No

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR REHABILITATION

OF

BRIDGES ON THE HIGHLANDS HIGHWAY

IN

PAPUA NEW GUINEA

FINAL REPORT

July 2004

JAPAN INTERNATIONAL COOPERATION AGENCY
NIPPON KOEI CO., LTD.

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PREFACE

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

JICA sent to Papua New Guinea a study team from January 15 to February 12, 2004.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of Papua New Guinea for their close cooperation extended to the teams.

July 2004

Yasuo Matsui
Vice-President

Japan International Cooperation Agency

July 2004

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Rehabilitation of Bridges on the Highlands Highway in Papua New Guinea.

This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from January to July, 2004. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Papua New Guinea and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

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

Very truly yours,

Tetsu Nakagawa

Chief Consultant,

Basic design study team on the Project for Rehabilitation of Bridges on the Highlands Highway in Papua New Guinea

Nippon Koei Co., Ltd.

The Basic Design Study
on The Project for Rehabilitation of Bridges
on The Highlands Highway in Papua New Guinea

Project Location Map

The Basic Design Study on The Project for Rehabilitation of Bridges on The Highlands Highway in Papua New Guinea	Perspective (Bena Bena Bridge)

The Basic Design Study on The Project for Rehabilitation of Bridges on The Highlands Highway in Papua New Guinea	Perspective (Umbaka Bridge)

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Abbreviations

A $	Australian Dollar
AIDS	Acquired Immuno-Deficiency Syndrome
Alt	Alternative
AM	Ante Meridiem
ASTM	American Society for Testing and Materials
AusAID	Australian Agency for International Development
Austroads	Australian Road & Bridge Standard
DBST	Double Bituminous Surface Treatment
DoW	Department of Works
E/N	Exchange of Notes
EIA	Environmental Impact Assessment
EMP	Environmental Monitoring Plan
H.W.L	High Water Level
IMF	International Manetary Fund
JICA	Japan International Cooperation Agency
kph	Kilometers Per Hour
Max.	Maximum
Min.	Minimum
NCD	National Capital District
No’s	Numbers
PC	Prestressed Concrete
PNG	Papua New Guinea
PQ	Pre-Qualification
RC	Reinforced Concrete
ROW	Right of Way
ROW	Right of Way
SMEC	Snowy Mountains Engineering Corporation
UK	United Kingdom
USGS	United States Geological Survey
WB	World Bank

SUMMARY

SUMMARY

Papua New Guinea (PNG) with a land area of 462,000 sq.km has a diverse terrain ranging from extremely rugged with sharp mountain ranges in the central area, to extensive marshes in the southern coastal area. For that reason, the population of the National Capital District (NCD) accounts only for 4.8% (about 250,000) of the total population of 5.19 million. About 65% of the total population lives in the highland region in central PNG. As a result of population scattering and restraint of economic activities due to the country's rough terrain, Port Moresby, the capital of PNG, is linked to provincial capitals only by air and sea transport. The road network, which should support the national economy is still poor.

Of the total road length of 26,962 km in the whole country, the Department of Works (DoW) has jurisdiction over 7,397 km of national roads, of which pavement covers only 28% (2,053 km). The lack of maintenance caused by continuous budget constraint, however, induces road surface deterioration, landslide and slope surface failure, etc., which in turn generate frequent traffic interruption and high transportation cost.

To cope with such a situation, the Government of PNG formulated in 2000 the "National Transport Development Plan for 2001-2010" aimed at providing safe and dependable transport services to all sections of the community in a cost-efficient manner. The Plan envisages the investment of an estimated amount of Kina 3.4 billion over 10 years for improvement and rehabilitation of the existing infrastructure for land and water transport and civil aviation. Ninety percent of the said amount will be used for improving the road network. The aim of land transport improvement is to prevent further damage to highways by natural conditions and to upgrade and restore those sections that have deteriorated. Among the highways, the Highlands Highway, which is the most important artery to support economic activities in PNG, was selected as a first priority project under the Plan.

The Highlands Highway with a total length of 605 km is the only direct road link from Lae, which has the biggest Port in PNG, through Goroka and Mt. Hagen to Mendi where many agricultural and mining centers are located. The Highway has been suffering from pavement deterioration, washing out of bridges and embankment by flood, landslide and slope failures, resulting in frequent traffic interruptions. Furthermore, aged and single-lane bridges without sidewalks on the Highway cause traffic bottlenecks due to their low load carrying capacity and also pose a threat to the safety of pedestrians since heavy vehicles with excessive axle loads frequently travel on the Highway. In order to improve such situation, the Government of PNG is implementing a plan to upgrade damaged sections and widen all single-lane bridges on the Highway to two-lane bridges. In line with the plan, international funding agencies such as the World Bank, Asian Development Bank and International Cooperation Agencies like AusAID are assisting the PNG Government through various projects related to the Highlands Highway.

Taking the above situation into account, the Government of PNG asked the Government of Japan to provide a Grant Aid for the replacement of 12 single-lane bridges on the Highlands Highway. These include the 11 single-lane bridges located near Goroka and the old Bitija Bridge beside the newly completed single-lane Bitija Bridge. These bridges are rather concentrated in a section of about 80 km, therefore the bridge rehabilitation cost for this section is high among the 605 km of the Highlands Highway. This request was made in line with the above-mentioned Plan with the aim of increasing reliability and safety of the traffic on the Highway.

