.1 Map of Target Structures

2.2 Outline Design of the Japanese Assistance

2.2.1 Design Policy

(1) Basic Policy

The request of the Government of Papua New Guinea regarding the basic design is for the rebuilding of Kapiura Bridge and Aum Bridge on West New Britain Highway. On Kapiura Bridge, repeated passage by heavy vehicle convoys has caused torsional oscillation over the entire bridge, as a result leading to the fatigue cracking of hanging members. To address the situation, the Government of Papua New Guinea in 2004 conducted reinforcement of the lower lateral bracing aimed at enhancing torsional rigidity, and it also installed a gate at the bridge entrance as a means of preventing heavy vehicle convoys. Kapiura Bridge also has deformed stiffening girders and has lost its balustrades due to logs and so on crashing into it during floods.

Aum Bridge is a lower deck truss bridge constructed over Aum River in a section where the national highway descends steeply and curves sharply at the bottom of a valley. The portal bracing and end posts of the bridge have been damaged by a large vehicle that collided with the bridge when it couldn't turn at the steep curves, and the bridge is currently in a collapsed state supported by temporary pillars.

When rebuilding the two damaged bridges, in addition to eliminating the causes of the damage, the bridges will be planned according to modern technological standards that are more than 30 years more up to date than when the bridges were originally constructed. The following paragraphs describe the concrete basic policy of design.

Basic Policy-1 Secure safe running

Considering the past experience where a vehicle collided with Aum Bridge, the policy shall be to establish road alignment that enables safe running. Also, rather than a lower deck bridge, adoption of an upper deck bridge shall be prioritized.

Basic Policy-2 Bridge plan that mitigates the risks of flood damage

In addition to setting high water line (HWL) that is underpinned by hydraulic examination, the policy shall be to adopt plans that mitigate the flood disaster risk while referring to the Japanese Government Ordinance concerning Structural Standards for River Management Facilities, etc. Also, the forecast river bed scouring depth shall be calculated and incorporated into the design and, referring to Australian standards, the driftwood load caused by 2000-year flooding shall be targeted in the design.

Basic Policy-3 Realization of economical bridges

Since the target bridges cross rivers in a single span, they are constructed as lower deck bridges in consideration of the bridge scale and topographical conditions. Adopting the current technological standpoint, since it is deemed possible to construct bridge piers inside the river without adversely affecting economy, the policy shall be to adopt generally economical upper deck bridges with span length of no greater than 50 meters assuming the establishment of bridge piers.

Basic Policy-4 Secure consistency with projects by other donors

In the Bridge Replacement for Improved Rural Access Project (BRIRAP) being implemented under funding from the ADB, it is planned to replace 12 bridges on New Britain Highway. Detailed design for this has been finished, and contractors are currently being selected. Moreover, in the Major Bridge Study that was also financed by the ADB, it is planned to replace eight bridges on New Britain Highway. In these projects, since important themes are to abolish single-lane bridges that can only permit alternate passage and to increase the load bearing capacity from T33 to T44, it is necessary to secure consistency with these specifications in this preliminary survey too. Consistency will be actively sought regarding the following items.

1) Design standards

Table 2.2.1 and Table 2.2.2 show the design standards that are being used in BRIRAP (ADB). In bridge design, priority has been given to Australian standards, except for seismic design where Japanese standards have been adopted; however, in this preliminary survey, considering that primarily Japanese products will be used, it has been agreed with the DoW to apply Japanese Design Specifications for Highway Bridges based on JIS. Concerning design live load too, upon comparing the Papua New Guinea design live loads (used in BRIRAP) and the B live loads in the Japanese Design Specifications for Highway Bridges, it has been decided to adopt the B live loads.

Table 2.2.1 Design Standards and Manuals Issued in Papua New Guinea

No	Title and Contents	Issue Date	Remarks
1	Specification for Road and Bridge Works	1995, August	
2	Road Design Manual	1994, June	
3	Goods Procurement Manual Ver.3	2005, March	
4	Flood Estimation Manual	1990, December	Published by PNG DOE, CBOW
5	Earthquake Engineering for Bridge in Papua New Guinea	1985 Revision	DOW
6	River Training Manual	1987	DOW
7	Standard Engineering Drawings Bridge/Road	2008	DOW

Table 2.2.2 Other Reference Standards in ADB Projects

No	Title and Contents	Issue Date	Remarks
1	Design Specifications for Highway Bridges	2012	Japan
2	AS5100 and supplements	2004~2007	Australian Bridge Design Standards

2) Road width and bridge width

Emphasizing uniformity along the route, the same widths as adopted in the ADB projects will be adopted as shown in Figure 2.2.1 and Figure 2.2.2.

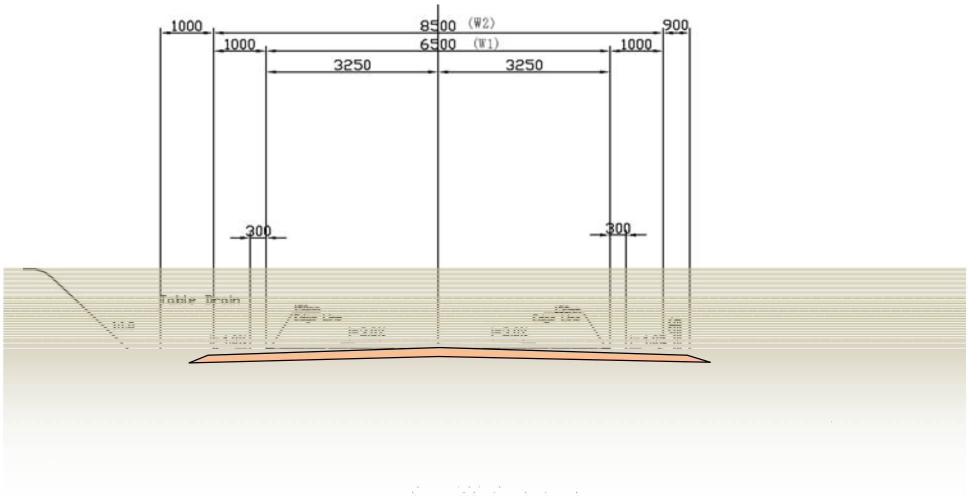


Figure 2.2.1 Standard Width of Road

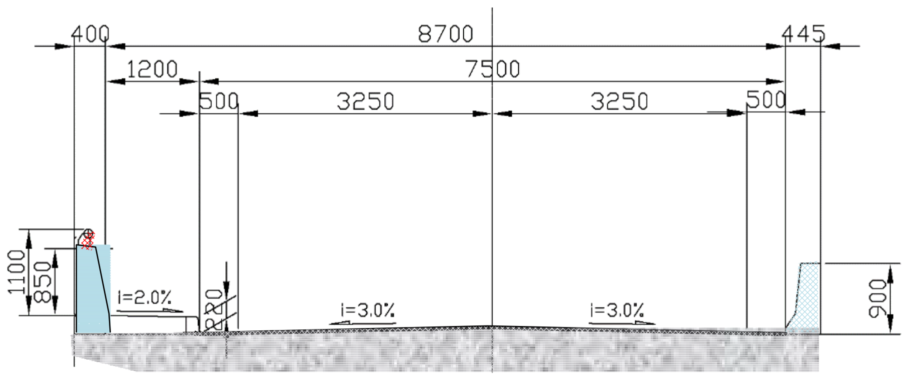


Figure 2.2.2 Standard Width of Bridge

3) Design live load

The B live load defined in the Japanese Design Specifications for Highway Bridges will be used. → See 2.2.1(3)1).

4) Earthquake resistance design

The Japanese Design Specifications for Highway Bridges, Part V Seismic Design will be applied. → See 2.2.1(2)3).

(2)Policy regarding Natural and Environmental Conditions

1) River characteristics

① Outline of the catchment basin

i) Kapiura River

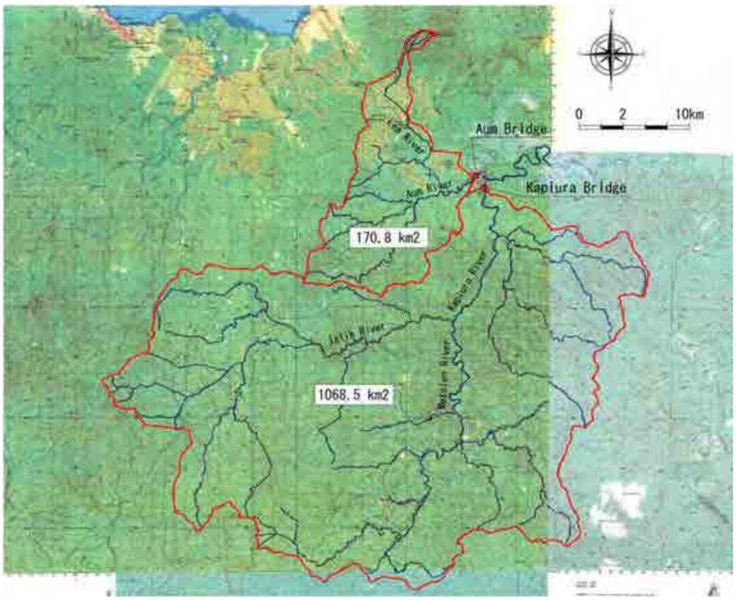
Kapiura River originates in the central mountain forests of New Britain Island and also receives waters from Iglik River in the west and Metelen in the south. After heading north and merging with Aum River from the west, it changes direction to the northeast. Further tributaries such as Laeuru River converge before it flows through the flood plain and reaches Commodore Bay. The catchment basin mostly consists of natural mountain forest (Montane forest). At the Kapiura Bridge point, where the river intersects with New Britain Highway, the river has a wide basin that stretches for approximately 45 kilometers from east to west and 35 kilometers from north to south, and the basin area is approximately 1,068.5 square kilometers (see Figure 2.2.3).

The riverbed gradient is steep at between 1/50~1/100 in mountain areas but it becomes a gentler 1/330 in the lower reaches after merging with Iglik River and Metelen River.

ii) Aum River

Aum River, a tributary of Kapiura River, has a basin that stretches for approximately 15 kilometers from east to west and 20 kilometers from north to south and covers an area of approximately 170.8 square kilometers (see Figure 2.2.3). As the river flows eastwards, Lea River converges from the north, and it merges with Kapiura River downstream of Kapiura Bridge. Unlike the case of Kapiura River, land use in the catchment basin largely comprises plantations and farmland (agricultural ecosystem).

The riverbed gradient is steep at 1/40 in mountain areas but it becomes a gentler 1/300 in the lower reaches.



Source: Prepared by the Study Team based on the 1/10,000 topographical map

Figure 2.2.3 Catchment Basin Map

② River channel characteristics at the bridge points

i) Kapiura Bridge

Concerning the river channel cross section around Kapiura Bridge, the riverbank is approximately 8 meters high and the river channel is more than 100 meters wide. The riverbanks are densely vegetated and it wasn't possible to confirm signs of riverbank erosion and scouring by visual inspection. In the hearing survey, however, it was confirmed that riverbank erosion and scouring have occurred at numerous locations on the upstream side of Kapiura Bridge. As for the riverbed materials, judging from visual inspection, there was a lot of gravel with particle sizes of a few centimeters. Large-size driftwood could also be observed floating in the local area. The riverbed gradient around the bridge section is 1/500.

Concerning past floods, the results of conducting hearings with the Kapiura Bridge guardhouse and the DOW are as follows.

- In recent years, major flooding has occurred in 1999 and March 2013.
- In the flooding of March 2013, the bridge surface and surrounding area were inundated.
- In the flooding of 2007, driftwood collided with the bridge and broke the balustrade fencing.

a) Looking upstream from Kapiura Bridge	b) Balustrade fencing damaged by driftwood	c) Floating driftwood

Figure 2.2.4 River Channel Conditions around Kapiura Bridge

ii) Aum Bridge

Around Aum Bridge, the riverbank is approximately 7~8 meters high and the channel is around 50 meters wide, meaning that there is greater relative height than compared to around Kapiura Bridge. It wasn't possible to confirm signs of riverbank erosion and scouring by visual inspection or in the hearing surveys. Riverbed materials mainly consist of gravel but with smaller particle size than around Kapiura Bridge. The riverbed gradient around the bridge section is 1/400. A temporary bridge comprising banked earth structure has been constructed immediately downstream of Aum Bridge, and as a result the river gradient differs between the upstream and downstream. Moreover, since the temporary bridge causes afflux, it is desirable to remove it when replacing the bridge, however, it will be necessary to pay close attention to the flow regime after the bridge has been removed.

Concerning past floods, as a result of conducting hearings at the DOW and NBPOL, there has been no record of Aum Bridge being inundated in the past, however, water did flow over the temporary bridge during the flooding of March 2013.

		
a) Looking upstream from the temporary bridge	b) Looking downstream from the temporary bridge	c) Traces of high water

Figure 2.2.5 River Channel Conditions around Aum Bridge

2) Hydraulic and hydrological characteristics

① Rainfall analysis

Using the rainfall data at Dami Station, rainfall analysis was implemented and daily rainfall was calculated according to each return period. The rainfall analysis was conducted for both the annual maximum daily rainfall (yearly value) and upper maximum daily rainfall over the observation period (non-yearly value), and values were adopted on the safe side. In addition, for the probable daily rainfall in Kapiura River basin, a correction value of 1.23 was multiplied by the probable daily rainfall at Dami Station. Table 2.2.3 shows the results of the rainfall analysis.

The daily rainfall at Dami Station during the biggest floods of recent years in March 2013 was 208.2 mm/day, indicating that rainfall on the 6~7 year scale occurred.

Table 2.2.3 Probable Daily Rainfall in Kapiura River Basin and Aum River Basin

Return Period	Daily Rainfall (mm)		
	Dami Station	Kapiura River Basin	Aum River Basin
2-year	142.4	175.2	142.4
5-year	196.1	241.2	196.1
10-year	245.0	301.4	245.0
20-year	305.3	375.5	305.3
50-year	428.9	527.5	428.9
100-year	572.8	704.5	572.8

② Discharge analysis

Since flow observations are not conducted on Kapiura River and Aum River, discharge at the bridge points was calculated based on the Papua New Guinea Flood Estimation Manual, 1990. Table 2.2.4 shows the discharge according to each return period.

Table 2.2.4 Discharge by Return Period in Kapiura River Basin and Aum River Basin

Return Period	Discharge (m^3/s)		Remark
	Kapiura Bridge	Aum Bridge	
2-year	1,250 (1,203)	300 (265)	Serviceability loading
5-year	1,500 (1,478)	350 (341)	
10-year	1,700 (1,661)	400 (391)	
20-year	1,850 (1,835)	450 (439)	Revetment
50-year	2,050 (2,049)	500 (499)	
100-year	2,250 (2,222)	550 (547)	Bridge clearance
2000-year	3,750 (3,713)	950 (908)	Ultimate loading

3) Earthquake resistance design

Situated on the boundary of the Philippine Plate, Australia Plate, and Pacific Plate, Papua New Guinea has a lot of seismic activity and a relatively high earthquake occurrence probability.

Referring to the earthquake resistance standard currently used in Papua New Guinea, comparison was implemented between the earthquake acceleration response spectrum (reoccurrence period 600 years) for verifying bridge collapse and the "L1, Type 1 spectrum" in the Japanese Design Specifications for Highway Bridges, Part V Seismic Design. The results are shown in Figure 2.2.7.

As may be gathered from Figure 2.2.7, the response spectrum in the Design Specifications for Highway Bridges is slightly larger than the Papua New Guinea standard but is deemed to be roughly the same. However, the Papua New Guinea standard was revised in 1985 and is relatively old, and because the references used for the design regulations and methods are relatively dated, it would not be practically feasible to apply this standard to the design here. In contrast, the Japanese earthquake resistance standard has been revised and design techniques have been established in light of recent major earthquake experience, so it is deemed more appropriate for application to bridges in the seismically active country of Papua New Guinea.

Accordingly, upon holding discussions with DoW officials in Papua New Guinea, it was decided to conduct design using the Japanese Design Specifications for Highway Bridges, Part V Seismic Design.

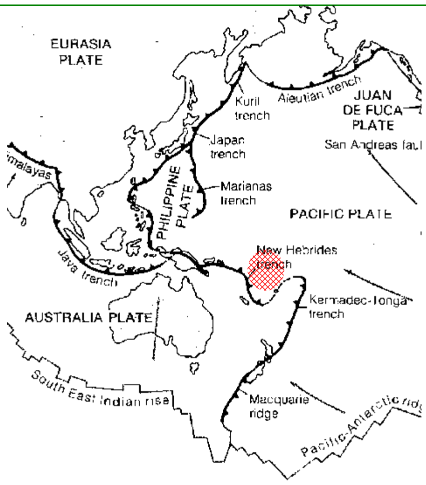


Figure 2.2.6 Plate Boundaries and Bridge Positions

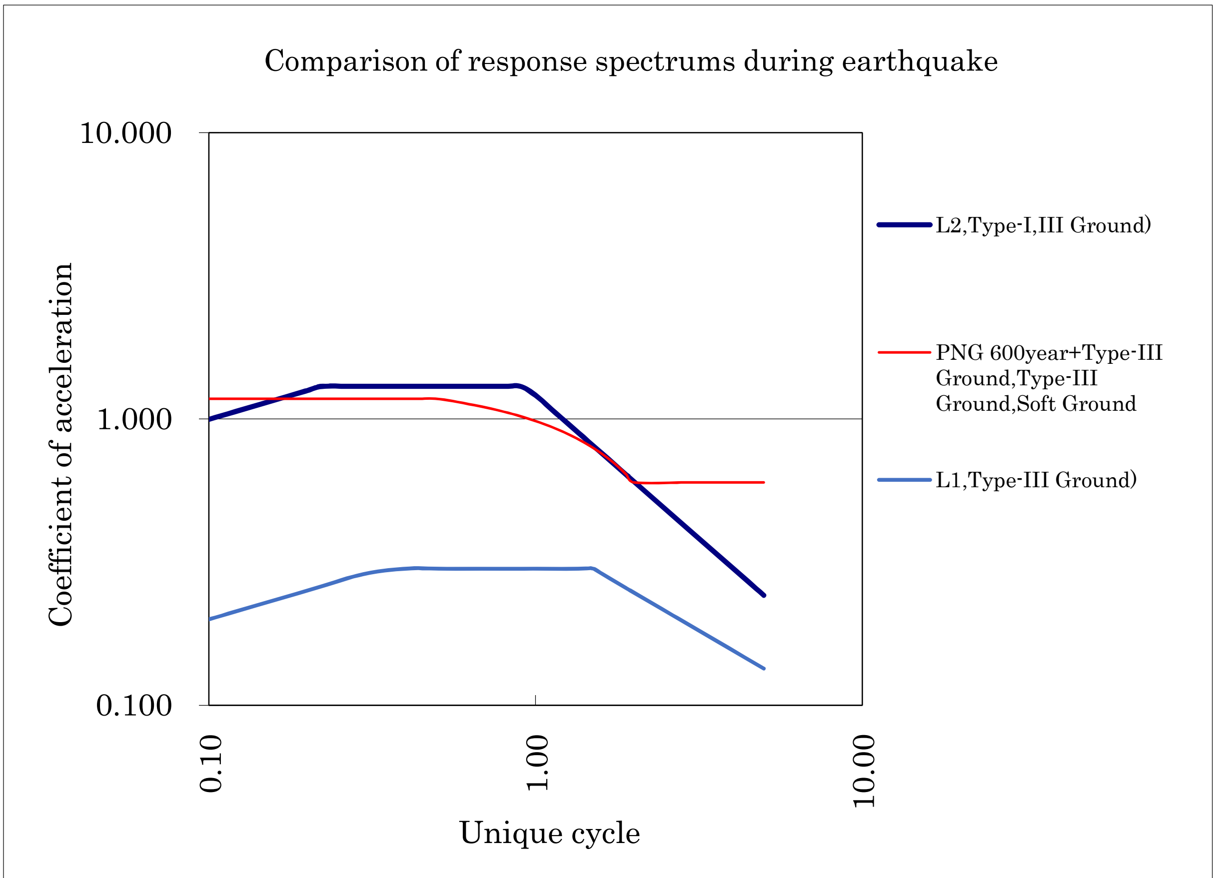


Figure 2.2.7 Comparison of Earthquake Response Spectrum

4) Examination of liquefaction

—Liquefaction calculation based on the Specifications for Highway Bridges

Liquefaction review for Level 2 seismic activity Type I was implemented with respect to local ground based on the liquefaction review conditions and method prescribed in the Specifications for Highway Bridges and Commentary (Earthquake Resistance Edition) (Japan Road Association, March 2012).

The survey area is composed of sandy riverbed sediments up to GL-20 meters, where liquefaction review should be conducted. Moreover, because the river water line becomes very high during the rainy season, all geological strata up to GL-20 meters were targeted for liquefaction review in order to be on the safe side.

As a result of the liquefaction judgment, it is judged that the FL value in this area is less than 1 and that liquefaction is apt to occur.

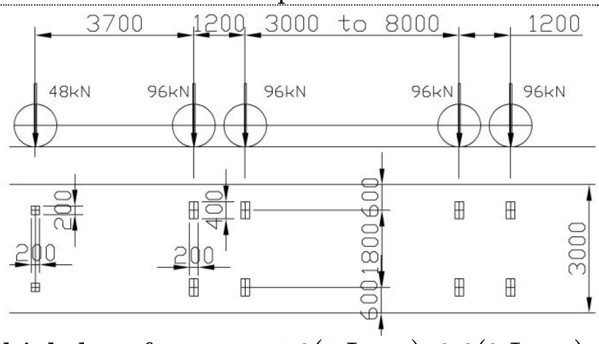
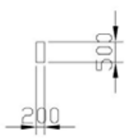
(3) Policy concerning Social and Economic Conditions

1) Design live load

Papua New Guinea uses the T44 trailer moving load and T66 load (excess load) that are defined in Australia, although it also employs some differences with Australia in that it doesn't take the necessary distributed load into account and so on. Moreover, the load coefficient method used in Papua New Guinea is different from the design technique used in Japan. In the work here, comparison was implemented between the B live load, which is the design load in Japan, and the live load effect. As a result, <u>although the B live load imparts a large load effect when the span length exceeds 30 meters, the two are deemed to have almost the same design load. Therefore, the policy shall be to conduct design based on the B live load upon utilizing the design and works execution systems of Japan, where design standards are well established</u>.

Table 2.2.5 shows the live loads that are used in the BRIRAP (ADB funding) bridge replacement project currently in progress.

Table 2.2.5 Design Live Load in Papua New Guinea

No	Item	Explanation	Remarks
1	T44 truck loading (The L44 lane loading shall not apply.)	 Multiple lane factor: m=1.0(1-Lane), 0.9(2-Lane) γ_{LL}: SLS=1.0, ULS=2.0 Dynamic load allowance: α=0.4	
2	W7 wheel load	 70kN γ_{LL}: SLS=1.0, ULS=2.0 Dynamic load allowance: α=0.25	

No	Item	Explanation	Remarks
3	T66 Truck over load	T44 x 1.5	
4	Footway loading	5kPa (not loaded simultaneously with other live loads)	

Outline Results of Comparing Live Loads

Comparison of the span-center bend moment was implemented targeting a basic steel plate girder bridge with four main girders (G1~G4) assuming B live load and the T44 (T66) load effect. Figure 2.2.8 shows the results of comparison.

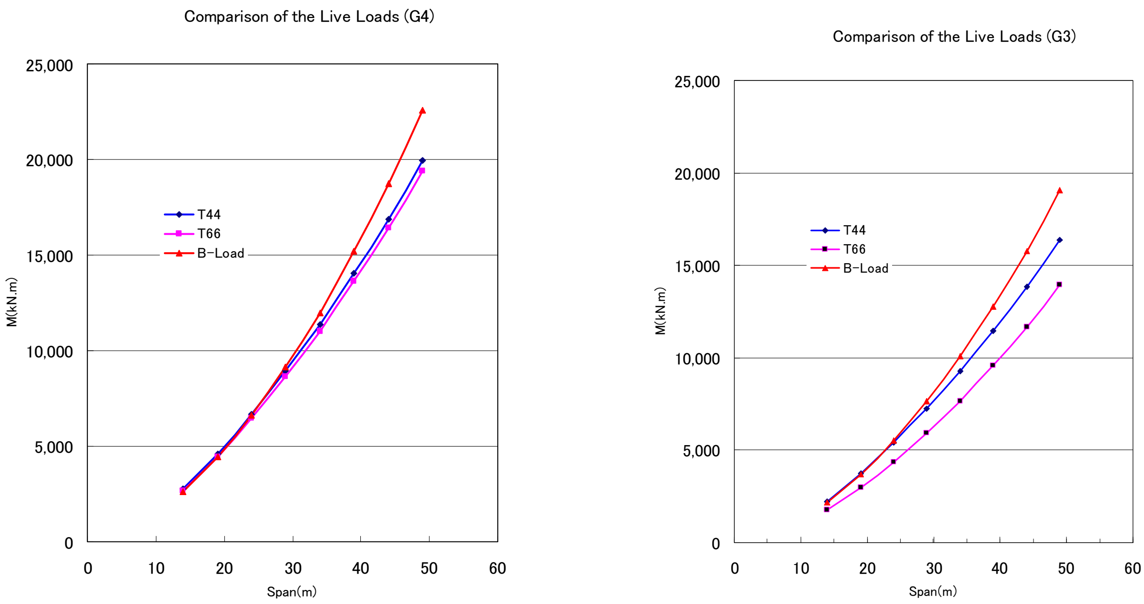


Figure 2.2.8 Comparison of Live Load Effect

Referring to the figure, it can be seen that the central girder (G3) and outer girder (G4) display almost the same load effect up to span width of around 30 meters, and the B live load becomes more dominant as the span length increases. Accordingly, design in the Project will be conducted using the B live load, which will make it possible to obtain similar quality to that seen in Japan.

(4) Policy regarding the Construction Situation and Procurement Conditions

Blessed with natural resources, Papua New Guinea prospers from exporting minerals and other natural resources in line with the growing worldwide demand for resources, and its per capita GDP has been growing at more than 6% over the past few years. In recent years, there has been rapid increase in construction works not only for roads and other public works but also domestic private sector buildings and hotels and so on, and the construction sector has been booming.

However, Papua New Guinea does not conventionally have many construction operators, and hardly any overseas operators want to enter the country due to the poor public security situation. As a result, it is no exaggeration to say that the principle of competition is not operative in the domestic construction industry. Accordingly, it is forecast that unit prices for locally procured labor, materials and equipment will be set "boldly," thereby leading to expensive costs.

In the Project, it has been decided to compare local unit rates with unit rates (including transportation cost) when procuring from Japan and to select the more economically advantageous case.

1) Personnel plan

① Situation regarding procurement of engineers and laborers

In the Project, similar projects were referred to in order to grasp the situation regarding procurement of skilled workers.

② Regulations and labor conditions, etc. based on the labor standards law and related legislation

Labor-related legislation in Papua New Guinea mainly stipulates the following items.

Standard working hours: 08:00~17:00, 12:00~13:00 break, 8 working hours/day
Weekly holidays: Saturdays, Sundays, national holidays
Normal overtime allowance: 150% premium
Holiday overtime allowance: 200% premium
Minimum wage: Approximately 7 kina/day
National Public Service: According to General Orders

2) Materials plan

① Materials procurement situation

The aggregate and stone materials for use in concrete and roads will be procured from a government-owned quarry (approximately 1 kilometer from Aum Bridge). Steel (mold steel, etc.) and steel sheet piles are not manufactured in Papua New Guinea, so will need to be procured from Japan. Since the bridge girders will be manufactured in Japan, steel materials and members such as high-pressure bolts and metal supports will also be procured in Japan.

Concerning concrete, since there is a plant in Kimbe that stably manufactures and retails raw concrete, this plant will be used in the Project.

Concerning asphalt, equipment such as a mobile asphalt plant and so on will be procured in Japan.

3) Construction machinery for the works

In Papua New Guinea, general construction machines such as backhoes, bulldozers, tire rollers, etc. will be procured from local construction operators. As for the asphalt plants, asphalt finishers, truck cranes, crawler cranes and so on, since these cannot be procured in Papua New Guinea, they will be procured in Japan.

4) Transportation and packing plan

The equipment, materials, steel, and construction machinery will be shipped oversea from Yokohama, via Lae to Kimbe, and from there carried overland to the construction sites.

5) Consultant design and construction supervision plan

① Survey and design setup

In conducting the implementation design, a preliminary field survey will be implemented first. This survey is intended to reflect information that has been renewed from the basic design, and new conditions (revisions to laws and design standards, etc.) into the implementation design. Following completion of the survey, these new items of information will be promptly reflected in the design work.

(5) Policy regarding utilization of local operators

The PNG side promised in the M/D to take human and budget measures regarding maintenance of the bridges following completion.

The West New Britain branch of the DoW in Kimbe (with approximately 40 employees) will implement the actual maintenance work, and its department comprising project engineers and supervisors (roughly 10 personnel) under the control of civil engineers will be responsible for conducting the maintenance activities. This department is currently effective in preparing detour routes at times of flooding, conducting road paving repairs, and performing other mainly road-related work. However, concerning bridge maintenance, for example measures to address gusset stress cracking on Kapiura Bridge, it currently conducts emergency repairs after major problems have occurred. Concerning maintenance activities, it is effective to perform preventive maintenance for addressing problems before they get bigger, and it is necessary to do this through conducting inspections. However, due to personnel considerations in the DoW, actual maintenance activities are consigned to private sector companies or they are directly entrusted to local resident organizations.

(6) Policy regarding Operation and Maintenance

Maintenance of the West New Britain Highway is implemented by DoW that is civil engineering department of the State. The number of staff of DoW is about 10 people. However, in road maintenance utilizing the consignment system to local residents and local suppliers, have been made efforts to national road is kept in good condition.

However, due to the budget, good maintenance is not implemented. For the bridges, it is not implemented even basic maintenance such as cleaning. Repair and reinforcement of post-disaster are carried out. However, in April this year New Britain national highway culvert washout disaster (2 places), is built promptly detour after washout (Malta Bridge), are reserved current bridge traffic without any trouble, management capacity for road maintenance is higher it is inferred that. From these circumstances, the potential capabilities regarding maintenance of bridges seems high. If maintenance of technology transfer from Japanese of contractors is carried out in this project, local suppliers' technology level is also improved, and would allow appropriate management of bridges.

(7)Policy regarding the setting of facility grade

This project has the goal of obtaining a quantitative and qualitative effects of the following.

1) Quantitative Effects

① Increase in bridge load bearing capacity

The existing bridges were designed to bear load of T33 and special vehicle load of 44 tons per lane. The new bridges will be able to withstand loads of T44 per lane on two lanes, i.e. loads of 88 tons in total.

② Increase in Average Running Speed

The average running speed of vehicles over the detour route of Aum Bridge was measured as 11.0km/h, while the average running speed over the existing Kapiura Bridge, where vehicles need to stop once at the gate, was 18.4km/h. When the new bridges are finished, it will be possible for vehicles to cross them at design velocity of 60km/h.

③ Average daily traffic volume

Daily traffic volume in the field survey of New Britain Highway was 493 vehicles per day. Assuming that the traffic volume increases in line with GDP, the daily traffic volume in 2020 that is three years after completion of construction project will be 772 vehicles per day.

2) Qualitative Effects

① Improvement in Bridge Performance and Safety

With the new construction of Aum Bridge and Kapiura Bridge, the load bearing capacity will increase and, because upper deck structures whereby the main structure is located below the road surface will be adopted, there will be less chance of vehicles crashing into the bridges. Thus, safety will be improved.

② Increased and Smoother Physical Distribution

Because a temporary wooden structure is used as a detour around the existing Aum Bridge, while vehicles need to stop at the gate on the existing Kapiura Bridge, vehicles cannot run smoothly over the bridges. With the new construction of Aum

Bridge and Kapiura Bridge, vehicles will immediately pass over the bridges and this will contribute to the promotion of physical distribution over New Britain Highway.

③ **Securing of Traffic at Times of Disaster**

Because the detour for the existing Aum Bridge is located in a lower position than the existing bridge, there is a high risk of the bridge detour becoming inundated and impassable at times of flooding. Following completion of the new bridge, vehicles will be able to pass and traffic will be secured even when flooding occurs.

④ **Safety of pedestrians**

There are no sidewalks on the Aum Bridge detour or on the existing Kapiura Bridge. However, because sidewalks will be included on the new bridges, the safety of pedestrians will be secured.

⑤ **Effective use of river water**

In New Britain Island, washing, bathing, fish birds are frequently done in the river. However, there is no clear path approaching the river in Aum Bridge and Kapiura Bridge. Therefore, use of the river is limited. On the other hand, other donors projects, in BRIRAP, paying attention to women often as river water users, and is a standard that installing the stairs.

Therefor, Aum Bridge and Kapiura Bridge also was determined the same policy. Thus it is possible to effectively use the river water.

(8)Policy regarding Construction Methods and Schedule

1) Construction methods

① Superstructure works

- Structural type: Continuous plate girder bridge
- Construction method: Crane construction

② Substructure works: piers: T type, wall type, abutments: Reverse T type

③ Foundation works: steel pipe pile foundations (φ800)

2) Schedule

① Thinking on operating rate

Non-working days will be set depending on rainfall.

2.2.2 Basic Plan

(1)Overall Plan

1) Positional Examination of Kapiura Bridge

Kapiura River has a relatively large basin area among rivers in West New Britain Province. The existing bridge is a lower deck steel stiffened arch bridge 116 meters in length. It is a large bridge with a span of 100 meters.

The existing bridge will be used as the detour route during the new bridge construction works in order to save on temporary bridge works costs and shorten the works schedule. Therefore, the new bridge will be situated either on the upstream side or downstream side of the existing bridge.

① Distance between the new bridge and existing bridge:

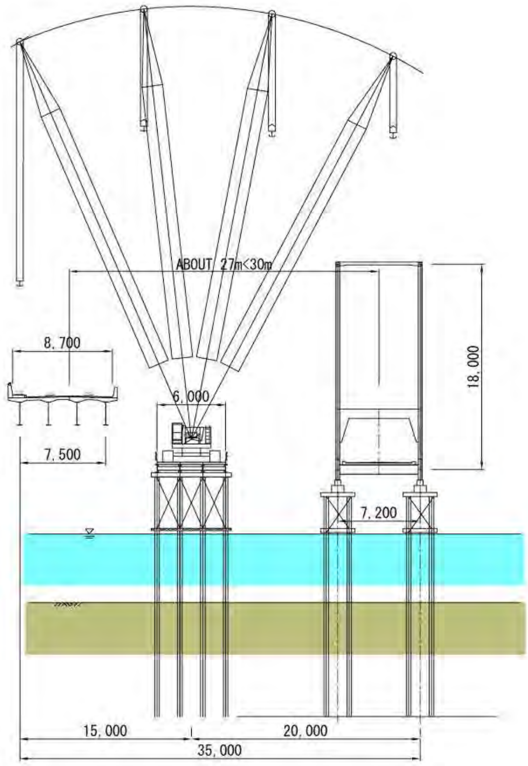


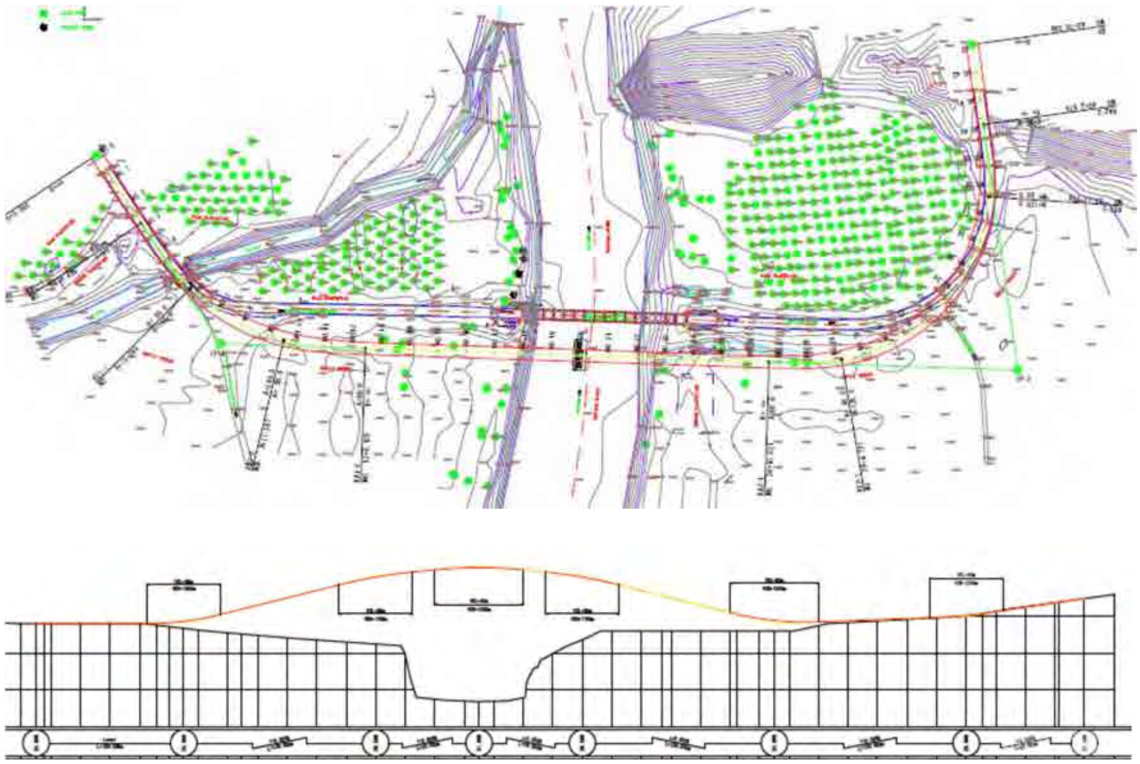
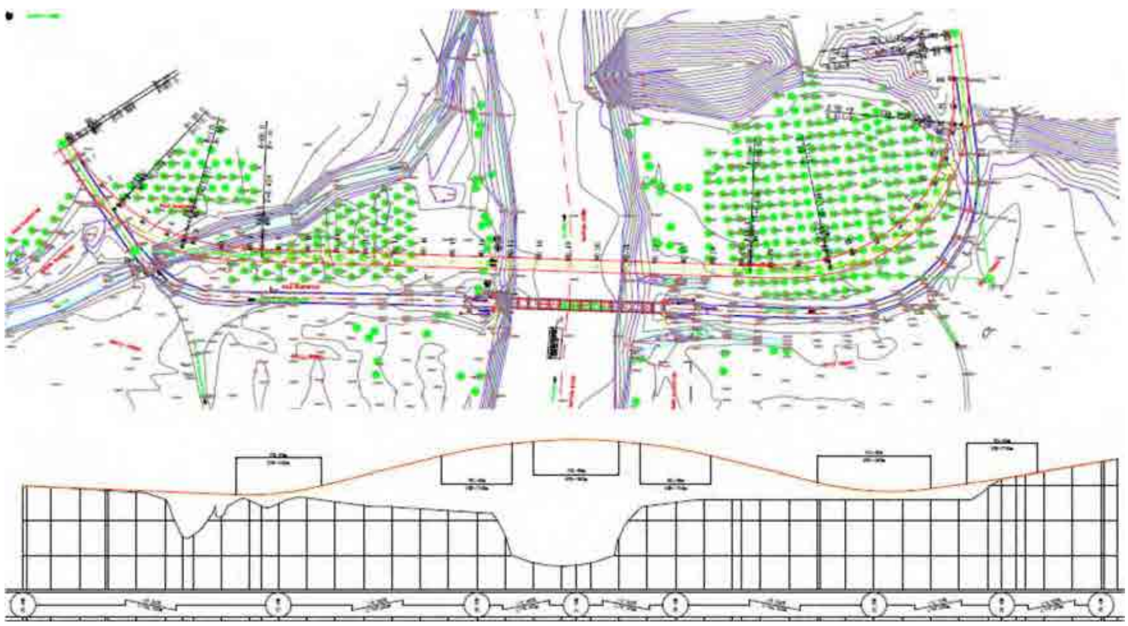
Figure 2.2.9 Explanatory Drawing of Distance between New Bridge and Existing Bridge

The works pier will be used for both the new bridge construction and existing bridge removal works, and the distance between the two structures (distance between center points of roads) will be 30 meters as shown in the drawing. The prerequisites assumed for examining the distance are as follows.

- The crane working radius when placing the main girders of the new bridge will be set at 15 meters
- The work radius when dismantling the existing bridge will be 20 meters
- Bent pile installation when dismantling the existing bridge: work radius of 21 meters

② Selection of bridge position: Table shows the comparison table of bridge positions.

Table 2.2.6 Comparison of Bridge Positions (Kapiura Bridge)

Plan	Explanatory Figure
Plan 1 Upstream plan	
Plan 2 Downstream plan	

Plan	Comparison of Characteristics					
Plan 1 Upstream side plan	Design velocity		V=60km/h	Planned length	L=710m Shorter than Plan 2	
Plan 1 Upstream side plan	Geometric structure	Minimum curve radius	R=125m (Sight distance widening=2.25m) A larger radius than in Plan 2 can be established.			
Plan 1 Upstream side plan	Geometric structure	Curve length / Transition section length	L=269.1m (R=125m) / L=51.2m(R=125m)			
Plan 1 Upstream side plan	Geometric structure	Steepest longitudinal gradient	I=5.0%			
Plan 1 Upstream side plan	Geometric structure	Steepest super elevation / combined gradient	9.0% (maximum of 6.0% is planned in BRIRAP) / I=10.3%			
Plan 1 Upstream side plan	Earthworks section	Earthworks cost (cutting + banking)	0.26%	Bridge section	Superstructure works	31.76%
Plan 1 Upstream side plan	Earthworks section	Paving cost (roadbed + paving)	18.25%	Bridge section	substructure works	9.64%
Plan 1 Upstream side plan	Earthworks section	Road drainage works	1.76%	Bridge section	Foundation works	38.40%
Plan 1 Upstream side plan	Earthworks section	Total	20.27%	Bridge section	Total	79.73%
Plan 1 Upstream side plan	Total works cost		1.00			
Plan 1 Upstream side plan	Handling of closed culvert on the starting side		・As existing covered culverts are used, this is better in terms of ease of execution and economy			
Plan 1 Upstream side plan	Ease of execution / Works schedule		・There is no major or significant difference in the main works.			
Plan 1 Upstream side plan	Topographical alteration		・It is necessary to fill the natural waterway and secure an alternative means of drainage treatment. ・As banked slopes will adjoin the existing road, there is hardly any impact of land division caused by remnants.			
Plan 1 Upstream side plan	Environmental impact		・There are no objects that require protection of note.			
Plan 1 Upstream side plan	Traffic safety		・As is also the case in Plan 2, the longitudinal gradient increases on the bridge section, however, safety is improved through widening and easing the alignment.			
Plan 1 Upstream side plan	Land acquisition		・This is SBLC-managed land, so there is no problem concerning land acquisition.			
Plan 1 Upstream side plan	Roadside accessibility		・There is no impact on current accessibility and there is no difference with Plan 2.			
Plan 1 Upstream side plan	Evaluation		First			
Plan 2	Design velocity		V=60km/h	Planned length	L=760m Longer than Plan 1	
Plan 2	Geometr	Minimum curve radius	R=115m (Sight distance widening=2.65m) Curve radius is smaller than in Plan 1			
Plan 2	Geometr	Curve length / Transition section length	L=165.6m (R=115m) /L=55.7m (R=115m)			
Plan 2	Geometr	Steepest longitudinal gradient	I=5.0%			

Plan	Comparison of Characteristics					
		Steepest super elevation / combined gradient	9.5% (maximum of 6.0% is planned in BRIRAP) / I=10.7%			
	Earthworks	Earthworks cost (cutting + banking)	0.35%	Bridge section	Superstructure works	31.76%
		Paving cost (roadbed + paving)	19.68%		substructure works	9.64%
		Road drainage works	2.14%		Foundation works	38.33%
		Total	22.18%		Total	79.73%
	Total works cost		1.02			
	Handling of closed culvert on the starting side		・As it is necessary to install new culverts on the starting side, this detracts from the economy and ease of execution.			
	Ease of execution / Works schedule		・ There is no major or significant difference in the main works between both plans.			
	Topographical alteration		・ It is necessary to fill the natural waterway and secure an alternative means of drainage treatment. ・Land is divided by remnants of palm fields around the start and end points.			
	Environmental impact		・There are no objects that require protection of note.			
	Traffic safety		・As is also the case in Plan 1, the longitudinal gradient increases on the bridge section, however, safety is improved through widening.			
	Roadside accessibility		・ There is no impact on current accessibility and there is no difference with Plan 1.			
	Land acquisition		・ This is NBPOL-managed land, so there is no problem concerning land acquisition.			
	Evaluation		Second			

Ground height around the existing bridge is EL≒22.0 meters close to the riverbanks and EL≒23.5 meters around 100 meters from the banks. A similar trend can be seen on the upstream and downstream sides of the existing bridge, and there is no significant difference between the two. Also, no major differences exist in terms of the comparison items of road geometric structure, ease of execution, topographical alteration, environmental aspects, and traffic safety.

Large differences arise in the part that crosses the water channel on the start side. In the upstream side plan, the existing pipe culverts are utilized, however, in the downstream side plan, the channel is traversed at a minor angle and it is necessary to install new transversal structures. Therefore, since the road length is shorter and there is no need to install new transversal structures, the more economical upstream side plan will be adopted.

2) Positional Examination of Aum Bridge

Aum Bridge is currently impassable due to damaged portal bracing (truss diagonal bracing) caused in a collision by a large trailer. Since the factors contributing to the collision were reduction of the road width to a single lane, steep gradient, and sharp curve, an important point in replacing the bridge will concern how far the road alignment can be improved.

Here, the road alignment and bridge plan were examined for three possible bridge positions, i.e. upstream of the existing bridge (Plan 1), at the existing bridge location (Plan 2), and downstream of the existing bridge (Plan 3), and the results have been summarized in Table 2.2.7 and Table 2.2.8.

① Outline of each plan: In all three plans, the alignment is sufficient to satisfy Design velocity V=60km/h, however, in the upstream side plan (Plan 1), R is 210 meters, which corresponds to design velocity V=80km/h, while in Plans 2 and 3 it is 115 meters. There is no need for sight distance widening in Plan 1, however, it is required in Plans 2 and 3, which adopt a minimum curve radius of R115 meters with respect to design velocity of 60 km/h.

② Alignment improvement effect: The current alignment is R80 meters (design velocity 50km/h) and the longitudinal gradient is 7~8%. All three options here have a road width of two lanes, design velocity of V=60km/h, and alignment improvement to no more than 6%. In particular, alignment in Plan 1 corresponds to V=80km/h.

③ Bridge plan: In Plan 1, the bridge is designed with a length of 105 meters and three spans according to topographical conditions. In Plans 2 and 3, the bridge is 60~70 meters long and has two spans. In all the plans, a plane curve exists at the bridge position, however, in Plan 1 (R210 meters) and Plan 2 (A80+R115 meters), the bridge can be planned with bent main girders at the fulcrum point. In Plan 3, because a circular curve of R115 meters is established on the bridge, it is necessary to adopt a curved bridge with a curved structure.

Works cost is highest in Plan 1, which has the longest bridge, followed by Plan 3, which adopts a curved bridge. Plan 2, which entails building the new bridge in the existing location, is the most economical plan. There is a difference of approximately 170,000,000 yen between the most economical Plan 2 and the most expensive Plan 1.

④ Economy: The plans are more economical as the length of improved road section decreases. The order in terms of works cost is Plan 1 < Plan 2 < Plan 3. There is a difference of approximately 90,000,000 yen between Plan 1 and Plan 2. In terms of total cost combined with the bridge works cost, Plan 2 is the most economical, and there is a difference of approximately 80,000,000 yen (approximately 10%) between Plans 1 and 2.

⑤ Selection of bridge position: Plan 1 is superior in terms of alignment improvement, however, because the bridge works are more expensive, the overall works cost is approximately 10% (80,000,000 yen) higher than in Plan 2. Accordingly, the most economical Plan 2 shall be selected.