In response to the PNG Government's request, the Government of Japan decided to conduct a basic design study the "Project for Rehabilitation of Bridges on the Highlands Highway in Papua New Guinea" and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent a study team to PNG from January 14, 2004 to February 12, 2004. As a result of field surveys in PNG, 12 priority bridges among a total of 23 bridges, including 12 bridges requested by PNG and another 11 bridges located near Kainantu, were selected for study as agreed with the PNG side by a Minutes of Discussion. After the team's return to Japan, further studies were conducted and a draft

final report was prepared in Japan. Then JICA sent the Basic Design Explanation Team to PNG from May 19, 2004 to May 30, 2004 to explain the study results and a Minutes of Discussion, mainly covering the recipient country's obligations was signed by the two parties on May 27, 2004.

The original request from PNG side was to replace 12 single lane bridges as cited above. There are however another 11 aged single lane bridges in the section between Goroka and Kainantu and it is possible to rehabilitate instead of replace those bridges. Considering this fact, 12 priority bridges were selected for urgent rehabilitation considering the extent of damage, channel clearance and alignment as observed during the field surveys. A comparison between the bridges originally requested by PNG and those finally selected in the Study for possible rehabilitation is shown in the table below.

Comparison Between the Scope of Works Originally Requested by PNG and the Result of the Basic Design Study

Bridge ID	Bridge Name	Bridge Length	Location (distance from Lae, km)	Bridges originally requested by PNG	Urgency of Rehabilitation	Assistance by other Donors	Bridges Selected for Japanese Assistance with Rehabilitation method
1	Bitija	49.2	155.0	○ (Replacement)	C	No plan	—
2	Undono	21.2	176.5	—	C	Yumi Yet	—
3	Tapiruna	27.3	178.2	-	C	Yumi Yet	—
4	Darasimpi	27.2	196.7	-	C	Yumi Yet	—
5	Luwin	9.1	198.4	-	C	Yumi Yet	—
6	Namupimpa	18.3	203.8	-	B	Yumi Yet	—
7	Banepa	37.0	208.6	-	A	AusAID	—
8	Orompaka	21.1	218.8	-	B	WB/1	○ (Improvement /Widening)
9	Nonompinka	14.9	219.0	-	A	WB/1	○ (Improvement /Widening)
10	Honeranka	18.1	221.0	-	B	WB/1	○ (Improvement /Widening)
11	Ofiga	24.1	221.3	-	B	WB/1	○ (Improvement /Widening)
12	Umbaka	12.0	222.2	-	B	WB/1	○ (Improvement /Widening)
13	Kingkio	15.0	232.3	○ (Replacement)	B	No plan	○ (Improvement /Widening)
14	Avani	18.0	234.9	○ (Replacement)	C	No plan	—
15	Kamanotina	24.0	246.6	○ (Replacement)	C	No plan	—
16	Kurongka	18.0	246.8	○ (Replacement)	C	No plan	—
17	Berefi	24.0	248.1	○ (Replacement)	C	No plan	—
18	Dirty Water	49.0	255.4	○ (Replacement)	A	No plan	○ (Replacement)
19	Siguya	18.0	263.6	○ (Replacement)	B	No plan	○ (Improvement /Widening)
20	Yasifo	18.0	269.0	○ (Replacement)	B	No plan	○ (Improvement /Widening)
21	Parirosay	24.0	269.9	○ (Replacement)	B	No plan	○ (Improvement /Widening)
22	Bena Bena	96.0	277.9	○ (Replacement)	A	No plan	○ (Replacement)
23	Sunufamu	12.0	282.8	○ (Replacement)	A	No plan	○ (Replacement)

Notes
○: Applicable
-: Not applicable or passed over
/1 Change from WB to JICA with WB's concurrence
A: High priority
B: Moderate priority
C: Low priority

The basic design of the 12 bridges selected for rehabilitation was carried out based on the DoW Road Design Manual, Austroads Bridge Design Code partially modified using the Bridge Design Specifications of Japan and referring to the concept design of the Highlands Highway Rehabilitation Project funded by the World Bank. It should be noted that the design flood discharge with a 50-year return period was applied in lieu of the 100-year probable flood stipulated in the PNG Flood Estimate Manual, considering the scale of the bridges.

The number and locations of the bridges were considered in formulating the project implementation. From the bridge location aspect, 5 small bridges, i.e. Oronpaka, Nonompinka, Honeranka, Ofiga and Umbaka bridges are located close to each other within 4 km of Kainantu, and the remaining 7 bridges are somewhat scattered over a section of 50 km between the Paroja Pass to Goroka through Henganofi.

Taking into account the size and location of the bridges, it is planned that the project implementation will be divided into two phases: Phase-1 covering the first 5 small bridges mentioned above, and Phase-2 the remaining 7 bridges. The facility layout based on the basic design is as follow:

Summary Rehabilitation Plan for 12 Bridges

Bridge ID (Bridge No.)		Bridge Name	Rehabilitation Method	Magnitude and Scale			
				Bridge Length /Span Length (m)	Superstructure Type	Substructure Abutment/Pier	Approach Road Length （m）
Phase- 1	8 (1)	Orompaka	Widening and Improvement of Existing	21.4/ 20.8	Single Span Composite H-shaped Beam	Pile Bent Type, Steel H Pile 250*250, L=4.5, n=12 /None	Lae side: 35.0 Goroka side: 38.6
	9 (2)	Nonompinka	Widening and Improvement of Existing	15.3/ 14.7	Single Span Composite H-shaped Beam	Pile Bent Type, Steel H Pile 250*250, L=5.5, n=6 / None	Lae side: 60.0 Goroka side: 34.7
	10 (3)	Honeranka	Widening and Improvement of Existing	18.6/ 18.0	Single Span Composite H-shaped Beam	Pile Bent Type, Steel Pile 250*250, L=10.5, n=10 /None	Lae side: 40.0 Goroka side: 41.4
	11 (4)	Ofiga	Widening and Improvement of Existing	24.5/ 23.9	Single Span Composite H-shaped Beam	Pile Bent Type, Steel H Pile 250*250, L=2.5, n=22/ None	Lae side: 40.0 Goroka side: 25.5
	12 (5)	Umbaka	Widening and Improvement of Existing	12.3/ 11.7	Single Span Composite H-shaped Beam	Pile Bent Type, Steel H Pile 250*250, L=7.0, n=22/None	Lae side: 20.0 Goroka side: 17.7
Phase-2	13 (6)	Kingkio	Widening and Improvement of Existing	15.3/ 14.7	Single Span Composite H-shaped Beam	Pile Bent Type, Steel H Pile 250*250, L=8.0, n=12/None	Lae side: 20.0 Goroka side: 44.7
	18 (7)	Dirty Water	Replacement with dual lane bridge	60.0/ 2@29.62	2 Span Continuous Plate Girder	Pile Bent Type Steel Tubular Pile Dia. 600、L=8.0、n=10/ T shape Pier on steel pile Dia. 600、L=7.0、n=12	Lae side: 131.5.0 Goroka side: 118.5
	19 (8)	Siguya	Widening and Improvement of Existing	18.3/ 17.7	Single Span Composite H-shaped Beam	Spread footing/None	Lae side：25.0 Goroka side：41.7
	20 (9)	Yasifo	Widening and Improvement of Existing	18.4/ 17.8	Single Span Composite H-shaped Beam	Pile Bent Type, Steel HPile 250*250, L=3.5, n=12/None	Lae side：35.0 Goroka side：26.6
	21 (10)	Parirosay	Widening and Improvement of Existing	24.0/ 23.8	Single Span Composite H-shaped Beam	Spread footing/None	Lae side：50.0 Goroka side：31.0
	22 (11)	Bena Bena	Replacement with dual lane bridge	120.0/ 28.62+2@29. 0+32.62	4 Span Continuous Plate Girder	Pile Bent Type Steel Tubular Pile Dia. 600、L=12.0、n=10～8/ Wall type pier on steel pile Dia. 600、L=10.0, n=12	Lae side：110.5 Goroka side:109.5
	23 (12)	Sunufamu	Replacement with dual lane bridge	18.0/ 17.34	Single Span Composite H-shaped Beam	Pile Bent Type, Steel HPile 250*250, L=6.0, n=10/None Not Applicable	Lae side：72.0 Goroka side:105.0

The overall implementation period until the completion of the project is about 33 months consisting of 9 months of detailed design /tendering and 24 months of construction.

The project cost is estimated at Japanese Yen 1,298 million consisting of 1,278 million yen to be financed by Grant Aid and 20 million yen to be borne by the PNG side.

The impact and effects generated by the Project Implementation are as follows:

(1) Direct Impact and Effects

1. A total of 2,511,000 people (accounting for about 48% of the total population of PNG) will benefit from the project implementation. The project impact will spread to six highland provinces: Morobe, Southern Highlands, Chimbu, Western Highlands, Southern Highlands, and Enga Provinces.
2. Because all the existing study bridges have a single lane with a narrow carriageway of 3.65 m without sidewalk, they cause traffic bottlenecks and there is danger for pedestrians using those bridges. Under the project, the replaced or widened bridges with a dual lane and a standard carriageway of 7.5 m with sidewalk will enable to ensure safety for pedestrians and to save both travel time and operation cost.
3. Because all the existing study bridges were designed with an old standard live load of T33, some of their structural members have inadequate load carrying capacity. Those bridges will be rehabilitated applying the B Loading design of Japan which is slightly heavier than the T44 Loading prevailing in PNG. The bridges will also be upgraded to accommodate the flood discharge with a 50-year return period. Such rehabilitation and upgrading works will prolong the bridge life by 50 years and reduce the bridge maintenance cost and collapse probability.
4. The absence of sidewalk of the existing bridges presents a danger for pedestrians crossing the bridges. Under the project, a 1.0 m wide sidewalk will be designed for each bridge, thus the number of accidents resulting in injury or death will be substantially reduced.

(2) Indirect Impact and Effects

1. Acceleration of agricultural and mining development of the highland regions, improvement of transport facilities, correction of regional disparities, and expansion of market sphere; and
2. Stabilization of people's livelihood and improvement of accessibility to educational and medical facilities.

Although the importance and urgency of the project implementation to sustain the PNG economy are obvious, the PNG Government is not in a position to materialize the project by its own means due to present limitations of its budget and technology. It is therefore recommended that significant assistance in the form of Japan's Grant Aid be provided to the Government of PNG for the implementation of the Project.

After completion of the Project, the DoW Eastern Highland Provincial Office will be responsible for the maintenance of the project structures. The annual maintenance cost is estimated at 119,800 Kina, which is equivalent to 0.38% of DoW's annual average maintenance budget of 31 million Kina, and DoW's staffs are well experienced in such labor-intensive maintenance work as they are doing it at present for other structures. Therefore, from budgetary and technical viewpoints, it is considered that DoW will be capable of undertaking the maintenance of the project structures properly and adequately.