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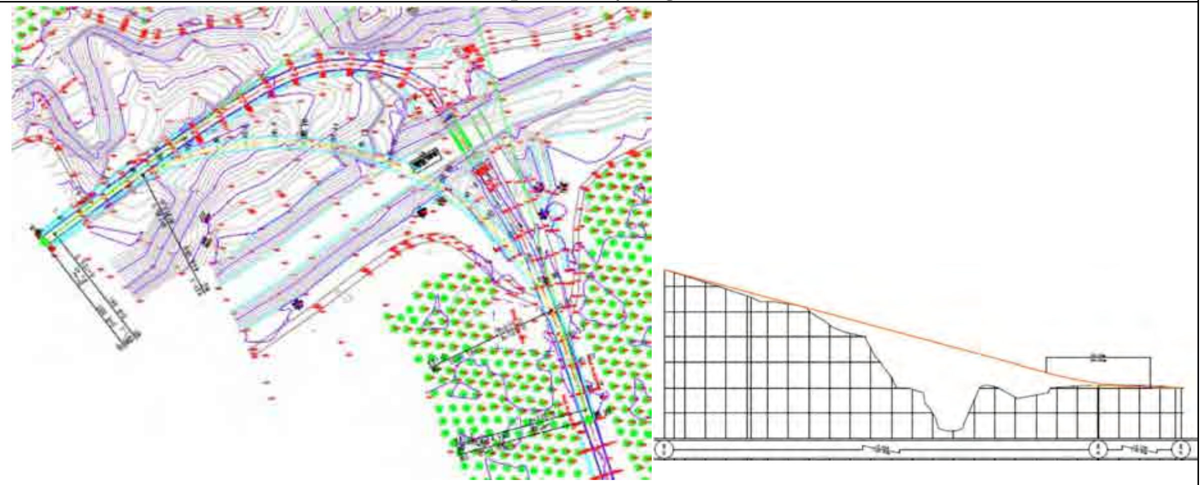
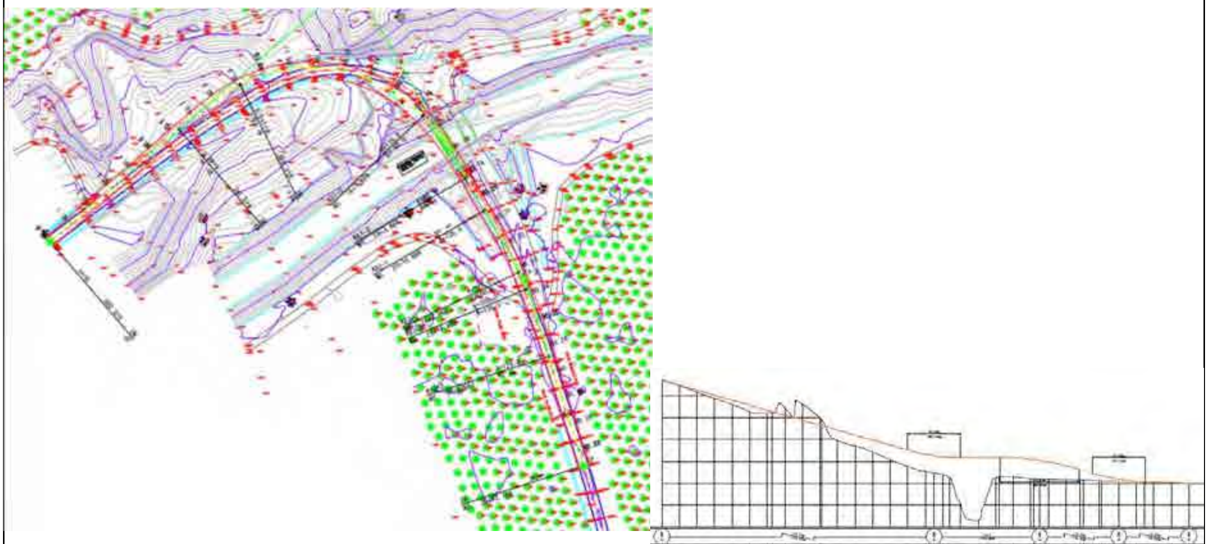
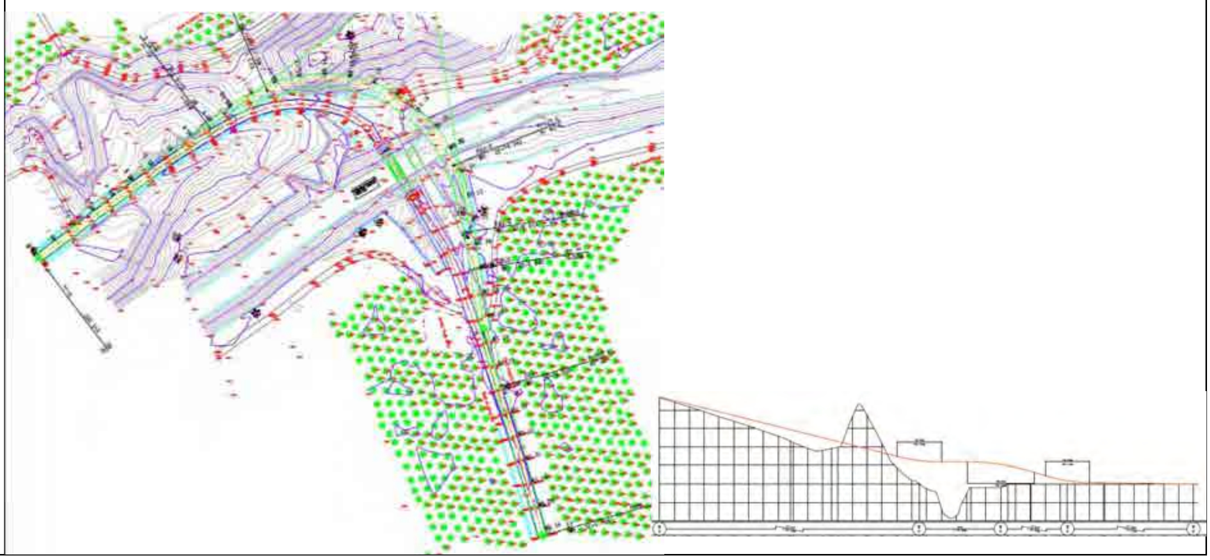
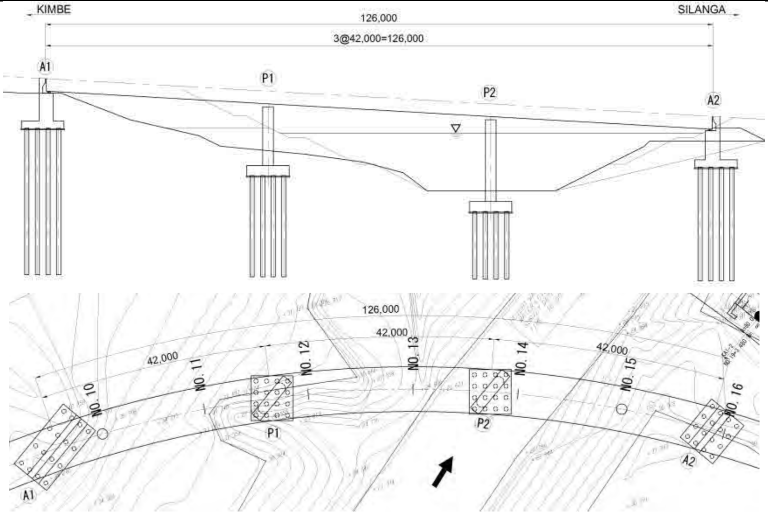
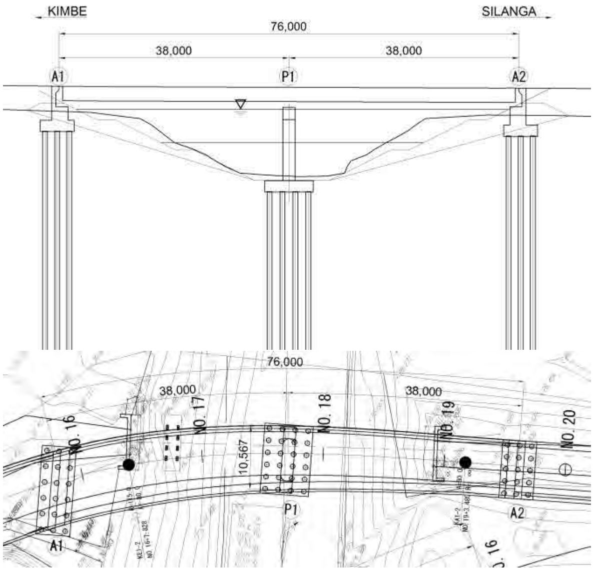
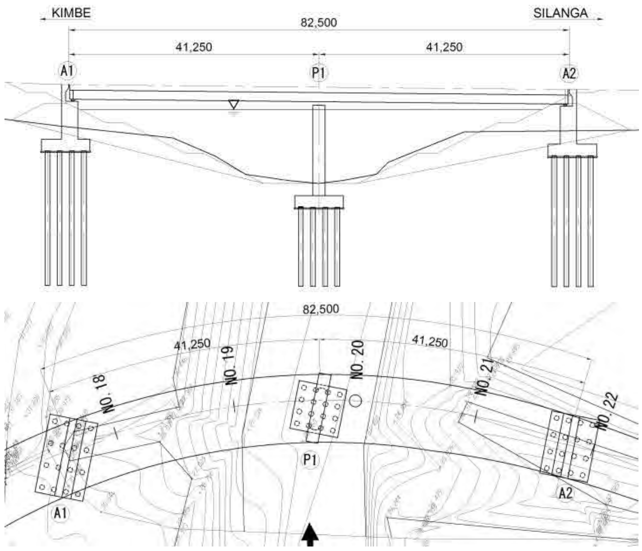
Table 2.2.7 Comparison of Bridge Positions (Aum Bridge)

Plan	Explanatory Figure
Plan 1 Upstream side plan	
Plan 2 Current bridge position	
Plan 3 Downstream side plan	

Plan			Plan 1: Upstream side plan	Plan 2: Current bridge position	Plan 3: Downstream side plan
Design velocity			V=60km/h	V=60km/h	V=60km/h
Planned length			L=500m	L=600m	L=700m
Geometric structure	Minimum curve radius		R=210m (Sight distance widening = 0.20m)	R = 115m (Sight distance widening = 2.65m)	R=115m (Sight distance widening＝2.65m)
	Curve length Transition section length		L=485.0m L=74.4m	L=125.8m(R = 115m) L=52.1m (R＝300m)	L=293.9m(R＝115m) L=55.7m (R＝115m)
	Steepest longitudinal gradient		I=5.5%	I=6.0%	I=6.0%
	Steepest super elevation Combined gradient		6.0% I=8.1%	9.5% (maximum of 6.0% is planned in BRIRAP) I=11.1%	9.5% (maximum of 6.0% is planned in BRIRAP) I=10.8%
Earthworks cost	Earthworks cost	Cutting	0.00%	0.39%	1.71%
		Banking	2.36%	4.06%	3.56%
	Paving cost	Roadbed	2.70%	3.68%	4.30%
		Paving	3.69%	5.41%	6.26%
	Road drainage works		2.04%	3.33%	3.93%
	Total		11.19%	16.87%	19.75%
Bridge works cost	Superstructure works		39.38%	29.39%	31.74%
	Substructure works		13.01%	9.71%	10.49%
	Foundation works		59.42%	44.03%	48.02%
	Total		111.81%	83.13%	90.25%
Total works cost			123%	100%	110%
Ease of execution / Works schedule			・Out of the three plans, this has the smallest impact on current traffic during execution. ・In constructing the new bridge, there is no need to remove the existing bridge or build a new road. ・It is necessary to build a temporary pier for removing the existing bridge separate from the main works.	・A temporary road (I > 10% with paving) is required in order to secure the current road traffic. ・As it is necessary to first remove the existing bridge, the works schedule is longer. ・As a rule, work can be executed without stopping traffic.	・Management during execution is needed in order to secure the current road traffic. ・In constructing the new bridge, it is not necessary to remove the existing bridge. ・It is necessary to construct a temporary pier for removing the existing bridge separate from the new bridge works.
Topographical alteration			・It is necessary to fill a basin.	・High earth banking arises at the bridge section. ・It is necessary to fill a basin.	・Large-scale cutting arises on the sloped land on the left bank, and high earth banking is necessary at the abutments.
Environmental impact			In all three plans, environmental impacts are limited and there is no discernible difference.		

Plan	Plan 1: Upstream side plan	Plan 2: Current bridge position	Plan 3: Downstream side plan
Traffic safety	・This has the biggest improvement to the horizontal alignment (curve radius corresponding to 80km/h) and vertical alignment.	・ Improvement to the horizontal alignment and vertical alignment is smaller than in Plan 1.	・Improvement to the horizontal alignment and vertical alignment is smaller than in Plan 1.
Land acquisition	As this is NBPOL-managed land and a riverside buffer zone (nationally owned land), there is no problem concerning land acquisition.		
Evaluation	Plan 1 is superior in terms of improvement to road alignment, however, it is less economical than Plan 2 because the bridge length increases. The road alignment improvement effect of Plan 3 is similar to that of Plan 2, however, Plan 3 is not as economical as Plan 2. It is recommended that the most economical Plan 2 be adopted upon satisfying the road geometric structural standard assuming design velocity of V=60km/h.		

Table 2.2.8 Comparison of Bridge Positions (Aum Bridge)

Plan	Explanatory Figure
Plan 1 Upstream side plan	
Plan 2 Current bridge position	
Plan 3 Downstream side plan	

Plan	Plan 1: Upstream side plan	Plan 2: Current bridge position	Plan 3: Downstream side plan
Structure	・ Due to the topographical conditions, it is necessary to set the abutments around 30 meters from the river, meaning that the bridge becomes longer by that amount. ・ The superstructure comprises three-span continuous plate girders with the main girders bent at the fulcrum point (horizontal alignment R210m). ・ The substructure comprises a reverse T abutment, overhanging pier, and the foundation works comprise steel pipe piles. ・ One pier is constructed in the river, and the bridge has three spans in total. ・It is an upper deck bridge, so there is no risk of vehicles directly colliding with the bridge body.	・The abutments are established on the river embankment and the bridge length is shortest. The new bridge abutments are constructed behind the existing bridge abutments. ・ The superstructure comprises two-span continuous plate girders with the main girders bent at the fulcrum point (horizontal alignment A80+R115m). ・ The substructure comprises a reverse T abutment, overhanging pier, and the foundation works comprise steel pipe piles. ・ One pier is constructed in the river, and the bridge has two spans in total. ・It is an upper deck bridge, so there is no risk of vehicles directly colliding with the bridge body.	・The bridge is planned downstream of the existing detour route. Since the horizontal alignment is small at R115m, the bridge is planned as a curved girder bridge. ・ The superstructure comprises continuous box girders over two spans. ・ The substructure comprises a reverse T abutment, overhanging pier, and the foundation works comprise steel pipe piles. ・ One pier is constructed in the river, and the bridge has two spans in total. ・It is an upper deck bridge, so there is no risk of vehicles directly colliding with the bridge body.
Ease of execution	・Because there is a large gap between the current bridge and the new bridge, the same pier cannot be used for removing the existing bridge and constructing the new one. ・Since there are more substructure works bases and the bridge length is longer, the site works are longer than in the other plans.	・The new bridge is constructed after first removing the existing bridge. As the pile foundations of the existing bridge are misaligned, they can be left as they are. ・The same pier can be used for removing the existing bridge and constructing the new one.	・Because there is a large gap between the current bridge and the new bridge, the same pier cannot be used for removing the existing bridge and constructing the new one. ・ The bridge size is smaller than in Plan 1, allowing the implementation schedule to be shortened.

Plan		Plan 1: Upstream side plan	Plan 2: Current bridge position	Plan 3: Downstream side plan
			・The bridge size is smaller than in Plan 1, allowing the implementation schedule to be shortened.	・This plan uses curved girders, but execution is easy.
Maintenance		・ If extended corrosion-proof fluoride resin coating is used, durability of around 50 years can be expected.	・Ditto	・Ditto
Works cost	**Superstructure works**	47.37%	35.35%	38.18%
	substructure works	15.65%	11.68%	12.62%
	Foundation works	70.98%	52.97%	57.20%
	Total	134.00%	100.00%	108.00%
Evaluation			**First**	
		In all three plans, the design velocity is set at 60km/h, however, in terms of horizontal alignment, Plan 1 has the biggest curve radius and is deemed to be best for vehicle running. However, this plan is not adopted because it entails higher costs by more than 30%. Comparing Plans 2 and 3, Plan 2 is superior in terms of impact on current road, structural characteristics (height of banked land when completed), ease of execution, and economy. To sum up, when comparing in terms of bridge planning, the plan to replace the bridge in its current position is deemed to be the best.		

3) Embankment, revetment, and step works plan

The bridge sites on Aum River and Kapiura River are thought to have relatively stable river courses judging from the river conditions and the existing bridges that were constructed 30 years ago. Accordingly, assuming the bridges to be constructed on rivers, the embankments and revetments will be planned based on the Japanese government ordinance concerning structural standards for river management facilities, etc.

① Embankment plan

Embankments in principle consist of earth levees, however, in general these are extremely fragile structures with respect to overflow. Therefore, embankments should be constructed to prevent overflow of water below the design high water line, and it is thus necessary to add an appropriate allowance to the embankment height in order to counter temporary increases in water line caused by wind and waves, swells and splashing at times of flooding.

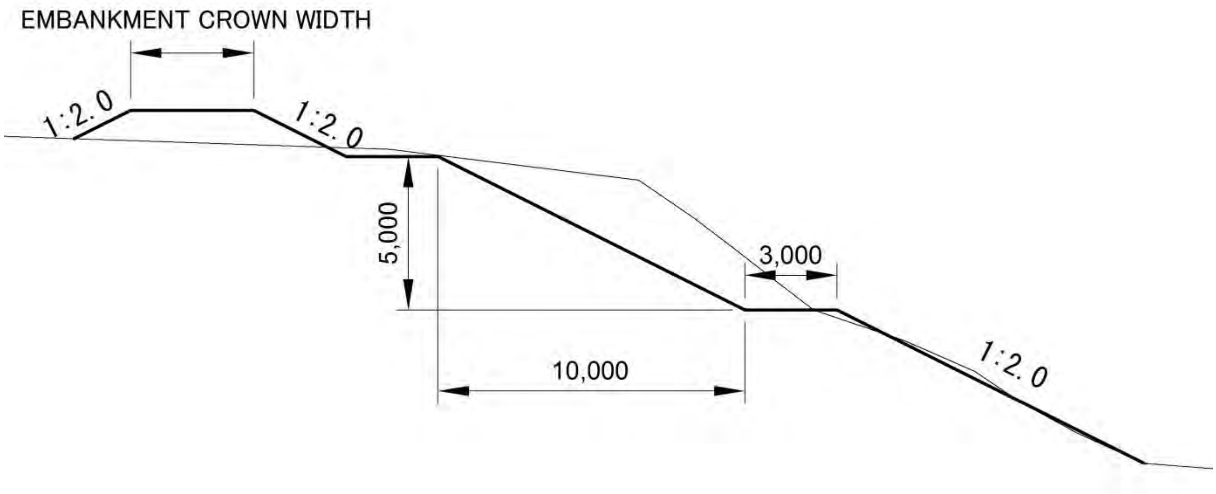
The embankment crown needs to have sufficient width to secure the necessary cross section for countering infiltrating water. It also has to be wide enough to allow river patrols at ordinary times and flood fighting activities at times of flooding.

According to the Government Ordinance concerning Structural Standards for River Management Facilities, etc., the height and crown width of embankments shall be as indicated in Table 2.2.9.

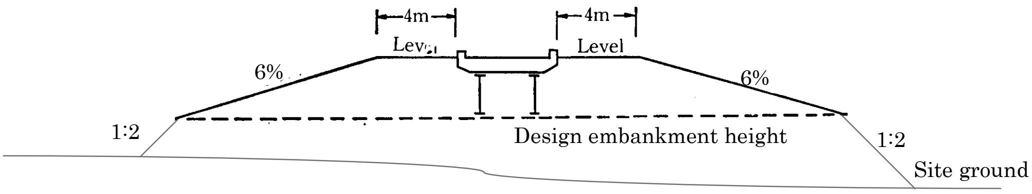
Table 2.2.9 Embankment Height and Appropriate Allowance

	Embankment height (m)	Crown width (m)
Aum Bridge	Design high water line +1.0	4.0
Kapiura Bridge	Design high water line +1.2	5.0

Concerning the embankment slope gradient, since the current riverbanks have a gradient of roughly 1:20, the same gradient will be adopted for the embankments as shown in the following figure. Moreover, considering utilization of the embankment slopes, small berms of 3 meters in width will be established at every 5 meters of perpendicular height. Moreover, to ensure that the embankment slopes are safe with respect to slope failure and scouring caused by rainfall and flowing water, it will be necessary to cover the parts that have no revetment with grass lawn.



Concerning the length of embankments, level sections of 4 meters will be established between the bridge edges and embankment, and the embankments will have a gradient of 6% over the embankment height plus an additional 2% down to the existing ground line.



② Revetment plan

Revetment will be applied to the embankment slopes and berms in order to protect them against the effects of flowing water. In the Project, revetment works will be implemented between points at a distance of half the standard span in both the upstream and downstream directions from the abutments.

Table 2.2.10 Upstream and Downstream Lengths of Revetment

	Flow rate (m^3/s)	Revetment length in the upstream and downstream directions (m)
Aum Bridge	550	12.0
Kapiura Bridge	2250	16.0

Note) Standard span length L_{req}=20+0.005Q (Q:flow rate)

Concerning the height of revetments, as is shown in Figure 2.2.10, the sections of 10 meters in both the upstream and downstream directions from the abutments will be regarded as “sections where the water flow will dramatically change in line with bridge construction,” and revetment works will be implemented up to the height of the access road. In other sections, revetment works will be implemented up to the height of the planned embankment.

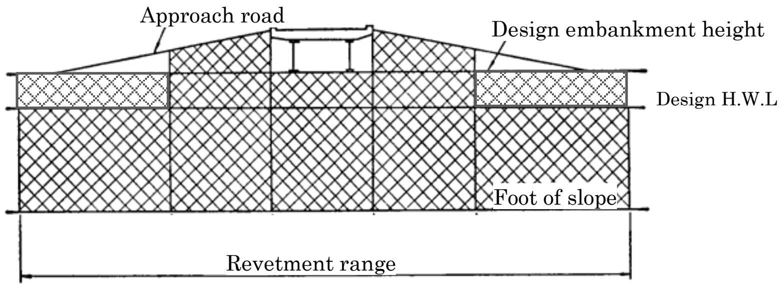


Figure 2.2.10 Necessary Height of Embankment Revetment in Line with Bridge Construction

The revetment and retaining wall works conducted in local areas of Papua New Guinea usually comprise gabion. Such structures are suited to the local conditions because they enable revetments and retaining walls to be repaired at times of flooding or other disaster without employing special heavy machinery. In the Project too, gabion will be adopted for revetments and banked earth retaining walls upon considering the local conditions. For gabion, Japanese "corrosion-proof gabion" will be used.

③ Stairway works

The stairway works plan will comply with the requirements of AS1657. In cases where straight stairways are planned as in the Project, the maximum number of steps between landings is 18, and it is necessary to add landings if there are more steps than this. Also, in consideration of human falls and so on, if the landing is no greater than 2 meters, straight stairs of 36 steps or more will be prohibited. In cases of long stairs with more than 36 steps, the direction of the stairs must be changed. However, exceptions can be made in cases where the landing is greater than 2 meters.

(2)Road Plan

1) Basic Items

Since Aum Bridge is currently impassable due to collapse following collision by a vehicle, top priority was given to improving running safety through adopting appropriate geometric structure when examining improvement of the road alignment for the bridge. In particular, on the left bank, downhill slope entering the bridge, an exterior curve, and poor visibility caused by forests alongside the road are factors that could induce accidents. Therefore, running safety from the perspective of drivers was confirmed by conducting examination based on three-dimensional imaging using CG technology.

Furthermore, because there is a plantation access road that joins the main road close to the bridge on the left bank side, in addition to reconstructing the main road, it has been decided to include items for improving traffic safety such as changing the shape of the road convergence, establishing intersection warning signs, installing safety posts on the main road and so on.

In the case of Kapiura Bridge, the surrounding terrain is relatively flat, there are no problems regarding road alignment in the connecting sections before and after the bridge, and the existing bridge is straight and has good visibility. However, because the existing bridge body has been damaged during flooding, it has been decided to adopt a bridge plan and secure road height that will not be affected during flooding based on the results of local hearing survey and hydraulic and hydrological analysis.

Moreover, because paving has been damaged due to incoming rainwater in parts and very heavy vehicles of more than 60 tons sometimes cross over the bridge, the paving structure was examined based on local and Japanese standards, and a systematic rainwater drainage plan was implemented in line with the local conditions.

2) Applicable Standards

In consideration of running safety for general vehicles in the local area, as well as satisfying the local applicable standards, concerning the parts that are not covered by local standards and it is deemed necessary for securing running safety, preserving road functions and securing the management level, it has been decided to adopt Japanese standards beginning with Government Orders on Road Design Standards.

The main standards used were as follows:

① Local

a) ROAD DESIGN MANUAL (PNG: DEPARTMENT OF WORKS)
b) OVERSEAS ROAD NOTE (UK: DEPARTMENT FOR INTERNATIONAL DEVELOPMENT)

② Japan

a) Government Order on Road Design Standards – Commentary and Implementation (Japan Road Association)
b) Road Earthworks Guidelines (Japan Road Association)
c) Paving Design Handbook (Japan Road Association)

3) Width composition

In accordance with the Papua New Guinea Road Design Manual, since the design road is a trunk national highway with traffic volume of 400 vehicles/day or more and it is located on relatively flat terrain, the road width has been set as 6.5 meters for the standard traffic lanes (two lanes) and 8.5 meters for the motorway including shoulder.

Moreover, this width is consistent with the values adopted in the BRIRAP undertaking being implemented ahead of the Project.

Table 2.2.11 Traffic Category and Cross Section Details (DoW)

Traffic Category	Volume Range (v/d)	Terrain Type	Design Speed (km/h)	Width of Pavement (m)	Width of Formation (m)
Heavy	400	Flat/Rolling	80	6.5	8.5
		Hilly	50	6.5	8.0
		Mountainous	30	6.0	7.5
Medium	100-400	Flat/Rolling	70	6.5	7.5
		Hilly	50	6.0	7.0
		Mountainous	25	5.5	6.5
Light	<100	Flat/Rolling	60	N/A	6.5
		Hilly	40	N/A	6.0
		Mountainous	25	N/A	5.5

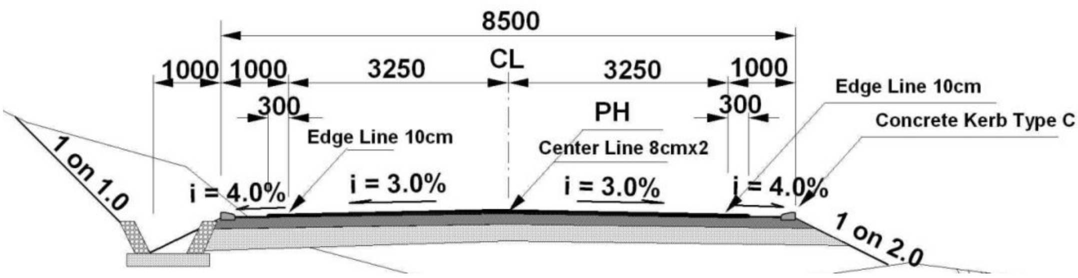


Figure 2.2.11 Standard Width Composition

4) Geometric structure

The geometric structure has been set according to the Papua New Guinea Road Design Manual.

The basic design velocity in

Table 2.2.11 is 80km/h, however, since this section has topographical constraints, 60 km/h has been adopted as the optimum velocity upon implementing comparative examination on the overall plan including the bridge plan from the viewpoints of local environmental protection and cost reduction.

Moreover, bicycle traffic, albeit minor, has been confirmed in the local area, and because no dedicated bicycle lane is provided along the main road, the maximum super elevation on curves has been set at 6% in accordance with the Japanese Government Order on Road Design Standards Article 16 in consideration of bicycle safety.

Also, concerning the reduced design velocity due to topographical conditions and limiting of the super elevation to 6%, similar constraints are imposed in the related BRIRAP project.

Table 2.2.12 shows the geometric structure standard concerning design velocity in the Road Design Manual.

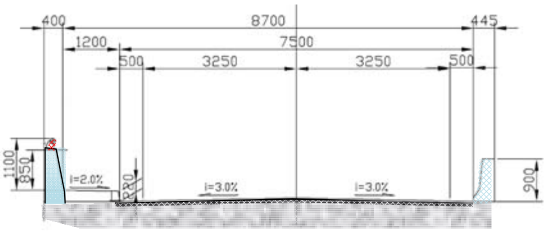
Table 2.2.12 Geometric Design Standards (DoW)

Design Speed	Sight Distance				Horizontal Radius (e=0.10)		Gradients			
	Gravel		Seal				General Max		Absolute Max	
	Stopping	Over-taking	Stopping	Over-taking	Gravel	Seal	%	Length	%	Length
100	-	-	170	800	-	340	5	-	7	750
80	135	480	115	480	250	210	6	-	8	1000
70	105	350	90	350	185	155	6	-	8	700
60	80	300	70	300	130	115	7	1100	9	400
50	60	200	55	200	85	75	8	600	10	300
40	45	160	40	160	55	45	10	500	12	250
30	30	90	30	90	27	25	10	500	12	250
25	25	75	-	-	-	-	12	300	14	150

5) Traffic safty measures

In traffic safety measures, current state linear (design speed of 50km / h equivalent of Papua New Guinea criteria) in mounting road section of Aum Bridge Kapiura Bridge was improved the vertical alignment and horizontal alignment to 60 km / h to using the same criteria. It is possible to improve greatly the running-performance and the visibility.

The planned facilities is as following.

1	Lane Mark (Center line / Outside line) ➢ Separate of up and down line ➢ Prevention of lane departure	 Ex. : West New Britain Highway
2	Waikway (Bridge section) ➢ Pedestrian protection	 Typical cross-section : Bridge section
3	Guardrail ➢ Prevention of vehicle off-road departure	 Ex. : Australia

4	Guidepost (Delineator) ➢ Prevention of vehicle off-road departure ➢ Improvement of nighttime visibility	 Ex. : Australia
5	Danger warning sign (There is mounting road within the curve) ➢ Reminder ➢ Accident prevention in passing another	 Reference : Australian Standard

6) Checking of running safety based on three-dimensional images

Concerning the road alignment plan for Aum Bridge, a three-dimensional image was prepared based on the road's horizontal alignment, longitudinal alignment, and transverse composition in order to confirm visibility from the viewpoint of drivers.

Running visibility was confirmed in two positions entering the bridge traveling both towards the end point (downhill) and towards the start point (uphill) (see Figure 2.2.12).

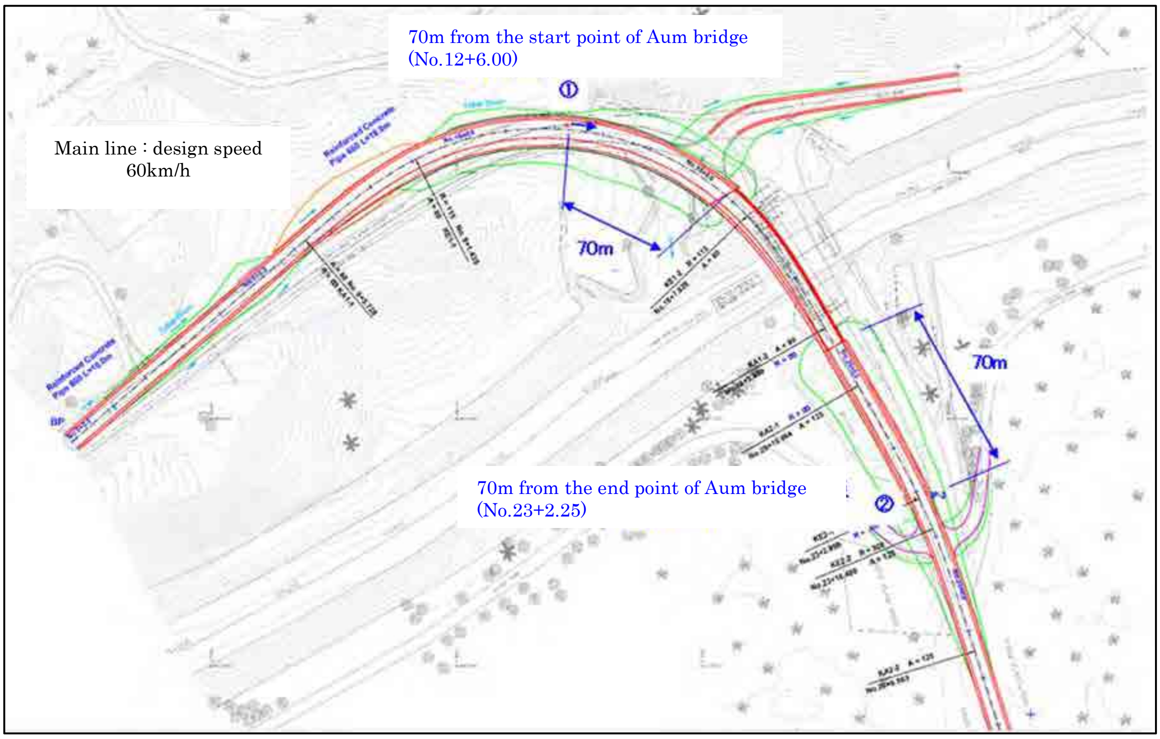


Figure 2.2.12 Confirmation Positions based on Three-dimensional Image

① Aum Bridge left bank side (No.12+6.0)

Figure 2.2.13 shows driver visibility heading towards the end point from a position 70 meters (necessary stopping sight distance at 60 km/h) to the connection with Aum Bridge (downhill gradient 6%).

From this image it can be confirmed that there is no problem regarding visibility at the stopping sight position and that there is a smooth curve looking ahead, thus allowing drivers to drive with peace of mind.

Figure 2.2.13 Going Towards Aum Bridge from the Start Point Side (70 meters to bridge)

② End point side (No.23+2.25)

Figure 2.2.14 shows driver visibility heading towards the start point from a position 70 meters (necessary stopping sight distance at 60 km/h) to the connection with Aum Bridge (uphill gradient 6%).

From this image it can be confirmed that there is no problem regarding visibility at the stopping sight position. Also, following the uphill gradient, the road shifts to a gentle gradient from the bridge connection and the road ahead can be easily grasped from the bridge railings ahead, thus allowing drivers to drive with peace of mind.

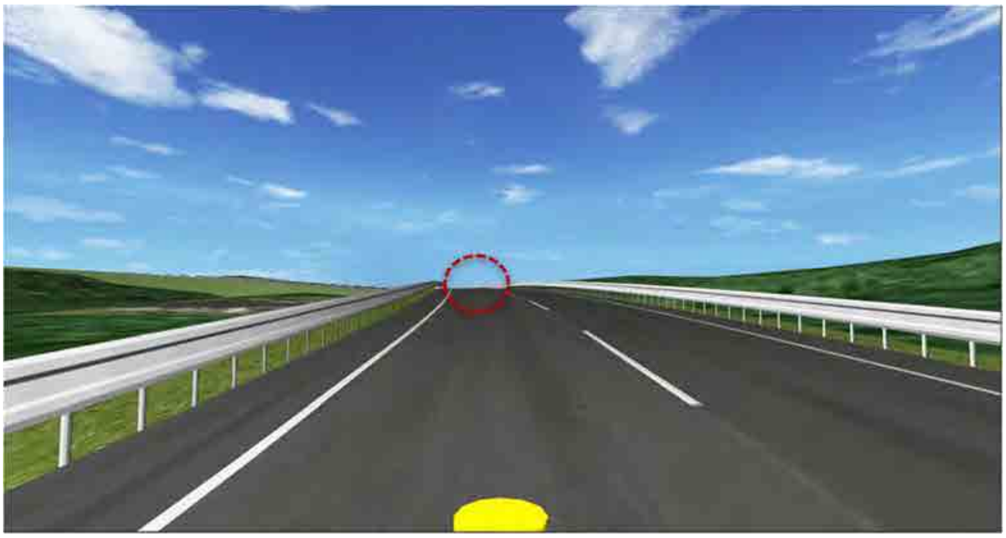


Figure 2.2.14 Going Towards Aum Bridge from the End Point Side (70 meters to bridge)

7) Paving

Current paving on the New Britain Highway consists of Double Bituminous Surface Treatment (DBST) over the entire course. This can be applied quickly and at low cost using a simple method, however, because it is a thin layer with weak paving strength, flaking can be seen at the edges; moreover, especially on areas around rivers that are prone to flooding and sections that have poor rainwater drainage capacity, flaking caused by water inundation is advancing and seriously curtailing the service life.

Moreover, based on the results of traffic volume survey and axle load survey, trucks carrying palms with load of more than 11 tons per axis regularly use the road together with timber trucks, etc. weighing close to 15 tons (a few vehicles per day), meaning that the road is also subject to loads by very heavy vehicles. In view of these conditions, a survey was conducted on the local compatibility of hot mix asphalt (HMA) paving, which is commonly used in Japan and offers good paving strength and long service life.

① Examination of paving composition

The paving structure was decided based on the results of locally implemented traffic volume survey and axle load survey.

i) Design standard traffic volume and design axle load

Concerning the design standard traffic volume, because the local nighttime traffic volume is extremely small and in particular very few large vehicles can be seen running, the 12-hour traffic volume at Mai Junction going in the direction of Bialla was adopted.

ii) Design period and design traffic volume

The design period for paving is generally given as between 10~20 years in Papua New Guinea and Japan, but the most common figure of 10 years has been adopted here. Design traffic volume is the cumulative total of the traffic volume in the design period. it was calculated in consideration of the elongation of the calculated future traffic volume in the "2.2.4 (2) 2) future traffic volume estimates". (See Table 2.2.13)

Table 2.2.13 Vehicle classification by weekday 12-hour traffic volume

Type	Current			Total of 10 years		
	Kinbe	Bialla	Total	Kinbe	Bialla	Total
A	52	95	147	771	1,408	2,179
B	153	165	318	2,268	2,446	4,713
C	16	15	31	237	222	459
D	5	5	10	74	74	148
E	25	19	44	371	282	652
F	6	15	21	89	222	311

iii) Examination of paving composition

In examining the paving composition, hearings were conducted with the overseas business officers of paving contractors and bitumen materials operators in Japan regarding overseas asphalt paving work and materials procurement. In doing so, confirmation was carried out on Japanese paving technology and problems facing paving work in Papua New Guinea.

- Bridge sections

For paving on bridge sections, it is essential to ensure running safety and secure waterproof functions for floor slabs in order to prevent degradation and realize long service life. It is necessary to have a paving composition that does not crack and allow water to infiltrate.

As a result of conducting hearings with paving contractors and bitumen materials operators, it was found that the DBST that is commonly adopted for local paving is applied at ordinary temperature not requiring a heating plant and that the adhesion between bitumen and aggregate is weaker than compared to HMA. Accordingly, this paving is inappropriate for application to bridges because the aggregate is apt to detach, causing the waterproof layer to peel off due to the vibration and displacement of passing vehicles.

Moreover, concerning concrete paving integrated with floor slabs as used on general bridges, since tensile force on the upper surface causes the paved surface to crack and allow rainwater to infiltrate and deteriorate the floor slabs in cases of continuous girder bridges, it is concluded that HMA, which has excellent waterproofing performance, needs to be adopted as the paving on bridge sections.

- General parts

Paving composition on general parts other than bridge sections shall be based on the local standard (Overseas Road Note 21 (ORN 31)) upon considering the local execution characteristics. For the purpose of comparison, examination was also implemented with the case where the Japanese paving design handbook is complied with.

In addition, the design CBR at this time is assumed 6%. 6% of CBR is standard value in general embankment material.

Note that the final pavement structure is determined by checking the material actually be secured locally.

Paving composition according to ORN31 is as follows.

Paving thickness 52.5cm + DBST (surface layer: DBST, upper roadbed: 200mm (crushed rock), lower roadbed: 325mm (natural gravel)

Moreover, under the same conditions, the paving composition based on the Japanese paving design handbook was decided as follows.

Necessary equivalent value converted thickness T_A: $3.84N^{0.16}/ CBR^{0.3} = 22.55$cm (reliability 90%, design CBR = 6%)

Table 2.2.14 Paving Composition based in the T_A Method

Category	Materials / Method	Equivalent value conversion coefficient	Paving thickness (cm)	TA value (cm)
Surface layer + base layer	HMA (5cm x 2 layers)	1.00	10	10
Upper roadbed	Graded crushed stone	0.35	15	5.25
Lower roadbed	RC40	0.25	30	7.50
Total			55	22.55 < 22.75

② Examination of rough works cost

When calculating the rough works cost, DBST can be implemented by using locally procured materials, however, in the case of HMA, since the facilities needed for execution (AS plant and execution machinery) do not exist in Papua New Guinea, it is necessary to add the cost of procurement from Japan or neighboring country to the works cost.

Concerning the AS plant, etc., according to a hearing survey of Japanese paving works contractors, when installing mobile or small-scale plants, because the initial cost of introduction greatly impacts the construction cost, paradoxically the works cost per unit area decreases and it becomes more economical as the worked area becomes bigger.

In consideration of this, comparison was carried out on the following two cases.

- Case 1: Bridge section: HMA＋Earthworks section: DBST
- Case 2. Entire section: HMA

As a result of the examination, it was confirmed that Case 2 is approximately 7% more economically advantageous for the scale of work planned in the Project (see Table 2.2.15).

Moreover, from the functional and structural viewpoints too, HMA is superior to DBST and can offer greater safety and high quality running on both bridge and earthwork sections. Accordingly, in the Project, it was concluded desirable to adopt HMA on all sections including the earthwork parts.

Table 2.2.15 Comparison of Rough Works Costs

Category	Case 1		Case 2	
	Bridge section	Earthworks section	Bridge section	Earthworks section
Paving type	HMA	DBST	HMA	HMA
Work area	2,000	9,000	2,000	9,000
Unit rate (yen/㎡)	92,000	3,400	18,200	18,200
Works cost (yen)	184,000,000	30,600,000	36,400,000	163,800,000
Rough works cost	214,600,000(1.07)		200,200,000(1.00)	

Table 2.2.16 Unit Rates by Work Area

Case of work area of 2000 ㎡

Type	Construction cost (per 2,000㎡)			Equipment			Transportation cost	Total	Work unit rate	Remarks
	Materials cost	Work cost	Subtotal	Plant	Construction machinery	Test equipment	(yen/set)	(yen)	(yen/㎡)	
HMA	3,419,149	92,000	3,511,149	27,400,000	58,020,000	15,000,000	80,000,000	183,931,149	91,966	
DBST	—	—	6,720,000					6,720,000	3,360	Dekenai estimate

Case of work area of 11,000 ㎡

Type	Construction cost (per 11,000 ㎡)			Equipment			Transportation cost	Total	Work unit rate	Remarks
	Materials cost	Work cost	Subtotal	(yen)	(yen/㎡)		(yen/set)	(yen)	(yen/㎡)	
HMA	18,805,322	506,000	19,311,322	27,400,000	58,020,000	15,000,000	80,000,000	199,731,322	18,157	

③ Decision on paving composition

As a result of the comparative examination, HMA paving with the composition shown in Table 3.2.16 shall be adopted on earthwork sections in the Project.

Table 2.2.17 Paving Composition based on the T_A Method

Category	Materials / Method	Equivalent value conversion coefficient	Paving thickness (cm)	TA value (cm)
Surface layer + base layer	HMA (5cm x 2 layers)	1.00	10	10
Upper roadbed	Graded crushed stone	0.35	15	5.25
Lower roadbed	RC40	0.25	30	7.50
Total			55	22.55 < 22.75

8) Drainage plan

① Local conditions

In the area around Aum Bridge, since roadside collapse caused by breakage of existing water channels can be seen (see Photograph 3.2.1), in order to prevent destruction of the road body and paving due to torrential rainfall, it will be necessary to repair or newly construct roadside drainage facilities for stopping runoff from surrounding slopes and quickly removing rainwater from the right of way.

Photograph 2.2.1 Roadside Erosion and Collapse caused by Channel Damage

Furthermore, on the current DBST paved road, damage on the road edges caused by rainwater flows and vehicle deviations from the road is spreading over time.

Photograph 2.2.2 Damage to Paving Edges

In view of the above points, since protecting the edges of paving is deemed important for extending the service life of paving, it has been decided to adopt shoulder protection based on HMA binder course and to install concrete curves for protecting paving edges and strengthening drainage functions. Moreover, installation of binder course on shoulders and site distance width expansion parts will help reduce maintenance costs through controlling weed growth.

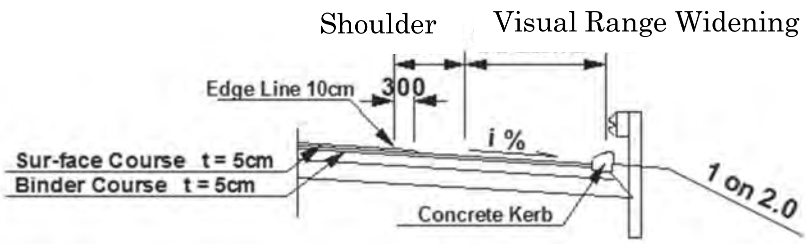


Figure 2.2.15 Structure of Shoulder Paving

② Drainage structures plan

The cross-sectional shape of drainage structures will be determined based on the drainage volume and permissible maximum flow velocity.

Concerning the design drainage volume, the probable daily rainfall was determined using rainfall data from the local observation station at Dami (as in the case of calculating river flow).

The cross-sectional shape of drainage structures will be determined based on the Road Earthworks Manual (the guidelines used by the Japan Road Association) and the DOW's Manual for the Design of Drainage Structures for Rural Roads.

The permissible maximum flow velocity will be as follows:

a) Road transversal concrete pipe =3.0m/s (Road Earthworks Manual)

b) Masonry lining channel (concrete bottom) = 4.6m/s (DOW Manual for the Design of Drainage Structures for Rural Roads)

The design cross section at each point was decided as follows according to the above conditions.