For smooth and efficient project implementation, it is requisite that the PNG side complete the relocation of utility poles and compensation for affected crops before commencement of the Project; ensure tight security and safety for the personnel engaged in the Project during the entire period of project implementation; demolish the existing Dirty Water bridge and Bena Bena bridge; and maintain the project structures after completion of the Project.

THE BASIC DESIGN STUDY
ON
THE PROJECT FOR REHABILITATION OF BRIDGES ON THE HIGHLANDS HIGHWAY
IN PAPUA NEW GUINEA

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CHAPTER 1 BACKGROUND OF THE PROJECT

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The Highlands Highway is a vital road connecting the Highland region, where agricultural and mining centers are located, with Lae, the biggest port in PNG in terms of cargo handling volume. This road is important to sustain the PNG economy.

In spite of the above, a part of the road section running through hilly terrain from Lae to Watarais is suffering deterioration of the road surface due to insufficient maintenance. Some bridges in the section had been washed away by flood or had been submerged due to inadequate channel clearance resulting from riverbed aggregation.

In the section beyond Watarais, running through steep mountainous terrain, the road surface has been damaged at many places because of insufficient drainage systems and maintenance. Collapses of riverside embankments and cut side slopes had also been observed at several locations. Due to these incidents, the traffic on the highway is frequently interrupted, which in turn induces huge losses to the PNG economy.

Under such situation and considering the role of the Highlands Highway, the Government of PNG has put priority on rehabilitation of the Highlands Highway, including widening of single lane bridges to dual lane bridges and the International Funding Agencies and donors are supporting such strategy.

Taking into account above the situation, the Government of PNG asked the Government of Japan to provide Grant Aid for replacement of 12 single lane bridges along the Highlands Highway. The bridges consist of 11 single lane bridges out of 22 located between Kainantu and Goroka and the old Bitija Bridge, which is situated beside the newly completed Bitija Bridge.

In response to a request from the Government of PNG the Government of Japan decided to conduct a basic design study on “the Project for Rehabilitation of Bridges on the Highlands Highway in Papua New Guinea” and entrusted the study to the Japan International Cooperation Agency (JICA). Prior to dispatch of the study team, JICA decided, based on review of the request, that 1: the scope shall include 23 bridges located at Kainantu and Goroka adding 11 bridges not originally requested by PNG and that from these 23 bridges 12 priority bridges shall be selected and 2: the number of lanes and the improvement method shall be carefully studied and decided even through the request is to replace the existing bridges with dual lane bridges.

Based on final scope of the Study, JICA sent to PNG a study team from January 14, 2004 to February 12, 2004. In the field survey in PNG, 12 priority bridges among the 23 bridges were selected and agreed with the PNG side in the Minutes of Discussion. After the team returned to Japan, further studies were conducted and the draft final report was prepared in Japan. Then, JICA sent to PNG the Basic Design Explanation Team from May 19, 2004 to May 30, 2004 and the Minutes of Discussion, which mainly covered the recipient country’s obligations, were signed on May 27, 2004 by both sides.

CHAPTER 2 CONTENTS OF THE PROJECT

Chapter 2 Contents of the project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Purpose

The Government of Papua New Guinea (hereinafter called PNG) in the year 2000 formulated a "National Transport Development Plan: 2001-2010" covering three modes, Land transport, Water transport and Civil aviation with the overall goal of provision of safe and dependable transport services to all sections of the community in PNG in a cost efficient manner. In the Plan, total proposed investment is estimated at 3, 405.8 million Kina over a 10 year period, of which about 90 % is allocated to the land transport sub-sector and the most will be used for road improvement projects.

In the plan for the land transport sub-sector with purposes of eliminating traffic bottlenecks and lowering transportation cost, the Highlands Highway is defined as a national economic backbone in PNG and the improvement of the highway has been designated a first priority by the Government of PNG.

The Highlands Highway is the single most important Highway in PNG and is the economic backbone of PNG in terms of trade volume and value. It is the only direct road link totaling 605 km from Lae where the biggest port in terms of cargo handing volume is located via Mount Hagen to Mendi where the centers of agricultural and mining industries are situated. However, the Highway has frequently been impassable and induced high transportation cost because of deterioration of surface condition due to improper maintenance, flooded bridges by river bed aggradation, landslide or cut slope failure, and erosion of embankment by flood.

2-1-2 Outline of the Project

In line with the overall goal of the National Transport Development Plan: 2001-2010, the Government of PNG is implementing the following projects on the Highlands Highway with financial assistance from several funding agencies.

Table 2-1 Foreign Assistance Projects on Highlands Highway

Funding Agency	Name of Project	Outline of the Project	Remarks
AusAID	Highlands Highway Maintenance Project	Maintenance and repair of deteriorated sections in the Highway	A$ 60 M over five year period in Grant Aid
World Bank	Highlands Highway Rehabilitation Project	Rehabilitation of damaged /critical sections and widening of single lane bridges in the Highway	Project cost is estimated at US $ 40 M (US $ 25 M in Loan)
Asian Development Bank	Five Highlands Provinces Road Maintenance	National & Provincial Roads maintenance in five Provinces (Enga, Southern, Western, Eastern Highlands and Chinbu)	Project cost is US$ 114.6 M (US $ 60 M in Loan)

It is expected that eliminating traffic bottlenecks, lowering transportation cost, reducing traffic accidents, expansion of socio-economic activities, stabilization of the people's livelihood and improvement of security will result from the project implementation.

As a project to improve the Highlands Highway, the Government of PNG asked the Government of Japan for a grant aid for the replacement of 12 single-lane bridges. The requested bridges, located on the highway in Goroka district in the Eastern Highlands Province, have deteriorated due to aging over 40 years, become traffic bottlenecks because of narrow one lane width, have insufficient load carrying capacities, and show inadequate channel clearances, that pose a risk of washout.

The Government of PNG intended to replace these aged bridges with new two-lane bridges. If the bridge replacement project requested to Japan is realized, it could contribute to the rehabilitation of

the 80km road between Kainantu and Goroka. This is the most costly section of the 605 km rehabilitation plan for the highway because there are many bridges.

2-1-3 Determination of Bridges selected for Assistance and Improvement Priorities

2-1-3-1 Background to Determination of Assistance for Bridges

The scope of the works requested by the Government of PNG is mentioned above, i.e. 11 one lane bridges located near Goroka, and additionally, Bitija bridge totaling 12 to be replaced with new two lane bridges for provision of smooth transportation over the Highlands Highway. However, there would remain 11 one lane aged bridges between Kainantu and Watarais. If one of those is damaged or washed out, the project target to provide smooth transportation over the Highlands Highway will not have been accomplished. Therefore, the scope of the work has been modified from 11 one lane bridges located near Goroka plus the Bitija Bridge to add the 11 one lane aged bridges between Kainantu and Watarais totaling 23 bridges at the initial stage and selection of priority assistance for 12 bridges among the 23 surveyed bridges taking into account urgency and commitment by the other donors. In addition to this, a word "Replacement" in the request is replaced with "Rehabilitation" considering possible reinforcement or retrofitting of the single lane bridges.

2-1-3-2 Inspection of 23 Bridges and Selection of 12 Bridges

The existing condition of the 23 surveyed bridges, consisting of 22 one lane bridges located between Goroka and Wataris and also the Bitija Bridge, were visually inspected and rated from view points of extent and degree of defects, adequacy degree of channel clearance and approach road alignment condition. These three evaluation items have weighted points, such as 50 points for extent and degree of defects, 35 points for adequacy degree of channel clearance and 15 points for alignment condition, and a bridge with a higher score in total indicates a higher priority for rehabilitation. Table 2-2 shows rating criteria of each main evaluation item.

Table 2-2 Rating Criteria for Evaluation of Bridge Condition

Main Evaluation Items	Evaluation Sub Items and Rating Criteria	Rating		
		A	B	C
Extent and Degree of Defects	Main girders	8	4	0
	Deck slabs	13	7	0
	Parapet walls	0.5	0.3	0
	Pavement	0.5	0.3	0
	Expansion joints	0.5	0.3	0
	Drains	0.5	0.3	0
	Abutments	13	7	0
	Piers	13	7	0
	Wing walls	0.5	0.3	0
	Bank Protection	0.5	0.3	0
	Subtotal	50	27	0
Adequacy Degree of Channel Clearance	Clearance below Girder less than 0.0 m	35		
	Clearance below Girder less than 0.5 m		18	
	Clearance below Girder more than0.5 m			0
Alignment of Approach Road	Radius less that 100m, and beginning and end of curve w/in Stopping Distance	15		
	Radius more that 100m, and beginning and end of curve beyond stopping distance		8	
	Radius more than 200m, and beginning and end of curve w/in Stopping Distance			0
Point in Total		100	53	0

For evaluation of extent and degree of defects, each bridge component was evaluated and rated with the following 3 ranks:

A : severe deterioration needing urgent rehabilitation.
B : moderate damage requiring periodic inspection and repair needed within 5-10 years.
C : light or no damage.

The total rating of a bridge is evaluated by the total of component ratings.

The adequacy degree of channel clearance was surveyed by interview with the local residents at each bridge site about the clearance between the soffit level of the girder and flood water level, and evaluated based on the rating criteria given in Table 2-2.

Also, the alignment of the approach road was surveyed at sites and evaluated based on the rating criteria given in Table 2-2.

Based on the rating criteria as mentioned above for evaluation of bridge condition, each evaluation item was rated with points and rated points were aggregated in total for each of the 23 surveyed bridges as summarized in Table 2-3.