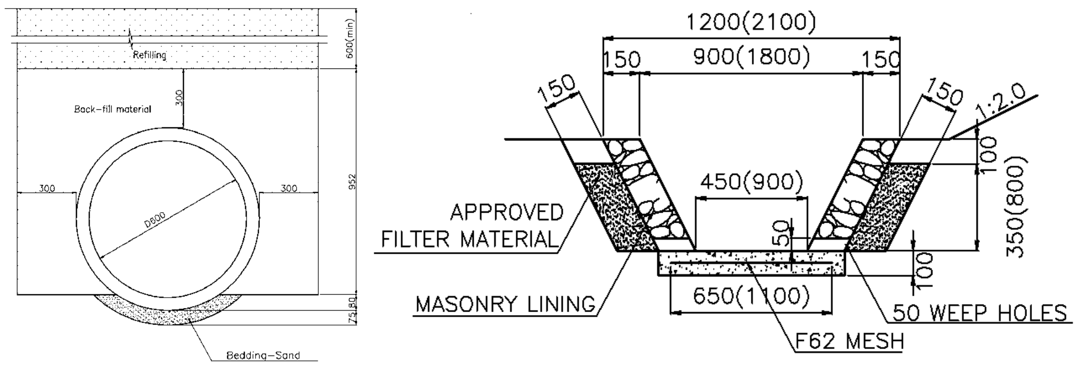


Figure 2.2.16 Drainage Structures

➢ Aum Bridge Left Bank Mountain Side

Measurement point	Place	Design flow rate (m^3/s)	Structural type	Necessary cross-sectional area (m^2)	Design cross-sectional area (m^2)	Remarks
No.15＋16	Road left side	0.251	Masonry lining channel W=900	0.055	0.227	At 80% water depth
Ditto	Ditto	0.251	Concrete pipe (D600)	0.084	0.243	Ditto

➢ Aum Bridge Left Bank River Side

Measurement point	Place	Design flow rate (m^3/s)	Structural type	Necessary cross-sectional area (m^2)	Design cross-sectional area (m^2)	Remarks

No.1＋15	Road left side	0.215	Masonry lining channel W=900	0.047	0.227	At 80% water depth
Ditto	Ditto	0.215	Concrete pipe (D600)	0.072	0.243	Ditto
No.9＋7	Road left side	0.032	Masonry lining channel W=900	0.007	0.227	Ditto
Ditto	Ditto	0.032	Concrete pipe (D600)	0.011	0.243	Ditto
No.15＋16	Road left side	0.824	Masonry lining channel W=1800	0.179	0.907	Ditto

- Aum Bridge Right Bank

Measurement point	Place	Design flow rate (m^3/s)	Structural type	Necessary cross-sectional area (m^2)	Design cross-sectional area (m^2)	Remarks
No.19＋12	Road left side	0.039	Masonry lining channel W=900	0.008	0.227	At 80% water depth
No.19＋12	Road left side	0.050	Masonry lining channel W=900	0.011	0.227	Ditto

- Kapiura Bridge Left Bank

Measurement point	Place	Design flow rate (m^3/s)	Structural type	Necessary cross-sectional area (m^2)	Design cross-sectional area (m^2)	Remarks
No.15＋15	Road left side	0.075	Masonry lining channel W=900	0.016	0.227	At 80% water depth
No.15＋15	Road left side	0.075	Masonry lining channel W=900	0.016	0.227	Ditto

- Kapiura Bridge Right Bank

Measurement point	Place	Design flow rate (m^3/s)	Structural type	Necessary cross-sectional area (m^2)	Design cross-sectional area (m^2)	Remarks
No.22＋13	Road left side	0.147	Masonry lining channel	0.032	0.227	At 80% water depth

			W=900			
No.22+13	Road left side	0.064	Masonry lining channel W=900	0.014	0.227	Ditto

9) Detour route during works

Since Aum Bridge will be rebuilt in its current position, it will be necessary to close the existing road and use the works road for general traffic during the works period. Accordingly, a detour plan will be implemented corresponding to the stage of works. As for Kapiura Bridge, because the bridge will be rebuilt upstream of the current bridge, the existing bridge can be used during the works and there will be no need to reroute the existing road.

Start of construction

↓

STEP.1 Establishment of temporary road on the left side connecting to the outer side of the existing road

↓

STEP.2 Construction of main road and bridge and establishment of temporary road on the left side

↓

STEP.3 Construction of the replacement road on the left bank side

↓

STEP.4 Closure and removal of temporary road on the right bank and temporary bridge

↓

STEP.5 Construction of revetment and replacement of drainage channels

↓

Completion of works

Figure 2.2.17 Detour Routing Procedure during Construction Work on Aum Bridge

10) Alignment plan

The alignment calculation sheets concerning the design roads are attached in the appendices.

11) Quantities calculation

The quantities calculation sheets concerning the design roads are attached in the appendices.

(3)Bridge Plan

1) Design conditions

① Applicable standards

As a result of holding discussions with the responsible engineers in the DoW, it was decided to use Papua New Guinea standards as the basis for designing the target structures and the Japanese Design Specifications for Highway Bridges for the specific design methods. Moreover, Australian standards, which are frequently referred to in Papua New Guinea, shall be used as reference standards.

② Design live load

The B live load in Specifications for Highway Bridges will be applied.

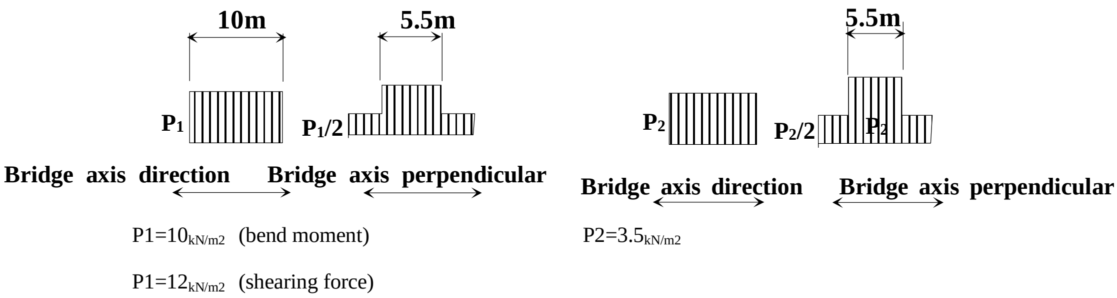


Figure 2.2.18 B Live Load

③ Seismic load

Design Specifications for Highway Bridges, Part V Seismic Design will be applied.

④ Consideration of riverbed scouring

The forecast scouring depth will be considered in the design. However, combining with the L2 seismic load will not be done.

⑤ Flood debris and driftwood load

The Australian standards take into account debris and driftwood load in 2,000-year flooding, so this will be applied in this design too.

⑥ Used materials

Since construction materials will mainly be procured locally in Papua New Guinea or imported from Japan, design will be conducted assuming the following materials that are based on JIS.

Table 2.2.18 Main Used Materials

Type	Material Specifications	Remarks
Concrete	Design standard strength for substructure works: 30N/mm2 (abutment, pier) Design standard strength for superstructure floor slabs: 30N/mm2	
Reinforcing bars	SD345 yield point 345~440N/mm2, SD390 yield point 390~510N/mm2	
Steel materials	SM400: Based on yield point/plate thickness 245~215N/mm2 or more SM490Y(SM520): Based on yield point/plate thickness 365~325N/mm2 or more SM570: Based on yield point/plate thickness 460~420N/mm2 or more	
Steel pipe pile	SKK400: Yield point 235N/mm2 or more	

⑦ Results of hydraulic and hydrological analysis

The hydraulic and hydrological specifications required for the bridge design are as follows. Detailed examination contents are indicated in the appendices.

Table 2.2.19 Hydraulic and Hydrological Specifications Required for Bridge Design

Item		Kapiura Bridge	Aum Bridge
In planning (100 year probability)	Design flow rate	2,250m³/s	550m³/s
	H.W.L.	EL+26.20m	EL+32.50m
	Design flow velocity	2.60m/s	2.33m/s
	Design riverbed height	EL+13.00m	EL+20.80m
	Design riverbed gradient	1/500	1/450
	Water line afflux caused by piers	46mm	21mm
	Scouring depth around piers	2.50m	2.50m
	Scope of protective works around piers	5.00m	5.00m
In construction (roughly 2 year probability)	Flow rate	1,200m³/s	290m³/s
	Water line	EL+20.82m	EL+26.99m
	Flow velocity	2.17m/s	1.95m/s
At ultimate load (2000 year probability)	Flow rate	3,750m³/s	950m³/s
	Water line	EL+26.86m	EL+31.68m
	Flow velocity	3.09m/s	2.71m/s

⑧ Temperature changes

The following values, also used in the BRIRAP/ADB project, will be adopted.

Table 2.2.20 Scope of Temperature Changes

Item	Maximum (℃)	Minimum (℃)	Remarks
Temperature	46	0	
Mean temperature of bridge structure	50	6	
Bridge temperature	60	1	
Temperature during construction	30		
Temperature change	30	-29	ΔT=59

Source: TOR of the ADB BRIRAP project

2) Policy for deciding bridge length and span arrangement

The relationship between bridge and terrain around Aum River and Kapiura River is the same as indicated in the original construction documents, and a stable river course has been maintained for more than 30 years. The bridge length and span arrangement for the two bridges will be planned according to the government ordinance concerning structural standards for river management facilities, etc., which is used for planning river bridges in Japan.

Figure 2.2.19 shows the procedure for determining bridge length and span arrangement

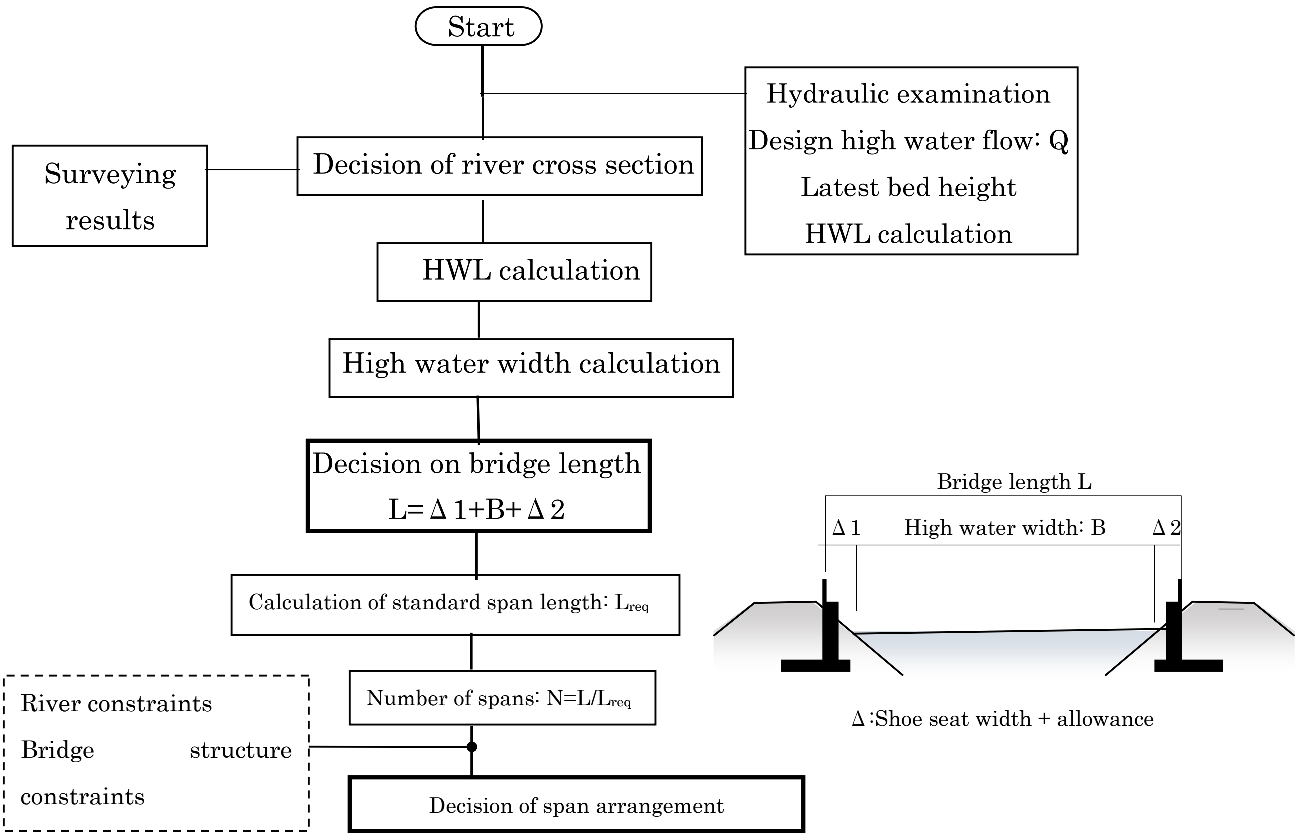


Figure 2.2.19 Flowchart for Deciding Bridge Length

The specific conditions concerning bridge length and span arrangement are as follows.

① The current riverbank comprises a rough gradient of 1:2.0, and this gradient will be used for defining the design river section at the bridge positions.
When doing this, berms of 3 meters in width will be placed at every 5 meters of perpendicular height with a view to securing banking stability and utilizing embankment slopes.

② The HWL calculated from hydraulic and hydrological analysis will be used (see Table 2.2.19). Abutments will connect to the bed below the line that links the ground inside embankments to the river bottom.

③ Abutments will be set behind the intersection between HWL and embankments.

④ Piers will be set at least 0.5 meters deeper than the deepest riverbed in the river cross section at the bridge positions. However, they will be designed to remain stable even if the riverbed is scoured to the forecast scouring depth.

⑤ The span length shall be at least the standard span length L=0.005Q+20 (see Table 2.2.19).

⑥ The bridge clearance allowance will be at least 1.0m (Aum Bridge), and in cases where the high water flow rate Q100 is 2000m3/s or more, 1.2 meters will be adopted upon applying the government ordinance concerning structural standards for river management facilities, etc. (Kapiura Bridge).

⑦ The increase in HWL (Afflux) due to pier construction will be no more than 100 mm (applying the conditions of the ADB project).

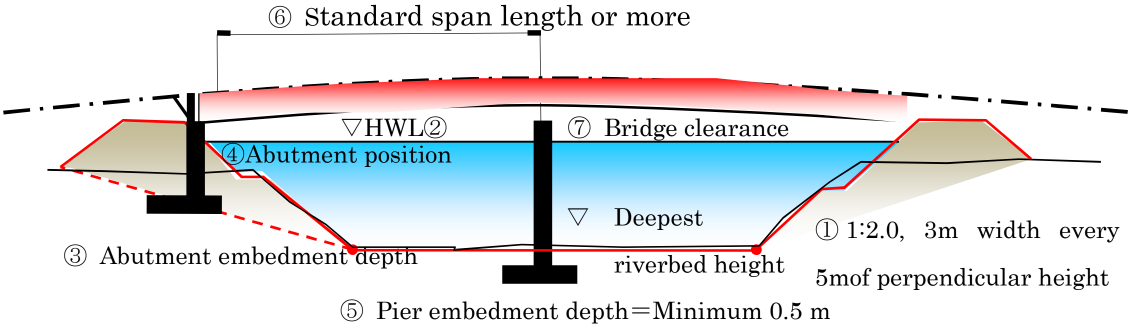


Figure 2.2.20 Bridge Planning Constraints

3) Decision on bridge length and span arrangement (Kapiura Bridge)

① Decision on bridge length

The bridge length will be decided using the method described above.

- Assuming the deepest riverbed height EL=13.0m to be standard, the design embankment cross section will be decided (gradient 1:2.0, with berms of 3 meters in width placed at every 5 meters of perpendicular height).

- Assuming HWL=EL 26.2m, the distance between the design embankment and HWL intersection (high water width) will be sought.
- Bridge length will be determined in such a way that the abutment fronts do not interfere with the high water width (assuming the shoe seat width to be 1.5m).
- As a result, as shown in Figure 2.2.21, the high water width will be 134.165m and bridge length will be L= 137.3m.

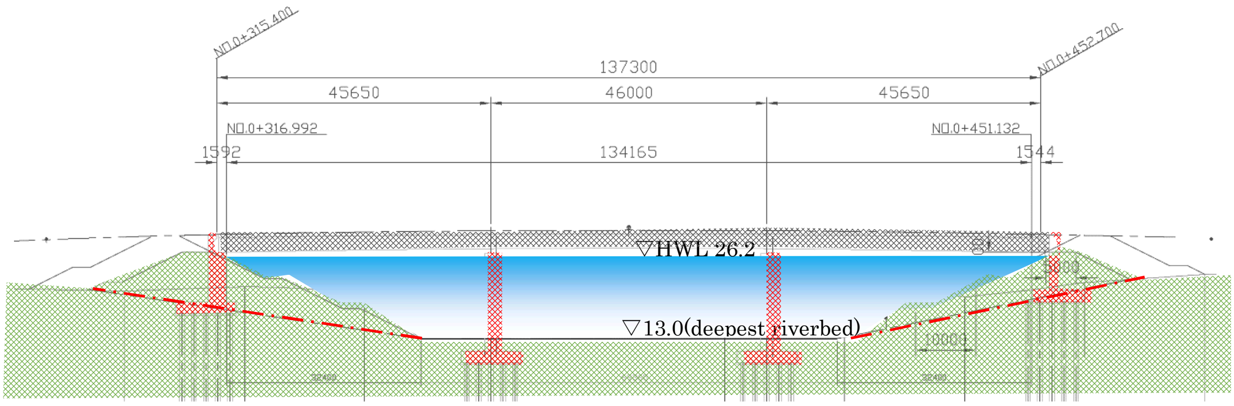


Figure 2.2.21 Explanatory Figure of Bridge Length and Span Arrangement for Kapiura Bridge

Bridge length＝137.3m

② Decision of span arrangement

Assuming the standard span length to be L_{req}=31.25 m:

N= (bridge length) / L_{req} = 137.3 / 31.25 =4.39 > (no more than 4 spans), so 4 spans are possible.

Table 2.2.21 Comparison of Number of Spans (Kapiura Bridge)

Plan		4 spans	3 spans
Works cost	Superstructure	40%	40%
	Substructure	12%	12%
	Foundations	49%	48%
	Total	101%	100%
Compatibility with the river		Because piers are situated in front of the embankment slopes, there is risk of adverse impact on the revetment.	Piers are at least 10 meters from the revetment, so there is less impact on revetment than in the plan with 4 spans.
Structural characteristics		The average span is 35 meters, within the scope of general girder bridges, and there is little structural difference with the 3-span plan.	The average span is 45 meters, within the scope of general girder bridges, and there is little structural difference with the 4-span plan.
Ease of execution		3 piers are constructed in the water, making execution more difficult than in the 3-span plan.	2 piers are constructed in the water, making execution easier than in the 4-span plan.
Judgment			Adopt

※The works costs indicate direct works costs.

Table 2.2.21 shows the comparison of both plans.

<u>The 3-span plan is economically advantageous compared to the 4-span plan.</u>

Meanwhile, referring to the Design Procedure Volume 2 (NEXCO), the economically advantageous span length (optimum span length) is roughly given as follows.

L =(1.0 ~1.5) xH' H'=pier height + 1/3 x (foundation structure embedment depth)

According to this, the optimum span length for Kapiura Bridge is calculated as: L = (1.0 ~1.5) x (20+1/3 x 45) = 35~52m. Therefore, it will be economically disadvantageous to plan a bridge with a single span (140 meters) and no piers as in the case of the existing lower deck langer bridge (Kapiura Bridge), or a bridge with two spans of 70 meters each.

In consideration of the above examination, Kapiura Bridge will be planned with three spans.

The span arrangement will basically be spans of equal length, however, the central span will be rounded off to the nearest meter to give the following arrangement.

Span arrangement: 3 spans (L=45.65m+46.0m+45.65m)

4) Decision on bridge length and span arrangement (Aum Bridge)

① Decision on bridge length

The bridge length will be decided using the method described in the previous section.

- Assuming the deepest riverbed height EL = 20.8 meters to be standard, the design embankment cross section will be decided (gradient 1:2.0, with berms of 3 meters across placed at every 5 meters of perpendicular height).
- Assuming HWL = EL 32.5 meters, the distance between the design embankment and HWL intersection (high water width) will be sought.
- Bridge length will be determined in such a way that the abutment fronts do not interfere with the high water width (assuming the shoe seat width to be 1.5 meters).
- As a result, as shown in Figure 2.2.21, the high water width will be 71.355 meters (river perpendicular direction) and bridge length will be L = 76.0 meters (on the road center line).

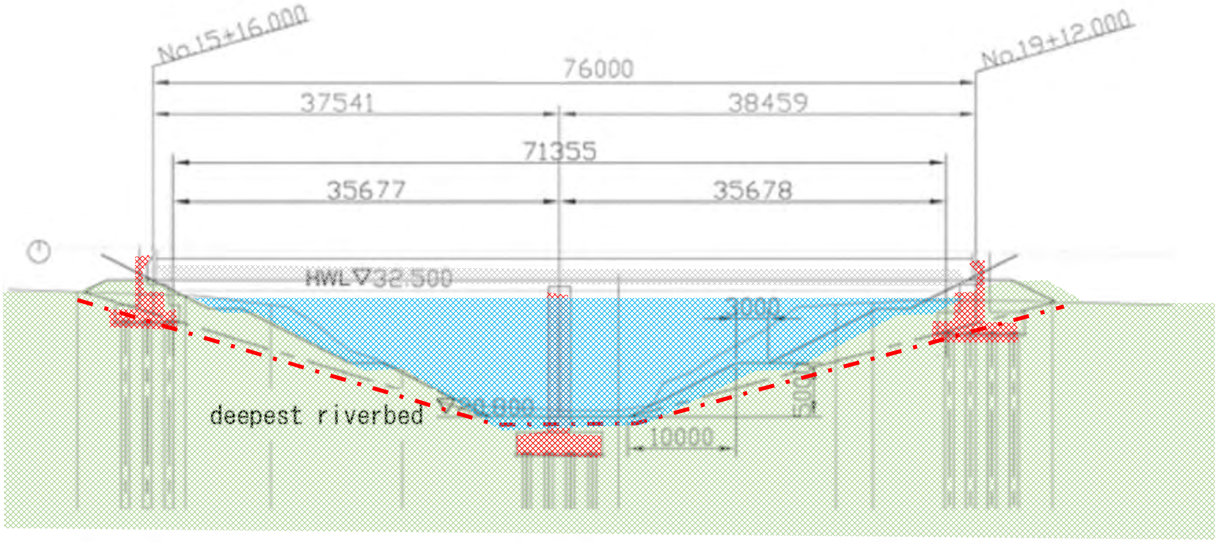


Figure 2.2.22 Explanatory Figure of Bridge Length and Span Arrangement for Aum Bridge

Bridge length＝76.0m

② Decision of span arrangement

- Assuming the standard span length to be L_{req} = 22.75 meters (see Table 3.2.18):
- N = (bridge length) / L_{req} = 74.80 / 22.75 = 3.28 > (no more than 3 spans), so 3 spans or 2 spans are possible.
- Table 2.2.22 shows a comparison of the two options.

Table 2.2.22 Comparison of Number of Spans

Plan		2 spans	3 spans
Works cost	Superstructure	35%	37%
	Substructure	12%	12%
	Foundations	53%	55%
	Total	100%	104%
Compatibility with the river		Pier width is 2.0 meters and the river obstruction rate is 2.8% < 5.0%, so there is room to spare.	Pier width is 1.5 meters and the river obstruction rate is 4.2% < 5.0%, which is relatively large.
Structural characteristics		Superstructure works: The horizontal curve is addressed using bent girders at the fulcrum point, however, the large span length makes this plan structurally inferior to the 3-span plan.	Superstructure works: Handling of the horizontal curve is easier than in the 2-span plan.
Ease of execution		1 pier is constructed in the water, making execution easier than in the 4-span plan.	2 piers are constructed in the water, making execution more difficult than in the 2-span plan.
Judgment		Adopt	

※The works costs indicate direct works costs.

Comparing the 2-span plan and 3-span plan, the 2-span plan is 2% more advantageous in terms of economy. Moreover, it also has the advantage in terms of impact on the river (river obstruction rate) and ease of execution.

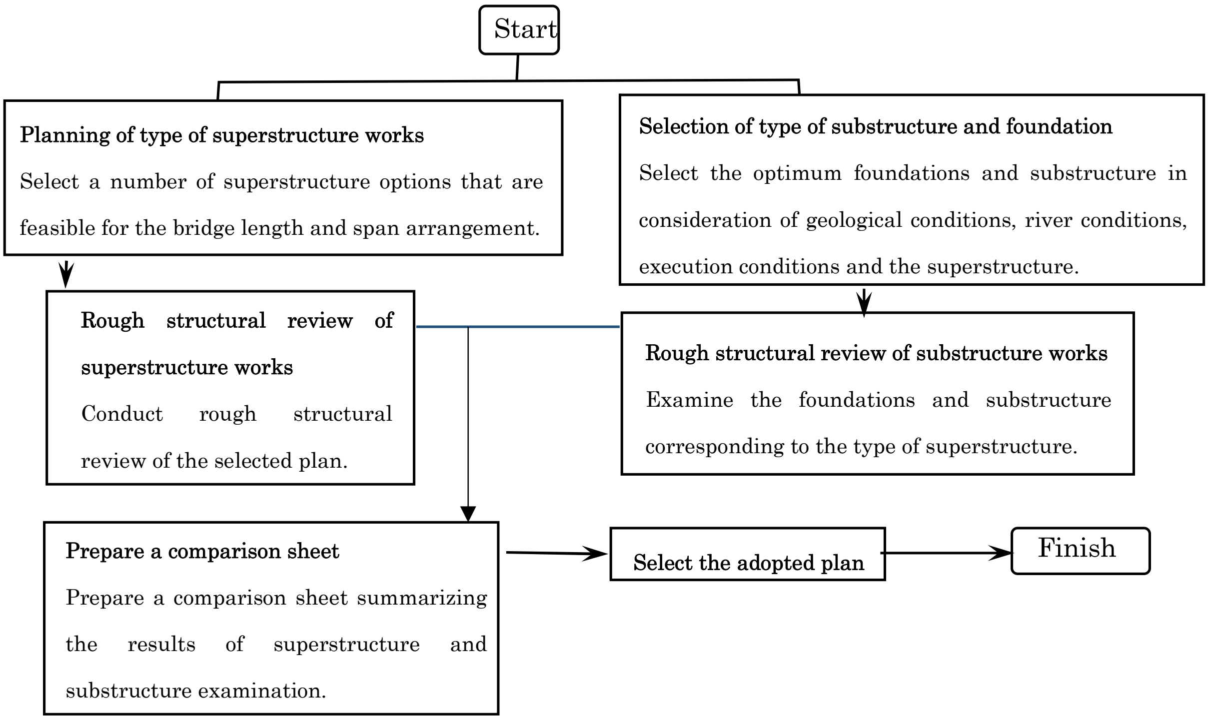
As for the 1-span plan, since this is not feasible for addressing the curved horizontal alignment, it is excluded from the examination.

In consideration of the above examination for Aum Bridge, assuming that the pier is established in the center of the river, the span arrangement will comprise A1 abutment (No.15+16.0), P1 pier (No.17 + 14.429), and A2 abutment (No.19 + 12.0) and L = 38.429 meters + 37.571 meters.

Span arrangement: 2 spans (L = 38.429m+37.571m)

5) Selection of bridge type

Selection of the bridge type is carried out according to the following procedure.



① Planning of type of superstructure

Table 2.2.24 and Table 2.2.25 show the standard applicable spans for types of superstructure.

Assuming span length to be L = 46 meters in the case of Kapiura Bridge and L = 38 meters in the case of Aum Bridge, the following bridge types are proposed as candidates based on the "applicable span sheet." Table 2.2.23 shows comments regarding these.

Table 2.2.23 List of Feasible Bridge Types

Type	Option	Comment	Judgment
Steel bridge	Simple plate girder bridge	The simple style will not be adopted in consideration of earthquake resistance.	x
	Simple box girder bridge	Ditto	x

Type	Option	Comment	Judgment
	Continuous plate girder bridge	This is the most common style for small- and medium-size bridges.	○
	Continuous box girder bridge	This is the most common style for medium-size bridges.	○
	Steel floor slab bridge	This type is adopted for small and medium spans in cases where there are restrictions on girder height, the bridge comprises plate girders with reinforced concrete floor slabs, or the box girder style is incompatible. Alternatively, it is limited to cases where it is important to reduce the weight of superstructure works. It is not as economical as plate girder or box girder types.	x
PC bridge	Simple posten T	The simple style will not be adopted in consideration of earthquake resistance.	x
	Simple PC composite bridge	〃	x
	Continuous posten T	A common style for small- and medium-size bridges, this is applicable, however, since it is similar to the continuous PC composite bridge but is not as economical as composite bridges, it will not be adopted.	x
	Continuous PC composite bridge	A common style for small- and medium-size bridges, this is applicable. In economic comparison with post tension T bridges, since this style which doesn't entail floor slab transverse prestressing is better, it will be adopted as an option.	○
	Falsework/ Simple box girders	Since the Project targets river bridges, construction based on fixed falsework should be avoided.	x
	Falsework/ Continuous box girders	〃	x
	π rigid frame	This is incompatible with the terrain.	x
Concrete arch		This is incompatible with the terrain.	x

Based on the above examination, continuous plate girders and continuous box girders are applicable for steel bridges, while the PC composite (continuous girder) type can be applied for PC bridges. The optimum bridge types will be selected upon comparing these types.

Structural types targeted for comparative examination:

Plan 1　Continuous plate girders
Plan 2　Continuous box girders
Plan 3　PC composite bridge (continuous girders)

Table 2.2.24 Superstructure Standard Applicable Span (Steel Bridge)

(m) Bridge type				Span length: 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150	Girder height / Rough span	Remarks
Steel bridge	Plate girder	Simple type	H steel bridge		-	
			Plate girder bridge		1/18	
			Box girder bridge		1/22	
		Continuous type	Plate girder bridge		1/17	
			Box girder bridge		1/23	
		Steel floor slab bridge			鈑桁 1/25 箱桁 1/27.5	
	Rigid frame bridge				-	
	Truss	Simple truss bridge			1/9	
		Continuous (cantilever) truss bridge			1/10	
	Arch	Reversed Langer girder bridge			1/6.5	
		Reversed Lohse girder bridge			1/6.5	
		Langer girder bridge			1/6.5	
		Trussed Langer girder bridge			1/6.5	
		Lohse girder bridge			1/6.5	
		Nielsen Lohse girder bridge			1/6.5	
		Arch bridge			1/6.5	
	Cable-stayed bridge				-	
	Suspension bridge				-	

Source: Ministry of Land, Infrastructure and Transport, Design and Construction Manual

Kapiura Bridge L=46m

Aum Bridge L=38m

Table 2.2.25 Superstructure Standard Applicable Span (Concrete Bridge)

Bridge type					Span length (m) 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150	Girder height / Rough span	Remarks
PC bridge	Precast girder erection	Pre-tension	Simple	Hollow floor slab		1/24	
				T girder		1/18	
			Continuous girder	T girder		1/18	
		Post-tension	Simple	T girder		1/18	
				PC Composite bridge		1/15	
			Continuous	T girder		1/18	
				PC Composite bridge		1/15	
	Falsework erection		Simple girder	Hollow floor slab		1/22	
				Box girder		1/20	
			Continuous	Box girder		1/20	
	Overhang erection		Continuous rigid frame	Box girder		1/18	
	Others		π rigid frame	Hollow floor slab		-	
			Cable-stayed bridge	T(plate girder)		-	
RC bridge	Hollow floor slab					1/18	
Concrete arch						-	

(Note) 1. Girder height in the truss and arch bridges denotes the main truss or arch rise.

2. Curve applicability: ○ indicates that curve can be applied along the main truss; X indicates that the main truss cannot be curved.

Source: Ministry of Land, Infrastructure and Transport, Design and Construction Manual

Kapiura Bridge L=46m

Aum Bridge L=38m

② Selection of foundation type

i) Examination of load bearing layer

As a result of the geological survey, ground along the main road was found to consist solely of riverbed deposits with no bedrock. It was not possible to confirm a clear base layer in the survey. Accordingly, as the bridge load bearing layer, a continuous stratum where the average N value is 30 or higher was selected. The depth of the load bearing layer differs slightly between each bridge, however, it can generally be found around EL-20.0mfor both Aum Bridge and Kapiura Bridge. Figure 2.2.23 and Figure 2.2.24 show the projected strata cross section drawing for Aum Bridge and Kapiura Bridge.

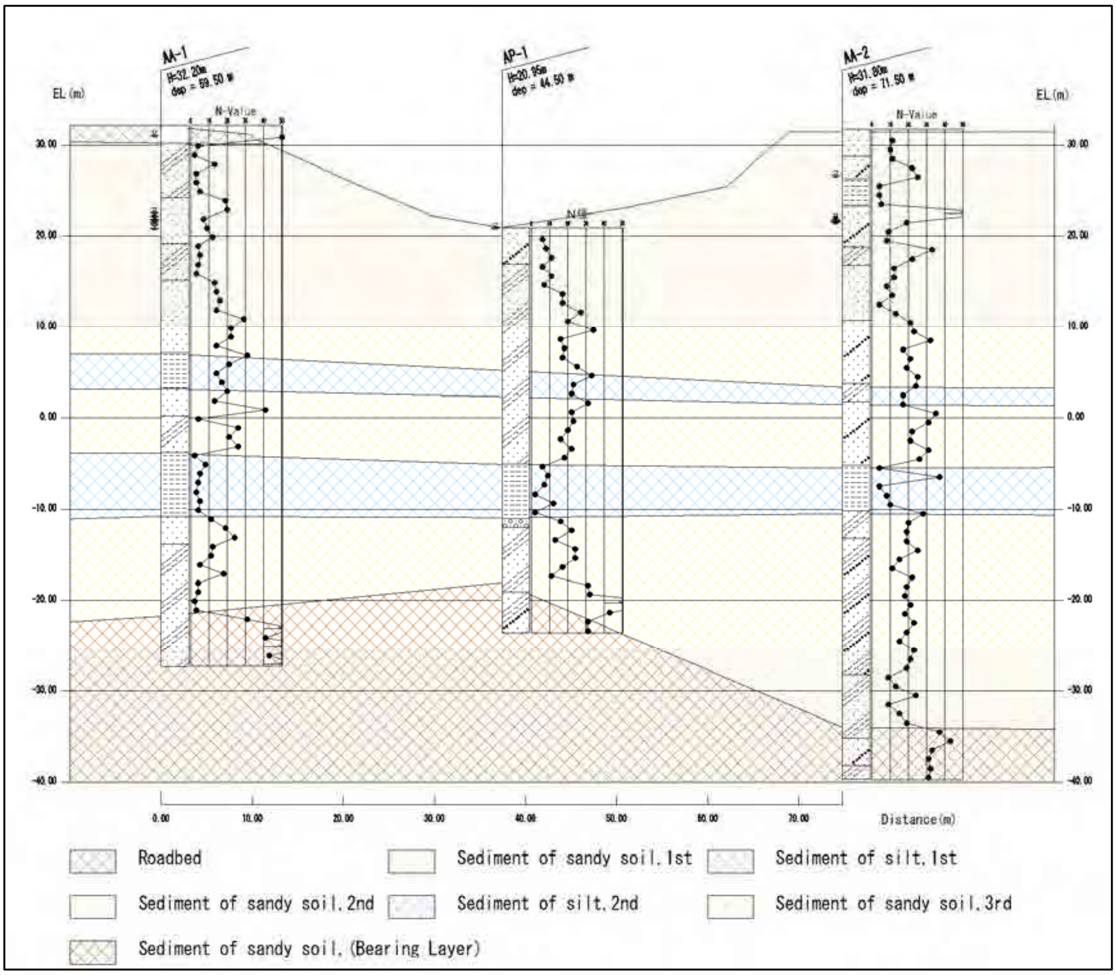


Figure 2.2.23 Projected Strata Cross Section - Aum Bridge

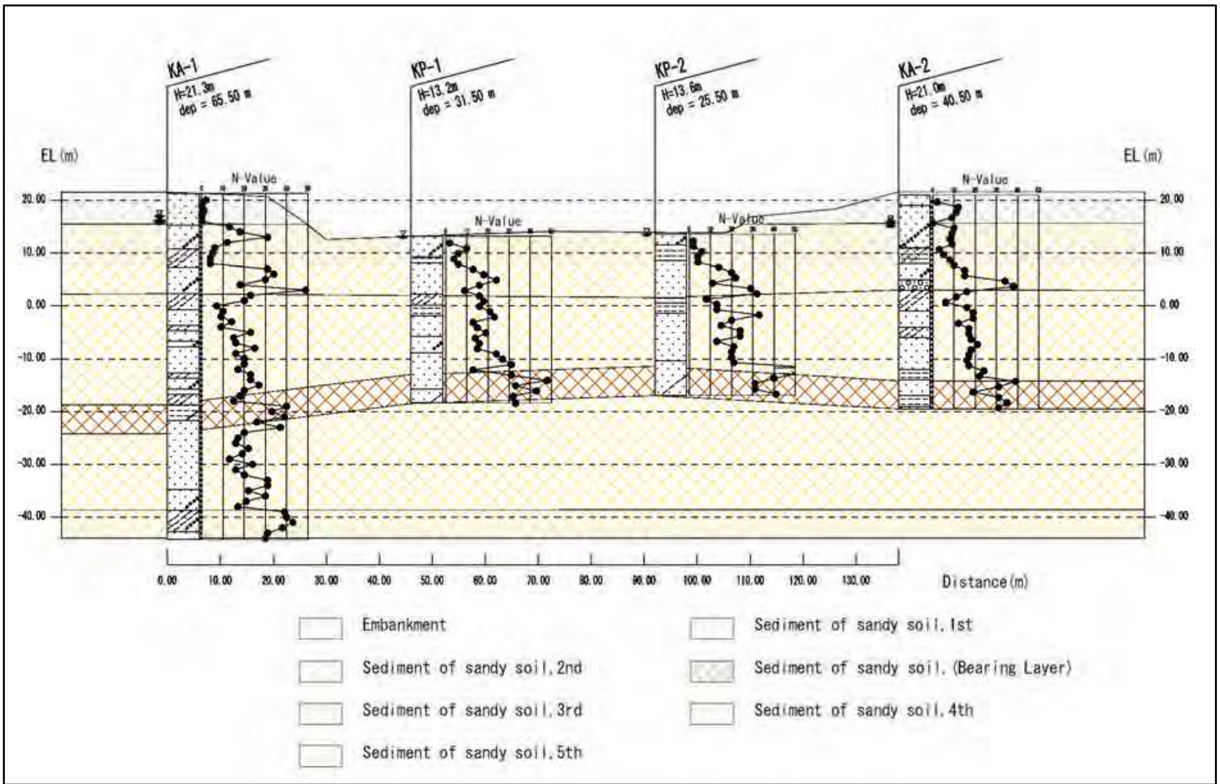


Figure 2.2.24 Projected Strata Cross Section - Kapiura Bridge

ii) Examination of soil parameters

—Policy for setting soil parameters

The soil parameters for use in the design calculation will be set based on the following policy.

- Unit volume weight of soil γ (kN/m3): Concerning sediment, this will be set based on the results of laboratory soil tests and the NEXCO design manual.
- Angle of shearing resistance φ (deg): Concerning sandy soil, estimate values based on standard penetration test (N values) will be used. Concerning sandy soil of N>5, estimate will be made using the formula $\varphi=15+\sqrt{15N}$ from the Design Specifications for Highway Bridges (1996). As for sandy soil of N<5, the soil modular standard values from the NEXCO design manual will be used.
- Adhesive force c (kN/m2): Concerning clayey soil and silt, estimates will be derived from the N value. In the Design Specifications for Highway Bridges, this is given as c = 6~10N, so c = 6N is adopted here to be on the safe side.
- Modulus of deformation E_0 (kN/m2): As the modulus of deformation for soil, the estimation formula E0 = 700N indicated in the Design Specifications for Highway Bridges will be used.

－Results of examining soil parameters

Table 2.2.26 shows the soil parameters used in the design.

Table 2.2.26 List of Soil Parameters

Boring No.	Soil Type	N blow	Unit weight γ (kN/m3)	Angle of Shear Resistance φ (deg)	Adhesion c (kN/m2)	Elastic Modulus E0 (kN/m2)
Kapiura	Sandy soil 1	**9**	17.0	27.0	0.0	6,300
	Sandy soil 2	**17**	17.0	31.0	0.0	11,900
	Sandy soil 3	**22**	17.0	33.0	0.0	15,400
	Sandy soil 4	**32**	19.0	37.0	0.0	22,400
	Sandy soil 5	**22**	18.0	33.0	0.0	15,400
	Sandy soil 6	**36**	19.0	38.0	0.0	25,200
Aum	Sandy soil 1	**15**	17.0	30.0	0.0	10,500
	Silt 1	**19**	17.0	32.0	0.0	13,300
	Sandy soil 2	**23**	17.0	34.0	0.0	16,100
	Silt 2	**8**	16.0	26.0	0.0	5,600
	Sandy soil 3	**16**	17.0	30.0	0.0	11,200
	Sandy soil 4	**41**	19.0	40.0	0.0	28,700

iii) Examination of foundation works

－Classification of foundation work types

Bridge foundation work types are often divided into spread foundations and pile foundations depending on the depth of the load bearing layer. Generally speaking, spread foundations are more economical when the load bearing layer is around 5 meters below the surface, while pile foundations become more economically advantageous at depths beyond that.

Considering that the load bearing layer in the Project is deep, pile foundations will be adopted.

－Selection of type of pilesTable 2.2.27 shows the standard selection sheet for the type of pile foundations.

Table 2.2.27 Standard Selection Sheet for Type of Pile Foundations

Selection conditions \ Foundation type			Pile foundation														
			Displacement pile foundation			Inner excavation pile foundation						Steel pipe soil cement pile foundation	Pre-boring pile foundation	Cast-in-situ pile foundation			Rotating pile
				Steel pipe pile		PHC and SC piles			Steel pipe pile								
			PHC pile and SC pile	Impact drivingmethod	Vibro hammer method	Final driving method	Spout mixing mathod	Concrete casting mathod	Final driving method	Spout mixing mathod	Concrete casting mathod			All casing	Reverse	Earth drill	
Ground conditions	Conditions up to the bearing layer	A very soft layer in the suface and intermediate layer	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○
		A very hard layer in the intermediate layer	△	△	△	○	○	○	○	○	○	○	○	△	○	×	○
		Gravel in the intermediate layer: Gravel diameter under 50mm	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Gravel in the intermediate layer: Gravel diameter 50 to 100mm	△	△	△	△	△	△	△	△	△	○	○	△	×	○	○
		Gravel in the intermediate layer: Gravel diameter 100 to 500mm	×	×	×	×	×	×	×	×	×	×	×	△	×	×	×
		Ground with possibility of liquefaction	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Conditions in the bearing layer	Depth: Under 5m	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
		Depth: 5 to 15m	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○
		Depth: 15 to 25m	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Depth: 25 to 40m	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○
		Depth: 40 to 60m	△	○	○	△	△	△	○	○	○	○	○	△	○	×	○
		Depth: Over 60m	×	△	△	×	×	×	×	×	×	△	△	×	△	×	○
		Soil: Sand and gravel (30≦N)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Soil: Cohesive soil (20≦N)	○	○	○	○	△	×	○	△	×	△	△	○	○	○	△
		Soil: Soft rock and mud stone	×	○	△	○	△	×	○	△	×	△	△	○	○	○	△
		Soil: Hard rock	×	×	×	×	×	×	×	×	×	×	×	△	△	△	×
		Steep slope and Very uneven bearing layer surface	△	△	△	△	△	△	△	△	△	△	△	○	○	○	○
	Ground water conditions	Ground water level close to ground level	○	○	○	○	○	○	○	○	○	○	○	△	△	△	○
		Large amount of spring water	○	○	○	○	○	○	○	○	○	△	△	△	△	△	○
		Confined groundwater more than 2m from ground level	○	○	○	×	×	×	×	×	×	×	×	×	×	×	○
		Ground water speed of 3m/min or more	○	○	○	○	×	×	○	×	×	×	×	×	×	×	○
Type of support		Bearing pile	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Friction pile	○	○	○	×	×	×	×	×	×	○	×	○	○	○	×
Construction conditions	Over-water construction	Water depth of less than 5m	○	○	○	△	△	△	△	△	△	△	×	×	○	△	○
		Water depth of 5m or more	△	○	○	△	△	△	△	△	△	△	×	×	△	×	○
		Small work space	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△
		Use of batter piles	○	○	○	×	×	×	×	×	×	×	×	×	×	×	○
		Influence of toxic gases	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Surrounding environment	Vibration and noise control	×	×	△	△	○	○	△	○	○	○	○	○	○	○	○
		Influence on adjacent structures	×	△	△	△	○	○	△	○	○	○	○	○	○	○	○

○ : High conformity △ : Conformity × : Low conformity

Since it is planned to construct piers in the river for both Aum Bridge and Kapiura Bridge, Table 2.2.28 shows the feasible types of foundations and comments about them with emphasis on foundations that are excellent at depths of less than 5 meters assuming that the river is coffered.

Table 2.2.28 Comparison of Feasible Pile Foundation Types

Foundation type	Comments	Judgment
PHC piles and SC piles	These are not adopted due to fears over damage during transportation and hammering and because there is no record of use in PNG.	x
Steel pipe piles (hammering)	Construction is easy and the works period is short. Moreover, this method is the most commonly adopted in PNG.	○
Steel pipe piles (vibro-hammering)	These are not adopted because control of the vibro-hammering is difficult and because there is no record of use in PNG.	x
Cast-in-place piles (reverse method)	Execution management is not easy because it is necessary to confirm the load bearing layer and manage the stabilization fluid and quality disparities arise in piles. Moreover, there is hardly any record of application in PNG.	○
Rotational press-in steel pipe piles	There is no record of application in PNG, however, this method makes it possible to confirm the load bearing layer based on the rotational torque resistance value; moreover, piles can be certainly and easily inserted into hard ground layers, and the works period is also the shortest.	○

Based on the above comparison, the candidate foundation types here are steel pipe piles (hammering), cast-in-place piles (reverse method), and rotational press-in steel pipe piles. The optimum method will be adopted upon comparing these three types.

Foundation types targeted in the comparative examination:

Option 1 Steel pipe piles (hammering)

Option 2 Cast-in-place piles (reverse method)

Option 3 Rotational press-in steel pipe piles

Table 2.2.29 Comparison Sheet of Pile Types for Kapiura Bridge A1 Abutment

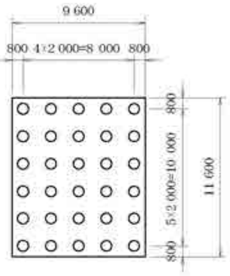
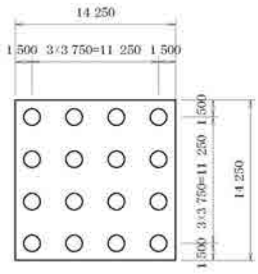
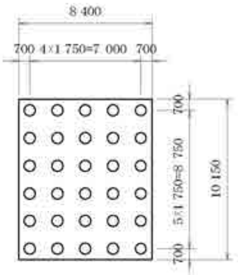
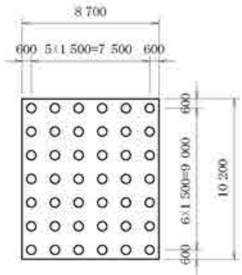
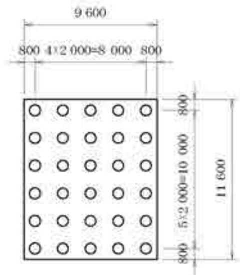
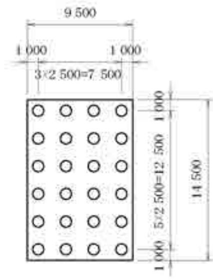
Pile Type (Diameter)				Steel Pipe Pile (Dia.800, t=16mm)				Cast in Place Pile (Dia.1500)				Screwed steel pile (wing dia.=1.5D) (Dia.700, t=16mm)			
Schematic Diagram				 Length ℓ= 37.0 m Pile number n= 30 pcs				 Length ℓ= 37.5 m Pile number n= 16 pcs				 Length ℓ= 36.5 m Pile number n= 30 pcs			
Cost Estimation	Working Item	Unit		Qty.		Retio		Qty.		Retio		Qty.		Retio	
	Concrete work	m3		535		10.3%		662		12.7%		278		5.3%	
	Re-bar work	t		54		1.6%		100		2.9%		41		1.2%	
	Excavation work	m3		1373		0.3%		2221		0.5%		1119		0.3%	
	Piling work	m		1110		87.8%		600		122.6%		1095		108.9%	
	Total	-		-		100.0%		-		138.8%		-		115.7%	
	Rate	-		100%			○	139%			△	116%			△
Construction days	Working Item	Unit		Qty.	U-days	Days		Qty.	U-days	Days		Qty.	U-days	Days	
	Pile cap work	m3	day	302	2.25	134.22		659	2.25	292.89		277	2.25	123.11	
	Excavation work	m3	day	1373	132.00	10.40		2221	132.00	16.83		1119	132.00	8.48	
	Piling work	pcs	day	30	0.78	38.46		16	0.75	21.33		30	0.75	40.00	
	Total	-	day	-		184.00		-		332.00		-		172.00	
	Rate	-	-	107%			△	193%			△	100%			○
Structural features				- Rigidity of the pile body is low, horizontal displacement of the pile is large. - Pile pointed end is the open end, bearing capacity of the pile pointed end is slightly smaller.			△	- Rigidity of the pile body is high, horizontal displacement of the pile is small. - Pile pointed end is the closed end, bearing capacity of the pile pointed end is big.			○	- It is a steel pipe piles fitted with wings of 2.0 times or 1.5 times of diameter of the pile pointed end. - Wing of pointed end has a role in supporting the weight of the pull and push on a large bottom area in-service time			○
Construction workability				-Pile is prefabricated in a factory, so the quality of pile is very good. - Bearing capacity of each pile can be confirmed easily by hammering. - Surplus soil does not occur. - Performance of construction is most often in PNG.			○	- High construction technology is required because it is difficult to confirm of the load bearing layer, control of stable liquid and the difference in the quality of the pile body by contractor. - Treatment of muddy water and excavated soil is required. - Few experience in PNG.			△	- Confirmation of the load bearing layer is possible by value of rotational resistance. Reliable construction is possible also for the hard layer, and workability has been excellent. - Surplus soil does not occur. - No experience in PNG.			△
Evaluation				Construction workability and economy is most excellent.				Construction workability and economy is inferior.				Construction workability in PNG and economy is inferior.			
				○				△				△			

Table 2.2.30 Comparison Sheet of Pile Types for Kapiura Bridge A1 Abutment

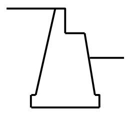
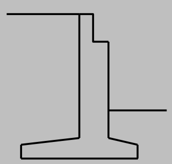
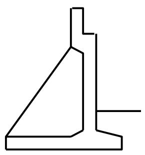
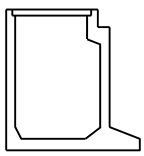
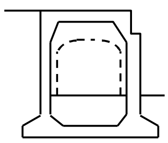
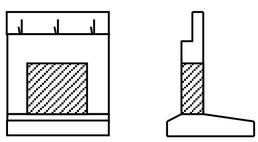
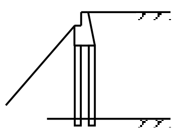
Pile Diameter				Steel Pipe Pile (Dia.600, t=16mm)				Steel Pipe Pile (Dia.800, t=16mm)				Steel Pipe Pile (Dia.1000, t=19mm)			
Schematic Diagram				 Length ℓ= 37.0 m Pile number n= 42 本				 Length ℓ= 37.0 m Pile number n= 30 本				 Length ℓ= 37.5 m Pile number n= 24 本			
Cost Estimation	Working Item	Unit		Qty.		Costs		Qty.		Costs		Qty.		Costs	
	Concrete work	m3	1,000JPY	426		8.2%		535		10.3%		548		10.5%	
	Re-bar work	t	1,000JPY	44		1.3%		54		1.6%		57		1.6%	
	Excavation work	m3	1,000JPY	1152		0.3%		1373		0.3%		1400		0.3%	
	Piling work	m	1,000JPY	1554		123.0%		1110		87.8%		888		70.3%	
	Total	-	1,000JPY	-		132.7%		-		100.0%		-		82.8%	
	Rate	-	-	132.7%			△	100.0%			○	82.8%			△
Construction days	Working Item	Unit		Qty.	U-days	Days		Qty.	U-days	Days		Qty.	U-days	Days	
	Pile cap work	m3	day	240	2.25	106.7		302	2.25	134.2		371	2.25	164.9	
	Excavation work	m3	day	1152	132.0	8.7		1373	132.0	10.4		1400	132.0	10.6	
	Piling work	pcs	day	42	0.75	56.0		30	0.75	38.5		24	0.78	30.8	
	Total	-	day	-		172.000		-		184.000		-		207.000	
	Rate	-	-	93.5%			△	100.0%			△	112.5%			○
Structural features				- Safety factor of bearing capacity of pile (Max.Pile head reaction/allowable bearing capacity) =0.898 - Safety factor of horizontal displacement (Max.horizontal displacement/allowable displacement) =0.800 - Safety factor of stress of steel pile (Max.stress/ allowable stress) =0.898			○	- Safety factor of bearing capacity of pile (Max.Pile head reaction/allowable bearing capacity) =0.877 - Safety factor of horizontal displacement (Max.horizontal displacement/allowable displacement) =0.851 - Safety factor of stress of steel pile (Max.stress/ allowable stress) =0.899			○	- Safety factor of bearing capacity of pile (Max.Pile head reaction/allowable bearing capacity) =0.892 - Safety factor of horizontal displacement (Max.horizontal displacement/allowable displacement) =0.913 - Safety factor of stress of steel pile (Max.stress/ allowable stress) =0.811			△
Construction workability				- Pile number is the largest. - Construction workability is inferior.			△	- Pile number is large. - Construction workability is inferior.			△	- Pile number is the smallest. - Construction workability is excellent.			○
Evaluation				Structural features is excellent. Construction workability and economy is inferior.				Construction workability is not optimal Structural features and economy is excellent.				Construction workability is most excellent. Structural features and economy is excellent.			
				△				○				△			

③ Selection of the type of substructure works

i) Selection of type of abutments

Reverse T abutments will be adopted in consideration of the structural height and size of bridges. Concerning the shape behind the vertical wall, in consideration of easier execution, linear shape will be planned without installing counterfort or changing the cross section.

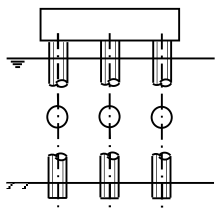
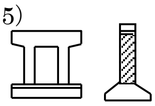
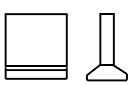
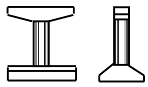
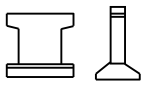
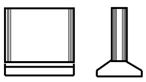
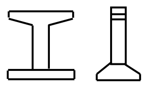
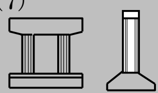
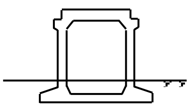
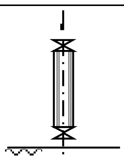
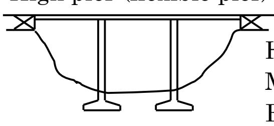
Table 2.2.31 Selection Sheet for Type of Abutments

Type		Height	Structural features
Gravity type		H≦4～5m	Cross sections of this abutment are designed to be dominated only compressive stresses by increasing self-weight. Benefits of facile construction in in terms of simple structure is obtained in exchange for greater reaction toward bearing stratum due to the heavier self-weight.
Inverted T type		5m≦H≦15m	Facile construction in terms of its simple structure. The maximum height of this type is approximately 15m according to actual achievement. Cross section of vertical wall is designed as RC structure, which axial force and bending moment act onto. The mass of the backfill behind the vertical wall maintains structural stability, and self-weight (concrete volume) can be reduced. When the front-footing can not be constructed due to the restriction of construction space, L-type abutment can be adopted.
Buttress type		12m≦H≦15m	Design model of vertical wall and buttress are continuous members and T-section beam. Casting concrete shall be compacted carefully because of larger density of rebar arrangement. The compaction of backfill near buttress shall be carefully implemented.
Box type		13m≦H≦20m	Seismic momentum force can be reduced due to the box behind the vertical wall. For this reason, construction cost might be minimized when a pile foundation is adopted this abutment type. When spread footing is adopted, box might be filled with backfill in order to stabilize against a sliding.
Rigid frame type			For reducing seismic momentum force and/or larger mass of backfill are need to be reduced, this type could be beneficial. When a greater superstructure's lateral force should be supported, this type could be beneficial. When cross road is planed behind the abutment, this type might be suitable. Other than the above, when certain benefits such as cost, structure, or else can be obtained, this type is to be adopted.
Others	Midair type abutment (midair at wall center)  Note; Examination of lateral flow of soil is necessary		Bank seat abutment on piles 

ii) Selection of type of piers

Common reverse T piers will be adopted. Concerning the horizontal sectional shape of piers, since they will be installed in the river, a narrow elliptical shape facing the direction of flow will be adopted on the parts that are subject to the action of flow.

Table 2.2.32 Selection Sheet for Type of Piers

Type			Application	Technical features
Pile bent Pier (Multi-column foundation)			Coastal zone, lagoon, lakes and river.	Pile heads are connected with beam, and rigid frame analysis is to be applied. Difficulty in reinforcing at corner of connection beam. Due to the flexibility in longitudinal direction of the structure, pier head width should be sufficiently secured for avoiding unseat of superstructures.
Inverted T Type	Wall type: (1) rectangle, (2) oval Overhanging type: (3) cylinder, (4) square, (5) distyle, (6) rectangle, (7) oval		(5) 	Commonly used types. Rebar is used resisting tensile stress generated in member. Overhanging beam type has an advantage in beneficial use of space under the beam. (2)(7) To be commonly used when river of which center of flow is mostly stable. (3) To be used when river of which center of flow is not stable, or when sight distance at intersections under flyover bridge is necessary to be secured. Trade-off between good aesthetics and workability & economy. (5) Rigid-frame model is to be applied in transversal direction of structure.
	(1) 	(3) 	(6) 	
	(2) 	(4) 	(7) 	
Rigid-framed pier		Commonly applied to viaduct of railway due to smaller dimension of structure with high rigidity. Superstructure and substructure are to be an integral structure. Considering the thermal change of the structure, the number of continuous spans would be limited approximately 3 to 4 spans in general. In a crowded urban area, heteromophic rigid frame structure using steel pier columns is likely to be applied considering construction conditions.		Due to its slender structural dimensions, this type of structure is used for overhead crossing in urban area and railway viaduct expecting good sight distance for traffic and beneficial use of the space under the bridge.
Colum type		・ Rocker pier, Fixed pier		Rocker pier Slender column due to application of pin connection at the both ends of column Fixed pier Fixed into transversal beam, which connects girders, and strengthen transversal rigidity
Others	High pier (flexible pier)  H : Hinge M : Move F : Fix			A flexible pier, which allows larger column displacement, has advantage in terms of dispersal of earthquake horizontal force due to mass self weight.

iii) Examination of structural height

- Structural height of abutments

The bases of abutments constructed on embankments will be set below the ground height of the embankments. Here, "ground height of the embankments" refers to the line that connects foot of the front slope and foot of the rear slope of the embankment as shown in the figure below. However, in cases where the high water width is small and it is more appropriate to have a front berm, this must also be considered in tandem with the embankments.

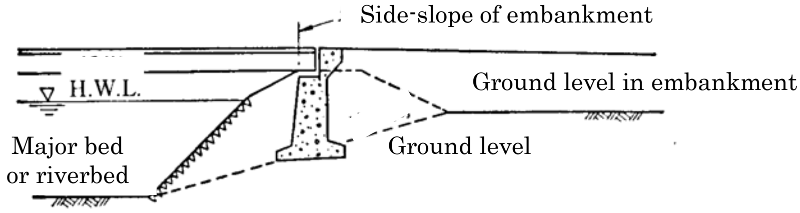


Figure 2.2.25 Abutment Position

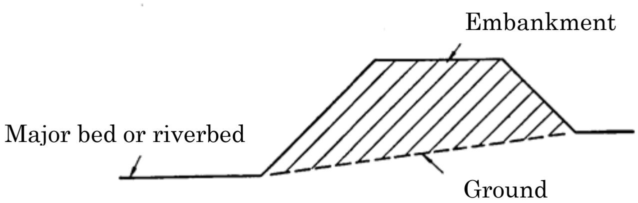


Figure 2.2.26 Division of Embankment and Ground

- Structural height of piers

In order to avoid situations where the base slabs of piers obstruct the river water flow, basically pier base slabs shall be set deeper than the riverbed.

Assuming a sediment riverbed, the crown of the pier base slabs will be buried around 0.5 meters below the current riverbed.

- Pile length

Pile length will be determined according to the following policy.

－Length of embedment in the supporting soil

If the supporting soil is sediment, the minimum embedment length will be no less than the pile diameter (D).

－Length of embedment in base slabs

The length of embedment in the pile head base slab will basically be 0.1 meter.

－Length of pile

The length of pile, including the length of embedment in the base slab, will be set in units of 0.5 meters.

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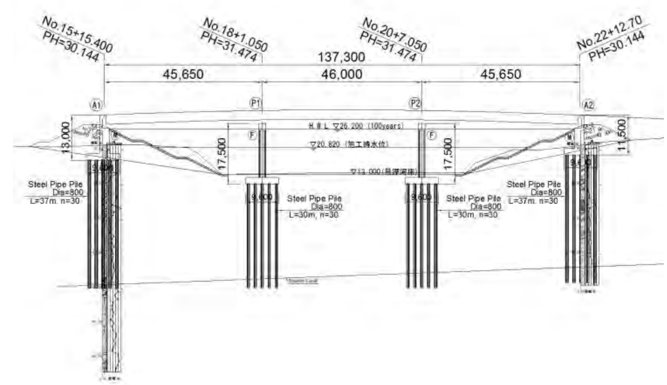
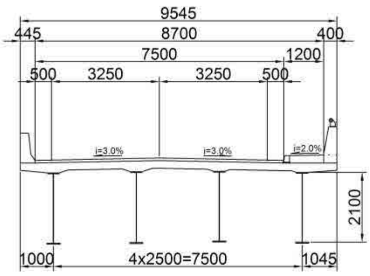
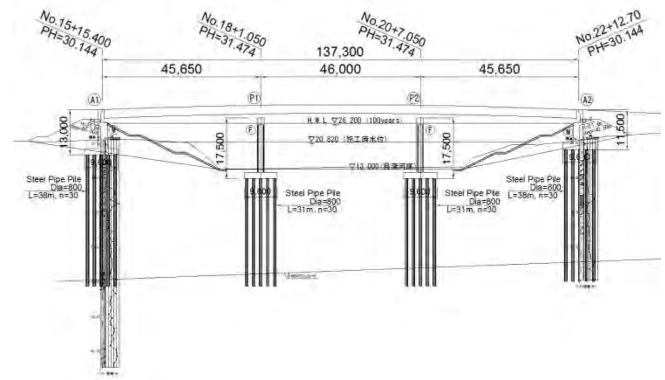
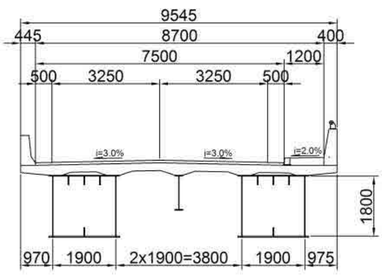
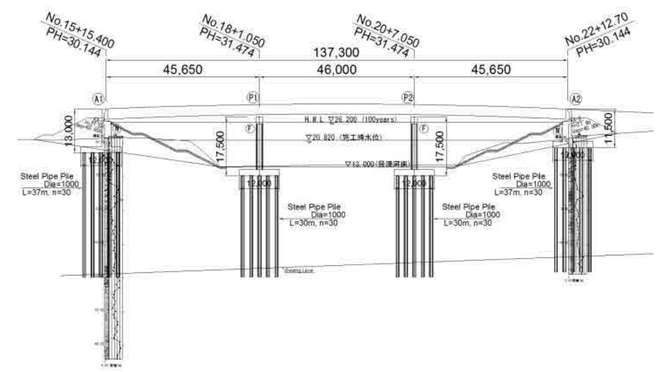
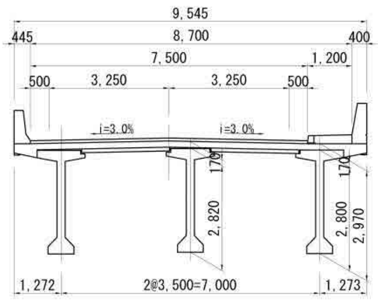
④ Selection of bridge type

Concerning the bridge types selected in planning of the superstructure works, the following comparison sheets show the results of examination.

i) Kapiura Bridge

Table 2.2.33 Bridge Type Comparison Sheet (Kapiura Bridge)

	Side View	Girder Cross Section
Plan 1 Continuous plate girder		
Plan 2 Continuous box girder		
Plan 3 PC Composite bridge connecting girder		

<table>
<tr><th></th><th colspan="5">Comparison of Characteristics</th></tr>
<tr><td rowspan="6">Plan 1

Continuous plate girder</td><td>Economy</td><td>Superstructure works
39.9%</td><td>substructure works
12.1%</td><td>Foundation works
48.0%</td><td>Total
100% (○)</td></tr>
<tr><td>Structural characteristics</td><td colspan="4">・This is the simplest structural form comprising steel I section main girders and RC floor slabs.
・As the superstructure is light, quantities for the foundations are also small. (○)</td></tr>
<tr><td>Ease of execution</td><td colspan="4">・Because the girders are the lightest, they can be placed by crane from a pier, so this method entails the easiest execution and shortest works period. (○)</td></tr>
<tr><td>Earthquake resistance</td><td colspan="4">・Since the steel is the lightest and continuous girders are adopted, this type has the best earthquake resistance and also minor impact on the foundations. (○)</td></tr>
<tr><td>Maintenance</td><td colspan="4">・On this bridge, since it is difficult to maintain the corrosive environment for weather-proof steel materials and conduct maintenance up to the formation of stabilized rust, corrosion proofing based on periodic coating is needed. (△)</td></tr>
<tr><td>Evaluation</td><td colspan="4">・Since this type has the best economy, ease of execution, and earthquake resistance, and it is also most commonly adopted in Papua New Guinea, it is deemed to be the most appropriate for this bridge (○)</td></tr>
<tr><td rowspan="6">Plan 2

Continuous box girder</td><td>Economy</td><td>Superstructure works
48.0%</td><td>substructure works
14.4%</td><td>Foundation works
57.6%</td><td>Total
120.0% (△)</td></tr>
<tr><td>Structural characteristics</td><td colspan="4">・Comprising steel main girders with box cross section, and RC floor slabs, this structural type has stronger bend and torsional rigidity than Plan 1, and it also allows floor framing and lateral bracing to be abbreviated. (○)</td></tr>
<tr><td>Ease of execution</td><td colspan="4">・Because the girders are heavier than in Plan 1 and cannot be placed by crane, it is necessary to use erection beams or vents for placing girders, so this type is inferior in terms of ease of execution. (△)</td></tr>
<tr><td>Earthquake resistance</td><td colspan="4">・Because the steel is heavier than in Plan 1 and there is a strong possibility that the local ground could liquefy in the event of an earthquake, it is better to have light superstructure, so this type is slightly inferior in terms of earthquake resistance. (△)</td></tr>
<tr><td>Maintenance</td><td colspan="4">・On this bridge, since it is difficult to maintain the corrosive environment for weather-proof steel materials and conduct maintenance up to the formation of stabilized rust, corrosion proofing based on periodic coating is needed. (△)</td></tr>
<tr><td>Evaluation</td><td colspan="4">・Although this method has excellent structural characteristics, it is not appropriate for this bridge due to inferior economy, ease of execution, earthquake resistance, and maintenance characteristics. (△)</td></tr>
<tr><td rowspan="4">Plan 3

PC Composite bridge connecting girder</td><td>Economy</td><td>Superstructure works
50.4%</td><td>substructure works
15.1%</td><td>Foundation works
60.5%</td><td>Total
126.0% (△)</td></tr>
<tr><td>Structural characteristics</td><td colspan="4">・This structure uses few main girders and intermediate cross beams, and it also adopts composite floor slabs using PC slabs.
・Compared to conventional bridges that use many main girders, structure is more rational and LCC is reduced thanks to higher durability of floor slabs, however, this is the heaviest option and uses the largest quantities in foundations. (○)</td></tr>
<tr><td>Ease of execution</td><td colspan="4">・When placing the large precast girders, it is necessary to use erection beams installed by gantry crane. When the carrying-in of such equipment to the works site is also considered, this type is inferior in terms of ease of execution. (△)</td></tr>
<tr><td>Earthquake resistance</td><td colspan="4">・Since there are fewer precast girders than in conventional bridges, earthquake resistance is improved, however, the girders are still heavier than steel girders in the other options and this type still has inferior earthquake resistance and bigger impact on foundation works than in the other types. (△)</td></tr>
</table>

	Comparison of Characteristics	
	Maintenance	・Since PC composite bridge members are made in the plant and it is possible to cast high-strength and high-quality concrete, this type offers good durability against salt damage. (○)
	Evaluation	・Although this method has excellent structural and maintenance characteristics, it is not appropriate for this bridge due to inferior economy, ease of execution, and earthquake resistance. (△)

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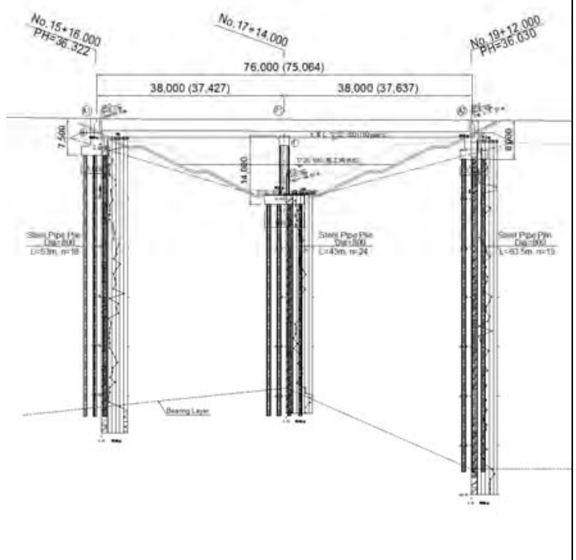
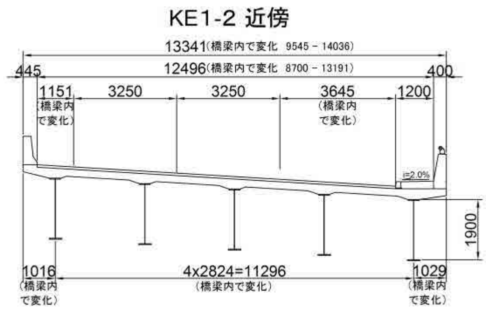
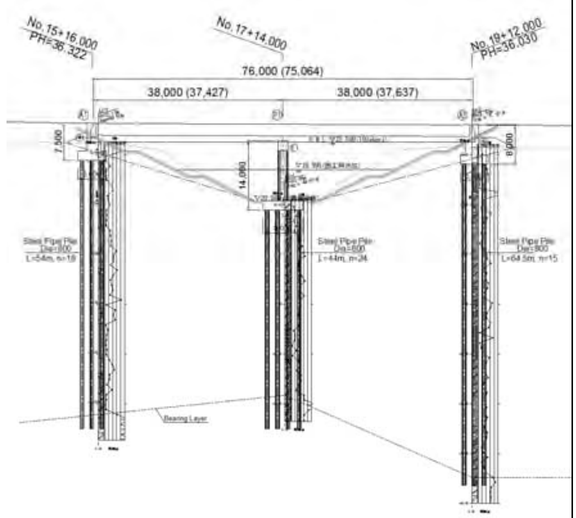
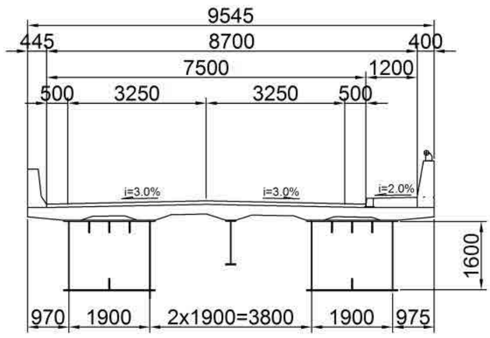
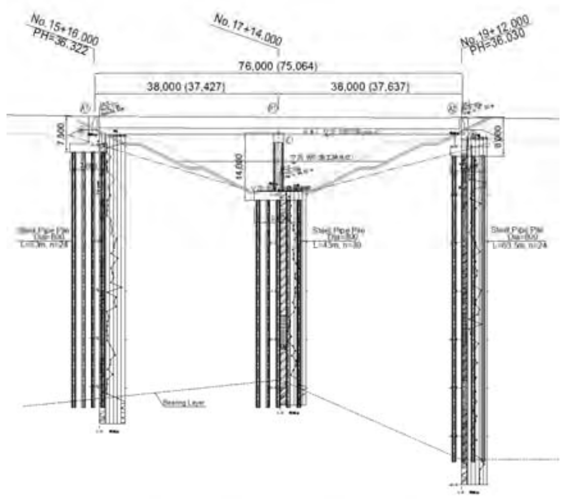
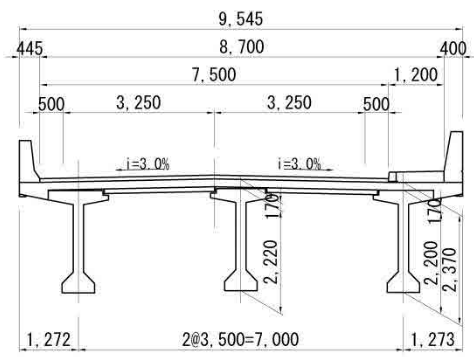
ii) Aum Bridge

Table 2.2.34 Bridge Type Comparison Sheet (Aum Bridge)

Plan	Side View	Girder Cross Section
Plan 1 Continuous plate girder		
Plan 2 Continuous box girder		
Plan 3 PC Composite bridge connecting girder		

	Comparison of Characteristics				
Plan 1 Continuous plate girder	Economy	Superstructure works 35.3%	substructure works 11.7%	Foundation works 53.0%	Total 100.0% (○)
	Structural characteristics	・This is the simplest structural form comprising steel I section main girders and RC floor slabs. ・As the superstructure is light, quantities for the foundations are also small. (○)			
	Ease of execution	・Because the girders are the lightest, they can be placed by crane from a pier, so this method entails the easiest execution and shortest works period. (○)			
	Earthquake resistance	・Since the steel is the lightest and continuous girders are adopted, this type has the best earthquake resistance and also minor impact on the foundations. (○)			
	Maintenance	・On this bridge, since it is difficult to maintain the corrosive environment for weather-proof steel materials and conduct maintenance up to the formation of stabilized rust, corrosion proofing based on periodic coating is needed. (△)			
	Evaluation	・Since this type has the best economy, ease of execution, and earthquake resistance, and it is also most commonly adopted in Papua New Guinea, it is deemed to be the most appropriate for this bridge. (○)			
Plan 2 Continuous box girder	Economy	Superstructure works 41.7%	substructure works 13.6%	Foundation works 61.7%	Total 117.0% (△)
	Structural characteristics	・Comprising steel main girders with box cross section, and RC floor slabs, this structural type has stronger bend and torsional rigidity than Plan 1, and it also allows floor framing and lateral bracing to be abbreviated. (○)			
	Ease of execution	・Because the girders are heavier than in Plan 1 and cannot be placed by crane, it is necessary to use erection beams or vents for placing girders, so this type is inferior in terms of ease of execution. (△)			
	Earthquake resistance	・Because the steel is heavier than in Plan 1 and there is a strong possibility that the local ground could liquefy in the event of an earthquake, it is better to have light superstructure, so this type is slightly inferior in terms of earthquake resistance. (△)			
	Maintenance	・On this bridge, since it is difficult to maintain the corrosive environment for weather-proof steel materials and conduct maintenance up to the formation of stabilized rust, corrosion proofing based on periodic coating is needed. (△)			
	Evaluation	・Although this method has excellent structural characteristics, it is not appropriate for this bridge due to inferior economy, ease of execution, earthquake resistance, and maintenance characteristics. (△)			
Plan 3 PC Composite bridge connecting girder	Economy	Superstructure works 51.3%	substructure works 16.8%	Foundation works 76.9%	Total 145.0% (△)
	Structural characteristics	・This structure uses few main girders and intermediate cross beams, and it also adopts composite floor slabs using PC slabs. ・Compared to conventional bridges that use many main girders, structure is more rational and LCC is reduced thanks to higher durability of floor slabs, however, this is the heaviest option and uses the largest quantities in foundations. (○)			
	Ease of execution	・When placing the large precast girders, it is necessary to use erection beams installed by gantry crane. When the carrying-in of such equipment to the works site is also considered, this type is inferior in terms of ease of execution. (△)			
	Earthquake resistance	・Since there are fewer precast girders than in conventional bridges, earthquake resistance is improved, however, the girders are still heavier than steel girders in the other options and this type still has inferior earthquake resistance and bigger impact on foundation works than in			

	Comparison of Characteristics	
		the other types. (△)
	Maintenance	・Since PC composite bridge members are made in the plant and it is possible to cast high-strength and high-quality concrete, this type offers good durability against salt damage. (○)
	Evaluation	・Although this method has excellent structural and maintenance characteristics, it is not appropriate for this bridge due to inferior economy, ease of execution, and earthquake resistance. (△)

6) Basic Design of Bridges

① Girder height and girder arrangement

i) Girder height

In order to select economical girder height, rough calculations were conducted and steel weights were compared upon varying girder heights for Kapiura Bridge and Aum Bridge.

As is indicated below, the lowest weight of steel is realized when girder height is 2.1 meters on Kapiura Bridge and 1.9 meters on Aum Bridge.

Therefore, <u>girder height of 2.1 meters on Kapiura Bridge and 1.9 meters on Aum Bridge will be adopted.</u>

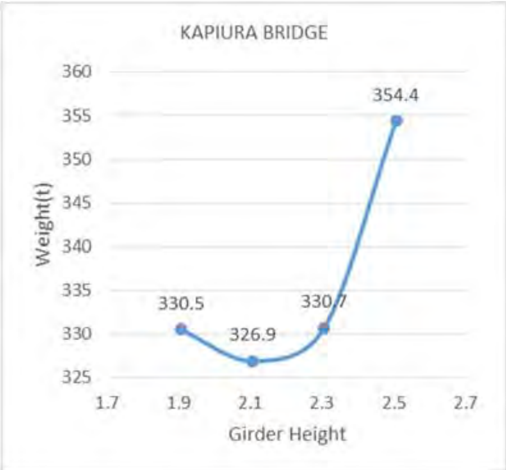


Figure 2.2.27 Relationship between Girder Height and Weight of Steel

ii) Girder arrangement

Concerning the main girder arrangement, assuming a floor slab overhang of around 1.0 meter, the floor slab span, i.e. the interval between main girders, will be no greater than 3.0 meters.

a) Kapiura Bridge

Four main girders will be adopted with an interval of 2.5 meters between them. The following figure shows the girder arrangement.

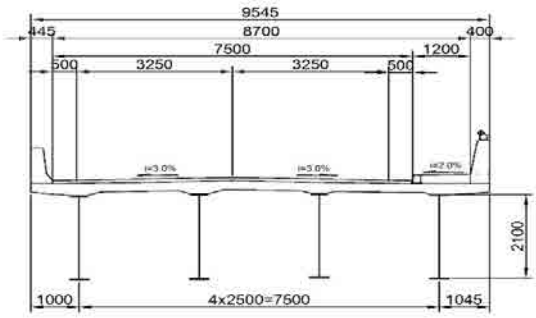


Figure 2.2.28 Kapiura Bridge Main Girder Arrangement

b) Aum Bridge

The horizontal alignment of Aum Bridge changes from a circular curve to a clothoid curve and then to a straight line over the bridge section. Also, in order to secure sight distance, the bridge width is modified over the clothoid section as shown below.

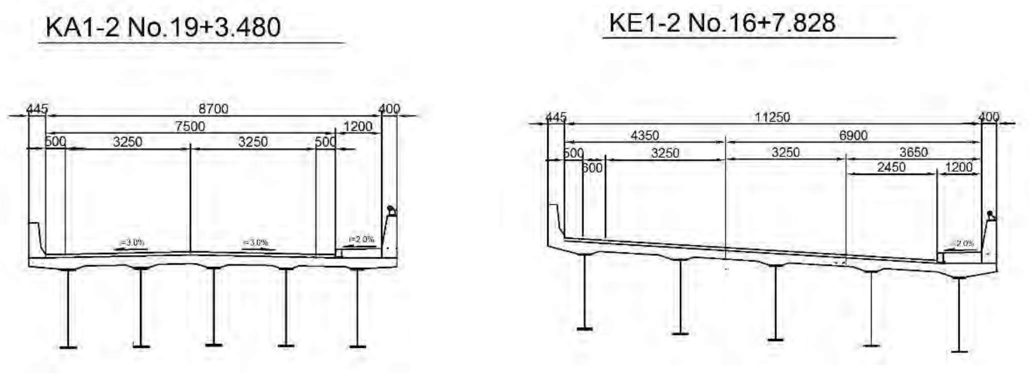


Figure 2.2.29 Alteration in Width of Aum Bridge

The bridge will comprise straight main girders over one span and continuous plate girders that are bent at the central fulcrum point. Usually when planning linear girders on a horizontal curve, the amount of overhang of floor slabs is often set at a maximum and minimum of Lmax ≦ 1.5 meters and Lmin ≧ 0.6 meters respectively. In the case of this bridge, because these limits cannot be satisfied due to the relationship between horizontal alignment and span arrangement, it will be necessary take countermeasures.

Specifically, the main girders can be arranged in a curve (curved plate girders) and the road surface can be widened. In the former case, it becomes necessary to add upper lateral bracing to give rigidity to the bridge, and to address the secondary stress (warp stress) that occurs due to the bending of girders. Both these measures are structurally undesirable and uneconomical. Accordingly, it has been decided to conduct the minimum necessary widening of the road surface.

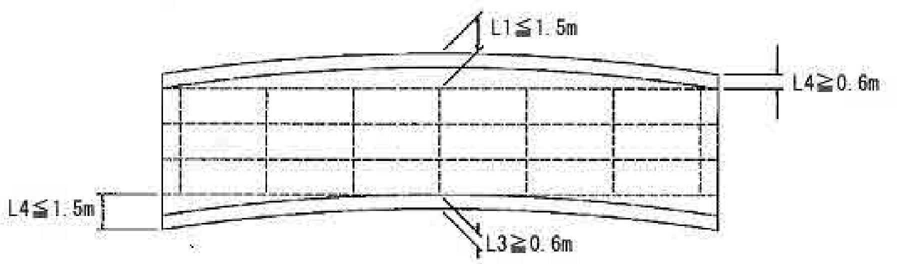


Figure 2.2.30 Amount of Floor Slab Overhang on a Curved Bridge

Figure 2.2.31 shows the method for conducting widening.

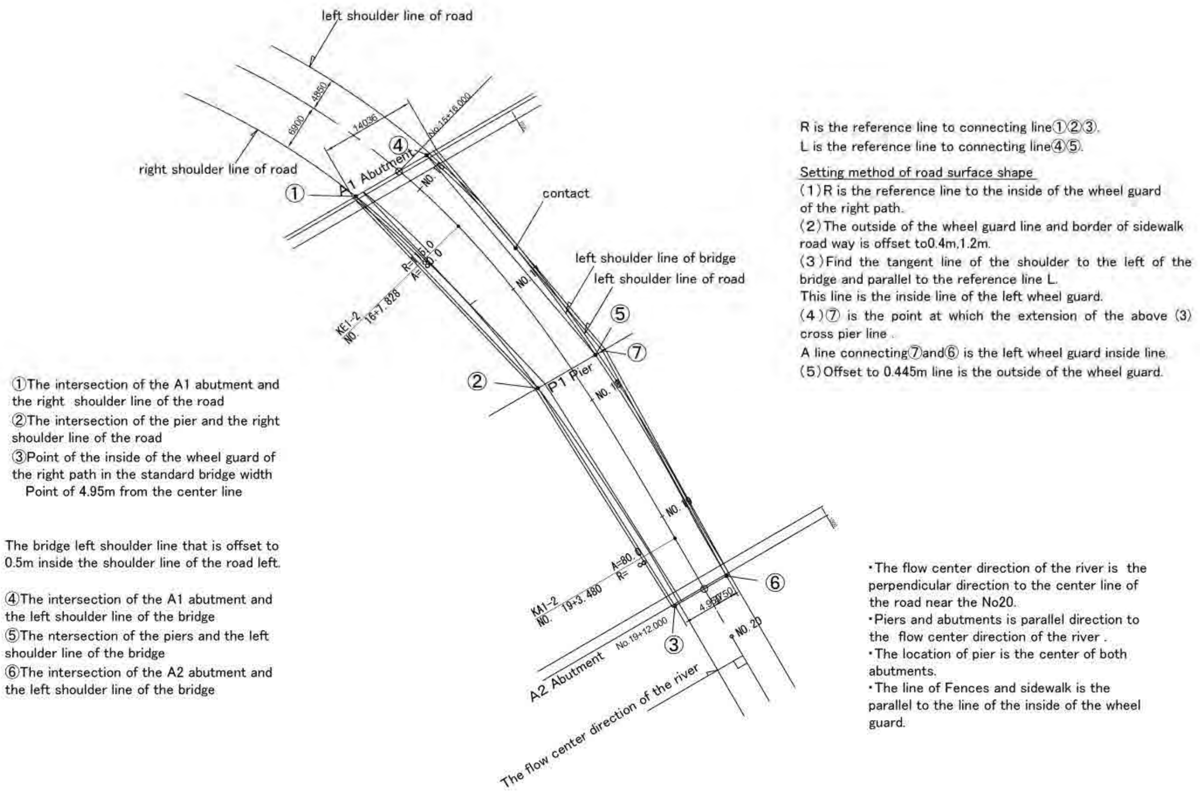


Figure 2.2.31 Bridge Widening Method on Aum Bridge

Five main girders will be arranged on the A1 abutment section, where the road is wide, to ensure that the interval between main girders is no greater than 3.0 meters. Figure 2.2.32 shows the main girder arrangement on Aum Bridge.

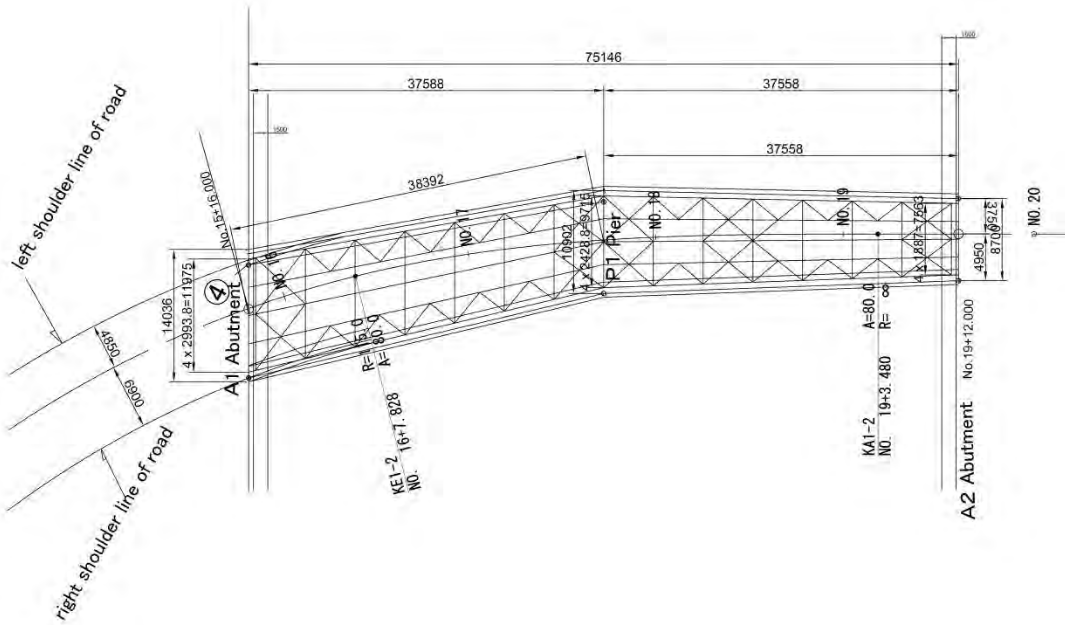


Figure 2.2.32 Main Girder Arrangement on Aum Bridge (1)

KE1-2 NEIGHBORHOOD

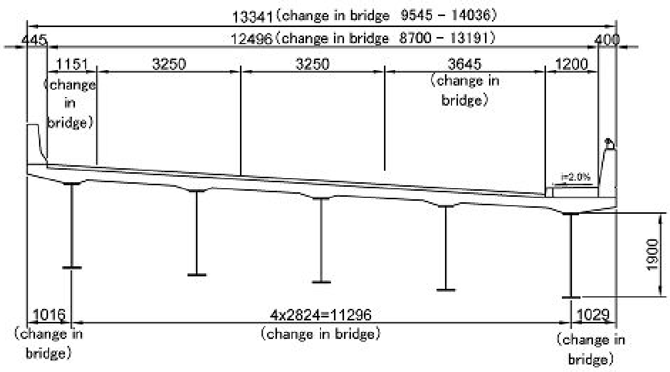


Figure 2.2.33 Main Girder Arrangement on Aum Bridge (2)

iii) Floor slab thickness

The floor slab thickness is determined upon considering a coefficient based on the interval between main girders and large vehicle traffic volume.

Using the large vehicle traffic volume in 20 years' time, the design large vehicle traffic volume in a single direction is assumed to be between 1,000~1,999 vehicles, and the large vehicle traffic volume coefficient shall be k = 1.2.

Minimum floor slab thickness (mm) $d_0 = 30 \times L + 110$ L: Main girder interval (m)

Floor slab thickness (mm) $d = d_0 \times k$ k: Large vehicle traffic volume coefficient shall be k = 1.2.

Table 2.2.35 Future Projected Large Vehicle Traffic Volume

Direction (Kimbe to Bialla)

Vehicle Type	Design Period		
	2014	2024	2034
Medium Bus/Large Bus,	126	327	848
2-axle Truck	39	101	262
3-axle Truck	15	39	101
4-axle Truck	5	13	34
5-axle Truck	19	49	127
6-axle Truck	15	39	101
TOTAL	219	568	1,473

Source: Prepared by the JICA Study Team/ annual rate of increase 10%, traffic volume survey results (2014 Mai-Junction, number of large vehicles traveling in a single direction)

a) Kapiura Bridge

$d_0 = 30xL + 110 = 30x2.5 + 110 = 185$ mm

$d = d_0 \times 1.2 = 185 \times 1.2 = 222$ mm → 220 mm

b) Aum Bridge

d_0 = 30xL + 110 = 30x3.0 + 110 = 200 mm

d = d_0 x 1.2 = 200 x 1.2 = 240 mm → 240 mm

c) Floor slab thickness

Floor slab thickness will be 220 mm on Kapiura Bridge and 240 mm on Aum Bridge.

② Support conditions

i) Functions required of supports

Supports are installed at the contacts between superstructure works and substructure works and need to possess functions for definitely conveying vertical load and horizontal load from the superstructure to the substructure. At the same time, they need to be able to adequately follow rotational displacement caused by the horizontal movement and deflection of superstructure. Additionally, supports are sometimes required to display attenuation and isolating functions for improving the earthquake resistance of the entire bridge.

ii) Classification of supports

Supports can be classified as follows according to their applications.

a. Classification based on method of support for horizontal force

Classification by support method of horizontal force, on top of the comparison in "iii) the type of bearing", perform the selection.

b. Classification by functional configuration

Integrated function types, which structurally integrate multiple functions (displacement follow-up, load conveyance) into a single support, are the most common type. Separated function types, on the other hand, are supports composed of an aggregate of independent functions.

c. Type of bearing in seismic design

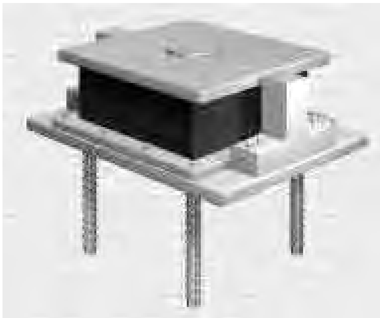
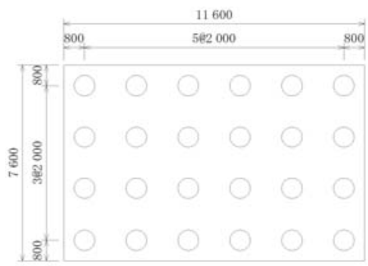
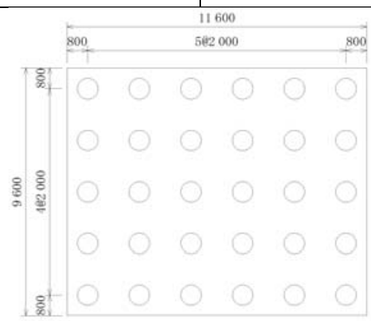
Type B supports satisfy performance regarding horizontal force and vertical force during earthquakes in the support part only. Type A supports, on the other hand, resist seismic loads not only in the support part but through complementing separate displacement control structures.

iii) Types of supports

It is necessary to certainly and rationally select the types of supports according to the type of bridge and the degree of earthquake resistance, etc. that is required.

Here, the rough shape of foundations was calculated through implementing earthquake response analysis at Kapiura Bridge concerning rubber shoes (dispersed supports and moving supports) and steel supports (surface contact supports, support plate supports). As a result of conducting comparison in terms of economy, ease of execution, and maintenance, steel supports are selected. However, the superiority of steel supports will be examined upon conducting detailed review of rubber shoes including the effects of liquefaction and price, etc. and once more implementing comparison.

Table 2.2.36 Comparison of Earthquake Response Values and Foundation Shapes according to Type of Supports (Kapiura Bridge)

		Rubber supports (Horizontal force dispersion rubber supports)		Steel supports (BP, B)	
Support image drawing					
Analysis model	Focused direction	Bridge axis direction	Bridge axis perpendicular direction	Bridge axis direction	Bridge axis perpendicular direction
	Abutment (A1, A2)	Elastic	Fixed	Moving	Fixed
	Pier (P1, P2)	Elastic	Fixed	Fixed	Fixed
Pier analysis results (L1)	Focused direction	Bridge axis direction	Bridge axis perpendicular direction	Bridge axis direction	Bridge axis perpendicular direction
	Response horizontal force*	1983kN	2427kN	3119kN	2428kN
Pier foundations schematic drawing (Rough examination results using response values)		 Pile diameter: 0.8m Number of piles: 24 Pile length: 30.0m		 Pile diameter: 0.8m Number of piles: 30 Pile length: 30.0m	
Rough works cost comparison	Supports	Abutment: 3.7 million x 2 = 7.4 million Pier:10.4 million x 2 = 20.8 million		Abutment: 0.60 million x 2=1.20 million Pier: 1.20 million x 2 = 2.40 million	
	Foundations	Abutment: 131 million x 2=262 million Pier: 85 million x 2=170 million		Abutment: 131 million x 2 = 262 million Pier:106 million x 2 = 212 million	
	Total	460.2 million yen (1.00)		477.6 million yen (1.04)	
Maintenance characteristics		Due to rubber shoes, maintenance characteristics are better than in steel shoes.		Regular work such as coating, etc. is needed, so the maintenance characteristics are slightly	

	Rubber supports (Horizontal force dispersion rubber supports)	Steel supports (BP, B)
		inferior.
Assessment	・Damping effect is large, enabling the quantity of foundations to be reduced. ・When installing rubber shoes, high-degree accuracy control is needed. ・Detailed confirmation is required concerning effectiveness of rubber shoes at times of liquefaction. ・Following detailed examination of the rubber shoes, it will be necessary to reconfirm the earthquake response values and price of shoes.	・ Damping effect is small, however, as the superstructure works are light, the impact on the type of foundations is limited. ・ Installation and execution management of the shoes is easier than for rubber shoes, so this type is better in terms of ease of execution.

*Earthquake response horizontal force at the bottom surface of the pile cap

③ Maintenance facilities

Structures that consider future maintenance will be adopted, or maintenance facilities will be installed.

i) Girder ends

Structures that enable maintenance to be performed will be adopted through inserting spaces between girder ends and abutment parapets.

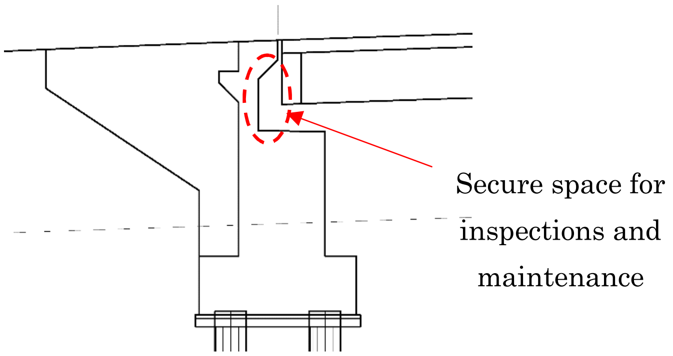


Figure 2.2.34 Structure of Girder Ends

ii) Intermediate piers

Structures will be adopted so that there is space between the main bridge clearance ends and pier crowns, thereby enabling maintenance to be performed around the intermediate pier sections. Through providing seats in the support sections, space of approximately 60 centimeters will be secured between the main bridge clearance ends and pier crowns. Also, hand railings will be provided to enhance safety during inspections.