Table 2-3 Rating Results of Existing Condition for 23 Surveyed Bridges

No	Bridge Name	Evaluation Item														Ranking	Group for Rehabilitation of Existing Bridges			Other Donor's commitment
		Bridge Condition Rating of each member											HWL & river width	Alignment of Approach Road	Total Points		I First Priority	II Second Priority	III Discarded	
		Main girder 8	Deck slab 13	Parapet /railing 0.5	Surf. 0.5	Joint 0.5	Drainage 0.5	Abut. 13	Pier 13	Wing. 0.5	Reve. 0.5	Sub total 50	35	15	100					
1	Bitija	C	C	C	C	C	C	C	C	C	C		C	C						
												0			0	23			◎	
2	Undono	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	Yumi Yet
3	Tapiruna	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	Yumi Yet
4	Darasimpi	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	Yumi Yet
5	Luwin	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	Yumi Yet
6	Namupimpa	C	C	A	C	C	C	C	C	C	C		B	C						
				0.5								0.5	18		18.5	6		◎		Yumi Yet
7	Banepa	C	C	A	C	C	C	C	C	C	C		A	A						
				0.5								0.5	35	15	50.5	1	◎			AusAID
8	Orompaka	C	B	A	C	C	C	C	C	C	C		C	C						
			7	0.5								7.5			7.5	12		◎		
9	Nonompinka	C	B	A	C	C	C	C	C	C	C		C	B						
			7	0.5								7.5		8	15.5	9		◎		
10	Honeranka	C	B	A	C	C	C	C	C	C	C		B	B						
			7	0.5								7.5	18	8	33.5	4	◎			
11	Ofiga	C	B	A	C	C	C	C	C	C	C		C	C						
			7	0.5								7.5			7.5	12		◎		
12	Umbaka	C	C	A	C	C	C	B	C	C	C		C	C						
				0.5				7				7.5			7.5	12		◎		
13	Kingkio	C	C	A	C	C	C	A	C	C	C		C	C						
				0.5				13				13.5			13.5	11		◎		
14	Avani	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	
15	Kamanotina	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	
16	Kurongka	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	
17	Berefi	C	C	A	C	C	C	C	C	C	C		C	C						
				0.5								0.5			0.5	15			◎	
18	Dirty Water	A	C	A	C	C	C	C	C	C	C		B	A						
		8		0.5								8.5	18	15	41.5	2	◎			
19	Siguya	C	C	A	C	C	C	C	C	C	C		C	A						
				0.5								0.5		15	15.5	9		◎		
20	Yasifo	C	C	A	C	C	C	C	C	C	C		B	C						
				0.5								0.5	18		18.5	6		◎		
21	Parirosay	C	C	A	C	C	C	C	C	C	C		B	C						
				0.5								0.5	18		18.5	6		◎		
22	Bena Bena	C	C	B	C	B	C	C	B	C	C		B	C						
				0.3		0.3			7			7.6	18		25.6	5	◎			
23	Sunufamu	C	C	A	C	C	C	C	C	C	C		A	C						
				0.5								0.5	35		35.5	3	◎			

: Bridges determined for Japanese Assistance

2-1-3-3 Determination of Assistance for Bridges

In addition to the evaluation of bridge condition, interview surveys with regard to commitment from other donors for bridge improvement/rehabilitation was carried out and the bridges, which were committed to any other donor, were passed over for consideration. Among the remaining bridges, the bridges with higher score from 1st to 12th were determined for assistance of the Japan's grant aid. The determination of assistance for bridges is summarized in Table 2-4.

Table 2-4 Determination of Bridges selected for Assistance

Bridge Name	Location (distance from Lae, km)	Bridges originally requested by PNG	Inspection results (damage rate)	Assistance by other Donors	Bridges determined for Japanese Assistance
Bitija	155.0	○	C	No plan	―
Undono	176.5	―	C	Yumi Yet	―
Tapiruna	178.2	-	C	Yumi Yet	―
Darasimpi	196.7	-	C	Yumi Yet	―
Luwin	198.4	-	C	Yumi Yet	―
Namupimpa	203.8	-	B	Yumi Yet	―
Banepa	208.6	-	A	AusAID	―
Orompaka	218.8	-	B	WB / 1	○
Nonompinka	219.0	-	A	WB / 1	○
Honeranka	221.0	-	B	WB / 1	○
Ofiga	221.3	-	B	WB / 1	○
Umbaka	222.2	-	B	WB / 1	○
Kingkio	232.3	○	B	No plan	○
Avani	234.9	○	C	No plan	―
Kamanotina	246.6	○	C	No plan	―
Kurongka	246.8	○	C	No plan	―
Berefi	248.1	○	C	No plan	―
Dirty Water	255.4	○	A	No plan	○
Siguya	263.6	○	B	No plan	○
Yasifo	269.0	○	B	No plan	○
Parirosay	269.9	○	B	No plan	○
Bena Bena	277.9	○	A	No plan	○
Sunufamu	282.8	○	A	No plan	○

Notes
○: Applicable
-: Not applicable or passed over
A: High priority
B: Moderate priority
C: Low priority
/1: Additional five bridges, which were not included in the original request from PNG and were scheduled to implement under WB, were changed from WB to JICA by a request from the government of PNG.

2-1-3-4 Rehabilitation Priority for Assistance for Bridges

Further evaluation of assistance for the selected 12 bridges was carried out in order to prioritize the rehabilitation order of each bridge. The evaluation items consist of damage, durability, functional and socio-economic influence aspects, and the total aggregated rated point of each item indicates the urgency of bridge rehabilitation. These priority evaluation criteria are shown in Table 2-5.

Table 2-5 Evaluation Criteria for Rehabilitation Priority

Evaluation Item	Sub items	Criteria	Stanard Rating		
			Point	Multiply Factor	Adjusted Point
Damage	1)Extent of Damage (Main Member:Girder、Deck slab、Abutment、Pier)	A: Severe damages requiring urgent repair	5	4	20
		B: Moderate damages requiring periodic inspecti and repair work needs within 5-10 years	1.5	4	6
		C: No or less damages	0	4	0
Durability	2)Durability of Main Girder	Not meeting present design requirements	5	2	10
		Meeting present design requirements	0	2	0
	3)Durability of Deck Slab	Not meeting present design requirements	5	2	10
		Meeting present design requirements	0	2	0
	4)Durability of Abutments	Not meeting present design requirements	5	2	10
		Meeting present design requirements	0	2	0
	5)Durability of Piers	Not meeting present design requirements	5	2	10
		Meeting present design requirements	0	2	0
	Subtotal				40
Function	6)Adequacy degree of bridge opening	Clearance below Girder to HWL < 0m	5	4	20
		Clearance below Girder to HWL < 0.5m	1.5	4	6
		Clearance below Girder to HWL > 0.5m	0	6	0
	7)Ratio of Passing time and Running across time (Q)	Q > 1.0	5	1	5
		Q < 1.0	0	1	0
	8)Availability of sidewalk	Available	5	1	5
		Not Available	0	1	0
	Subtotal				30
Socio-Economic Influence	9)Number of Pedestrian	More than 1000 people	5	1	5
		More than 500people	2.5	1	2.5
		Less than 500 people	0	1	0
	10)Bridge Length	More than 100m	5	1	5
		More than 50m, but less than 100 m	2.5	1	2.5
		Less than 50m	0	1	0
	Subtotal				10
Total					100

Based on the above criteria each bridge was evaluated for assistance and rated with corresponding points. The evaluation results and priority order for rehabilitation, i.e. higher score means higher priority, is tabulated in Table 2-6.