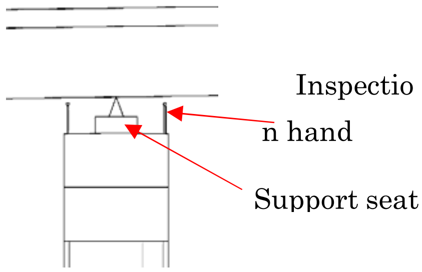


Figure 2.2.35 Structure of Intermediate Pier

iii) Superstructure inspection corridor

Large vehicles heading in the direction of Kimbe are often loaded with products (palm oil or timber) for shipping from port, so the vehicle loads tend to be heavy. Focusing on floor slabs, since the floor slabs under such vehicle lanes are easily damaged, a superstructure inspection corridor will be installed close to the traffic lane on the sidewalk side. Specifically, such corridors will be installed between G3-G4 on Kapiura Bridge and between G3-G4 on Aum Bridge. Moreover, the bottom surface of the inspection corridor will not protrude from the flange bottom surface.

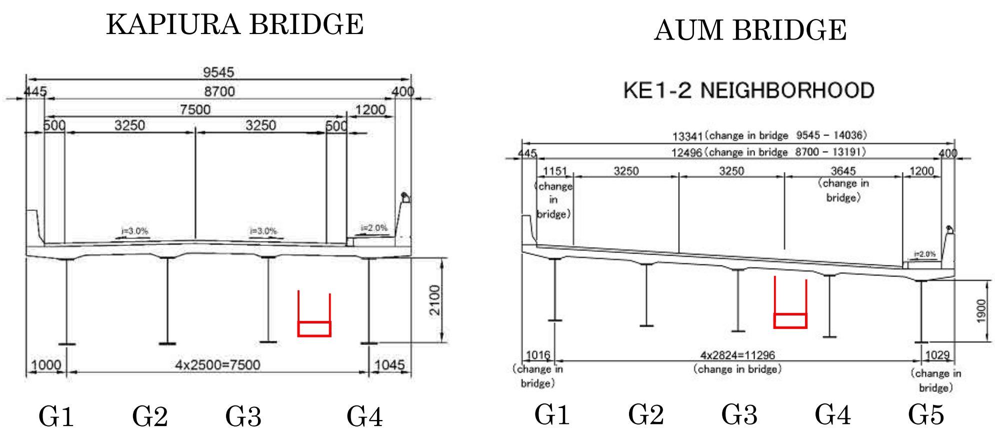


Figure 2.2.36 Position of Superstructure Inspection Corridor

iv) Hanging hooks

Since they are useful for conducting future maintenance and also during construction, hanging hooks will be installed from the plant manufacturing stage. The following two types of hanging hooks will be adopted at intervals of 1.8 meters for the A type and 1 meter for the B type.

A type: For falsework when placing floor slabs and performing coating

B type: For falsework when coating, and also used as form shoring when placing RC floor slabs, this type is fitted to exterior girders.

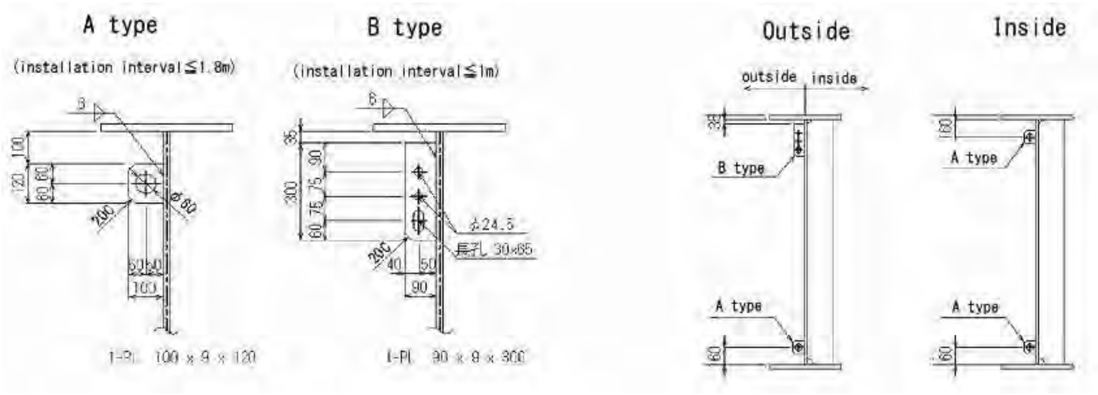


Figure 2.2.37 Hanging Hooks

④ Girder corrosion protection method

Methods for preventing corrosion of girders are as follows.

Corrosion protection methods on steel highway bridges
- Corrosion protection by covering
  - Non-metal covering--------Coating, anti-rust caps, etc.
  - Metal covering------------Galvanizing, metal spraying, cladding, etc.
- Corrosion protection using anti-corrosive materials------------------Weatherproof steel, stainless steel, etc.
- Corrosion protection based on environmental improvement---------- Structural improvement, dehumidification, etc.
- Electrolytic protection---------------- Galvanic anode system, impressed current system

Figure 2.2.38 Corrosion Protection Methods on Steel Highway Bridges

Source: Handbook of Coating and Corrosion Protection for Steel Highway Bridges (Japan Road Association)

Corrosion preventing by covering/coating are the usually adopted methods. Galvanizing and metal spraying also offer excellent corrosion protection, however, galvanizing is subject to restrictions on the size of members according to the plated layer, and it also causes deformation of members and deterioration of materials due to the use of heat. In the case of metal spraying, it is necessary to make adjustments for detailed structures and be careful when working on narrow areas. Metal covering generally tends to be more expensive than coating.

Concerning corrosion protection using anti-corrosive materials, weatherproof steel is the most common and economical approach, but it is necessary to confirm whether or not the environment is conducive to formation of protective rust. A simple on-site steel exposure test (badge exposure test) has been developed for this purpose, however, the test period is one year. Also, even in cases where it is deemed possible to apply weatherproof materials, it is necessary to maintain a favorable corrosive environment on the bridge (cleaning and ventilation control) and carry out checks to guard against formation of protective rust.

Selection of the rust prevention method:

Assuming that corrosion protection based on environmental improvement, and electrolytic protection are not applicable as methods for preventing corrosion in steel girders, the methods of coating or use of weatherproof steel materials can be considered for these bridges.

Concerning weatherproof steel, since the bridge sites are located in an area with high rainfall and high relative humidity of around 80% through the year, it is necessary to confirm whether or not use of non-coated material is appropriate. Because exposure tests on weatherproof steel are not conducted in Papua New Guinea, judgment on the applicability of weatherproof steel was made based on literature. The criteria for determining applicability is; "If the amount of plate thickness depletion after 100 years is no greater than 0.5 mm, use of weatherproof steel is appropriate." In order to satisfy this condition, it is necessary for the airborne salt concentration to be no higher than 0.02 mdd at the Aum and Kapira bridge sites, where annual wet time (when relative humidity is 80% or higher) is around 4,800 hours. Referring to the results of measurement in Japan, when the distance from the coast is 22 kilometers as in the case of Aum Bridge and Kapiura Bridge, the airborne salt concentration is given as 0.01 mdd (Seto Inland Sea), 0.012 mdd (Pacific Ocean) and 0.05mdd (Sea of Japan), meaning that a figure of no higher than 0.02 mdd is not necessarily guaranteed in the Project. According to the conventional standard in Japan, the bare use of weatherproof steel is permitted if the airborne salt concentration no higher than 0.05 mdd irrespective of the length of wet time, however, the environment surrounding weatherproof steel around the Project bridge locations, where humidity is even higher and wet time is longer, is harsher. In such circumstances, bare weatherproof steel will not be adopted on the Project bridges because of the major risk regarding formation of the protective rust layer.

In consideration of the above points, it is recommended that corrosion protection by coating be selected.

The used coating (general exterior surface coating) will be C-5 coating (fluoride resin) as stipulated in the Handbook of Coating and Corrosion Protection for Steel Highway Bridges. This is a long-term rust prevention coating and is used as a standard coating material on new bridges in Japan.

Supplementary explanation: Judgment on application of weatherproof steel based on literature

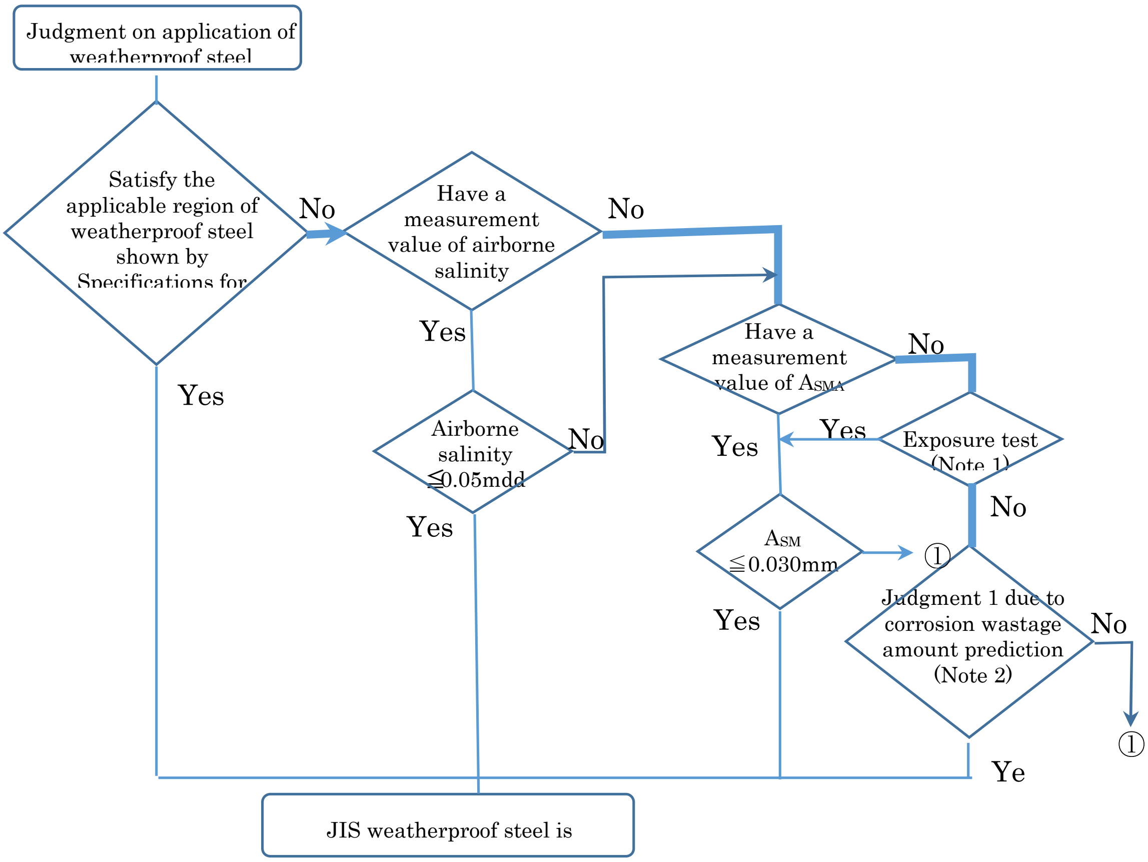
The applicability of weatherproof steel to the Project bridges will be tested while referring to the following literature.

Reference literature:

1) "Evaluation of Applicability and Preventive Maintenance for Corrosion Protection in Weatherproof Steel Bridges," (JSSC Technical report N0.86, 2009)

2) "Research concerning the Weatherproof Steel Corrosion Protection and Abrasion Forecasting Model (Japan Society of Civil Engineering Collection of Papers N0.780/I-70,71-86,2005.1)"

The first work above shows a flowchart for determining applicability of weatherproof steel, and this will be followed for making judgments here. When doing so, assuming good conditions without taking design corrosion into account, the corrosive abrasion of plate thickness will be set at no higher than 0.5 mm per surface over 100 years.



Note 1: There is at least one year for examination, and preparations for exposure testing have been made.

Note 2: It is necessary to have the client's judgment, and decision needs to be made based on expert knowledge.

#1 Application of nickel-based weatherproof steel will be examined.

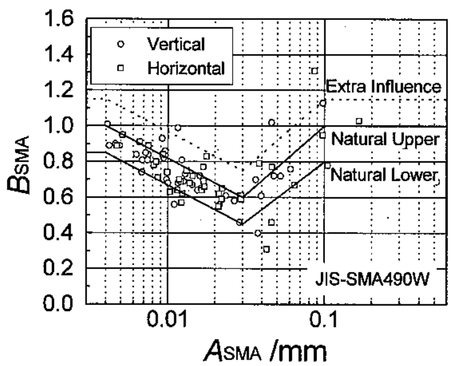
Figure 2.2.39 Flowchart for Determining Application of Weatherproof Steel

Predicted amount of corrosion wear loss (100 years)

Amount of corrosion wear loss: $Y = A_{SMA} \cdot X^{B_{SMA}}$

- X=100 years
- A_{SMA}=0.10517・Z+0.008672 : Considering corrosion in the first year of SMA horizontally exposed materials
- The relationship between B_{SMA} and A_{SMA} is formulated as shown in the figure based on 41 sets of exposure data from all over Japan.

Here, the amount of corrosion wear loss is estimated using the Natural Upper values in the figure.



- Z= α・TOW・exp(-κ・W)・(C+δ・S) / (1+ε・C・S)・exp(-Ea/R/T)

Here,

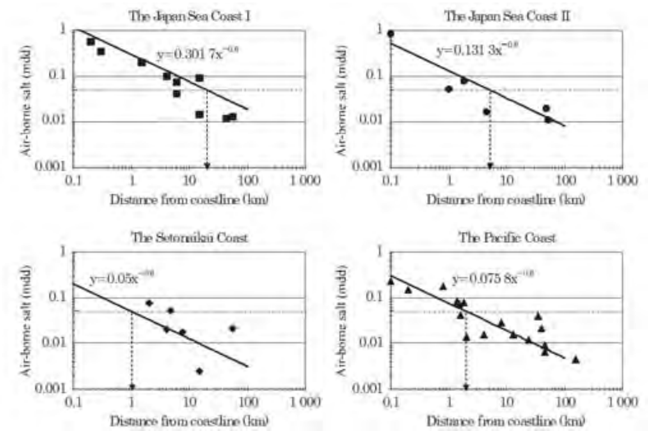
・α=1 x 10^6 coefficient

・TOW: Annual wet time = 8766・P1(rh)・P2(T) Assuming this to be the time when temperature is no less than 0℃ and humidity to be 80% or higher, the average temperature is 27℃ and annual average humidity is 77%, and this time is estimated to be <u>4813 hours (in Japan, the wet time is 3,238 hours when average humidity is 70% and average temperature is 15℃.)</u>

・κ=0.1

・W (m/s): Annual average wind velocity is assumed to be 1.0 meter.

・C: Airborne salt (mdd): Since distance from the coast is approximately 22 kilometers, this is assumed to be as follows: C = 0.01~0.05



・δ = 0.05

・ε = 10

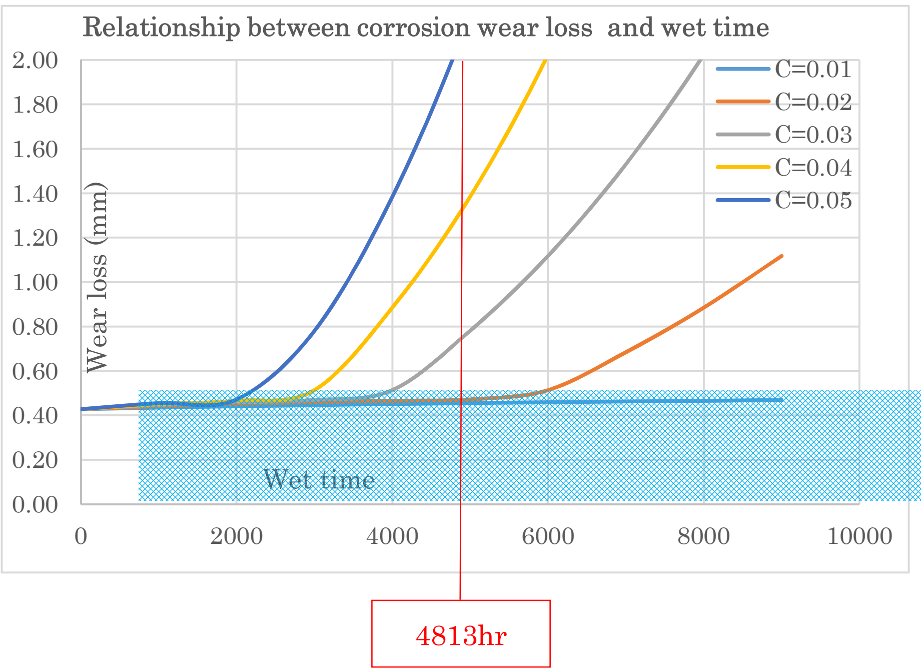
・S: Amount of sulfur oxides = 0

・Ea = 50kJ/mol・K：Activation energy

・R gas constant = 8.314 J・K^{-1}・mol^{-1}

・T annual average temperature (K)

➢ Results of estimation



According to the results of estimation, if the airborne salt concentration C is no higher than 0.02 md, the plate thickness loss limit of 0.5 mm per 100 years is satisfied. This is a low value for the estimated salt concentration, so investigation of airborne salt concentration is required when using weatherproof steel.

Initially the applicability of weatherproof steel was assessed by looking only at the conventional concentration of airborne salt, however, the above graph indicates that the impact of wet time too cannot be disregarded.

However, as the relationship between A_{SMA} and B_{SMA} used in the calculation is based on the results of Japanese exposure testing, they may not necessarily be applicable to Papua New Guinea.

⑤ Expansion devices

Expansion devices will be selected with the appropriate type, structure and materials to ensure that the following performance requirements are secured.

a) The devices secure enough road flatness to allow vehicles to pass without problem even when bridges experience deformation due to girder temperature changes and live load, etc.
b) The devices have the necessary durability to cope with passing vehicles.
c) The devices are sufficiently watertight to resist infiltration of rainwater, etc.
d) The devices comprise structure designed to minimize noise and vibration caused by passing vehicles.
e) The devices comprise structure that considers the ease of construction, maintenance and repair.

i) Design expansion amount

Because the average temperature of bridge structures reaches a maximum of 50℃ and minimum of 6℃, the amount of temperature change is 44℃, however, 50℃ will be assumed to be on the safe side.

Design expansion amount in Kapiura Bridge

Length of expansion girder: L = 45.650 m + 46.0 m / 2 = 68.650 m

Basic expansion amount: 1.2×10^{-5} x 50℃ x 68650 mm = 41.2 mm

Allowance amount: 8.2 mm at 20% → 10.0 mm

Design expansion amount: 41.2 mm + 10.0 mm = 51.2 mm → <u>60 mm (±30mm)</u>

Design expansion amount in Aum Bridge

Length of expansion girder :L = 38.540 m

Basic expansion amount: 1.2×10^{-5} x 50℃ x 38540 mm = 23.1 mm

Allowance amount: 4.6 mm at 20% → 10.0 mm

Design expansion amount: 23.1 mm + 10.0 mm = 33.1 mm → <u>40 mm (±20mm)</u>

ii) Type of expansion devices

Expansion devices are broadly divided into the following three types.

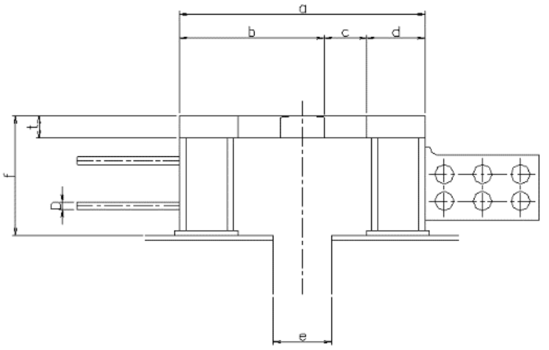
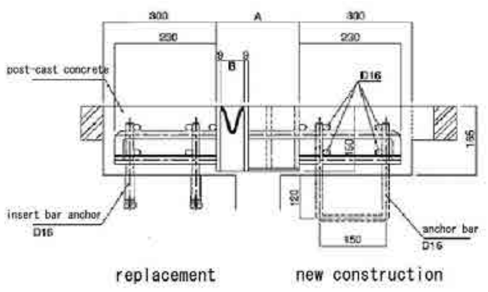
Expansion devices ------- a) Buried type, b) Butt type , c) Load supporting type

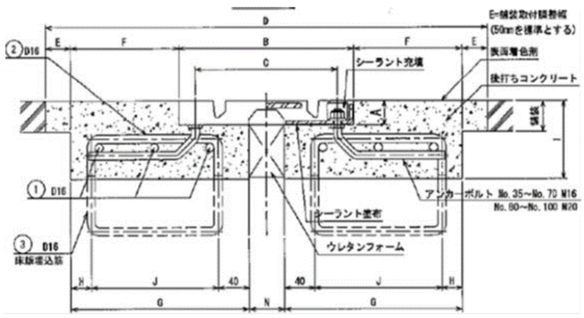
Buried type and butt type expansion devices are used on bridges with a small amount of expansion. In the Project, however, because the bridges are continuous girder structures with long expansion girders having expansion quantity of 40 mm and 60 mm, load supporting type expansion devices will be adopted.

There are three types of load supporting type expansion devices, i.e. steel (steel finger), steel ＋ rubber, and rubber. In cases where the expansion quantity is greater than 80 mm, the steel finger type is adopted, however, if the expansion quantity is 40 mm or 60 mm, the steel ＋ rubber type or rubber type can also be adopted.

All types are similar in terms of water-proofing, ease of maintenance, ease of execution, and running smoothness. Here, comparison of life cycle cost and economy is carried out on one expansion device each of the steel finger type, steel ＋ rubber type, and rubber type. The comparison sheet is shown in Table 2.2.37.

Table 2.2.37 Comparison of Lifecycle Cost of Expansion Devices

Expansion device type	Lifecycle cost
Load supporting type (steel fingers)  A non-drainage type (elastic seal + water stop rubber) is assumed.	Initial investment ¥595,000 /m Materials cost: ¥554,000 /m Construction cost: ¥ 41,000 /m Replacement works cost ¥812,000 /m Materials cost: ¥554,000 /m Construction cost: ¥258,000 /m Service life is assumed to be 30 years. Life cycle cost ¥595,000 + 812,000 x 3 times **= ¥ 3,031,000 /m**
Load supporting type (steel ＋ rubber) 	Initial investment ¥134,100 /m Materials cost: ¥103,000 /m Construction cost: ¥ 31,100 /m Replacement works cost ¥210,000 /m Materials cost: ¥103,000 /m Construction cost: ¥107,000 /m Service life is assumed to be 20 years. Life cycle cost ¥134,100 + 210,000 x 4 times **= ¥ 974,100 /m**
Load supporting type (rubber)	Initial investment ¥195,100 /m Materials cost: ¥164,000 /m Construction cost: ¥ 31,100 /m Replacement works cost ¥271,000 /m Materials cost: ¥164,000 /m Construction cost: ¥107,000 /m Service life is assumed to be 15 years.

Expansion device type	Lifecycle cost
	Life cycle cost ¥195,100 + 271,000 x 6 times = ¥ 1,821,100 /m

iii) Selection of the type of expansion devices

a) Steel finger type

The steel finger type is metal along the entire road surface and is estimated to have the longest service life (30 years), however, the lifecycle cost is high. This type is further divided into the drainage type (bucket type) and non-drainage type (elastic seal + water stop rubber), however, since the drainage type causes corrosion of girder ends and supports, the non-drainage type will be adopted here.

b) Steel + rubber

In steel ＋ rubber expansion devices, the rubber part does not directly support the wheel load, however, service life is thought to be shorter than that of the steel finger type due to the possible peeling and detaching of rubber. The service life is assumed to be 20 years, however, when lifecycle cost is considered, this type offers the best economy out of the three options.

The expansion devices for the Project bridges will basically be the load supporting type (steel ＋ rubber).

c) Rubber

Because wheel loads are supported by the rubber surface, durability is poor and the service life is estimated to be around 15 years. Since frequent replacement works are needed, this type is inferior to the steel + rubber type in terms of lifecycle cost too.

In consideration of the above points, load supporting type (steel ＋ rubber) expansion devices will be selected.

⑥ Fall prevention system

Fall prevention systems for superstructures comprise the following three elements: a) girder holding length, b) bridge fall prevention structure, and c) lateral displacement restraining structure. The girder holding length must be secured at all costs, however, the bridge fall prevention structure and lateral displacement restraining structure can be omitted in cases where the risk of bridge collapse is small. In the Project, the required fall prevention system will be decided upon determining whether or not it is necessary to install a bridge fall prevention structure and lateral displacement restraining structure.

a) Girder holding length

This serves to prevent the superstructure slipping off the top of the substructure when the supports break.

b) Bridge fall prevention structure

This serves to prevent the relative offset between the superstructure and substructure in the bridge axis direction exceeding the girder holding length when the supports break. (Bridge axis direction fall prevention measure)

c) Lateral displacement restraining structure

This serves to restrain displacement of the superstructure perpendicular to the bridge axis due to bridge structural factors when the supports break. (Fall prevention measure in the direction perpendicular to the bridge axis)

i) Girder holding length

The girder holding length shall be no less than the value calculated by the following formula.

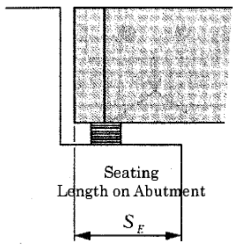


Figure 2.2.40 Girder Holding Length (extract taken from the Design Specifications for Highway Bridges, Part V Seismic Design)

In the Project bridges, abutment sections are applicable

$S_{ER} = U_R + U_G$

$S_{EM} = 0.7 + 0.005 \cdot l$

$U_G = \varepsilon_G \cdot L$

S_{ER}: Necessary girder holding length (m)

U_R: Maximum response deformation on supports arising in Level 2 seismic vibration (m)

U_G: Relative offset of ground arising due to ground distortion during earthquake (m)

S_{EM}: Minimum girder holding length (m)

ε_G: Ground distortion during earthquake will be 0.0025, 0.00375, and 0.005 respectively in ground types I, II and III.

L: Distance between substructures impacting the necessary girder holding length

(m)

l: Span length (m)

The minimum girder holding length on abutments where girder ends are situated on Kapiura Bridge and Aum Bridge are as follows.

Kapiura Bridge

$S_{EM} = 0.7 + 0.005 \text{ x } 45 = 0.925\text{m} \rightarrow 0.95\text{m}$

Aum Bridge

$S_{EM} = 0.7 + 0.005 \text{ x } 38 = 0.890\text{m} \rightarrow 0.90\text{m}$

ii) Feasibility of omitting the bridge fall prevention structure

If any of the following conditions are fulfilled, the bridge has structural characteristics that are not conducive to the occurrence of large displacement in the bridge axis direction, so the bridge fall prevention structure in the bridge axis direction can be omitted.

a) The bridge has a series of superstructures whereby both ends are supported by abutments

b) The bridge has a series of superstructures whereby elastic or fixed support is provided in four or more substructures in the bridge axis direction

c) The bridge is a rigid frame structure having a superstructures whereby two or more substructures are rigidly connected

In both Kapiura Bridge and Aum Bridge, since both ends are supported by abutments and comprise a series of superstructures with continuous girders, they come under type a) above.

Accordingly, **the bridge fall prevention structure in the bridge axis direction can be omitted for both Kapiura Bridge, and Aum Bridge.**

iii) Feasibility of omitting the lateral displacement restraining structure

If any of the following conditions are fulfilled, there is a risk of the bridge collapsing due to movement of the superstructure in the direction perpendicular to the axis, so a lateral displacement restraining structure must be installed.

a) Due to the structural and geometric conditions of the superstructure, the bridge superstructure can rotate without being restrained by adjoining girders or abutments following breakage of the supports, and moreover the bridge has a series of superstructures of one or two spans.

b) The bridge has a substructure with a narrow crown width (bridges such as ramp bridges where there are few supports on a single support line and the substructure crown width is narrow)

In a), the bridge superstructure can rotate without being restrained by adjoining girders or abutments in cases of a curved bridge or bridge that possesses an angle of skew. However, even in cases of these bridge types, if the bridge has a series of superstructures comprising three of more spans and there is little likelihood of it rotating even if the supports break, there is no need to install a lateral displacement restraining structure.

① Skew bridges with a small skew angle satisfying Eq.

$$\frac{\sin 2\theta}{2} > \frac{b}{L}$$

② Curved bridges satisfying Eq.

$$\cos\theta' > \frac{b}{L}$$

where

L: Length of a continuous superstructure (m)

b: Whole width of the superstructure (m)

θ: Skew angle (degree)

θ' : Intersection angle (degree)

Figure 2.2.41 Conditions where Skew Bridge or Curved Bridge can Rotate (extracted from the Design Specifications for Highway Bridges, Part V Seismic Design)

<u>Kapiura Bridge is a straight bridge and not a type in which the superstructure can rotate.</u>

Since Aum Bridge is a skew bridge and curved bridge and it also has two continuous spans, it is necessary to judge whether or not it meets the conditions whereby the superstructure can rotate. In the case of Aum Bridge, because the width and curvature of the superstructure vary over the bridge, rather than using the above conditional formula, the following geometric conditions are used to make a judgment.

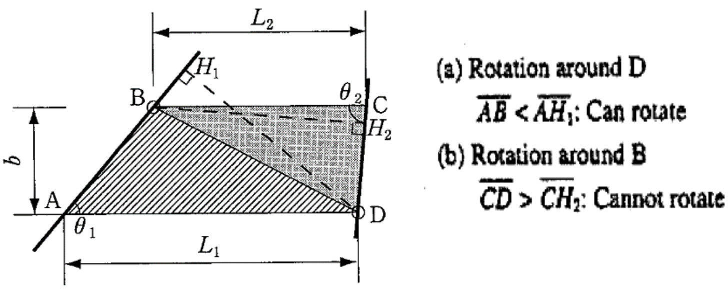


Figure 2.2.42 Conditions where the Superstructure can Rotate (extracted from the Design Specifications for Highway Bridges, Part V Seismic Design)

The following figure shows the results of examination on Aum Bridge. Assuming the four corners of the superstructure to be points A, B, C, and D, there is a possibility of the superstructure rotating due to the effects of oblique angle and curve when the superstructure moves from point B to point A centering on point D.

DH is the perpendicular line drawn along line AB from point D using CAD. Since AB >

AH(DB > DH), the superstructure cannot rotate.

Therefore, Aum Bridge is a skew bridge and curved bridge, however, it is a not a bridge where the superstructure can rotate.

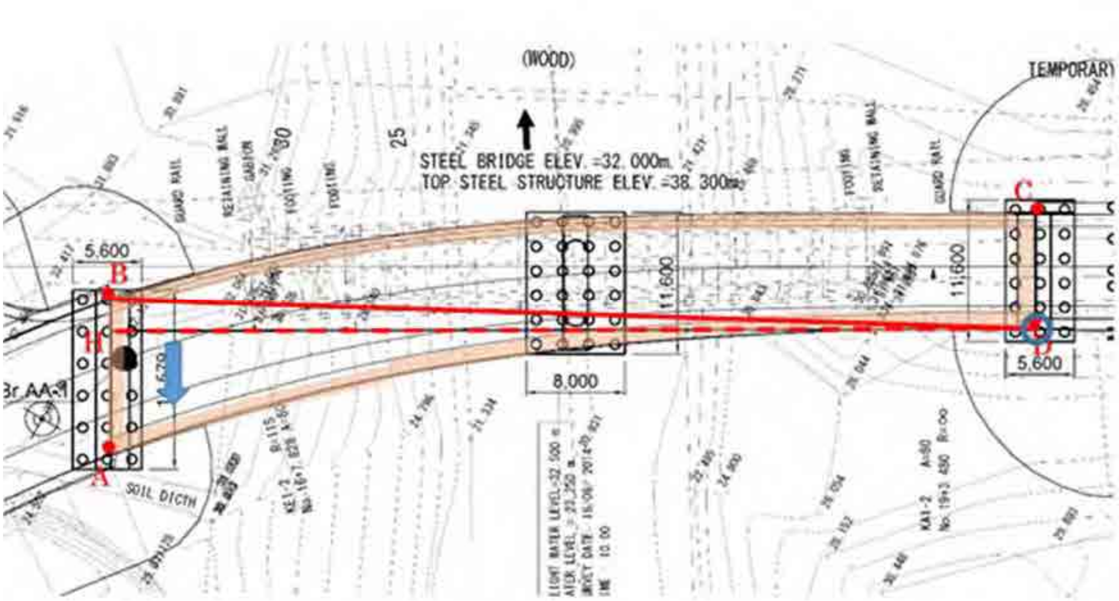


Figure 2.2.43 Verification of whether Aum Bridge can Rotate without the Influence of Abutments

Next concerning whether or not the bridges are classed as bridges having a substructure with a narrow crown width, since Kapiura Bridge has four supports on a single support line and Aum Bridge has five, neither bridge is this type.

Neither Kapiura Bridge, nor Aum Bridge have substructure with a narrow crown width.

Therefore, the lateral displacement restraining structure can be omitted in both Kapiura Bridge and Aum Bridge.

iv) List of bridge fall prevention systems

The following table shows the fall prevention systems that need to be installed on the Project bridges.

Table 2.2.38 List of Bridge Fall Prevention Systems on the Project Bridges

	Kapiura Bridge	Aum Bridge
Girder holding length	0.95 m or more	0.90 m or more
Bridge fall prevention structure	Unnecessary	Unnecessary
Lateral displacement restraining structure	Unnecessary	Unnecessary

7) Removal of existing bridge

① Kapiura Bridge

The existing Kapiura Bridge will be used as a detour route during construction of the new bridge, and the superstructure will be removed following completion of the new bridge. As may be gathered from collisions with driftwood and recent inundations, the existing bridge obstructs the safe discharge of flood flow, so it will need to be quickly removed following completion of the new bridge. Moreover, because Papua New Guinea lacks the technology, equipment and personnel for removing such large-size bridges, the request asks that removal be included in the Project. The old bridge will be removed by crawler crane using a pier that is established between the new bridge and existing bridge. Figure 2.2.44 and Figure 2.2.45 show the removal procedure.

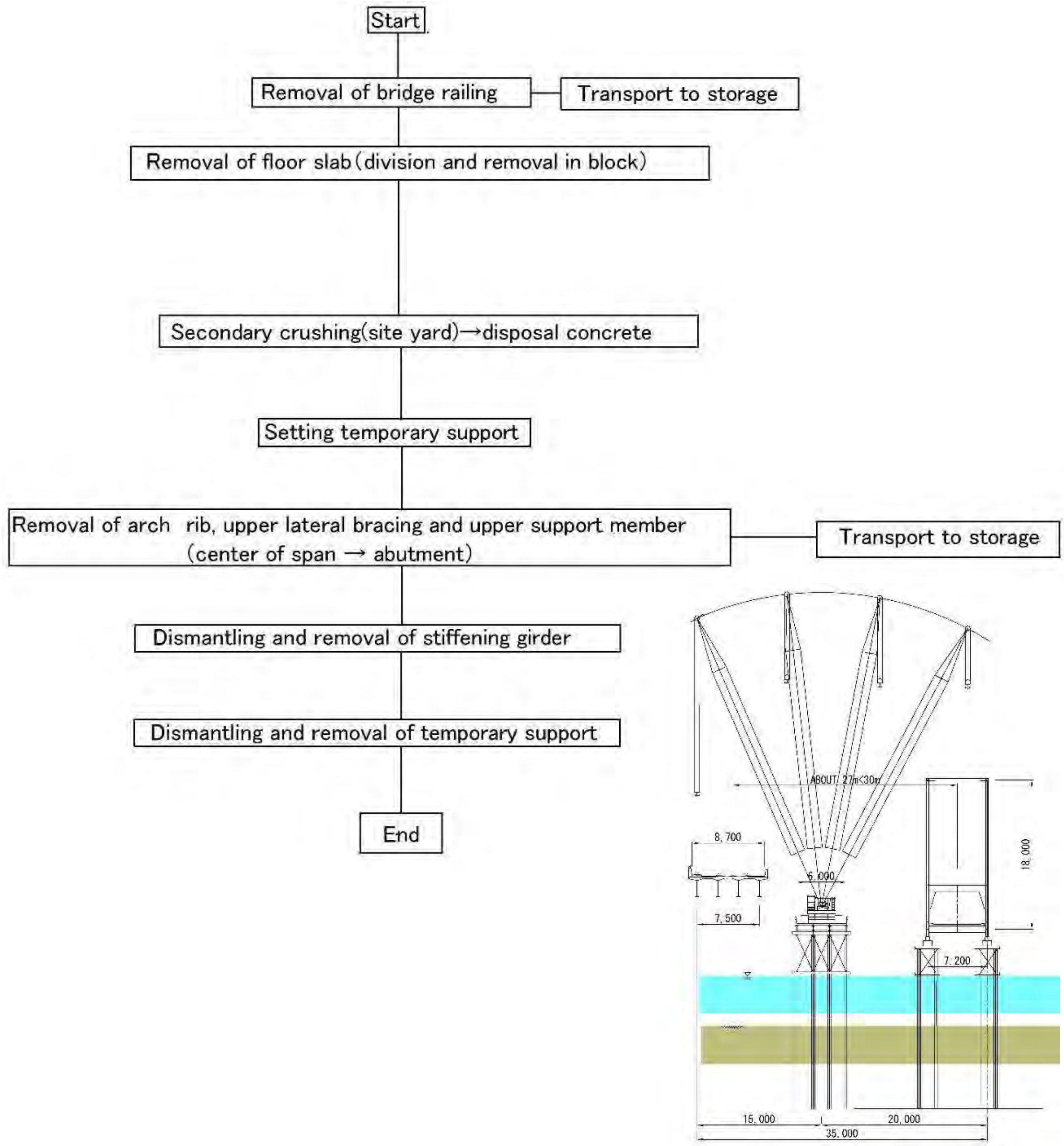


Figure 2.2.44 Kapiura Bridge Removal Drawing (1)

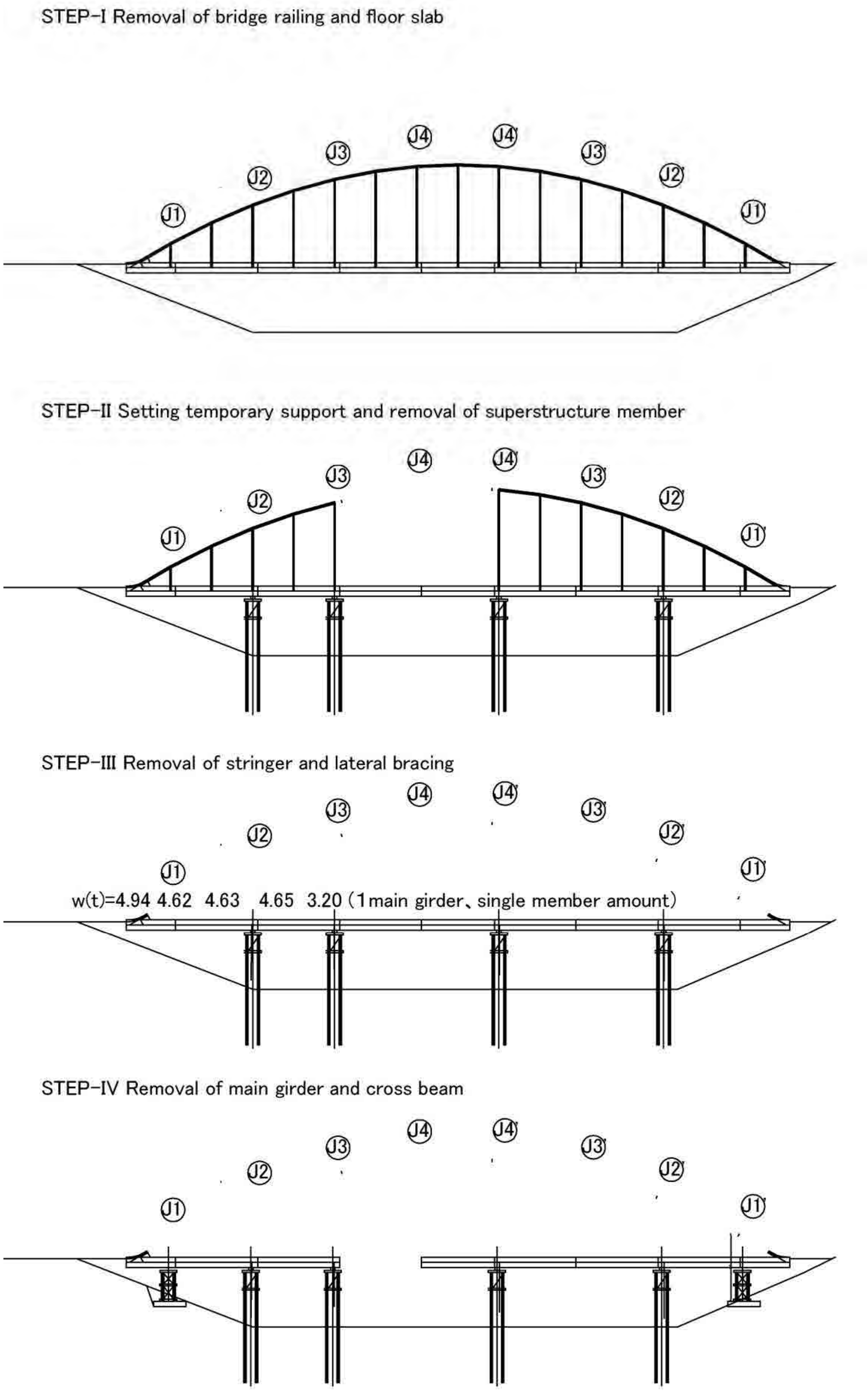


Figure 2.2.45 Kapiura Bridge Removal Drawing (2)

② Aum Bridge

Because Aum Bridge will be replaced in its existing position, it will be necessary to quickly remove the existing bridge following the start of works.

The old bridge will be removed by crawler crane using the pier that will be used for constructing the new bridge. The abutments will also be removed because they will interfere with the revetment works. Incidentally, the Papua New Guinea side will remove the temporary log bridge that is currently used as a detour route.

Figure 2.2.46 shows the existing bridge removal procedure.

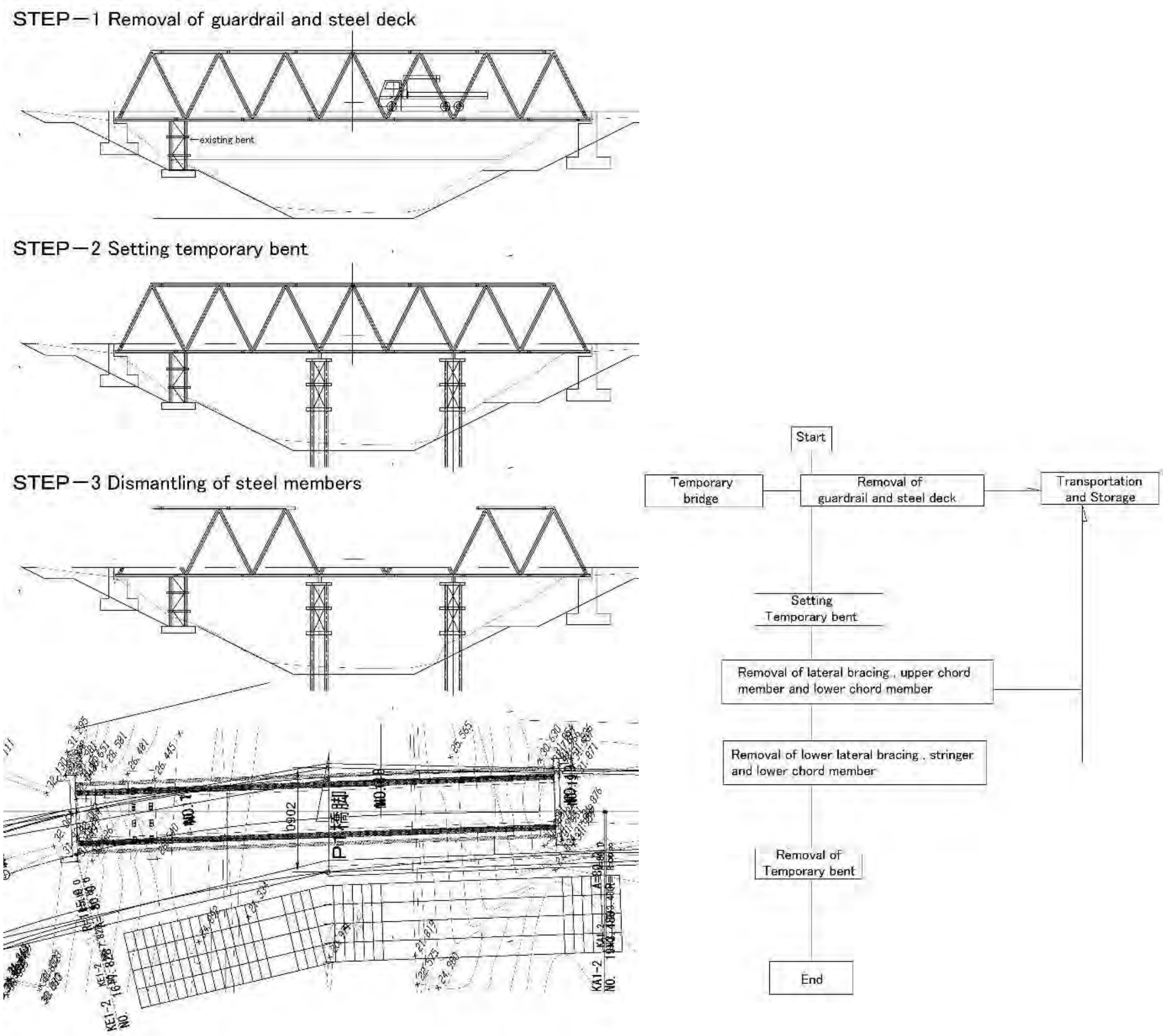
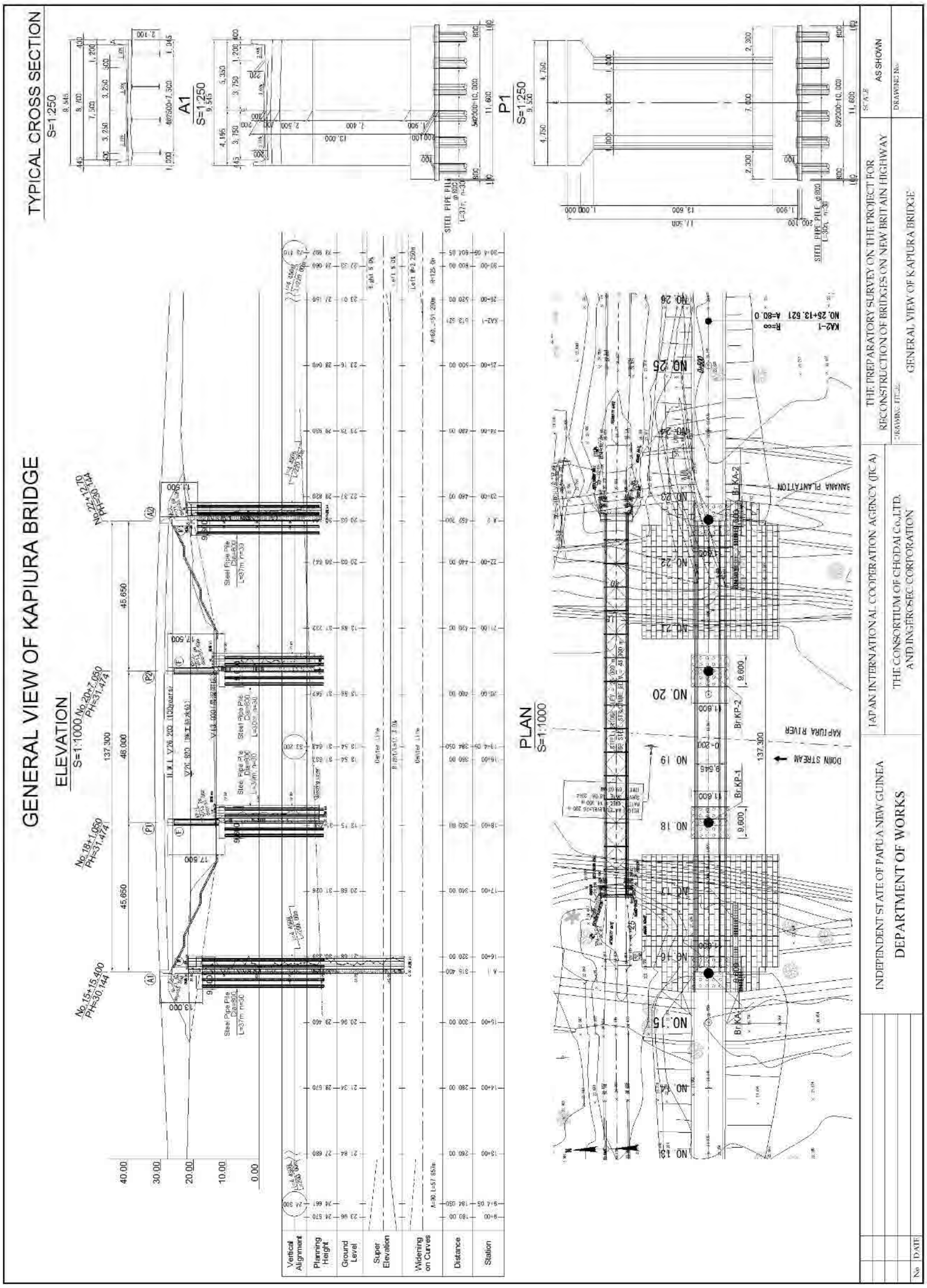


Figure 2.2.46 Aum Bridge Removal Drawing

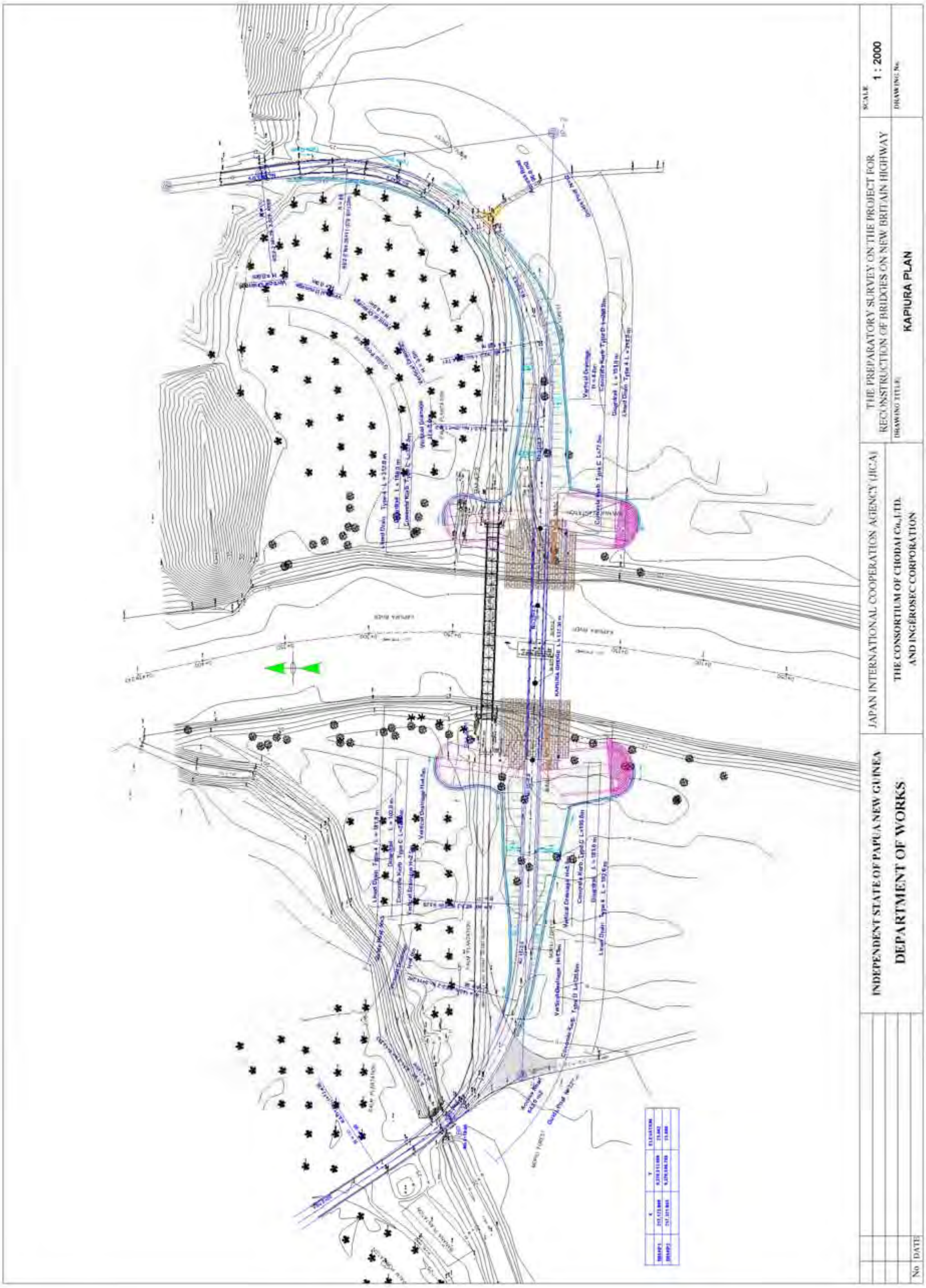
2.2.3 Outline Design Drawing

(1)Kapiura Bridge

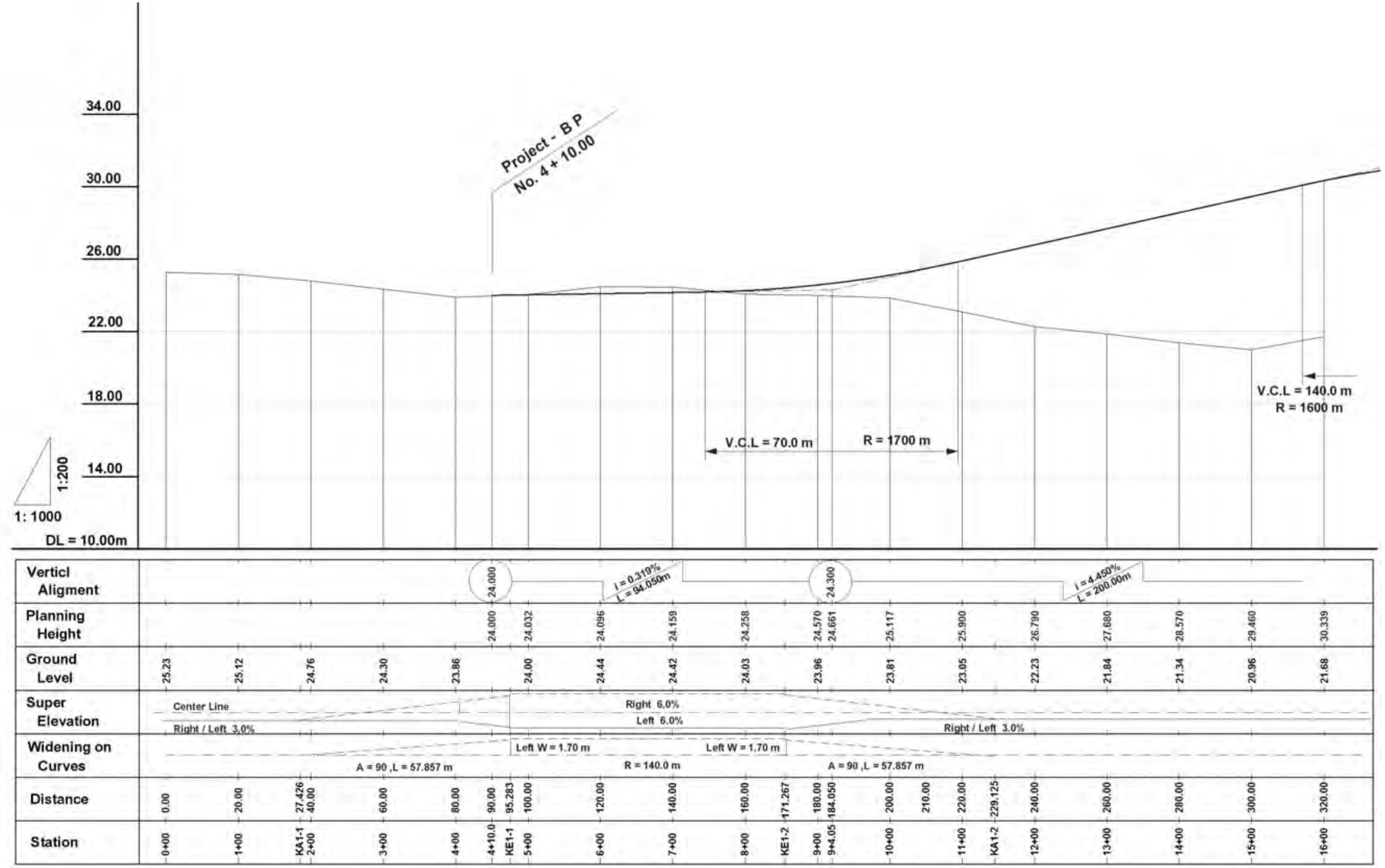
1) General Vew

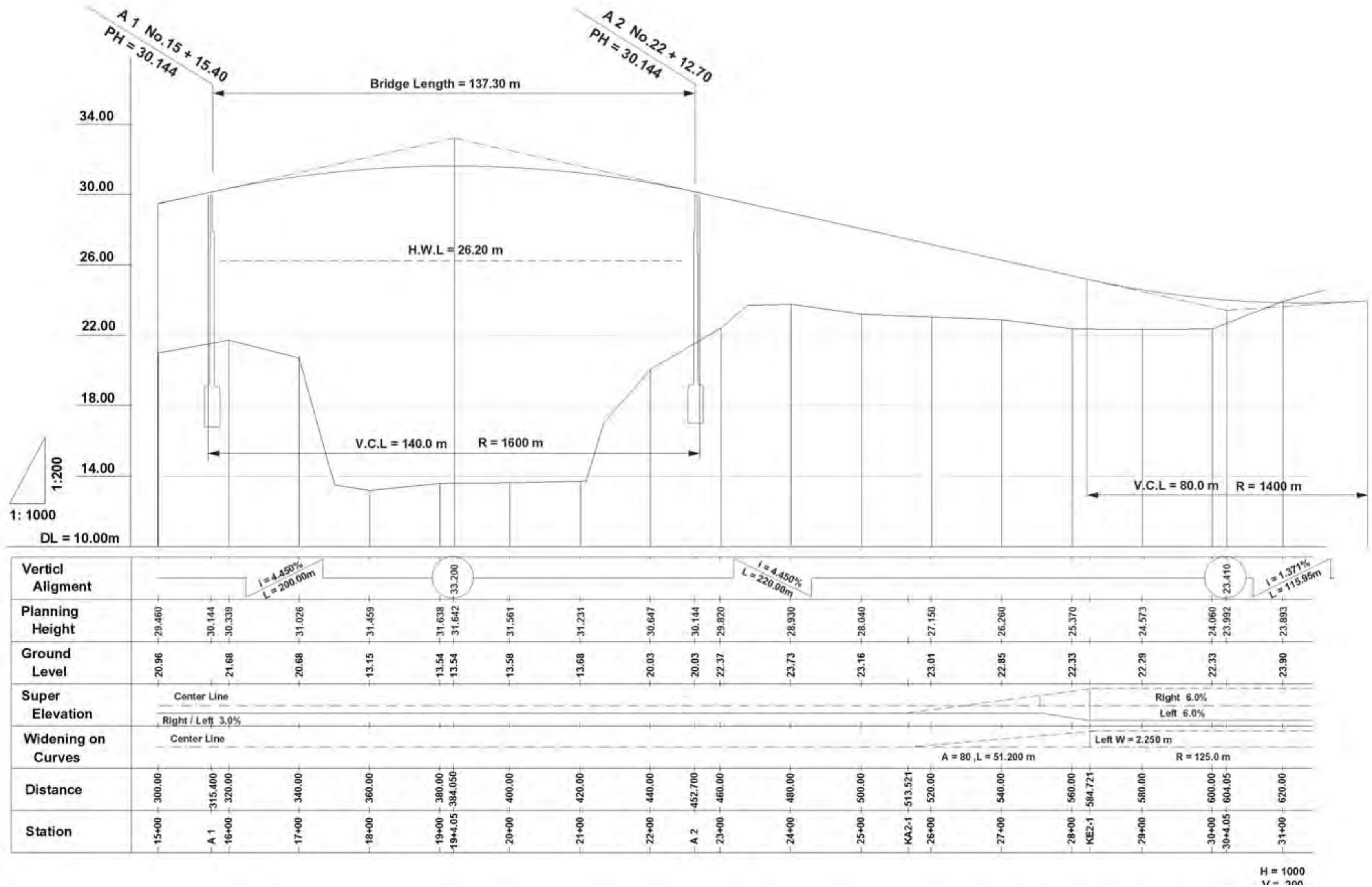


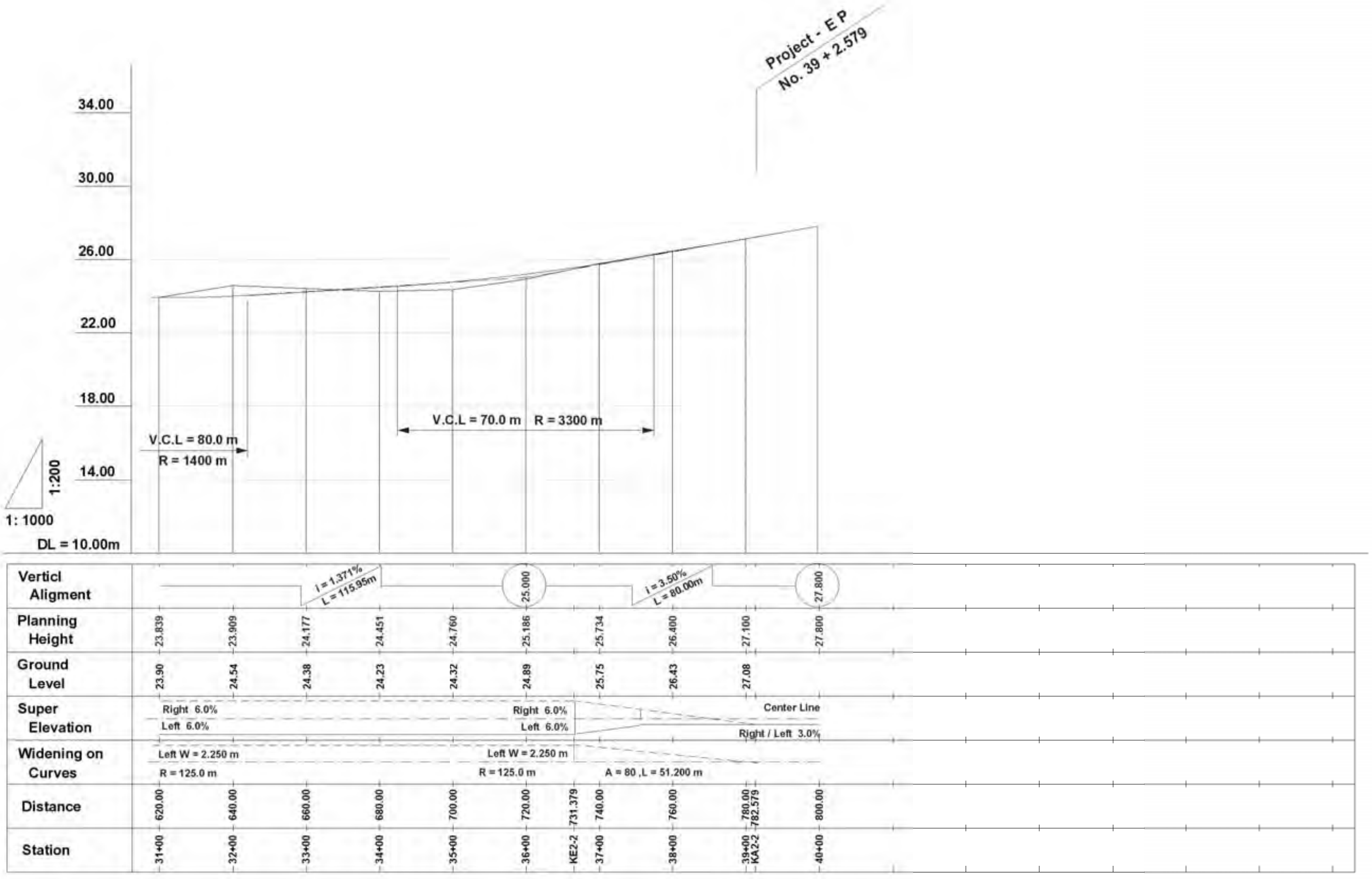
2) Plan view


INDEPENDENT STATE OF PAPUA NEW GUINEA
DEPARTMENT OF WORKS
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE CONSORTIUM OF CHODAI Co.,LTD.
AND INGÉROSEC CORPORATION
THE PREPARATORY SURVEY ON THE PROJECT FOR
RECONSTRUCTION OF BRIDGES ON NEW BRITAIN HIGHWAY
DRAWING TITLE
KAPIURA PLAN
SCALE
1 : 2000
DRAWING No.
No
DATE

3) Longitudinal view

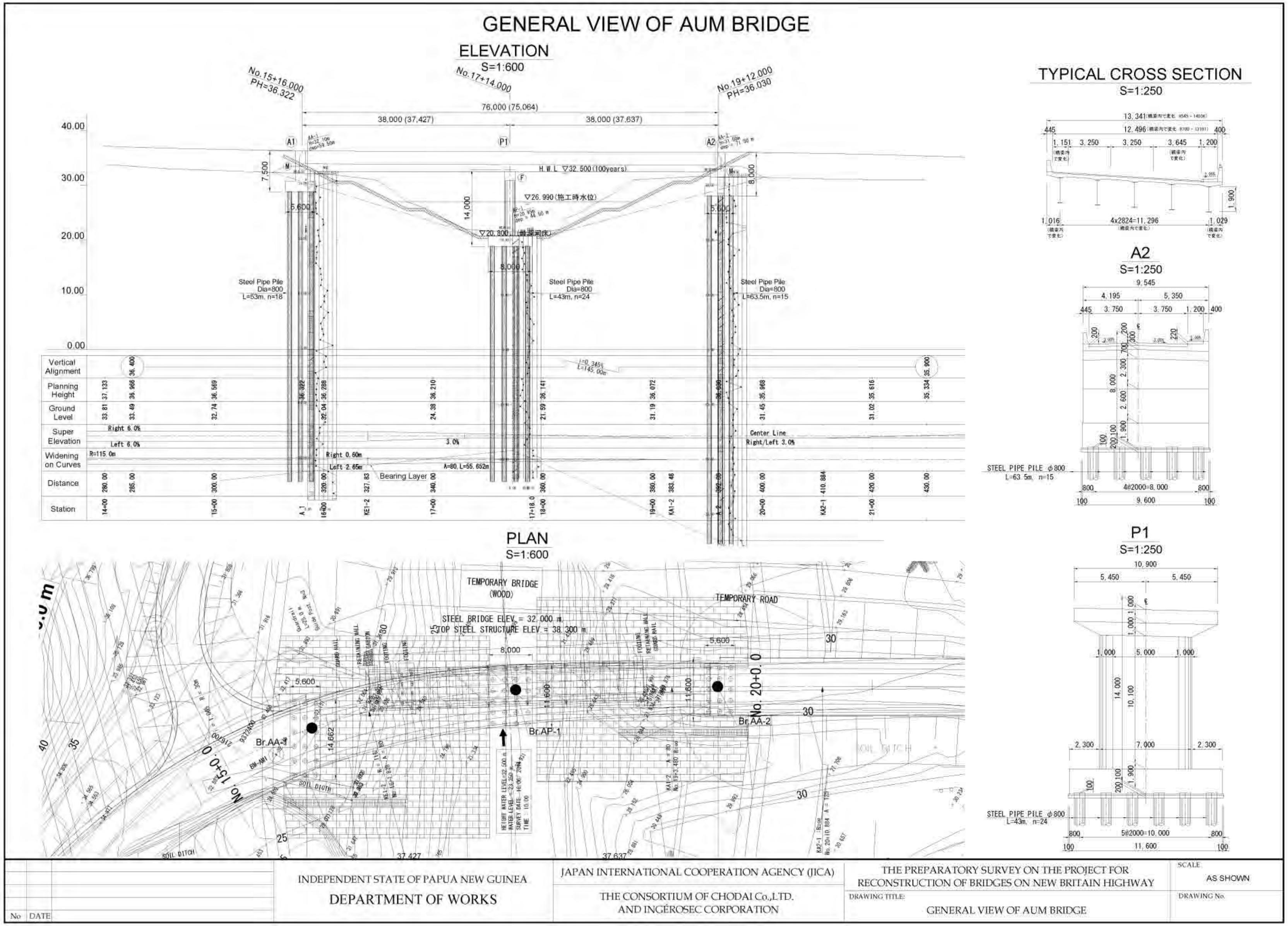



A 1 No.15 + 15.40
PH = 30.144
A 2 No.22 + 12.70
PH = 30.144
Bridge Length = 137.30 m
34.00
30.00
26.00
22.00
18.00
14.00
H.W.L = 26.20 m
V.C.L = 140.0 m R = 1600 m
V.C.L = 80.0 m R = 1400 m
1:200
1: 1000
DL = 10.00m
Verticl Aligment
i = 4.450% L = 200.00m
33.200
i = 4.450% L = 220.00m
23.410
i = 1.371% L = 115.95m
Planning Height
29.460 30.144 30.339 31.026 31.459 31.638 31.642 31.561 31.231 30.647 30.144 29.820 28.930 28.040 27.150 26.260 25.370 24.573 24.060 23.992 23.893
Ground Level
20.96 21.68 20.68 13.15 13.54 13.54 13.58 13.68 20.03 20.03 22.37 23.73 23.16 23.01 22.85 22.33 22.29 22.33 23.90
Super Elevation
Center Line
Right / Left 3.0%
Right 6.0%
Left 6.0%
Widening on Curves
Center Line
Left W = 2.250 m
A = 80 ,L = 51.200 m
R = 125.0 m
Distance
300.00 315.400 320.00 340.00 360.00 380.00 384.050 400.00 420.00 440.00 452.700 460.00 480.00 500.00 513.521 520.00 540.00 560.00 584.721 580.00 600.00 604.05 620.00
Station
15+00 A 1 16+00 17+00 18+00 19+00 19+4.05 20+00 21+00 22+00 A 2 23+00 24+00 25+00 KA2-1 26+00 27+00 28+00 KE2-1 29+00 30+00 30+4.05 31+00
H = 1000

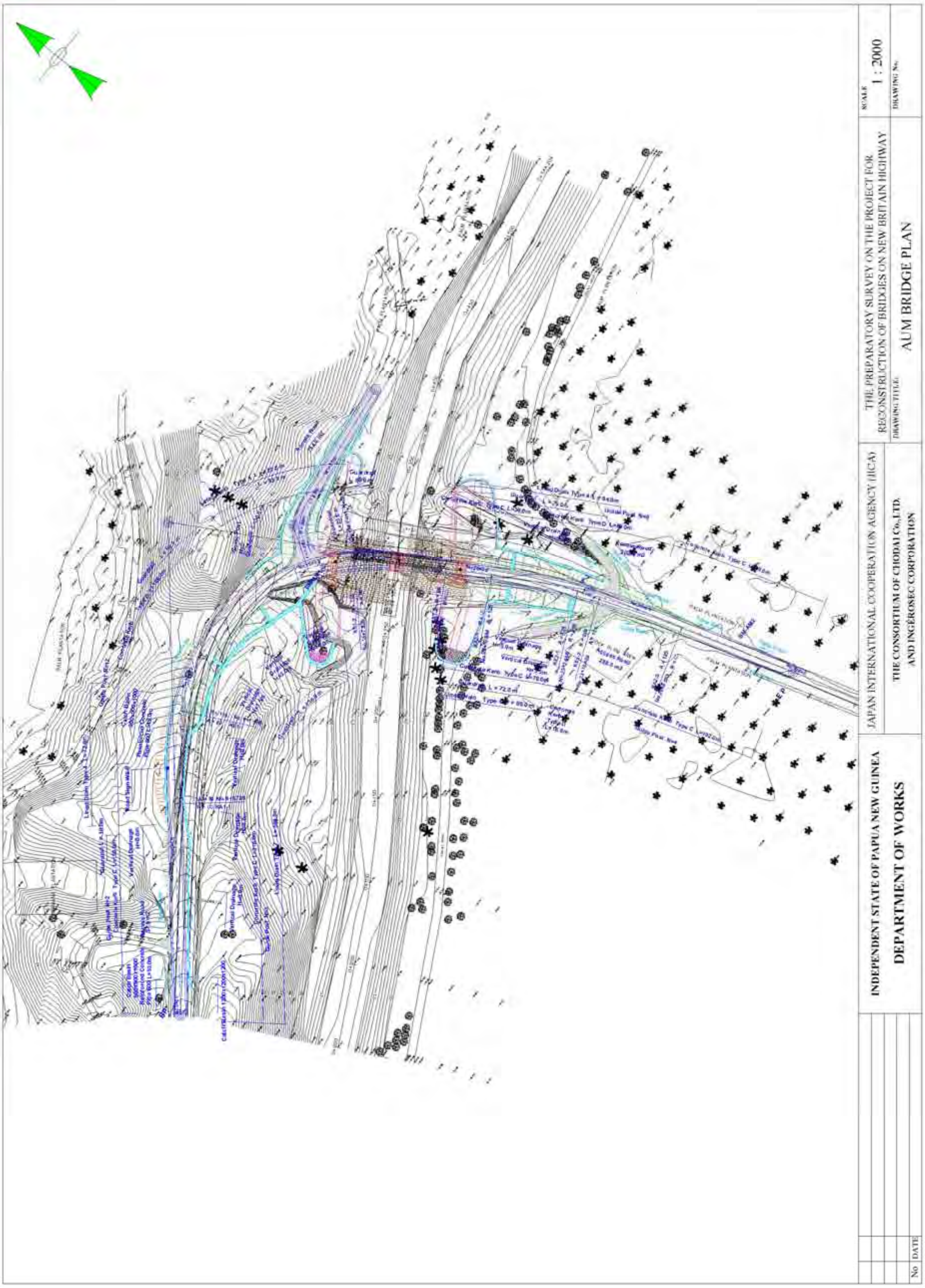

Project - E P
No. 39 + 2.579
34.00
30.00
26.00
22.00
18.00
14.00
V.C.L = 80.0 m
R = 1400 m
V.C.L = 70.0 m R = 3300 m
1:200
1: 1000
DL = 10.00m
Verticl Aligment
i = 1.371%
L = 115.95m
25.000
i = 3.50%
L = 80.00m
27.800
Planning Height
23.839
23.909
24.177
24.451
24.760
25.186
25.734
26.400
27.100
27.800
Ground Level
23.90
24.54
24.38
24.23
24.32
24.89
25.75
26.43
27.08
Super Elevation
Right 6.0%
Left 6.0%
Right 6.0%
Left 6.0%
Center Line
Right / Left 3.0%
Widening on Curves
Left W = 2.250 m
R = 125.0 m
Left W = 2.250 m
R = 125.0 m
A = 80 ,L = 51.200 m
Distance
620.00
640.00
660.00
680.00
700.00
720.00
731.379
740.00
760.00
780.00
782.579
800.00
Station
31+00
32+00
33+00
34+00
35+00
36+00
KE2-2
37+00
38+00
39+00
KA2-2
40+00

(2)Aum Bridge

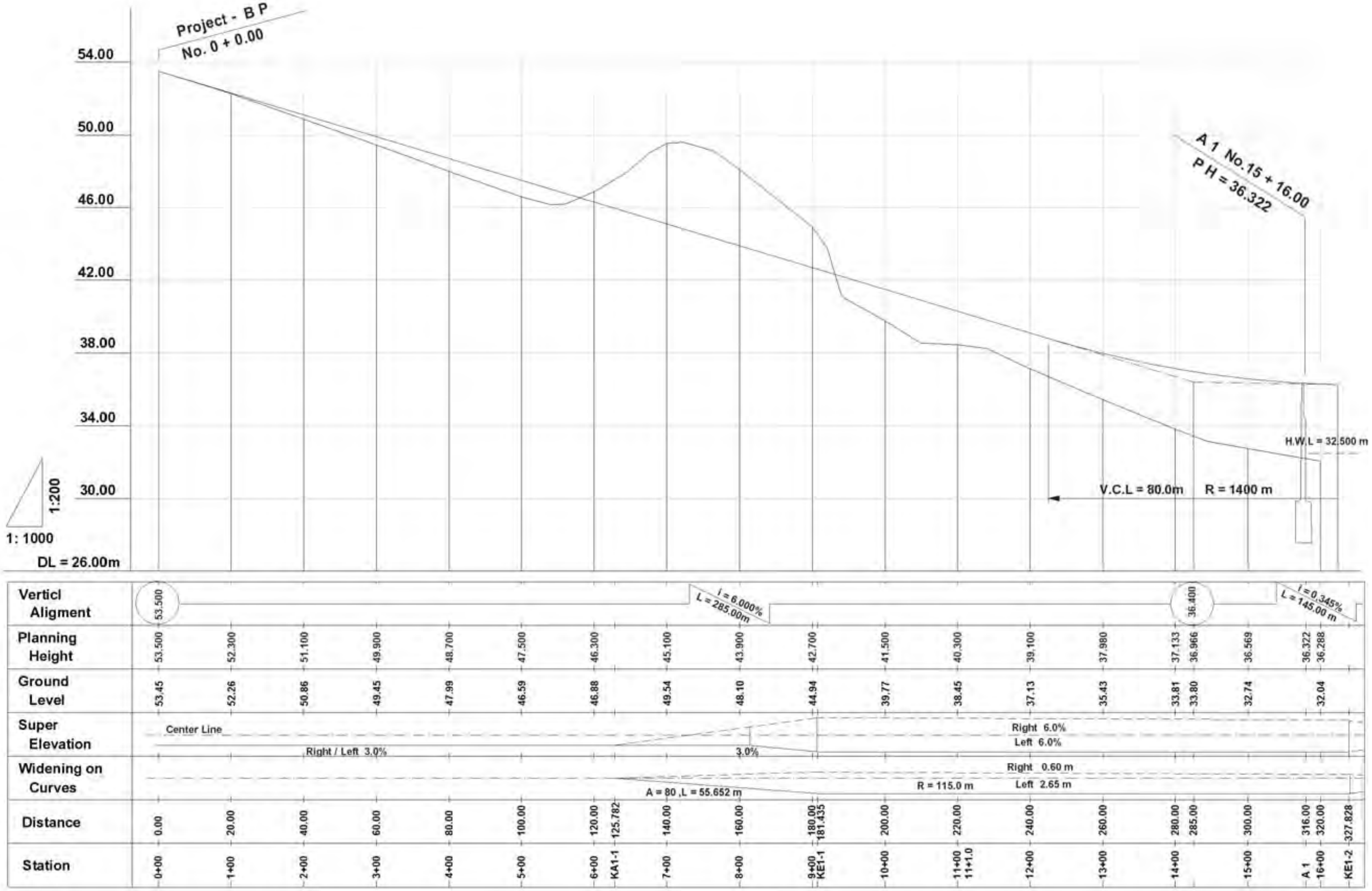
1) General Vew

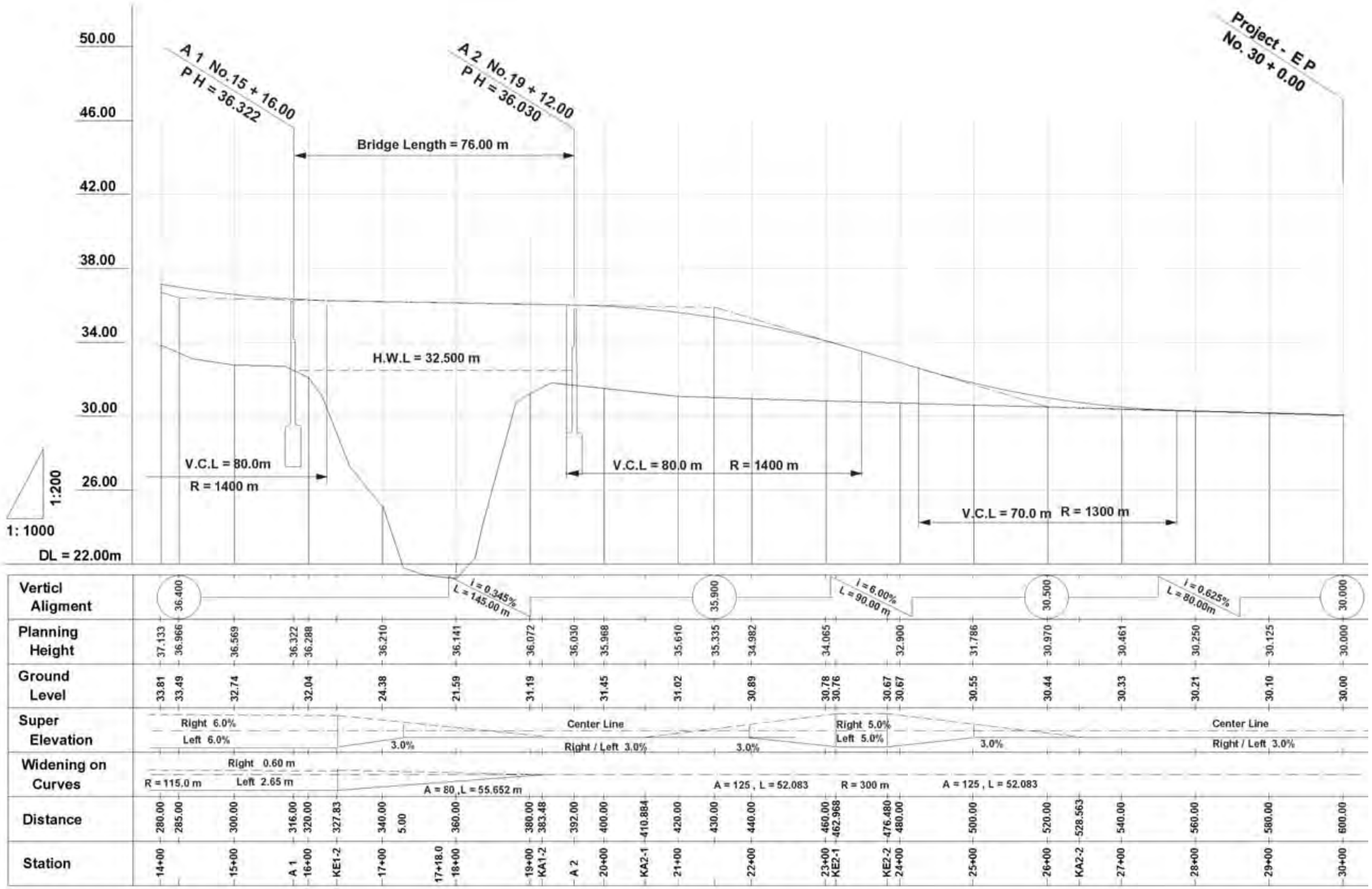


2) Plan view


INDEPENDENT STATE OF PAPUA NEW GUINEA
DEPARTMENT OF WORKS
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE CONSORTIUM OF CHODAI Co.,LTD.
AND INGÉROSEC CORPORATION
THE PREPARATORY SURVEY ON THE PROJECT FOR
RECONSTRUCTION OF BRIDGES ON NEW BRITAIN HIGHWAY
DRAWING TITLE:
AUM BRIDGE PLAN
SCALE
1 : 2000
DRAWING No.
No
DATE

3) Longitudinal view




50.00
46.00
42.00
38.00
34.00
30.00
26.00
1:200
1: 1000
DL = 22.00m
A 1 No.15 + 16.00
P H = 36.322
A 2 No.19 + 12.00
P H = 36.030
Project - E P
No. 30 + 0.00
Bridge Length = 76.00 m
H.W.L = 32.500 m
V.C.L = 80.0m
R = 1400 m
V.C.L = 80.0 m
R = 1400 m
V.C.L = 70.0 m
R = 1300 m
Verticl Aligment
36.400
i = 0.345%
L = 145.00 m
35.900
i = 6.00%
L = 90.00 m
30.500
i = 0.625%
L = 80.00m
30.000
Planning Height
37.133
36.966
36.569
36.322
36.288
36.210
36.141
36.072
36.030
35.968
35.610
35.335
34.982
34.065
32.900
31.786
30.970
30.461
30.250
30.125
30.000
Ground Level
33.81
33.49
32.74
32.04
24.38
21.59
31.19
31.45
31.02
30.89
30.78
30.76
30.67
30.67
30.55
30.44
30.33
30.21
30.10
30.00
Super Elevation
Right 6.0%
Left 6.0%
3.0%
Center Line
Right / Left 3.0%
3.0%
Right 5.0%
Left 5.0%
3.0%
Center Line
Right / Left 3.0%
Widening on Curves
Right 0.60 m
R = 115.0 m
Left 2.65 m
A = 80 , L = 55.652 m
A = 125 , L = 52.083
R = 300 m
A = 125 , L = 52.083
Distance
280.00
285.00
300.00
316.00
320.00
327.83
340.00
5.00
360.00
380.00
383.48
392.00
400.00
410.884
420.00
430.00
440.00
460.00
462.968
476.480
480.00
500.00
520.00
528.563
540.00
560.00
580.00
600.00
Station
14+00
15+00
A 1
16+00
KE1-2
17+00
17+18.0
18+00
19+00
KA1-2
A 2
20+00
KA2-1
21+00
22+00
23+00
KE2-1
KE2-2
24+00
25+00
26+00
KA2-2
27+00
28+00
29+00
30+00

2.2.4 Implementation Plan

(1)Implementation Policy

1) Implementation Plan

① Temporary works

i) Tree cutting and root removal work

Because temporary piers will be constructed upstream of both the existing Aum Bridge and Kapiura Bridge, access roads will be constructed between the existing road and the temporary piers. Tree cutting and root removal work will be conducted on the works road design traffic lines.

ii) Works roads

In order to secure access to the abutment and pier works area on the banks and rivers, temporary works roads will be established from the existing road. These works roads will be constructed using sediment carried from the earth quarry near to Aum Bridge (approximately 1.0 kilometer). Effort will be made to secure the bearing power of soil through carrying out compaction and improvement according to the soil characteristics.

iii) Temporary pier works

The works piers will be constructed on the rivers parallel to the new bridge positions. H piles will be installed using vibro-hammer, and the temporary piers will be constructed from both the east and west banks. The piers will be 6 meters wide, and overhanging assembly bases will be established in each pier position.

The temporary piers will be established on the upstream side of both the existing Aum Bridge and Kapiura Bridge and positioned in such a way that they can be used not only for the substructure works but also the girder placement works and removal works.

iv) Coffering works

Concerning Aum Bridge, because the floor surface is expected will be higher than the water line during construction, temporary coffering for draining water from the abutments will not be conducted. Concerning the abutments of Kapiura Bridge, consideration will be given to levee coffering and shallow sump drainage in line with the local site conditions such as rainfall and water line, etc.

Coffering works around the piers will be conducted by the shore strut method using steel sheet piles. At the same time, inflowing water from gaps in the steel sheet piles will be drained by means of shallow sump. In the case where it is necessary to secure river cross-sectional area for dealing with increased flow or sudden rise in water line due to rainfall, consideration will also be given to excavating the riverbed to widen the river when placing the steel sheet piles.

v) Existing bridge removal works

On Aum Bridge, since it is planned to construct the new bridge in the position of the existing bridge, the existing bridge will need to be removed before conducting the main works. As for Kapiura Bridge, since the current bridge is still being used, it will be removed following completion of the new bridge. The removed steel materials and so on will be transferred to a temporary site designated by the DoW (somewhere within 5.0 kilometers of the works site is envisaged).

② Bridge substructure works

Concerning construction of abutments, the steel pipe pile driving works, foundation works, and abutment works will be conducted from the access roads. The abutments will not be located in water but rather on land surrounded by the abovementioned works roads. Up to the east-west second piers, a flat ground area of around 30 meters (three times the width of bridge superstructure works) will be established as a holding yard and abutment construction yard, and work will be executed simultaneously with the pier construction. Out of the pier works implemented in the water, the steel pipe pile driving will be carried out by a hydraulic hammer from the temporary piers. When the pile driving work is finished, the assembly deck covering plates will be removed and used as falsework for conducting the next stage pile head treatment and connection concrete works.

i) Steel pipe pile driving works

Based on the results of geological survey, both bridges will be constructed using steel pipe pile foundations. The steel pipe piles will be inserted using a crawler crane and hydraulic hammer vibro-hammer, and end bearing capacity will be confirmed for all piles. It will be desirable to implement the pier construction works during the dry season.

ii) Excavation work

Pile head treatment will be implemented in order to join the inserted piles, piers, and abutment foundations by reinforced concrete. For this reason, excavation will be conducted in the pile driving positions. The abutment parts will undergo open excavation, while the piers will be excavated by small-size backhoe. The sediment excavated by backhoe will be loaded onto dump trucks and taken to a temporary earth dump.

iii) Foundation works

Levelling concrete will be placed and reinforcing bars will be arranged order to join the pile heads exposed by excavation with the piers and abutment foundations by reinforced concrete.

Moreover, in coffered areas for pier construction, shallow sumps will be provided and water will be constantly drained 24 hours a day by submersible pumps in order to facilitate the execution of works.

iv) Frame work

Concerning the form of abutments, the frames of reverse T abutments and piers are cylindrical overhanging piers. Materials (reinforcing bars, formwork, falsework) will be carried by trucks from temporary yards to the works sites and then moved by crane to the work areas. Basically the concrete for abutments and piers will be placed by concrete pumping vehicle. The areas behind abutments will be backfilled using good quality soil and managed based on the water content, etc.

v) Concrete works

Papua New Guinea has facilities that are capable of producing good quality cement (PNG Pacific Cement Co., Ltd.), and local operators also produce and manage good quality aggregate materials. There are concrete plants in Kimbe City approximately 40 kilometers from the bridge construction sites, and these plants will be used in the Project. Concrete will be placed by means of concrete pumping vehicle from the temporary piers.

③ Bridge superstructure works

Steel plate girders will be used for the superstructure works. The girders will be manufactured in Japan. Stock management will need to be conducted in the manufacturing plant and on the construction sites.

i) Support installation work

Supports will be the metal type. On the abutments and piers, anchor bolt holes for fitting the supports will be installed when processing the reinforcing bars and placing the formwork.

ii) Steel girder placement work

Steel girders will be placed from the piers that are established parallel to the new bridges. The girders will be temporarily assembled in the basic assembly yards located close to the new bridge positions before construction. Joints will be permanently tightened following placement, and then coating will be performed. A crawler crane will be used for placing the girders.

iii) Bridge floor slab work

Concrete floor slabs will be established on the placed bridge girders. Reinforcing bars and formwork will be installed using falsework that is installed when constructing the temporary piers and placing girders. Drainage channels will be constructed in tandem with the reinforcing bars and formwork. Also, concrete will be placed by concrete pumping vehicle from the temporary piers.

iv) Wall-type protective fence installation work

Concrete floor slabs and wall-type protective fences will be installed. Because the wall-type protective fences will also be made from concrete, the concrete will be placed following the installation of the reinforcing bars and formwork. Also, concrete will be placed by concrete pumping vehicle from the concrete floor slabs.

v) Bridge face waterproofing work

The bridge faces will undergo waterproofing treatment before the execution of paving on the bridges. The waterproofing material will either be coating or mat. Drainage pipes will also be installed when conducting the waterproofing treatment.

④ Earthworks

Earthworks will be conducted when performing banking and roadbed works for the main roads and access roads. Sediment transported from an earth quarry close to Aum Bridge (approximately 1.0km) will be used for banking, however, consideration will also be given to using crushed stone recycled from the concrete shell arising from the removal of the existing bridge abutments. The materials will be levelled and compacted by bulldozer. Moreover, depending on the soil properties of the banking materials, works period, schedule, and weather conditions, soil improvement will be implemented simultaneously with the compaction in order to secure the soil bearing power.

⑤ Roadbed works

In the main road works, work will be executed in order from the lower roadbed and then the upper roadbed. The roadbed materials will undergo grading control and will be applied in such a way that there is no unevenness in the materials. Concerning the roadbed works, after materials have been leveled by motor grader, etc, they will undergo compaction by road roller and tire roller, etc.

⑥ Paving work

On New Britain Island, national highways and all other roads are paved using DBST (Double Bituminous Surface Treatment). In the Project, since it will not be possible to conduct DBST paving on the bridge floor slabs, heated asphalt paving will be applied. The work will be implemented using a mobile asphalt plant and asphalt finisher, etc. procured from Japan.

Concerning joins with the existing paved sections, care will be taken to achieve smooth connections through cutting the paved slabs.

⑦ Road attached structure works

Attached structures such as road markings, guard rails, and signs, etc. will be coordinated with the paving works to ensure they can be promptly executed after the paving.

⑧ Vegetation planting

Vegetation will be planted on cuttings and banks installed in accordance with the road alignment as a means of protecting the slopes.

⑨ Revetment works

Concerning the abutments and piers, gabion revetments and so on will be constructed to guard against future scouring. Because the gabions will be fitted after conducting bed excavation and banking, it will be necessary to execute some of the work upon first performing coffering. Accordingly, it will be necessary to finish work on the abutments and piers before placing the bridge girders.

2) Procurement policy

Blessed with natural resources, Papua New Guinea prospers from exporting minerals and other natural resources in line with the growing worldwide demand for resources, and its per capita GDP has been growing at more than 6% over the past few years. In recent years, there has been rapid increase in construction works not only for roads and other public works but also domestic private sector buildings and hotels and so on, and the construction sector has been booming.

However, Papua New Guinea does not conventionally have many construction operators, and hardly any overseas operators want to enter the country due to the poor public security situation. As a result, it is no exaggeration to say that the principle of competition is not operative in the domestic construction industry. Accordingly, it is forecast that unit prices for locally procured labor, materials and equipment will be set "boldly," thereby leading to expensive costs.

In the Project, it has been decided to compare local unit rates with unit rates (including transportation cost) when procuring from Japan and to select the more economically advantageous case.

① Personnel plan

i) Situation regarding procurement of engineers and laborers

In the Project, similar projects were referred to in order to grasp the situation regarding procurement of skilled workers. Specifically, the Markam Bridge repair project, Highland Bridge project, and Bougainville coastal trunk bridge construction project were referred to. Since the Markam Bridge repair project entails repair and reinforcement works, because an extremely expensive estimate for procurement of experienced engineers was obtained from a local operator, it was more advantageous to dispatch skilled workers from Japan. As for the Bougainville coastal trunk bridge construction project, which entails construction of a new bridge and work by ordinary engineers, as a result of conducting re-examination, it was found to be cheaper to recruit local engineers than to dispatch from Japan, so estimation was conducted based on unit rates for Papua New Guinean engineers.

However, because bridge works in Papua New Guinea have largely been implemented under projects by overseas donors, there are very few operators and engineers who can independently construct bridges. Since it is not possible to recruit specially skilled bridge workers and bridge supervisors capable of providing instructions on the ground from the local population, it is necessary to recruit from Japan or third countries.

Other workers will be procured in Papua New Guinea.

ii) Regulations and labor conditions, etc. based on the labor standards law and related legislation

Labor-related legislation in Papua New Guinea mainly stipulates the following items.

Standard working hours: 08:00~17:00, 12:00~13:00 break, 8 working hours/day

Weekly holidays: Saturdays, Sundays, national holidays

Normal overtime allowance: 150% premium

Holiday overtime allowance: 200% premium

Minimum wage: Approximately 7 kina/day

National Public Service: According to General Orders (Papua New Guinea. Department of Personnel Management, 2002)

② Construction machinery for the works

Construction machines in Papua New Guinea will be leased from local construction operators. On surveying the possibility of procuring from lease companies, it was found that transactions based on mutual trust are not widespread and that lease agreements are concluded in only limited cases where personal connections and so on exist. Moreover, the poor public security situation and inadequate maintenance services in Papua New Guinea make it difficult to lease machinery locally.

Accordingly, general construction machines such as backhoe, bulldozer, tire roller, etc. will be procured from local construction operators. As for the asphalt plant, asphalt finisher, truck crane, crawler crane and so on, since these cannot be procured in Papua New Guinea, they will be procured in Japan.