Table 2-6 Rehabilitation Priority for Bridges selected for Assistance

Bridge No.	Bridge Name	Rating Point											Priority
		Damages<20>	Durability <40>				Function <30>			Socio-Economic <10>		Total Point	
		Extent of Damage	Girder	Deck Slab	Abutment	Pier	Bridge Opening	Passing Time	Sidewalk	No. of Pedestrian	Structure Length		
		20	10	10	10	10	20	5	5	5	5	100.0	
1	Orompaka	6	0	10	0	0	20	0	0	0	0	36.0	4
2	Nonompinka	6	0	10	0	0	10	0	0	0	0	26.0	7
3	Honeranka	6	0	10	0	0	20	0	0	0	0	36.0	4
4	Ofiga	6	0	10	10	0	0	0	0	0	0	26.0	7
5	Umbaka	6	0	10	10	0	0	0	0	0	0	26.0	7
6	Kingkio	20	0	10	0	0	0	0	0	0	0	30.0	6
7	Dirty Water	20	10	0	0	0	0	5	0	2.5	2.5	40.0	3
8	Siguya	0	0	10	0	0	0	0	0	0	0	10.0	11
9	Yasifo	0	0	10	0	0	0	0	0	0	0	10.0	11
10	Parirosay	0	0	10	0	0	0	0	0	2.5	0	12.5	10
11	Bena Bena	6	0	10	0	10	10	0	5	2.5	5	48.5	1
12	Sunufamu	6	0	10	0	0	20	0	0	5	0	41.0	2

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

(1) Policy to Determine Assistance for Bridges and Improvement Methods

In this basic design study, the number of surveyed bridges was expanded to more than requested by the Government of PNG after examining the request, and the bridges to be assisted by the Japan's grant aid were determined based on an extensive field survey for bridges by the study team.

As regards the bridge improvement method, although the Government of PNG intended to replace all the requested bridges with new two-lane bridges, the possibilities for reuse of the existing bridge components were studied as an alternative improvement method after a study of load carrying capacities of the components for the realization of a more economical improvement plan.

Moreover, considering the small sizes of the surveyed bridges, the policy to actively adopt more economical bridge structural types and construction methods was taken for planning their improvement.

(2) Consideration for Social and Natural Surroundings at Bridge Sites

DoW reported that the Right of Way (ROW) along the study bridge sites in the Highlands Highway had been acquired and registered under the state lands with 20 m each side from the center line totaling 40 m. The study area is relatively well populated and cultivated compared with the sites of Umi Bridge, Leron Bridge and Bitija Bridge constructed under the previous Japan's Grant Aid. Taking into account that a main point for smooth project implementation is to eliminate any troubles with local residents, a design concept applied in the Study is to layout permanent structures within the available ROW and also to minimize the damage to crops affected by temporary works.

2-2-1-2 Policy for Natural Environment

(1) Meteorological Condition

The annual rainfall at Goroka, located at the Western tip of the study, area is about 1,700 mm – 1,900 mm, and the maximum and minimum monthly rainfall months are March and June respectively. Therefore, the period from May to October is the dry season, while the rainy season is from November to April. Temperature fluctuation thorough a year is relatively small ranging from 28 centigrade to 7 centigrade. As such it is desirable in the work scheduling that river piers and detour roads over a river shall be constructed/utilized during the dry season in order to minimize the scale of the temporary facility required.

(2) Earthquake Condition

Because PNG is situated in one of the world's great earthquake zones, the past earthquake records within a radius of 30km around the geographical study area were obtained from the United States Geological Survey (USGS) for the purpose of calculation of seismic response acceleration spectrum. Table 2-7 shows the top 10 strongest earthquakes that occurred in the past within a radius of 200km around the geographical study area.

Table 2-7 Historical Earthquake Records around the Study Area

Order	Date	Location of epicenter		Depth of Epicenter (km)	Magnitude
		latitude	longitude		
1	1993/10/13	5°89′S	146°02′E	25	7.20
2	1992/05/15	6°07′S	147°57′E	58	7.10
2	1993/10/25	5°91′S	145°99′E	30	7.10
4	1984/03/27	4°65′S	145°80′E	27	6.80
5	1993/10/13	5°93′S	146°15′E	33	6.70
5	2000/03/03	6°82′S	143°81′E	10	6.70
7	1992/02/27	6°19′S	147°19′E	38	6.60
8	1993/10/16	5°90′S	146°20′E	27	6.50
8	1997/04/05	6°49′S	147°41′E	69	6.50
10	1981/10/04	4°57′S	146°12′E	33	6.40
10	1999/04/06	6°53′S	147°01′E	33	6.40
10	2001/06/05	6°88′S	146°39′E	10	6.40

Source: USGS Earthquake Data Base

Based on above data, maximum acceleration with a 100 year return period is estimated at 120 gal (equivalent to seismic coefficient: 0.12).

The seismic coefficient was calculated as follows in accordance with Earthquake Engineering for Bridges in Papua New Guinea, 1985 Revision.