③ Transportation and packing plan

i) The equipment, materials, steel, and construction machinery will be procured in

Papua New Guinea and Japan, and the transportation routes will be as follows.

Procurement source	Procured area	Oversea transportation	Land transportation
Papua New Guinea	Port Moresby	Kimbe Port	To each site
Japan	Yokohama Port	Kimbe Port (via Lae)	To each site

ii) The equipment, materials, steel, and construction machinery will be shipped oversea from Yokohama, via Lae to Kimbe, and from there carried overland to the construction sites.

iii) Transportation lead time

Equipment and materials will be shipped oversea from Japan to Kimbe Port and overland from Kimbe Port to each construction site.

(2) Implementation Conditions

1) Works yards

Space will be required for construction management offices and basic assembly yards and so on. The basic policy will be to utilize land that is owned by the local government.

2) Water line during works

When torrential rain falls, the water line at each bridge location increases rapidly. Therefore, it will be necessary to compile a safe construction plan upon reviewing the appropriate water line for conducting works.

3) Securing of safety

On New Britain Island, because there is a shortage of police officers, public security is unstable and it will be necessary to take ample security measures. A protective fence will be erected around site offices to prevent thefts and accidents, and guardsmen will be assigned to the entrances of offices 24 hours a day to prevent thefts and secure the safety of personnel.

(3) Scope of Works – Procurement and Installation

The scope of works in the Project on the Japan and Papua New Guinea sides will be as follows.

Scope of works on the Japan side	Scope of works on the Papua New Guinea side
-Construction of the two bridges and installation of the access roads and revetments indicated in the Basic Plan	-Cancellation of lease agreements within the construction sites
-Preparation of riverbed	-Leasing of construction work yards
-Removal of existing bridges	-Formulation and approval of an environmental management plan
-Construction and removal of temporary site offices and management offices	-Road and bridge maintenance
-Safety measures for general traffic passing through the area during the works	-Banking fees (opening of a banking arrangement (B/A) and procedure for authorization to pay (A/P))
-Procurement, import, transportation, and return to the original country of the construction equipment and materials indicated in the Equipment and Materials Procurement Plan	-Exemption and/refund of government taxes and duties on the import and purchase of Project equipment and materials
-Implementation design, preparation of tender documents, assistance for tender, and consultant supervision as indicated in the Consultant Supervision Plan	

(4) Consultant Supervision

1) Survey and design setup

In conducting the implementation design, a preliminary field survey will be implemented first. This survey is intended to reflect information that has been renewed since the basic design, and new conditions (revisions to laws and design standards, etc.) into the implementation design. Following completion of the survey, these new items of information will be promptly reflected in the design work.

Since the Project entails bridge construction, the work manager, bridge superstructure designer, bridge substructure designer, and person in charge of execution planning and estimation will conduct a field survey to collect information. When collecting information, they will receive cooperation from the DOW and ABG, which are the local road construction and maintenance agencies.

The implementation design will be mainly conducted by the engineers who conducted the field survey and other officers in charge of the bridge design (superstructure and substructure), road design, design drawings, quantity calculation sheets, estimates and works contracts, etc. In this stage, the design report, design drawings, quantity calculation sheets, Project cost estimation materials, and contract documents will be prepared.

The implementation design and tender assistance work will comprise the following items, also indicated in the implementation design personnel planning sheet showing each area of responsibility.

① Preparation of the superstructure design calculation sheets for Aum Bridge and Kapiura Bridge
② Preparation of the substructure design calculation sheets for Aum Bridge and Kapiura Bridge
③ Preparation of the road design plans for Aum Bridge and Kapiura Bridge Aum Bridge
④ Preparation of the bridge and road works drawings for Aum Bridge and Kapiura Bridge
⑤ Preparation of the bridge and road works quantity calculation sheets for Aum Bridge and Kapiura Bridge
⑥ Preparation of the Project cost estimation materials for Aum Bridge and Kapiura Bridge
⑦ Preparation of the tender procedure, works contract, particular specifications, and technical specifications
⑧ Preparation and binding of the consultant agreement
⑨ Approval of the tender documents
⑩ Distribution of the preliminary review advertisements, evaluation, and notification
⑪ Preparation and implementation of the tender meeting
⑫ Distribution of the tender documents, evaluation, notification, and contracting

2) Execution supervision setup

In the Project, one Japanese engineer will serve as the supervising engineer overlooking all works sites. The steel pipe pile driving works will entail a lot of piles of long length. Moreover, in terms of geology, because the local ground has hard intermediate strata expected to make the work technically difficult within the given schedule, it is planned to dispatch Japanese foundation engineers.

In addition, one handyman and one driver will be assigned to the management office. Also, the construction supervisor (work manager) will visit the construction sites once when the offices are established and once for the works completion inspection.

The contents of the construction supervision work are as indicated below. A construction supervision personnel plan showing the work divisions of each member is also indicated.

① Office management: ISO document management, budgetary control, cost management

② Safety management: Safety facilities management

③ Explanations to local residents: Explanation to and management of local residents concerning works progress by a local coordinator

④ Process management: Work implementation process management

⑤ Employment management: Management of locally recruited personnel (employment contracts, salary, etc.)

⑥ Review of plan documents: Implementation plan, plan for each works, completion ceremony plan, handover plan, maintenance plan, working drawings, safety plan, environmental management plan, quality control plan, performance plan, inspection results plan, daily work plans and daily work reports, test results reports, materials quality sheets

⑦ Materials inspections: Aggregate, concrete, water quality, asphalt, reinforcing bar inspections

⑧ Site inspections: Compaction of backfilled earth, pile driving, steel pipe pile welding, raw concrete, formwork progress, reinforcing bar diameters, quantities, progress, and covering concrete placement, pile works progress, abutment frame progress, approach cushion progress, wall balustrade progress, pier works progress, scaffolding, falsework, basic assembly, bolt tightening, materials mill sheet, coating, support installation works, floor slab works, curing, bridge drainage works, expansion device works, paving works, slope works, roadbed works, wastewater treatment works, revetment works, completion inspections, etc.

➢ Means of transport

Since the management office is situated up to 2 kilometers from the bridge construction sites and there are no local means of public transport, personnel will need to travel by car. The local roads are paved, however, because road conditions are poor after rainfall, large four-wheel drive vehicles will be used.

- Dormitory

Being a small town, Kimbe has very few properties that can be used for leased accommodation. Therefore, the local hotel will be used as lodging quarters.

3) Contractors execution management plan

Because the work will be simultaneously implemented on two sites, it will be necessary for work to be implemented by two work parties.

The civil engineers will take the initiative in preparing and implementing the site inspections for both Aum Bridge and Kapiura Bridge. In Papua New Guinea, because there are very few engineers who can implement materials inspections, it is planned to implement routine materials tests inside the materials test rooms in the site offices and to assign a materials inspection technician.

It is planned to procure works machinery and steel materials, etc. from Japan, so smooth customs clearance and refund procedures will be needed for this purpose.

In addition, it is planned to employ a quantity surveyor, surveying assistant, two office staffs, two office boys, and three drivers. Upon indicating the following contents of work that are envisaged by the contractors, the work personnel were selected and the staffing plan was compiled to ensure that the work is smoothly implemented.

① Procurement management: Customs clearance management at Lae Port, unloading management at Kimbe Port

② Office management: ISO document management, budget management, cost management

③ Safety management: Safety facilities management, machine inspections and maintenance

④ Explanations to local residents: Explanation to and management of local residents concerning works progress by a local coordinator

⑤ Process management: Work implementation process management

⑥ Employment management: Management of locally recruited personnel (employment contracts, salary, etc.)

⑦ Review of plan documents: Implementation plan, plan for each works, completion ceremony plan, handover plan, maintenance plan, working drawings, safety plan, environmental management plan, quality control plan, performance plan

⑧ Site management: Work instructions, inspection results reports, daily work plans and daily work reports, test results reports, materials quality sheets, equipment and materials procurement management

⑨ Materials quantities management, stock receiving management, inventory management

⑩ Materials inspections: Aggregate, concrete, water quality, asphalt, reinforcing bar inspections

⑪ Site inspections: Compaction of backfilled earth, pile driving, steel pipe pile welding, raw concrete, formwork progress, reinforcing bar diameters, quantities, progress, and covering concrete placement, pile works progress, abutment frame progress, approach cushion progress, wall balustrade progress, pier works progress, scaffolding, falsework, basic assembly, bolt tightening, materials mill sheet, coating, support installation works, floor slab works, curing, bridge drainage works, expansion device works, paving works, slope works, roadbed works, wastewater treatment works, revetment works, completion inspections, etc.

4) Formulation of the process schedule

Following the Cabinet decision in December 2014, the E/N, signing of the consultant agreement, and detailed design will be conducted. After that, it is planned to conduct the tender and binding of contract with construction operator in February 2015, and to commence the works in August 2015.

Being located in the tropical belt, New Britain Island has rainfall throughout the year and there are many days when work cannot be implemented. Moreover, because water levels increase and rivers become impassable following torrential rainfall, this will sometimes have an impact on the transportation of equipment and materials and commuting of site workers. It will be necessary to adopt appropriate work efficiency in consideration of these conditions.

① Works execution procedure

There are two Project bridges and works will be simultaneously implemented on multiple sites. Almost all equipment and materials will be landed at Kimbe Port following sea transportation. The execution procedure on each works site is indicated below.

a) Construction of the site management office: The site management office and dormitory will be constructed.

b) Construction of the site office: The site office and materials yard will be constructed.

c) Carrying-in of equipment and materials: The equipment and materials will be transported to each site.

d) Preparatory works: The works road, detour route, and coffering works will be implemented.

e) Foundation works and substructure works: The foundation works and substructure works will be implemented, and girders will be temporarily assembled in the basic assembly yard.

f) Superstructure works: The superstructure will be constructed in the order of: → floor slab concrete → accessory works.

g) Access road works, paving works, revetment works

h) Cleanup

② Conditions for setting schedule

i) Basis for setting the specifications and scale of machines and equipment, and composition of parties, etc.

The machinery for use in the works will be selected from that prescribed in the "Ministry of Land, Infrastructure and Transport Civil Engineering Works Estimation Standards." However, in cases where similar machines of differing specifications are used in the same type of works or cases where machines can be borrowed from other works sites, it will also be possible to use non-standard machines. In order to efficiently execute works on the two bridges that are separated by approximately 2 kilometers, the works will be implemented by two parties.

ii) Calculation of the actual number of work days

Based on the ratio of work times and workloads of general organizers, operators and major machinery in each type of works, the number of work days will be calculated according to the unit workload.

iii) Calculation of machine capability

Based on the ratio of used time and workload of the main machines in each works type, the time of machine use for each unit workload will be sought.

③ Calculation of the implementation schedule

i) Setting of the work stoppage coefficient

The area around Kimbe on New Britain Island has a tropical rain forest climate, which is a type of tropical climate. Therefore, non-working days will be set depending on rainfall.

(5)Quality Control Plan

The contractor will conduct quality control based on the test items, test methods and test standards that are prescribed in the quality control standards.

Details will be in accordance with the "Civil Engineering Works Execution Management Standards and Specified Values (Draft), March 2013, Ministry of Land, Infrastructure and Transport," This quality control standard will be fully implemented for those test items that are designated as "Essential" in the test classification. As for test items designated as 'Others" in the test classification, the contents prescribed in particular specifications will be implemented.

Concerning specified values, all measurements (from test, inspection, and instrumentation) taken based on the Performance Management Standards and Quality Control Standards must satisfy the specified values.

In these works, it is desirable to conduct direct confirmations in all processes according to the quality control standards, however, since two bridges will be constructed at the same time and busy times will occur simultaneously on the sites, works photographs will be used to manage execution. Photographs showing each works execution stage, progress on areas that cannot be visually verified after completion, finished dimensions, quality control conditions, and disasters during the works, etc. will be taken based on the Photograph Management Standard (draft), archived under proper control, promptly presented when requested by supervising personnel, and submitted when the works are completed.

(6)Procurement Plan

The aggregate and stone materials for use in concrete and roads will be procured from a government-owned quarry (approximately 1 kilometer from Aum Bridge). In West New Britain Province, because there is no average unit price for aggregate and the principle of price competition is not operative, estimate unit prices for aggregate are very high. Therefore, concerning the extraction and grading of aggregate, it will be necessary to examine the need for a crusher plant and other equipment.

Concerning the steel materials (form steel, etc.) for use in building the temporary piers for building the new bridges and removing the existing bridges, these are not manufactured in Papua New Guinea but are rather imported mainly from Australia. However, in West New Britain Province, because such materials are not available on the local market, it is hard to procure them, and they are expensive, they will be procured from Japan.

Also, steel sheet piles needed for the temporary coffering works are not manufactured in Papua New Guinea, so will need to be procured from Japan.

Since the bridge girders will be manufactured in Japan, steel materials and members such as high-pressure bolts and metal supports will also be procured in Japan.

Concerning concrete, Papua New Guinea has facilities that are capable of producing good quality cement (PNG Pacific Cement Co., Ltd.), and local operators also produce and manage good quality aggregate materials. There is a concrete plant (NIVANI Co.) in Kimbe City approximately 40 kilometers from the bridge construction sites, and this plant will be used in the Project.

Concerning asphalt, on New Britain Island, national highways and all other roads are paved using DBST (Double Bituminous Surface Treatment). In the Project, since it will not be possible to conduct DBST paving on the bridge floor slabs, heated asphalt paving will be applied. Accordingly, a mobile asphalt plant and asphalt finisher, etc. will be procured from Japan.

The following table shows the procurement sources of the main items of equipment.

Classification	Item	Country of Procurement	Reason for Selection
Materials	Aggregate	Papua New Guinea	Procurable
	Cement	Papua New Guinea	Procurable
	Reinforcing bars	Japan	As a result of price comparison
	Steel pipes	Japan	As a result of price comparison
	Steel girders	Japan	As a result of price comparison
	Metal supports	Japan	As a result of price comparison
	Timber	Papua New Guinea	Procurable
	Asphalt	Japan	As a result of price comparison
	Gabion	Japan	As a result of price comparison
Temporary installation materials	Steel sheet piles	Japan	As a result of price comparison
	H steel (form steel)	Japan	As a result of price comparison
	Formwork	Japan	As a result of price comparison

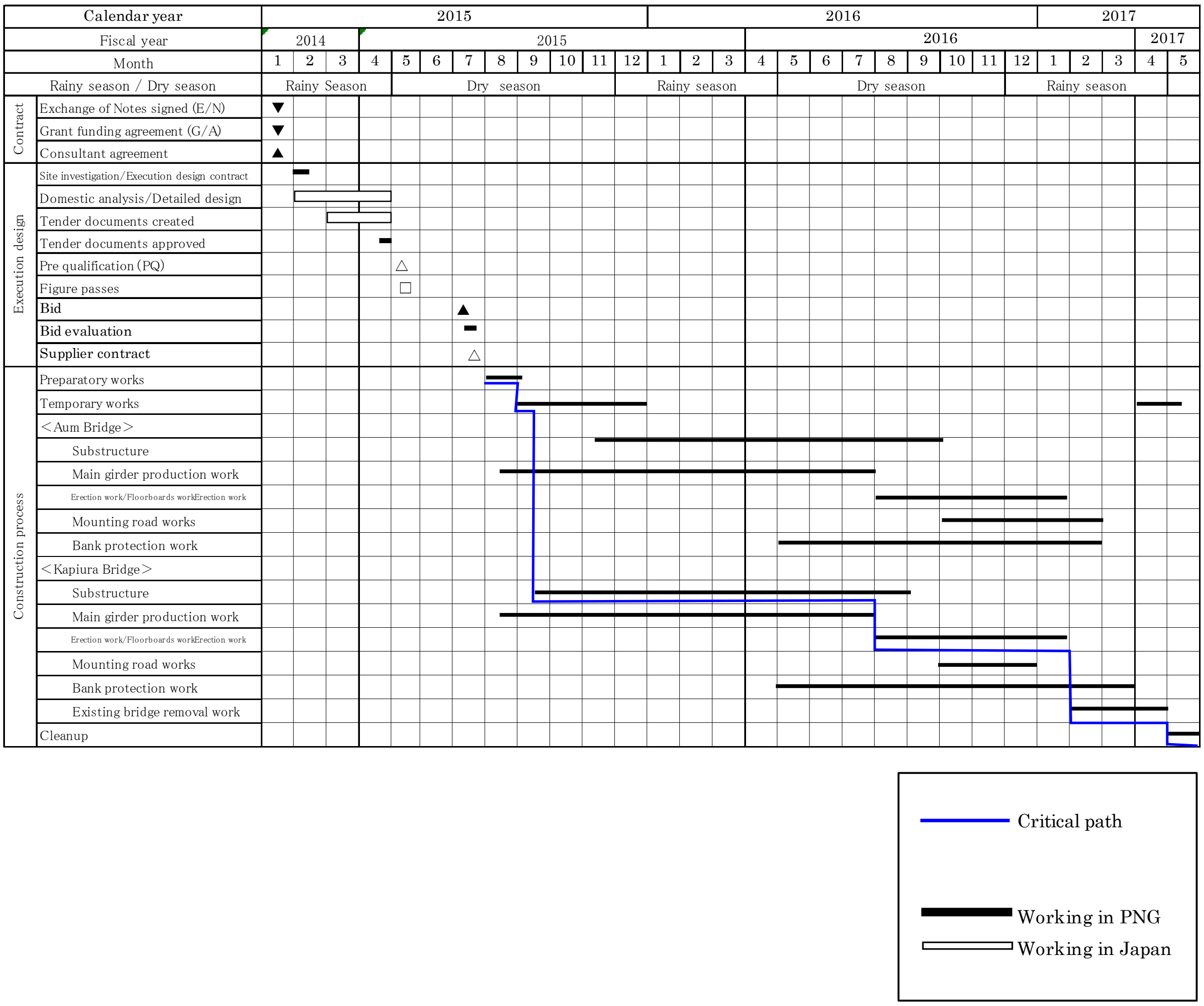
(7)Operation Guidance Plan

Not applicable

(8)Soft Component (Tachnical Assistance) Plan

Not applicable

(9)Implementation Schedule



2.3 Obligations of Recipient Country

2.3.5 Obligations of Recipient Country

(1)Matters to be implemented before the start of construction

—Cancellation of lease contracts concerning land required for the Project.

—Leasing of land for work yards

—Submission of the written application stating intent of Project implementation to the Department of Environment and Conservation(DEC)

—Procedure and bearing of costs for the banking arrangement (B/A) and authorization to pay (A/P)

(2)Matters to be implemented during project implementation

—Assistance for tax exemption measures and tariff procedures on equipment and materials carried into Papua New Guinea by Japanese corporations

—Exemption of duties and domestic taxes, etc. imposed on services and products provided by Japanese corporations in the Project

—Securing of earth dump and sediment and rock quarries

(3)Matters to be implemented after project implementation

—Removal of Aum Bridge(Log bridge) detour

—Operation and maintenance of facilities constructed in the Project

2.4 Project Operation Plan

The PNG side promised in the M/D to take human and budget measures regarding maintenance of the bridges following completion.

The West New Britain branch of the DoW in Kimbe (with approximately 40 employees) will implement the actual maintenance work, and its department comprising project engineers and supervisors (roughly 10 personnel) under the control of civil engineers will be responsible for conducting the maintenance activities. This department is currently effective in preparing detour routes at times of flooding, conducting road paving repairs, and performing other mainly road-related work. However, concerning bridge maintenance, for example measures to address gusset stress cracking on Kapiura Bridge, it currently conducts emergency repairs after major problems have occurred. Concerning maintenance activities, it is effective to perform preventive maintenance for addressing problems before they get bigger, and it is necessary to do this through conducting inspections. However, due to personnel considerations in the DoW, actual maintenance activities are consigned to private sector companies or they are directly entrusted to local resident organizations.

The following table summarizes the bridge inspection and maintenance activities that are required on the New Britain Highway.

Table 2.4.1 Inspection / maintenance work items

Maintenance item		Contents	Frequency	Inspector
Routine inspection	Road	Visual inspection： Street utilities, e.g. Paving, Drainage facilities, Fences, Guide posts, and labeling	Once per week	Directly implemented by the DoW
	Bridges	Visual inspection： Facilities on bridge (Drainage, Fences, and Expansion device) Bearing deformation, Sediment deposition, Slab cracks, Rust, and Paint film condition		
	Revetment	Visual inspection： Deformation of gabion, and Condition of gabion iron wire		
Maintenance work (cleaning)	Road	Grass cutting of shoulder, and Cleaning of drainage facility	Twice per year	Outsourced
	Bridges	Cleaning of drainage facility, Cleaning of the periphery of the bearing, and Grass cutting of the periphery of the bridge		
	Revetment	Repair of gabion iron wire, and Repair of settlement / deformation		
Abnormal inspection (Preliminary survey / Detailed survey)	Road	Inspection after the flood and earthquake： Embankment, pavement, and other facilities	Disaster Irregular	Directly implemented by the DoW Experts
	Bridges	Bearing, Deformation of the substructure, Crack, and Equipment of the bridge surface		
	Revetment	Collapse, and Deformation		
Repair and reinforcement	Road	Repair a partial pavement Re-construction of the pavement Replacement of street utilities	Arbitrarily Once per 20 years Arbitrarily	Outsourced
	Bridges	Replacement of the expansion device	Once per 20 years	Outsourced
	Revetment	Repair of gabion	Arbitrarily	Outsourced

Out of the above, particularly important are the routine inspections and maintenance work (mainly cleaning and grass cutting) based on them.

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

The total cost in the case where the Project is implemented will be million yen, and the breakdown of costs based on the scope of works of the Japan and Papua New Guinea sides will be as follows based on the following estimation conditions. However, this does not indicate the grant limit shown in the E/N. Table 2.5.1 shows the Project cost estimation.

(1) Cost burden on the Japan side

Table 2.5.1 Project Cost Estimation

Project Cost Classification		Estimated Cost (million yen)
Construction cost	Bridges and roads	
Implementation design and consultant supervision cost		
Total		

(2) Cost burden on the Papua New Guinea side

Cost for leasing construction yard: 400,000 kina

B/A, A/P commission fees: 50,000 kina

Total: 450,000 kina (18 million yen)

(3) Estimation conditions

1) Estimation date: 2014

2) Exchange rates: 1US$=103.17 yen

: 1 kina =40.23 yen

3) Works implementation period: The detailed design and works periods are as indicated in the implementation schedule.

4) Other: The Project will be implemented in accordance with the Grant Aid Guidelines of the Government of Japan. The above rough amount does not indicate the grant limit shown in the E/N; it will be reviewed by the Government of Japan before the E/N.

2.5.2 Operation and Maintenance Cost

Table 2.5.2 shows the budget for implementing the maintenance work described in the previous section.

Table 2.5.2 Maintenance Budget

Maintenance item		Frequency	Annual Budget (kina/year)	Remarks
Routine inspection	Road	Once per week	2,160	
	Bridges		4,320	
	Revetment		2,160	
	Total	-	8,640	
Maintenance work (cleaning)	Road	Twice per year	17,900	
	Bridges		1,200	
	Revetment		-	
	Total	-	19,100	
Repair and reinforcement	Road	Once/2 years	11,400	Minor repairs of paving
		Once/20 years	48,750	Repaving

Maintenance item		Frequency	Annual Budget (kina/year)	Remarks
	Bridges	Once/20 years	10,500	Replacement of expansion devices
	Revetment	Once per month	4,800	Repair
	Total	-	75,450	
Total			103,190	

Since the government's annual budget for road maintenance in 2013 was 924 million kina, the annual average maintenance cost in the Project of 320,000 kina is deemed to be affordable.

Chapter 3 Project Evaluation

3.1 Preconditions

Prerequisites for the implementation of the Project are deemed to be as follows.

(1)Return of leased land

Nationally owned land around Aum Bridge is currently leased to NBPOL, while that around Kapiura Bridge is leased to SBLC on the upstream side and NBPOL on the downstream side. Concerning the site land required in the Project, it will be necessary for the lease agreements with NBPOL and SBLC to be cancelled so that the land can be returned as nationally owned land before the start of works.

(2)Submission of written application stating intent of Project implementation to the Department of Environment and Conservation

Being an undertaking for the replacement of existing bridges, the Project is classified as a Level 2A project under the Papua New Guinea environment law. In Level 2A projects, although environmental approval procedures are not required, the Project operator must submit a written application stating intent of Project implementation to the Department of Environment and Conservation(DEC) and undergo review of the application contents

(3)Maintenance of the Existing Kapiura Bridge and Aum Bridge Detours

The existing Kapiura Bridge and Aum Bridge detours will continue to be used by general traffic and by works vehicles during construction of the new bridges. Accordingly, it will be necessary for the authorities in Papua New Guinea to continue maintenance of these existing bridges during the works. Traffic controls will continue to be enforced on Kapiura Bridge.

3.2 Necessary Inputs by the Recipient Country

The issues that need to be tackled by Papua New Guinea as preconditions for realizing and sustaining the effects of the Project are as follows.

(1)Maintenance of the constructed facilities

In order to use the newly constructed bridges and roads in good condition over the long term, it will be necessary to conduct appropriate maintenance. Accordingly, it will be important for the Government of Papua New Guinea to secure an adequate maintenance budget and implement routine and periodic inspections and necessary repairs.

(2)Definite implementation of tax exemption measures for equipment and materials

In the Grant Aid of the Government of Japan, construction costs are calculated assuming that equipment and materials can be carried into Papua New Guinea exempt from taxes. Accordingly, it is possible that the works will not finish on schedule if the Government of Papua New Guinea does not take definite tax exemption measures.

3.3 Important Assumptions

As important assumptions for realizing and sustaining the effects of the Project, the issues that need to be tackled by the Government of Papua New Guinea are as follows.

(1)Construction of New Britain Highway and Kimbe Road

Aum Bridge and Kapiura Bridge are located on New Britain Highway, in order for equipment and materials to be transported to the bridge building sites, Kimbe Road and New Britain Highway leading from Kimbe Port and Hoskins Airport will need to be maintained in good condition. For this reason, it will be necessary to secure the maintenance budget for these roads.

3.4 Project Evaluation

3.4.1 Relevance

(1)Project Beneficiaries

The Project aims to rebuild two bridges close to Kimbe on New Britain Highway. The direct beneficiaries will be approximately 180,000 residents who live along 229 kilometers of New Britain Highway. In future, it is planned for New Britain Highway to be linked to East New Britain, in which case roadside residents as far as Rabaul will gain benefits.

(2)Project Objectives and Urgency

The Project aims to construct Aum Bridge and Kapiura Bridge and thereby secure smooth and stable traffic on New Britain Highway. The existing Aum Bridge is currently closed to traffic after being damaged in a collision with a large vehicle, so traffic has to take a detour around the bridge. Moreover, Kapiura Bridge is subject to traffic controls due to insufficient load bearing capacity. Because there are no alternative roads in the area, the improvement of conditions on both bridges is an urgent issue for Papua New Guinea and the Project thus has a high degree of urgency.

(3) Achievement of Objectives in Medium- and Long-term Development Plans

In the PAPUA NEW GUINEA VISION 2050 and the Papua New Guinea Development Strategic Plan 2010-2030 (DSP), which are the long-term development plans for Papua New Guinea, based on the understanding that the road network is a lifeline for citizens using markets and services, it is intended to increase the length of national highways from 8,460 kilometers in 2010 to 25,000 kilometers by 2030 and to keep the entire network in good condition. The Project will contribute to the achievement of these development plans.

(4) Necessity and Significance of Using Japanese Technology

The existing Aum Bridge and Kapiura Bridge are 50 meters and 116 meters long respectively, making them relatively long for bridges on New Britain Highway, and they were not targeted in the ADB project. Since the Government of Papua New Guinea has no experience of constructing bridges of this length, it has requested construction to the Government of Japan. As it is planned to construct piers inside the river, continuous steel plate girders can be adopted, thereby making it possible to avoid building large-scale bridges. Through implementing coffering and constructing piers inside the river based on Japanese technology, it will be possible to construct the bridges economically.

3.4.2 Effectiveness

(1) Quantitative Effects

The quantitative effects that are anticipated from Project implementation are as described below.

1) Increase in bridge load bearing capacity

The existing bridges were designed to bear load of T33 and special vehicle load of 44 tons per lane. The new bridges will be able to withstand loads of T44 per lane on two lanes, i.e. loads of 88 tons in total.

2) Increase in Average Running Speed

The average running speed of vehicles over the detour route of Aum Bridge was measured as 11.0km/h, while the average running speed over the existing Kapiura Bridge, where vehicles need to stop once at the gate, was 18.4km/h. When the new bridges are finished, it will be possible for vehicles to cross them at design velocity of 60km/h.

3) Average daily traffic volume

Daily traffic volume in the field survey of New Britain Highway was 493 vehicles per day. Assuming that the traffic volume increases in line with GDP, the daily traffic volume in 2020 that is three years after completion of construction project will be 772 vehicles per day.

Table 3.4.1 Quantitative Effects

Indicator		Standard value (2014 actual value)	Target value (2017) 【3 years after Project completion】
Increase in bridge load bearing capacity (t)	Aum Bridge	44	88
	Kapiura Bridge	44	88
Increase in average running speed (㎞/h)	Aum Bridge	11.0	60
	Kapiura Bridge	18.4	60
Average daily traffic volume		493 vehicles/day	772 vehicles/day

(2)Qualitative Effects

The qualitative effects that are anticipated from Project implementation are as described below.

1) Improvement in Bridge Performance and Safety

With the new construction of Aum Bridge and Kapiura Bridge, the load bearing capacity will increase and, because upper deck structures whereby the main structure is located below the road surface will be adopted, there will be less chance of vehicles crashing into the bridges. Thus, safety will be improved.

2) Increased and Smoother Physical Distribution

Because a temporary wooden structure is used as a detour around the existing Aum Bridge, while vehicles need to stop at the gate on the existing Kapiura Bridge, vehicles cannot run smoothly over the bridges. With the new construction of Aum Bridge and Kapiura Bridge, vehicles will immediately pass over the bridges and this will contribute to the promotion of physical distribution over New Britain Highway.

3) Securing of Traffic at Times of Disaster

Because the detour for the existing Aum Bridge is located in a lower position than the existing bridge, there is a high risk of the bridge detour becoming inundated and impassable at times of flooding. Following completion of the new bridge, vehicles will be able to pass and traffic will be secured even when flooding occurs.

4) Safety of pedestrians

There are no sidewalks on the Aum Bridge detour or on the existing Kapiura Bridge. However, because sidewalks will be included on the new bridges, the safety of pedestrians will be secured.

5) Effective use of river water

In New Britain Island, washing, bathing, fish birds are frequently done in the river. However, there is no clear path approaching the river in Aum Bridge and Kapiura Bridge. Therefore, use of the river is limited. On the other hand, other donors projects, in BRIRAP, paying attention to women often as river water users, and is a standard that installing the stairs.

Therefor, Aum Bridge and Kapiura Bridge also was determined the same policy. Thus it is possible to effectively use the river water.

[Appendices]

1. Member List of the Study Team

1.1 First field survey (May 24th, 2014 ～ August 16th,2014)

	Responsible		Name	Organization	Dispatch period
(1)	Team Leader	:	Shigeru SUGIYAMA	JICA PNG Office Representative	5/24 – 5/31
(2)	Planning Coordinator	:	Yasunori TONEGAWA	JICA Social Infrastructure / Peace Building Unit	5/24 – 5/31
(3)	Chief Consultant / Bridge Planner	:	Masahiko MORI	CHODAI Co., Ltd.	5/24 – 6/21
(4)	Bridge Designer / Road Designer	:	Hitoshi NAKAMURA	CHODAI Co., Ltd.	5/24 – 6/21
(5)	Natural Condition Survey (Topography / Geology)	:	Masao WADA	CHODAI Co., Ltd. (Kiso - Jiban Consultants Co., Ltd.)	6/14 – 6/21, 7/19 – 8/16
(6)	Hydrology Specialist	:	Yoshiyuki AKAGAWA	INGEROSEC Corporation	6/21 – 7/12
(7)	Procurement Planner / Cost Estimator	:	Tatsumune HAYASHI	CHODAI Co., Ltd.	6/07 – 7/05
(8)	Environment and Social Impact Specialist	:	Kunihiko HARADA	CHODAI Co., Ltd.	6/14 – 7/12
(9)	Road Designer Ⅱ	:	Yoshinari KOITABASHI	CHODAI Co., Ltd.	5/24 – 6/14
(10)	Road Designer Ⅱ	:	Kouji NOMURA	CHODAI Co., Ltd.	6/07 – 6/21

1.2 Second field survey (October 11th ,2014 ～ October 18th ,2014)

	Responsible		Name	Organization	Dispatch period
(1)	Team Leader	:	Shigeru SUGIYAMA	JICA PNG Office Representative	10/11 – 10/18
(2)	Planning Coordinator	:	Yasunori TONEGAWA	JICA Social Infrastructure / Peace Building Unit	10/11 – 10/18
(3)	Chief Consultant / Bridge Planner	:	Masahiko MORI	CHODAI Co., Ltd.	10/11 – 10/18
(4)	Bridge Designer / Road Designer	:	Hitoshi NAKAMURA	CHODAI Co., Ltd.	10/11 – 10/18
(5)	Construction Plan / Cost Estimate	:	Tatsumune HAYASHI	CHODAI Co., Ltd.	10/11 – 10/18

2. Study Schedule

2.1 First field survey (May 24th, 2014 ～ August 16th,2014)

			Team Leader 杉山 茂 Mr. Shigeru Sugiyama	Planning Coordinator Mr. Yasunori Tonegawa	Chief Consultant/ Bridge Planner Mr. Masahiko Mori	Bridge Designer/Road Designer Mr. Hitoshi Nakamura	Natural Condition Surveyer (Topography & Geology) Mr. Masao Wada	Hydrology Specialist Mr. Yoshiyuki Akagawa	Procurement Planner/ Cost Estimator Mr. Tatsumune Hayashi	Environment & Social Impact Specialist Mr. Kunihiko Harada	Road Designer Ⅱ Mr. Yoshinari Koitabashi	Road Designer Ⅱ Mr. Koji Nomura
1	5/24	Sat		NARITA(21:00)PX0055→	NARITA(21:00)PX0055→	NARITA(21:00)PX0055→					NARITA(21:00)PX0055→	
2	5/25	Sun		PORT MORESBY(04:55)	PORT MORESBY(04:55)	PORT MORESBY(04:55)					PORT MORESBY(04:55)	
3	5/26	Mon	Meeting with JICA PNG Office (08 : 30) Explanation of Inception Report to DoW and DNPM (10 : 30) Discussion with DoW (13:30)								Meeting with JICA PNG Office (08 : 30) Explanation of Inception Report to DoW and DNPM (10 : 30) Discussion with DoW	
4	5/27	Tue	PORT MORESBY (6:15) →HOSKINS (7:45) (PX840) Discussion with Provincial Works Office and inspection of heavy equipment(10:00) Visit to NBPOL HQs and bio fuel plant(13:30)								PORT MORESBY (6:15) → HOSKINS (7:45) (PX840) Discussion with Provincial Works Office and inspection of heavy equipment(10:00) Visit to NBPOL HQs and	
5	5/28	Wed	Site Visit to 2 target bridges and go up to Ala Bridge (boundary of NBPOL and Hargy Oil Palm) Discussion with Provincial Works Office								Site Visit to 2 target bridges and go up to Ala Bridge (boundary of NBPOL and Hargy Oil Palm) Discussion with	
6	5/29	Thu	HOSKINS (8:10) →PORT MORESBY (9:40) (PX841) M/D Discussion with DoW								HOSKINS (11:10) →PORT MORESBY (12:20) (PX841) M/D Discussion with DoW	
7	5/30	Fri	Signing on the M/D (AM) Report to EOJ (15 : 00)								Signing on the M/D (AM) Report to EOJ (15 : 00)	
8	5/31	Sat		PORT MORESBY(14:00)PX0054→ NARITA(19:55)	Data collecting						Data collecting	
9	6/1	Sun			Arrangement of data						Arrangement of data	
10	6/2	Mon			Preparation of survey Agreement preparation of subcontract						Preparation of survey Agreement preparation of subcontract	
11	6/3	Tue										
12	6/4	Wed			Agreement of subcontract						Agreement of	
13	6/5	Thu			Data collecting, Study for the project implementation						Data collecting, Study for the project	
14	6/6	Fri										
15	6/7	Sat			Meeting with DoW and DNPM				NARITA(21:00)PX0055→		Arrangement of data	NARITA(21:00)PX0055→
16	6/8	Sun			Arrangement of data				PORT MORESBY(04:55)			PORT MORESBY(04:55)
17	6/9	Mon			Data collecting, Study for the project implementation				Meeting with JICA, DoW, DNPN		Data collecting, Study for the project implementation Meeting with DoW and	Data collecting, Study for the project implementation Meeting with DoW and
18	6/10	Tue			13:30 CHODAI Office SAIM TONE Meeting							
19	6/11	Wed			10:30 JICA Office SAIM TONE CONTRACT				Data collecting Arrangement of data			
20	6/12	Thu			PORT MORESBY (06:15) →HOSKINS (7:45) (PX840) 10:30 DOW WNB, 13:00 Site, 15:00 NBPOL, 16:00						Arrangement of data	PORT MORESBY (09:30) → HOSKINS (10:40) (PX840)
21	6/13	Fri			Traffice Suvey Consul Meetin at site, Axel Counter							
22	6/14	Sat			6:00 Bridge Inventry Survey, Siranga Check		NARITA(21:00)PX0055→			NARITA(21:00)PX0055→	PORT MORESBY(14:00)PX0054→ NARITA(19:55)	Same as MORI, NAKAMURA
23	6/15	Sun			6:00 Traffic Survey Start,9:35 Harada, Hayashi Pick up at Hoskins Air Port,		PORT MORESBY(04:55) PORT MORESBY(08:05)PX840 →HOSKINS (09:35)		PORT MORESBY(08:05)PX840 →HOSKINS (09:35)	PORT MORESBY(04:55) PORT MORESBY(08:05)PX840 →HOSKINS (09:35)		Implementation of axle load survey and traffic count
24	6/16	Mon			6:00 Trffic Survey and Axel Count Survey Start		Topographic Survey		Site Survey			
25	6/17	Tue			DOW WNB, NBPOL, SBLC Meeting		Topographic Survey					Site Survey
26	6/18	Wed			Meeting DOW WNB, HOSKINS (16:55) →PORT MORESBY (18:25) (PX845)				HOSKINS (16:55) →PORT MORESBY (18:25) (PX845)			HOSKINS (16:55) →PORT MORESBY (18:25) (PX845)
27	6/19	Thu			Arrangement of data				Data collecting Arrangement of data			Arrangement of data
28	6/20	Fri			Report to DoW, DNPN, JICA							Report to DoW, DNPN, JICA
29	6/21	Sat			PORT MORESBY(14:00)PX0054→NARITA(19:55)			NARITA(21:00)PX0055→				PORT MORESBY(14:00)PX0054→ NARITA(19:55)
30	6/22	Sun						PORT MORESBY(04:55)	Arrangement of data, Materials			
31	6/23	Mon								Meeting with		
32	6/24	Tue						Data collecting	Data collecting	Data collecting		
33	6/25	Wed										
34	6/26	Thu										
35	6/27	Fri										
36	6/28	Sat										
37	6/29	Sun						Arrangement of data	Arrangement of data	Arrangement of data		
38	6/30	Mon						PORT MORESBY(06:15)PX840	Data collecting	PORT MORESBY(06:15)PX840		
39	7/1	Tue						Site Survey		Site Survey		
40	7/2	Wed										
41	7/3	Thu						HOSKINS (8:10) →PORT MORESBY (9:40) (PX841)		HOSKINS (8:10) →PORT MORESBY (9:40) (PX841)		
42	7/4	Fri						Data collecting Arrangement of data	Arrangement of data	Data collecting Arrangement of data		
43	7/5	Sat							PORT MORESBY(14:00) PX0054→NARITA(19:55)			
44	7/6	Sun										
45	7/7	Mon										
46	7/8	Tue										
47	7/9	Wed										
48	7/10	Thu										
49	7/11	Fri						Report to DoW, DNPN, JICA and EOJ		Report to DoW, DNPN, JICA and EOJ		
50	7/12	Sat						PORT MORESBY(14:00) PX0054→NARITA(19:55)		PORT MORESBY(14:00) PX0054→NARITA(19:55)		
51	7/13	Sun										
52	7/14	Mon										
53	7/15	Tue										
54	7/16	Wed										
55	7/17	Thu										
56	7/18	Fri										
57	7/19	Sat					NARITA(21:00)PX0055→					
58	7/20	Sun					PORT MORESBY(04:55) PORT MORESBY(08:05)PX840 →HOSKINS (09:35)					
59	7/21	Mon					Geo Technical Survey					
60	7/22	Tue										
61	7/23	Wed										
62	7/24	Thu										
63	7/25	Fri										
64	7/26	Sat										
65	7/27	Sun										
66	7/28	Mon										
67	7/29	Tue										
68	7/30	Wed										
69	7/31	Thu										
70	8/1	Fri										
71	8/2	Sat										
72	8/3	Sun										
73	8/4	Mon										
74	8/5	Tue										
75	8/6	Wed										
76	8/7	Thu										
77	8/8	Fri										
78	8/9	Sat										
79	8/10	Sun										
80	8/11	Mon										
81	8/12	Tue										
82	8/13	Wed										
83	8/14	Thu										
84	8/15	Fri					HOSKINS (8:10) →PORT MORESBY (9:40) (PX4841)					
85	8/16	Sat					PORT MORESBY(14:00) PX0054→NARITA(19:55)					

2.2 Second field survey (October 11th ,2014 ～ October 18th ,2014)

			Team Leader Mr. Shigeru Sugiyama	Planning Coordinator Mr. Yasunori Tonegawa	Chief Consultant/ Bridge Planner Mr. Masahiko Mori	Bridge Designer/Road Designer Mr. Hitoshi Nakamura	Procurement Planner/ Cost Estimator Mr. Tatsumune Hayashi
1	10/11	Sat			NARITA(21:00)PX0055→		
2	10/12	Sun		NARITA → MNL	PORT MORESBY(04:55)		
3	10/13	Mon		MNL → POM Project team Meeting	Project team Meeting		
4	10/14	Tue	Meeting with JICA, DoW, DNPN,DEC, etc				
5	10/15	Wed	Meeting with JICA, DoW, DNPN,DEC, etc				
6	10/16	Thu	Meeting with JICA, DoW, DNPN,DEC, etc				
7	10/17	Fri	Signing on the M/M Report to DoW,DNPN,JICA and EOJ				
8	10/18	Sat		PORT MORESBY(14:00) PX0054→NARITA(19:55)			
9	10/19	Sun					

3. List of Parties Concerned in the Recipient Country

Organization	Position / Occupation	Name
Department of Works : DoW	First Assistant Secretary	Mr. Eric Sikam
	Assistant Secretary	Mr. Wilfred Peko
	Bridge Advisor	Mr. Keith Denyer
	Provincial Works Acting Manager	Mr. John Shitapai
Department of Works Environmental Unit	Manager	Mr. William Asigau
	Senior Environmental Monitoring Officer	Mr. Diro.G.GABI
	Environmental Monitoring Officer	Mr. OKO NOlA
Department of National Planning & Monitoring :DNPM	Assistant Secretary	Mr. Casper Auntaki
	First Assistant Secretary	Mr. Reichert Jonathan Thanda
	Aid Coordinator	Mr. Dan Lyanda
	Advisor	Mr. Hideo Kobayashi
West New Britain Province	West New Britain Province Governor	Mr. Hon Sasindran Muthuvel
New Britain Palm Oil Limited : NBOPL	General Manager	Mr. Harry Brock
	Head of Transport & Workshops	Mr. John Benseman
	Head of Mini Estates	Mr. Ashley Barnes
HARGY	General Manager	Mr. Graham King
Stettin Bay Lumber Company Limited : SBLC	General Manager / Director	Mr. Peter SC Yiu
Department of Transport : DoT National Weather Service	Quolity Control Cfficer	Ms. Ruth Wari Apuqahe
Embassy of Japan in PNG	First Secretary	Isamu AZECHI
	First Secretary	Shinji MATSUMOTO
	Second Secretary	Osamu SAKOSHI
JICA PNG Office	Representative	Shigeru SUGIYAMA
	Project Formulation Advisor	Yoshikazu TANIGUCHI
	Project Formulation Advisor	Naomasa KUGIMOTO

4. Minutes of Discussions (M/D)

4.1 First field survey (May 30th, 2014)

MINUTES OF DISCUSSIONS
ON
THE PREPARATORY SURVEY
ON
THE PROJECT FOR RECONSTRUCTION OF BRIDGES ON NEW BRITAIN HIGHWAY
IN
THE INDEPENDENT STATE OF PAPUA NEW GUINEA

In response to a request from the Government of the Independent State of Papua New Guinea (hereinafter referred to as "PNG"), Japan International Cooperation Agency (hereinafter referred to as "JICA") in consultation with the Government of Japan decided to conduct a Preparatory Survey (hereinafter referred to as "the Survey") on the Project for Reconstruction of Bridges on New Britain Highway (hereinafter referred to as "the Project").

JICA sent the Preparatory Survey Team (hereinafter referred to as "the Team") to PNG, headed by Mr. Shigeru SUGIYAMA, Chief Representative of JICA Papua New Guinea Office, from May 26 to July 19, 2014.

The Team held discussions with officials concerned of the Government of PNG and conducted a field survey in the Project area.

In the course of discussions and the field survey, both sides confirmed the main items described in the attached sheets. The Team will continue further studies and prepare the Preparatory Survey Report.

Port Moresby, May 30, 2014

杉山 茂

Mr. Shigeru SUGIYAMA
Leader
Preparatory Survey Team
Japan International Cooperation Agency
Japan

Mr. Reichert THANDAL
First Assistant Secretary, Foreign Aid Division
Department of National Planning and Monitoring
Independent State of Papua New Guinea

Mr. David WEREH
Secretary
Department of Works
Independent State of Papua New Guinea

ATTACHMENT

1. Title of the Project
   The both sides confirmed that the title of the project shall be "the Project for Reconstruction of Bridges on New Britain Highway".

2. Objective of the Project
   The both sides confirmed that the objective of the Project is to reconstruct Kapiura and Aum bridges to ensure smooth and safe traffic on the bridges.

3. Project Site
   The sites of the Project are shown in Annex-1.

4. Objective of the Survey
   4-1. To understand the back ground and objective of the Project and examine its impacts and appropriateness.
   4-2. To identify the components, outline design and cost estimation of the Project based on the data and information collected from and the results of meetings with PNG side.
   4-3. To study the issues of environmental and social considerations through the site survey.

5. Responsible and Implementing Organizations
   5-1. The responsible organization is the Department of Works (DOW).
   5-2. The organization chart of DOW is as shown in Annex-2.
   5-3. After completion, DOW will be responsible for maintenance and management of the bridges and the roads constructed by the Project.

6. Components of the Project
   6-1. The project include the following components
      6-1-1. Construction of the new two bridges with two vehicle lanes and pedestrian sidewalks,
      6-1-2. Construction of approach roads,
      6-1-3. Construction and removal of the temporary bridges if deemed necessary,
      6-1-4. Construction of scouring and erosion protection for the new bridges
   6-2. Technical matters
      6-2-1. The new bridges should be carefully planned with a consideration of earthquake resistance, high water level, and approach roads linearity.
      6-2-2. Other technical matters including the outline design of the new bridge will be considered by the Team and explained to PNG side around October 2014.

7. Japan's Grant Aid Scheme
   7-1. PNG side understands the Japan's Grant Aid scheme explained by the Team, as described in Annex-3 and Annex-4.
   7-2. PNG side will take the necessary measures, as described in Annex-5, to facilitate the smooth

implementation of the Project, as a condition for the Japan's Grant Aid to be implemented, according to the existing agreement between the Government of Japan and the Government of PNG.

8. Environmental and Social Considerations

8-1. The Team explained the Project is categorized as "Category B" according to the JICA Guideline, since the Project is reconstructing the two bridges and approach roads, and its impact on the environmental may be expected.

8-2. PNG side understands the Project needs to follow the JICA guideline. Therefore the initial environmental examination (IEE) shall be done through the survey.

8-3. In case of the Project Affected Persons (PAPs) within the Project sites, PNG side agreed to secure the appropriate budget to be allocated for resettlement and compensation and secure the land before the implementation of the Project. In this regard an Abbreviated Resettlement Action Plan (Abbreviated RAP) will be prepared and approved by the responsible authorities beforehand and PNG side will take necessary measures to PAPs according to an Abbreviated RAP in close communication with JICA.

9. Schedule of the Study

9-1. The Team will continue further studies in PNG until July 19, 2014.

9-2. JICA will prepare the draft Preparatory Survey Report and send a mission team to explain its contents to PNG side around October 2014. JICA will explain details of the Project including the final components and cost estimation to PNG side.

9-3. When the contents of the draft Preparatory Survey Report are accepted in principle by the Government of PNG, JICA will complete the final report and send it to the Government of PNG around January 2015.

9-4. The above schedule is tentative and subject to change.

10. Proper Use

PNG side shall secure enough budget and personnel necessary for operation and maintenance of the facilities implemented by the Project, including the periodical maintenance work after the completion of the Project.

11. Other Relevant Issues

11-1. PNG side shall, at its own expense, provide the Team with the following items in cooperation with other organizations concerned

(1) security-related information as well as measures to ensure the safety of the survey team;

(2) information as well as support in obtaining medical service;

(3) data and information necessary for the Survey;

(4) counterpart personnel;

(5) credentials or identification cards if necessary;

(6) entry permits necessary for the survey team members to conduct field surveys;

(7) permission for the implementation of traffic survey;

(8) necessary arrangement for exemption of the taxes, duties, and any charges on equipment, machinery and other materials brought into PNG for the implementation of the Survey; and

(9) support in obtaining other privileges and benefits if necessary.

11-2. PNG side agreed that the following undertakings should be taken by PNG side at the PNG's expenses under the Project if implementation of the Project is approved by the Government of Japan;

(1) to secure the lots of land necessary for the implementation of the Project including land for site office, plant yards, material storing yard, motor pool, temporary construction yard and waste disposal site;

(2) to relocate existing utilities within the Project site;

(3) to relocate existing buildings and facilities if necessary;

(4) to arrange issuance of license, permission and other necessary procedures for the Project;

(5) to obtain the royalties/permission for taking raw materials such as stone/rock/filling materials from the quarry/river-bed/borrow pit; and

(6) to provide security measures for all concerned working for the Project.

11-3. After being explained the methodology and techniques of the demolition of the existing bridges, PNG side requested to include it into the scope of the Project because of a lack of their capacity. The Team acknowledged the request and explained that it will bring the request back to Japan to examine such possibility, and will respond before the draft Report explanation.

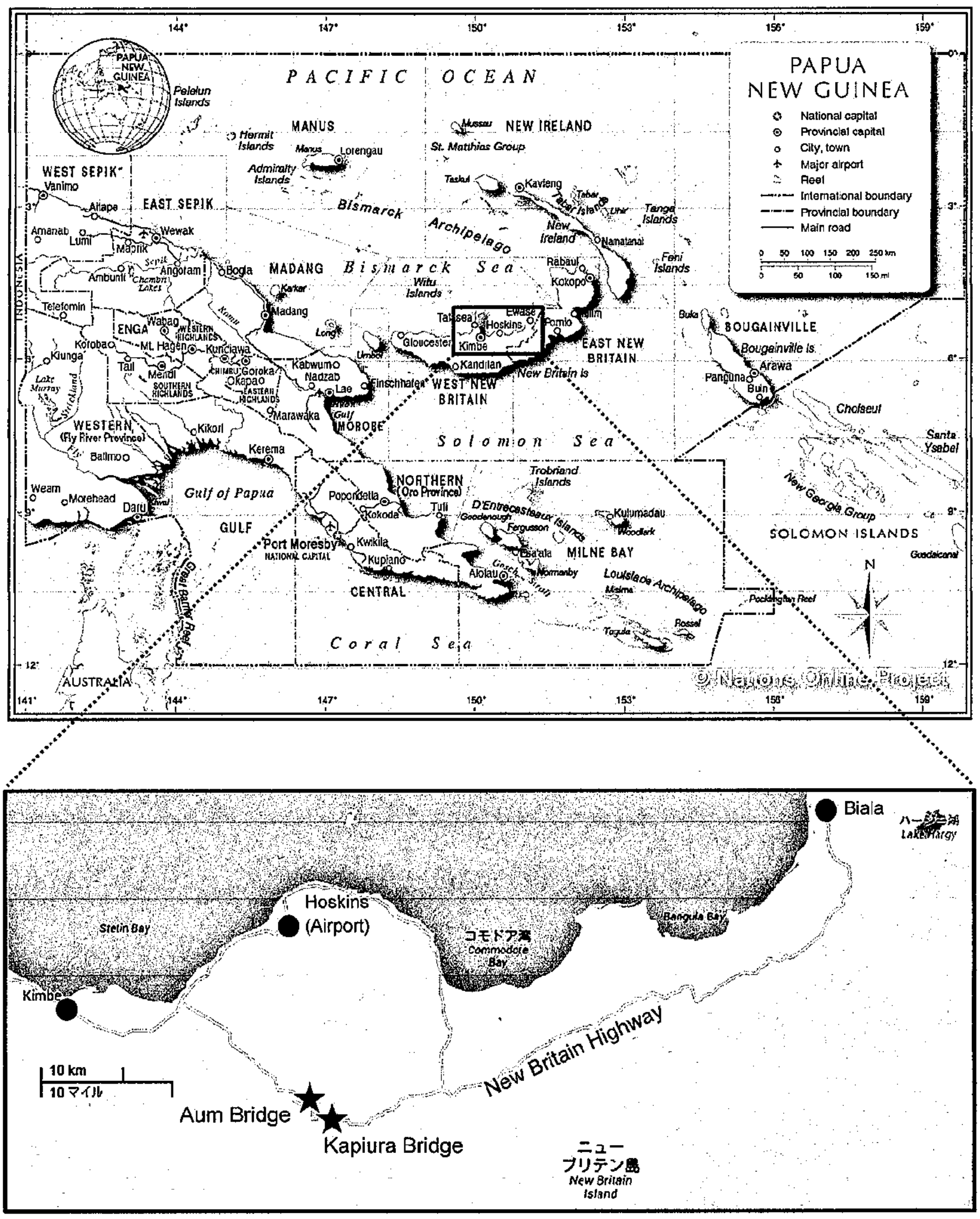
12. Disclosure of Information

Both sides confirmed that the study results excluding the Project cost will be disclosed to the public after the completion of the Survey. All the study results including the Project cost will be disclosed to the public after all the verification of contracts for the Project by JICA are concluded.

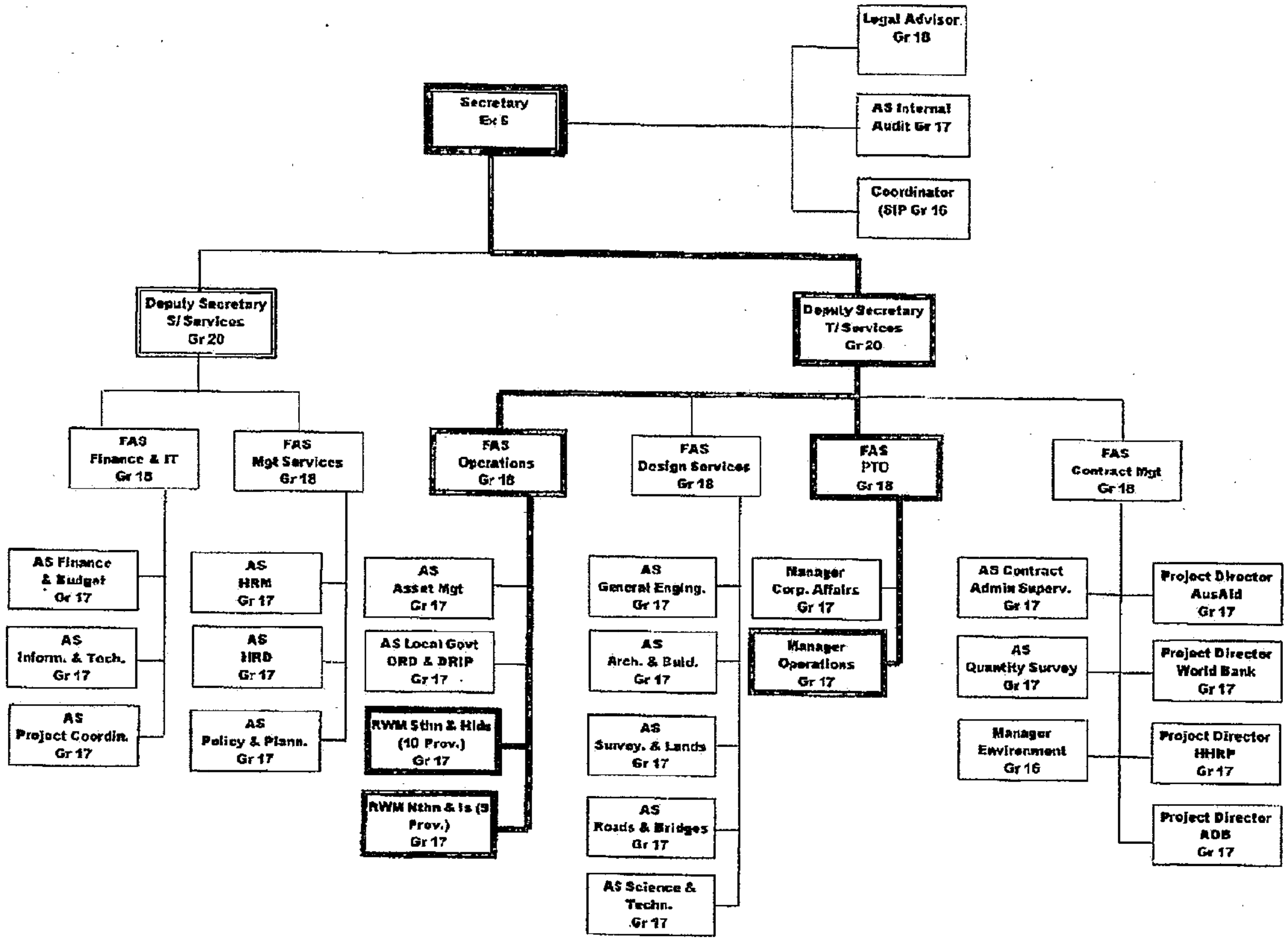
Annex-1: Project Sites
Annex-2: Organization Chart of DOW
Annex-3: Japan's Grant Aid Scheme
Annex-4: Flowchart of Japan's Grant Aid Procedure
Annex-5: Major Undertakings to be taken by Each Government

Annex-1

Annex-1: Project Site



Annex-2: Organization Chart of DOW



Annex-3

Annex-3: Japan's Grant Aid Scheme

JAPAN'S GRANT AID

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as a part of this realignment, a new JICA law was entered into effect on October 1, 2008. Based on this law and the decision of the GOJ, JICA has become the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc.

The Grant Aid is non-reimbursable fund provided to a recipient country to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedures

The Japanese Grant Aid is supplied through following procedures :

- Preparatory Survey
  - The Survey conducted by JICA
- Appraisal &Approval
  - Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet
- Authority for Determining Implementation
  - The Notes exchanged between the GOJ and a recipient country
- Grant Agreement (hereinafter referred to as "the G/A")
  - Agreement concluded between JICA and a recipient country
- Implementation
  - Implementation of the Project on the basis of the G/A

2. Preparatory Survey

(1) Contents of the Survey

The aim of the preparatory Survey is to provide a basic document necessary for the appraisal of the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of relevant agencies of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.

Annex-3

- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of a outline design of the Project.
- Estimation of costs of the Project.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Outline Design of the Project is confirmed based on the guidelines of the Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization of the recipient country which actually implements the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA employs (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the Report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the appropriateness of the Project.

3. Japan's Grant Aid Scheme

(1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the Exchange of Notes(hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the recipient country to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the recipient country to continue to work on the Project's implementation after the E/N and G/A.

Annex-3

(3) Eligible source country

Under the Japanese Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals".

(4) Necessity of "Verification"

The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to fulfill accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as Annex.

(6) "Proper Use"

The Government of the recipient country is required to maintain and use properly and effectively the facilities constructed and the equipment purchased under the Grant Aid, to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Grant Aid.

(7) "Export and Re-export"

The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account under the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment

Annex-3

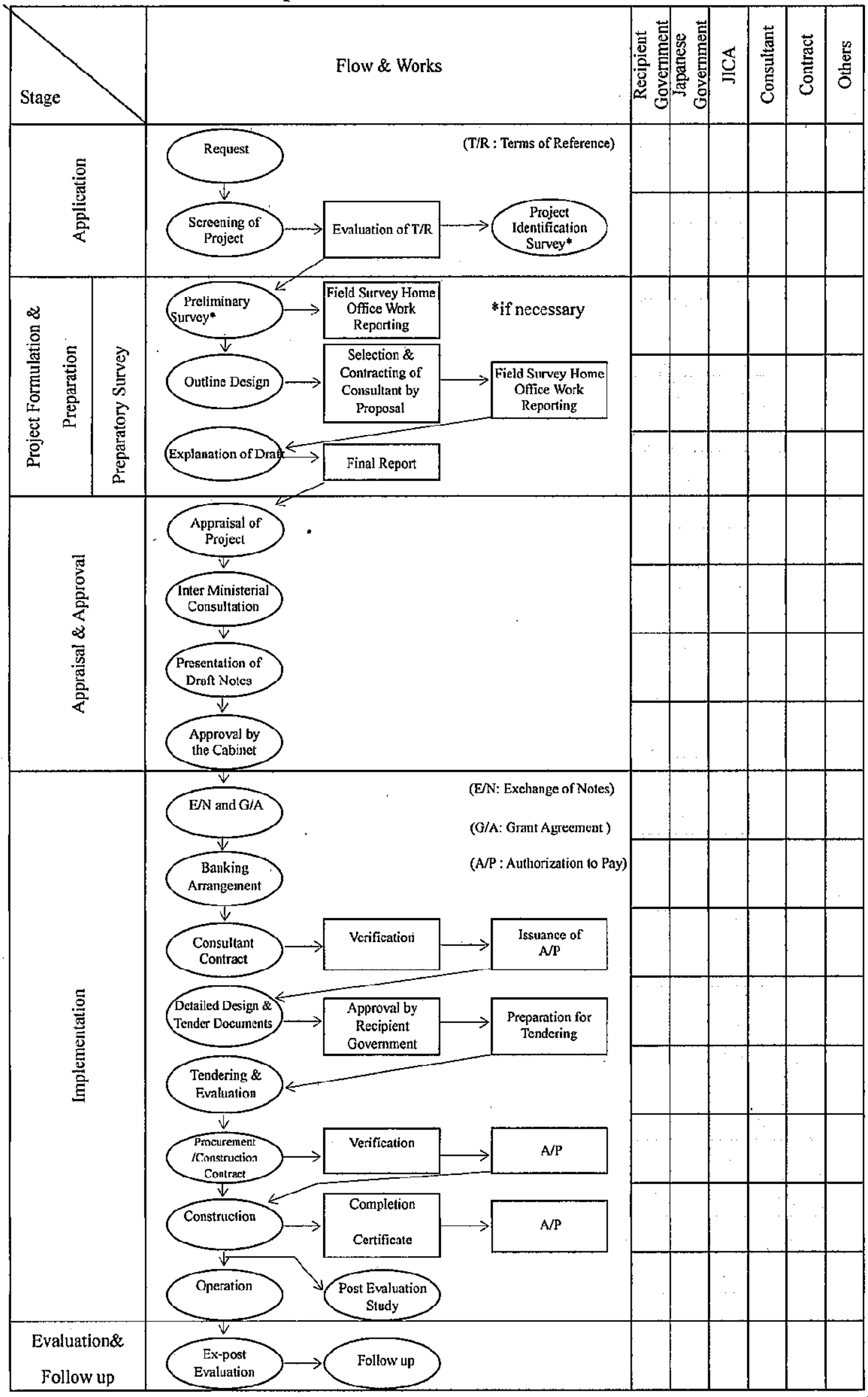
commissions paid to the Bank.

(10) Social and Environmental Considerations

A recipient country must carefully consider social and environmental impacts by the Project and must comply with the environmental regulations of the recipient country and JICA socio-environmental guidelines.

Annex-4

Annex-4: Flowchart of Japan's Grant Aid Procedure



Annex-5

Annex-5: Major Undertakings to be taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	To secure lots of land necessary for the implementation of the Project and to clear the site		●
2	To ensure prompt unloading and customs clearance of the products at ports of disembarkation in the recipient country and to assist internal transportation of the products.		
	1) Marine (Air) transportation of the products from Japan to the recipient country	●	
	2) Internal transportation from the port of embarkation to the project site	(●)	(●)
3	To ensure that customs duties, internal taxes and other fiscal levies, which may be imposed in the recipient country with respect to the purchase of the products and the services be exempted.		●
4	To accord Japanese physical persons and / or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the implementation of the Project.		●
5	To ensure that the Facilities be maintained and used properly and effectively for the implementation of the Project.		●
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project.		●
7	To bear the following commissions paid to the Japanese bank for banking services based upon the B/A		●
	1) Advising commission of A/P		●
	2) Payment commission		●
8	3) To give due environmental and social consideration in the implementation of the Project.		●

(B/A: Banking Arrangement, A/P: Authorization to Pay)

4.2 Second field survey （October 16th, 2014）

MINUTES OF DISCUSSIONS
ON
THE PREPARATORY SURVEY
FOR
THE PROJECT FOR RECONSTRUCTION OF BRIDGES ON NEW BRITAIN HIGHWAY
IN
THE INDEPENDENT STATE OF PAPUA NEW GUINEA

(Explanation of Draft Outline Design Report)

On the basis of the preparatory survey in the Independent State of Papua New Guinea (hereinafter referred to as "PNG") from May to September, 2014 and following technical examination in Japan, Japan International Cooperation Agency (hereinafter referred to as “JICA”) prepared a Draft Outline Design Report (hereinafter referred to as “the Report”) on the Project for Reconstruction of Bridges on New Britain Highway (hereinafter referred to as “the Project”).

The Preparatory Survey Team, headed by Mr. Shigeru Sugiyama, Chief Representative of JICA Papua New Guinea Office (hereinafter referred to as “the Team”) consulted with the Department of Works (hereinafter referred to as “DOW”) and the concerned officials of the Government of the Independent State of Papua New Guinea (hereinafter referred to as “the Government”) on the contents of the Report.

As a result of discussions, both sides confirmed the main items described in the attached sheets.

Port Moresby, October 16, 2014

杉山 茂

Mr. Shigeru SUGIYAMA
Leader
Preparatory Survey Team
Japan International Cooperation Agency
Japan

Ms. Linda Taman - EKO
Acting First Assistant Secretary, Foreign Aid Division
Department of National Planning and Monitoring
Independent State of Papua New Guinea

Mr. David WEREH
Secretary
Department of Works
Independent State of Papua New Guinea

ATTACHMENT

1. Components of the Draft Outline Design Report

1.1. As a result of the Survey the Team identified four main components of the Project consisting of the following construction works. PNG side agreed and accepted in principle the contents of the Report explained by the Team.
   a) Reconstruction of Kapiura and Aum bridges
   b) Construction of the access roads for Kapiura and Aum bridges
   c) Construction of revetment works for Kapiura and Aum bridges
   d) Removing the existing bridges of Kapiura and Aum bridges

2. Cost Estimation for the Project

2.1. The Team explained to PNG side the estimate of the Project Cost described in Annex-1; while, the final Project Cost described in the Exchange of Note (hereinafter referred to as "E/N") will be appraised by the Government of Japan (hereinafter referred to as "GOJ").

2.2. Both sides further confirmed that the Project Cost in Annex-1, and details of the construction works in the Report should never be duplicated and/or disclosed to any third parties until all the contracts for the Project are concluded.

2.3. The Team explained and PNG side agreed that the cost for land acquisition is also subject to change but in principle it will be compensated at full replacement cost according to the JICA Guidelines for Environmental and Social Considerations (hereinafter referred to as "JICA Guidelines").

3. Undertaking by PNG Side

3.1. PNG side is responsible to undertake the activities for the Project listed in Annex-2 at its own expenses based on the contents of the Report.

3.2. PNG side confirmed that the customs duties, internal taxes and other fiscal levies, imposed in PNG with respect to the purchase of the products and the services shall be exempted in accordance with the regulations of E/N between the two governments.
In case the exemption would not be processed in a timely manner, anyhow, both sides confirmed such tentative payment(s) would be owed by PNG side.

3.3. PNG side confirmed to execute the undertakings listed in Annex-2 in time, duly understanding the possibilities of the suspension / termination of this Grant Aid assistance if there will be violations on the undertakings.

3.4. PNG side is responsible to secure necessary budget in time and to report its progress to JICA Papua New Guinea office (hereinafter referred to as "JICA office"). If the budget cannot be secured in time and/or appropriately, there is a possibility that the Project might be suspended / terminated.

3.5. PNG side agreed that DOW will report to JICA office the progress of their undertakings by PNG side until all the works to be done. Reports to JICA office shall be submitted monthly with actual progress bar chart in Annex-2. Other than the monthly report, DOW shall reply when requested by JICA.

4. Operation and Maintenance of the Facilities

4.1. PNG side will secure enough staff and budgets necessary for operation and maintenance of the facilities constructed by the Project. The annual operation and maintenance costs are estimated and shown in the table below. Refer to the Report for further details.

Maintenance Item	Frequency	Location	Work Items	Annual Cost (Kina/year)
1. Inspection				
1) Approach Road	1 time/week	Pavement surface Inside of drainage	Inspection	2,160
2) Bridge	1 time/week	All parts of bridge	Inspection	4,320
3) Bank Protection	1 time/week	All parts of Revetment	Inspection	2,160
Subtotal of annual cost of inspection				8,640
2. Cleaning				
1)Approach Road	2 times /year	Inside of drainage Grass cut around shoulder	Cleaning	17,900
2)Bridge	2 times/year	All parts of bridge	Cleaning	1,200
Subtotal of annual cost of cleaning				19,100
3. Repair & Rehabilitation				
1) Approach Road	Once/2 year	Pavement	Repair	11,400
	Once/20 year		Replace	48,750
2) Bridge	Once/20 year	Expansion Joint	Replace	10,500
3) Bank Protection	Once/Month	All parts of Revetment	Repair	4,800
Subtotal of annual cost of repair and rehabilitation				75,450
Total				103,190

4.2. The Team stressed the following three points, and PNG side agreed;

(1) Although the project includes some facilities to ensure traffic safety such as sign posts, guardrail, etc., frequency of accidents might not be reduced due mainly to increased traffic volume.

(2) Passing the bridges by excessively overloaded vehicle will cause significant damage to the bridge structure which may lead to shorter lifespan.

(3) Proper asset management mainly for bridges will impact greatly to maintenance cost and lifespan.

5. Environment and Social Considerations

5.1. Both sides confirmed that information on environmental and social considerations including major impacts and relevant mitigation measures is summarized in the Environmental Checklist attached as Annex-3. DOW confirmed that they will inform JICA of any major changes, which may affect environmental and social considerations, by revising the Checklist in a timely manner.

5.2. Both sides confirmed continuous environmental monitoring will be conducted by DOW in accordance with the Environmental Checklist and Monitoring Form attached as Annex-3 and Annex-4.

5.3. DOW confirmed that the results of environmental monitoring will be provided to JICA by filling in Environmental Monitoring Form attached as Annex-4 on a quarterly basis until the completion of the Project, provided that there is no outstanding issue regarding the environmental and social considerations during implementation of the Project.
In case JICA finds that there is necessity for improvement in a situation with respect to environmental and social considerations after the agreed monitoring period, JICA can request to extend the period of monitoring and reporting until JICA confirms the issues have been properly addressed.

5.4. PNG side agreed JICA's disclosure of provided monitoring results in the Environmental Monitoring Form attached as Annex-4 on JICA's website.

6. Validity of the Previous Minutes of Discussions

Both sides confirmed that all the agreements in the Minutes of Discussions of the preceding Preparatory Survey signed on May 30, 2014 continue to be valid unless information is updated by the draft Preparatory Survey Report..

7. Japan's Grant Aid Scheme

7.1. PNG side fully understood and reconfirmed the scheme of the Japan's Grant Aid and the necessary measures to be undertaken by PNG side, which was explained by the Japanese side and agreed as the Minutes of Discussion signed on May 30, 2014.

8. Schedule of the Study

8.1. JICA will complete the Final Report of the Preparatory Survey both in Japanese and English, in accordance with the confirmed items and send it to PNG side around February, 2015.

8.2. The above schedule is tentative and subject to change.

9. Disclosure of Information

9.1. PNG side agreed to JICA's disclosure of the study results excluding the Project cost after completion of the Preparatory Survey, and all the study results including the Project cost after all the contracts for the Project are concluded.

10. Misconduct

If JICA receives information concerning suspected corrupt or fraudulent practices, the Government shall take necessary measures in accordance with the Procurement Guidelines in the competition for, or in execution of, the contract funded by the Grant:

(1) to provide JICA with such information as JICA may reasonably request, including information related to any concerned official of the government and/or public organizations of PNG;
(2) not to treat unfairly or unfavorably the physical persons and juridical persons, that provide the information.

Annex-1: Project Cost Estimation
Annex-2: Activitiess to be undertaken by the Government of the Independent State of Papua New Guinea
Annex-3: Environmental Checklist
Annex-4: Environmental Monitoring Form

Annex-1: Project Cost Estimation

CONFIDENTIAL

(1) Cost Borne by the Government of Japan

Components		Cost Estimation (Million Yen)
Building Construction	Construction of Kapiura Bridge (including approach road , revetment and removing the existing bridge)	1,746
	Construction of Aum Bridge (including approach road , revetment and removing the existing bridge)	1,161
Detailed Design and Procurement Supervision		229
Total		3,136

(2) Cost Borne by the Government of the Independent State of Papua New Guinea

Items	Cost Estimation (Kina)
Land Lease Fee	400,000
Removal of Temporary Bridge at Aum Site	10,000
Payment of bank commission	40,000
Total	450,000

(3) Conditions of Cost Estimation

- Estimated timing: July 2014
- Exchange rates: USD1.00 =103.16 JPY
  Kina 1.00 = 40.23 JPY
- Others: The project is implemented in accordance with the system of Japan's Grant Aid. The above cost estimation is not final, and GOJ is responsible for finalizing the ceiling amount of the Grant Aid assistance of the Project.

Annex-2: Activities to be undertaken by the Government of the Independent State of Papua New Guinea

(1) Undertakings of which progress required to be shared with and to be reported to JICA in a timely manner

PNG side is required to implement following items described below and report to JICA Papua New Guinea office monthly and the times when the items marked "▼" is done, as well as at the beginning and end points of the bar charts. Furthermore, DOW is also required to report to JICA on an ad hoc basis in response to JICA's inquiries.

Note : (P) means provisional

Undertaking		Month	2014 11	2014 12	2015 1	2015 2	2015 3	2015 4	2015 5	2015 6	2015 7	2015 8	2015 9	Remarks
Project Implementation	Exchange of Notes and Grant Agreement (P)				▼									
	Detailed design				▭	▭	▭	▭						
	Tender notice								▼					
	Construction Works											▭	▭	
Securing Budget *(See Annex-1 for items and estimated cost to be secured.)*	Request of budget for FY 2015	Plan												
		Actual												
	Request of budget for FY 2016	Plan							▼					To be prepared just after the detailed design will have finished.
		Actual												
	Approval of budget for FY 2015	Plan			▼									
		Actual												
	Available timing for payment	Plan				▼								In case of the delay, appropriation budget should be utilized.
		Actual												
Tax Exemption *(See 3. in the Attachemnt for exception)*	Submission and authorization of tax exemption from DOW	Plan			▬									Begin preparation of application and consultation with DOW refering to the existing E/Ns for the other projects.
		Actual												
	Submission of application for each tax payments	Plan												Application must be submitted each shipment time when the exemption will be required
		Actual												
Land Acquisition	Submission of letter about Replacement of Lease Land to Government	Plan				▬								
		Actual												
	Approval for Replacement of Lease Land	Plan						▼						
		Actual												
Environmental & Social Considerations	Submission of Project Implimentation Document from DOW to DEC	Plan				▬								
		Actual												
	Approval Level 2A Project from DEC	Plan					▼							
		Actual												
	Review and approval of Environmental Management Plan (EMP)	Plan										▬		EMP shall be submitted by the Contractor during the preparation of construction
		Actual												
	Submission Copy of Review EMP from DOW Environment Section to DEC	Plan										▼		
		Actual												
	Commencement of environmental monitoring	Plan										▬	▬	Monitoring report shall be submitted to JICA during construction
		Actual												
Provision of Temporary Work Yards include contractor's site office and plant yard	Negotiation with land owners	Plan										▬		Temporary work yards shall be at near Aum Bridge sites.
		Actual												
	Contracts for land rent	Plan										▬		
		Actual												
Provision of Borrow Pits and Quarry (ies)	Contract with borrow pits and quarry(ies) owners	Plan										▬		Borrow pits and Quatties shall be near both bridges.
		Actual												
Provision of waste disposal area	Acquisition of approval of soil and construction waste disposal from the dump site owner	Plan										▬		Dump site shall be near Temporary Work Yard.
		Actual												
Payment of bank commission	Openinng of bank account and arrange Authorization to Pay	Plan				▬								
		Actual												
	Payment commision	Plan					▪▪	▪▪	▪▪	▪▪	▪▪	▪▪	▪▪	
		Actual												

(2) Other Undertakings necessary for smooth implementation of the Project

Items
To ensure prompt unloading and customs clearance of the products at ports of disembarkation in the recipient country and to assist internal transportation of the products.
To accord Japanese physical persons and / or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the implementation of the Project.
To ensure that the Facilities be maintained and used properly and effectively for the implementation of the Project.
To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project even other than the cost shown in Annex-1 if necessary.
To support ensuring security for the personnel assigned to the Project and ensuring security at the Project sites, e.g. security information sharing, coodination with police, etc.
To cooperate in solving potential troubles with the local people or any third party in connection with the execution of the Project with close consultation with JICA.

Annex-3: Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have assessment reports (EIA reports) been already prepared? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N (c) Y (d) N	(a) When the Project contents have been finalized, the Project proposal will be submitted from the DoW (Project proponent) to DEC. (b) (c) The bridge reconstruction Project corresponds to Category 2A in the Environmental Guidelines; thus its implementation will be approved. The DEC branch in the DOW requires preparation of the CEMP. (d)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the Project and the potential impacts been adequately explained to the local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the local stakeholders? (b) Have the comments from the stakeholders (such as local residents) been reflected to the Project design?	(a) Y (b) Y	(a) Direct hearings have been held with the stakeholders comprising WNB Province Office and bridge users NBPOL and SBLC in order to provide explanations and listen to requests. (b) The outline design results, etc. will be announced to the stakeholders as necessary. Clearance of Bridge girder during High water Level was considered in design based on user's information and request.
	(3) Examination of Alternatives	(a) Have multiple alternative plans of the Project been examined with social and environmental considerations?	(a) Y	(a) Zero option of reconstruction bridges is impossible because of no alternative road network. Road alignment and river management plans that entail changing the positions of the existing Aum Bridge and Kapiura Bridge are not feasible because they would entail acquisition of plantation and customary land and large-scale alteration of the riverside buffer zones. Reconstruction of Bridges on existing position is feasible.
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that air pollutants emitted from the Project related sources, such as vehicle traffic, will affect ambient air quality? Does ambient air quality comply with the country's air quality standards? (b) If air quality already exceeds environmental standards near the route, is there a possibility that the Project will make air pollution worse? Are any mitigating measures for air quality taken?	(a) Y (b) N	(a) The generation of atmospheric polluting substances from passing vehicles is predicted to lead to air pollution, but the amount of DUST or other pollution substances generation over WNB is almost same with Project than without Project. (b) The emission gases will diffuse on the bridges, therefore, this Project will not lead to deterioration of air quality around the route.
	(2) Water Quality	(a) Is there a possibility that soil runoff from the bare land resulting from earth banking and cutting, etc. will cause water quality degradation in downstream water areas? (b) Is there a possibility that the Project will contaminate water sources, such as well water?	(a) N (b) N	(a) The planned approach roads are planned to be banked structures higher than the existing road due to flood water line constraints, etc. The case using banking structure for some part of the road also will be forcasted not cause water quality degradation(pH, Turbidity) with preventive measures against soil runoff such as early slope , greening. (b) When performing excavation for bridge foundations, use of the cofferdam method can minimize the impacts.
	(3) Noise and Vibration	(a) Do noise and vibrations from the vehicle and train traffic comply with the country's standards? (b) Do low frequency sounds from the vehicle and train traffic comply with the country's standards?	(a) Y (b) Y	(a) The noise on the bridges will be lower than noise on the flat road. If noise levels exceed the standard, There are no facilities that require protection in the local areas. (b) There are no houses near the bridges, so there will be little impact from low frequency vibration.
3 Natural Environment	(1) Protected Areas	(a) Is the Project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the Project will affect the protected areas?	(a) N	(a) The riverside band is designated as a buffer zone based on Logging Code Practice in the Project sites and surrounding area. Taking plants and hunting are prohibited in this area, however, the impact to ecological scheme will be negligible because the CEMP will be implemented during construction.
	(2) Ecosystem	(a) Does the Project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the Project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate protection measures taken to prevent impacts, such as disruption of migration routes, habitat fragmentation, and traffic accident of wildlife and livestock? (e) Is there a possibility that installation of bridges and access roads will cause impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystems due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered?	(a) Y (b) N (c) N (d) N (e) N	(a) Aum Bridge and Kapiura Bridge are situated in an area of palm and eucalyptus plantations, but riverside bands of 50 meters on both sides are designated as buffer zone, where the hunting of flora and fauna is controlled in line with the objectives of river protection. (b) No valuable and protected habitats have been confirmed on the proposed route. (c) As the Project entails bridge replacement, it is expected that the impact to ecosystem will be small. (d) No large-size wildlife or farm animals have been confirmed in the Project area. (e) The Project is not expected to cause loss of existing swamp, however, when greening slopes and so on, indigenous species will be planted to ensure there is no influx of foreign species or pests.
	(3) Hydrology	(a) Is there a possibility that hydrologic changes due to the installation of structures will adversely affect surface water and groundwater flows?	(a) N	(a) Aum Bridge is planned with two spans and Kapiura Bridge with three spans. Increase in HWL due to installation of piers will be limited to 100mm, and since the cross section of piers will be negligible compared to the river cross sections, there will be hardly any increase in water line that affects upstream areas.
	(4) Topography and Geology	(a) Is there any soft ground on the route that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there a possibility that civil works, such as banking and cutting will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? (c) Is there a possibility that soil runoff will result from bank and cut areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(a) N (b) N (c) N	(a) The Project area has such terrain that slope failures or landslides are not likely to be induced. Moreover, excavation works of the type that cause major topographical transformation will not be implemented. (b) The bridge approaches will basically be banked structures, which will be designed and constructed with steps to ensure that slope failures or landslides do not occur. Specifically, banking will be designed based on application of PNG's earthwork standards while also referring to Japanese standards. Up to the 100-year flood water line (HWL), banking will either comprise gabion (retaining wall) or be covered by gabion for slope protection. On surfaces above the HWL, slope protection will be provided by planting indigenous species (grass). (c) For the establishing and running the waste soil disposal sites and borrow sites, an CEMP for ensuring thorough safety measures such as assignment of safety guards at vehicle entrances will be compiled and implemented.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by Project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is compensation going to be paid prior to the resettlement? (e) Is the compensation policy prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) N (b) N (c) N (d) N (e) N (f) N (g) N (h) N (i) N (j) N	(a) Aum and Kapiura bridges are located around land leased from the state and used for plantations, so there are no residents or inhabited buildings for a few kilometers in the surrounding area. (b) (c) (d) (e) (f) (g) (h) (i) (j)
	(2) Living and Livelihood	(a) Where bridges and access roads are newly installed, is there a possibility that the Project will affect the existing means of transportation and the associated workers? Is there a possibility that the Project will cause significant impacts, such as extensive alteration of existing land uses, changes in sources of livelihood, or unCEMPloyment? Are adequate measures considered for preventing these impacts? (b) Is there any possibility that the Project will adversely affect the living conditions of the inhabitants other than the target population? Are adequate measures considered to reduce the impacts, if necessary? (c) Is there any possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the Project? Are adequate considerations given to public health, if necessary? (d) Is there any possibility that the Project will adversely affect road traffic in the surrounding areas (e.g., increase of traffic congestion and traffic accidents)? (e) Is there any possibility that Project will impede the movement of inhabitants? (f) Is there any possibility that bridges will cause a sun shading and radio interference?	(a) N (b) N (c) Y (d) N (e) N (f) N	(a) The works will create CEMPloyment opportunities for local residents living over a few kilometers from the sites. (b) There are no inhabitants. (c) To prevent the immigration of infectious diseases such as HIV in line with the immigration of workers, measures will be planned and implemented through lectures, etc. at the phase of CEMP during construction. (d) During construction, there will basically be no impact on local traffic because the existing road will be secured, however, measures to counter congestion caused by the work and works vehicles will be examined and implemented in the CEMP. (e) (f)
	(3) Heritage	(a) Is there a possibility that the Project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) There are no valuable heritage or historical sites of the archaeological, historical, cultural, or religious variety in the Project area, and no areas that are protected under domestic law.
	(4) Landscape	(a) Is there a possibility that the Project will adversely affect the local landscape? If that is the case, are necessary measures taken?	(a) N	(a) Both Aum Bridge and Kapiura Bridge will be designed to blend with the surrounding landscape through adopting appropriate color coating for girders and so on.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) Y	(a) There are no residential areas of ethnic minorities and indigenous peoples in and around the Project area. (b) The rights of ethnic minorities and indigenous peoples are respected based on law, etc.
	(6) Working Conditions	(a) Is the Project proponent not violating any laws and ordinances associated with the working conditions of the country which the Project proponent should observe in the Project? (b) Are tangible safety considerations in place for individuals involved in the Project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the Project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the Project not violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) The environment for workers will be upheld based on labor law ordinances concerning work times, break times, and worker health and safety. (b) In the works CEMP that is prepared in the D/D phase, safety measures will be considered. (c) In the works contract, it will be required to prepare a safety plan containing safety management measures such as appointment of a safety manager, and implementation will be thoroughly enforced. (d) In implementing the Project, stakeholder consultations will be frequently held, and the works contract will require appointments of an Environmental, Health and Safety Officer and Community Liaison Officer, etc. according to the PNG environmental guidelines.

[illegible]	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) N (c) N	(a) In the D/D phase, adequate pollution mitigation measures to reduce impact during the construction based on both national and international standards will be examined and stated in the CEMP and their implementation will be guaranteed. (b) In the case where tree cutting arises in the buffer zone in the upper reaches of Kapiura River, reforestation, etc. will be implemented as necessary. (c) In the D/D phase, the possibility of traffic congestion or maldistribution of benefits will be examined and countermeasures will be stated in the RAP or CEMP and their implementation will be guaranteed.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) Y	(a) Monitoring of the natural environment comprising air quality, noise, water quality, etc. during works will be planned in the CEMP and implemented. (b) The CEMP/MD will stipulate that the existence of variations in the natural environment comprising air quality, noise, surface water, groundwater, plant ecology, etc., should be grasped by sampling and visual inspection during and after construction for roughly 1 year. (c) The monitoring framework will be drafted in the CEMP and incorporated into the construction contract. (d) The CEMP/MD will stipulate that, except in emergencies, reports be given during works and once per year after works.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Roads, Railways and Forestry Projects checklist should also be checked (e.g., Projects including large areas of deforestation). (b) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., Projects including installation of power transmission lines and/or electric distribution facilities).	(a) N (b) N	(a) Because new bridges replacing the existing ones will be constructed on land adjoining the existing road, there will be no major deforestation. (b)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to trans-boundary or global issues should be confirmed (e.g., the Project includes factors that may cause problems, such as trans-boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) Being a small-scale Project, it will not have much of an impact.

Note 1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the Project is located diverge significantly from international standards, appropriate environmental considerations need to be made. In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

Note 2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the Project and the particular circumstances of the country and locality in which the Project is located.

Monitoring after construction of work shall be conducted by the DOW based on sampling and visual inspection for roughly 1 year. The monitoring result will be reported to JICA.

1. Pollution Countermeasures

—Water quality (wastewater measurements and environmental measurements in surrounding water bodies)

Item (unit)	Measurement (Mean value)	Measurement (Maximum value)	Local Standard	Reference International Standard	Remarks (Measurement location, frequency, method, etc.)
pH		-	Difference between upstream and downstream	-	Every month
Turbidity	-	-	There must be no difference of 25 NTU or more between the upstream and downstream.	-	Every month, Confirm by means of basic turbidity meter that uses electric conductivity.
Water temperature	-	-	Difference of 2°C or more between upstream and downstream	-	When measuring turbidity

2. Natural Environment

—Ecosystem

Monitoring Item	Conditions during the Report Period
Conditions of vegetation and biota around the sites	Monthly visual observations, record any changes and report as necessary.

3. Social Environment

—Traffic accidents, others

Monitoring Item	Conditions during the Report Period
Traffic accidents, Damage of facilities such as cracks of asphalt pavement or concrete structures, erosion of embankment etc. Contents of complaints from passers-by and other stakeholders.	Report to JICA according to necessity.

5. Other Relevant Data

5.1 First field survey (May 30th, 2014)

Minutes of Understanding
on
Technical Issues on the Preparatory Survey
on
the Project for Reconstruction of Bridges on
New Britain Highway

JICA Study Team had carried out data collection and analyses as well as field investigation on technical issues related to design and construction of the bridges, Aum and Kapiura bridge. Based on the results from those activities, the Team and the DoW, representative of the Government of the Independent State of Papua New Guinea held discussions on several technical issues pertaining to the project and reached the following understandings;

1. Design Standards

Following standards, specifications and manuals shall be used because of consistency with the other ongoing bridge construction project (BRIRAP) funded by ADB.

Table-1 Design Standards and manuals issued in PNG

No	Name and contents	Issued	Remarks
1	Specification for Road and Bridge Works	1995.8	
2	Road Design Manual	1994.6	
3	Goods Procurement Manual Ver.3	2005.3	
4	Flood Estimation Manual	1990.12	Published by PNG DOE, CBOW
5	Earthquake Engineering for Bridge in Papua New Guinea	1985 Revision	DOW
6	River Training Manual	1987	DOW
7	Standard Engineering Drawings Bridge/Road	2008	DOW

Table-2 Reference Specification

No	Name and Contents	Issued	摘要
1	Specification for Highway Bridges	2012	Japan
2	AS5100 and supplements		

In Japanese grant aid projects, since materials are often procured from Japan, DOW agreed to adopt the Japanese Specifications for Highway Bridges based

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on adoption of JIS, which provides the technical specifications for material.

2. Design Live load

B-load defined in the Japanese specification is applicable to design of Aum bridge and Kapiura bridge because load effect of T44 and B-load are almost same or B-load is prevailing. DOW agreed to adopt B-load.

3. Standard Width of Road and Bridge

The proposal of the road and bridge width was agreed as shown on the Figure-1 and Figure-2 which is consistent with the BRIRAP one.

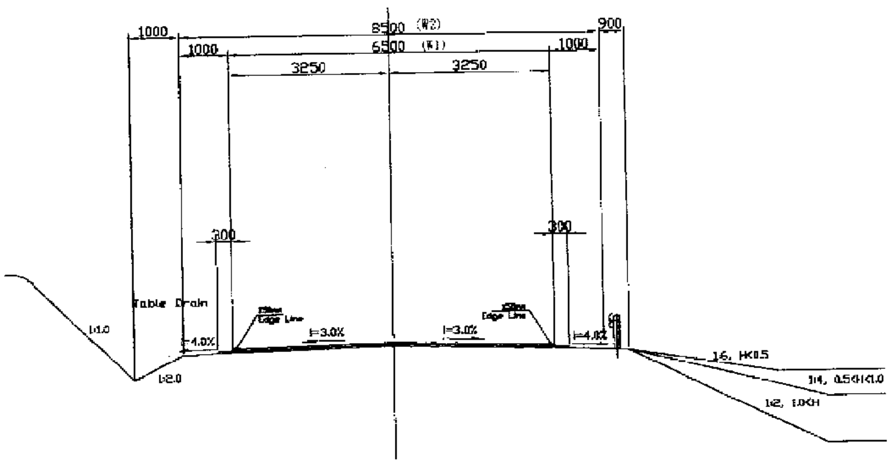

Figure-1 Road width

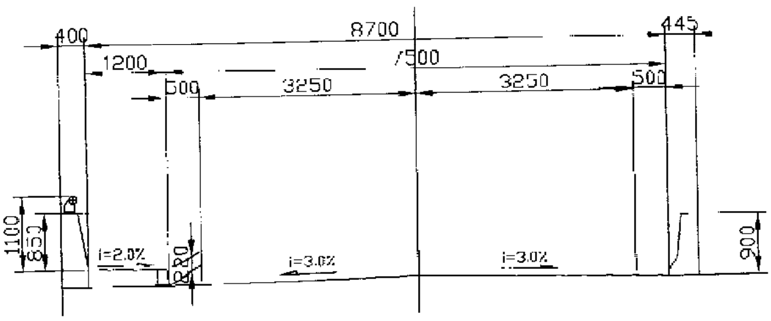

Figure-2 Bridge width

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4. Seismic Design

Japanese Specification, e.g. Specification for Highway Bridges V Seismic Design, shall be applied instead of the PNG's seismic design which was issued 30 years ago.

5. Hydraulics and Hydrology

Based on the BRIRAP Project, following restrictions shall be maintained.

- Clearance between soffit of the girder and H.W.L of 100-year return period shall be not less the 1.0m.

- Increase of HWL due to construction of the bridge should be within 100mm.

- Q_{2000} which is 2000-year return period shall be considered under ultimate loading.

  (Q_{2000} calculated as the Q100 discharge multiplied by 1.65. Refer to AS 5100)

  This Item is based on AS 5100 and applied to the BRIRAP bridge design criteria.

5. Removal of the old bridge structure

In the clause 7.7 of the proposal for Japanese Grant Request Application dated August, 2020, it was described that the removal of the old bridge structure is the item for which the costs will be borne by the requesting country.

Regarding this issue, followings were discussed.

- Removal of the existing bridges shall be implemented timely and harmony with construction of the new bridges in order to complete the project within the designated duration.
- Regarding Aum Bride, demolish of existing bridge may be implemented before the commencement of the new bridge construction.
- The existing log bridge at the Aum site shall be demolished just after the completion of the new bridge because it will be used as detour during construction term.
- Regarding Kapiura Bridge, existing bridge shall be dismantled quickly and

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safely after opening of the new bridge in order to construct river protection consecutively.

- If PNG side demolishes the both existing bridges, in order to lack of current division engineers and equipments, sequence of the construction activity for the new bridge implemented by the contractor will be disrupted.

Therefore, it is preferable that removal of the old bridge structure should be borne by Japanese grant.

30th June, 2010
Port Moresby

Mr. Wilfred PEKO
Department of Works
A / Assistant Secretary
Roads & Brides Design

Mr. Masahiko MORI
Chief Consultant
JICA Study Team

6. References

No.	Name of Document	Style	Published by
1	2013 NATIONAL BUDGET, Volume 1 Economic and Development Policies 31st December	Copy	2013, HON. DON POMB POLYE MP MNISTER FOR TREASURY
2	Daily data for Dami O P R S (2012-2014)	Copy	National Weather Service
3	Daily data for Hoskins Weather Office (2012-2014)	Copy	National Weather Service
4	Hydrology in Tropical Australia and Papua New Guinea	Copy	A. J. Hall, 1984
5	Seismicity Map of Papua New Guinea	Copy	USGS
6	Historical Earthquakes in Papua New Guinea	Copy	USGS
7	WEST NEW BRITAIN INTEGRATED PROVINCIAL DEVELOPMENT PLAN 2012-2015	Copy	WEST NEW BRITAIN PROVINCIAL ADMINISTRATION 2011
8	Guidelines for the Environmental Assessment of Road and Bridge Infrastructure Projects	Copy	Department of Works , September 2013
9	National Public Service: General Orders	Copy	Papua New Guinea. Department of Personnel Management, 2002