$Kh = C \cdot I \cdot M$

Where

Kh : Seismic Coefficient=0.17
C : Basic Seismic Coefficient =0.14(Zone3)
I : Importance Factor =1.2 (Arterial Road)
M : Material Factor =1.0(Concrete)

As shown in above, a basic seismic coefficient of 0.14 is applied in Earthquake Engineering for Bridges, while 0.12 is estimated from historical earthquake data. Hence, a basic seismic coefficient of 0.14, which is greater than the other is applied in the Study, so that applicable seismic coefficient is 0.17.

(3) Hydrology and River Condition

Since flood discharge data of the rivers at the surveyed bridge sites are very limited, the flood discharge is estimated based on the PNG Flood Estimation Manual of 1990 by SMEC. The return period applied in the Study is 50 years considering the importance of the bridge structures. It is however noted that a 5 year return period is used for temporary facilities such as coffer dams and opening of detour roads.

The estimated flood discharges with a 50 year return period, velocity, flood level and allowance between girder soffit and flood level in accordance with above Manual are tabulated in Table 2-8.

Table 2-8 Hydrographic Data at Bridge Sites

No.	Bridge Name	River Name	Catchment Area(km²)	Flood Discharge (m3/sec)	Velocity (m/s)	Flood Level (m)	Elevation of Girder Soffit (m)	Clearance (m)
1	Orompaka	Namura	70	180	4.5	1742.7	1742.5	-0.2
2	Nonompinka	Tributary of Namura	12	50	2.4	1742.7	1742.8	0.1
3	Honeranka	Namura	47	130	4.1	1761.6	1761.9	-0.3
4	Ofiga	Namura	9	40	1.4	1765.0	1768.2	3.2
5	Umbaka	Umbaka	8	40	3.0	1779.1	1780.8	1.7
6	Kingkio	Tributary of Gaftino	4	25	2.8	1637.1	1639.4	2.3
7	Dirty Water	Dunantina	300	650	5.6	1553.7	1555.5	1.8
8	Siguya	Tributary of Dunantina	21	70	3.7	1545.0	1548.0	3.0
9	Yasifo	Tributary of Dunantina	9	40	3.5	1507.6	1509.2	1.6
10	Parirosay	Tributary of Dunantina	22	75	6.1	1495.7	1499.3	3.6
11	Bena Bena	Bena Bena	370	950	4.5	1371.8	1372.1	0.3
12	Sunufamu	Tributary of Asatro	17	60	2.9	1373.5	1372.5	-1.0

(Data Source: Study Team)

It can be concluded based on Table 2-8 that Orompaka Bridge, Honeranka Bridge, Sunufamu Bridge and Bene Bena Bridge are of inadequate channel clearance to handle the design flood and these bridges require raising of the grade. It is noted that the grade of Nonompinka Bridge will not be raised considering a magnitude of the flood and a scale of the bridge even though the channel clearance is slightly insufficient.

2-2-1-3 Policy for Social Condition

(1) Traditional Land Tenure System

The principal form of land tenure within PNG is customary and accounts for about 97 % of the occupancies with the remaining 3% being purchased or leased State Land. This traditional land tenure induces difficulty in smooth implementation of public works projects if additional land acquisition is required. Under such a system, it is one of the concepts that the project facilities shall be laid out within the ROW limit of 20 m each side from the road centerline reported by DoW and the area affected by the temporary work shall be also minimized to eliminate compensation for cash crops.

Nevertheless, it is strongly suggested to assign a community liaison officer in the Provincial Work Manager's Office to cope with various problems with local communities since problems related with the compensation and ROW will arise during the implementation.

(2) Security Issues

Vicious crime incidents are increasing, especially in urban area and public security in PNG is becoming worse and worse. It has been reported that even in the project sites slow moving vehicles on steep gradients and supermarkets in the cities are being robbed.

Under such a situation, it is strongly requested to assign an adequate number of Policeman for ensuring security at project camp yards and traffic safety at each bridge site with the PNG side covering the expense, in addition to assignment of security guards by the civil work contract.

2-2-1-4 Policy for Construction Conditions

(1) Labor Condition

A minimum wage in PNG has been established but not updated and not applied in the private sector due to the high inflation rate. Labor force, except specialized skilled labors, can be procured locally, but wage rates compared with those in previous projects are increased considerably due to the recently raised inflation rate. Moreover, foreign engineers or expatriate foreman for bridge works are assigned commonly at present.

In this study, the construction work under the Japan's grant aid was planned with a policy to employ labors as well as engineers and technicians within PNG giving on-the-job training to them. However, for a shortage of engineers and technicians in PNG, it was intended to mobilize them from Japan.

(2) Procurement Condition for Construction Equipment and Materials

1) Cements

The sole cement factory in PNG, PNG Taiheiyo Cement Limited is in Lae city. This company is a wholly owned subsidiary of Taiheiyo Cement Limited in Japan and is producing the cement using clinker made in Japan. Annual production is 90,000 ton at present, even through the maximum capacity is 20,000 ton. The cement quality meets the requirements in accordance with ASTM-C150. It is therefore concluded that the cement available is acceptable to the Project in

terms of the capacity and quality.

2) Reinforcement Bars

There are several local suppliers such as Atlas Steel Pty. Ltd. in Lae that are importing rebars from the neighboring countries of Australia and New Zealand. The rebars are produced in accordance with Australian Standard. It is therefore planned these rebars will be utilized in the Project.

3) Structural Steel and Steel Bridge Fabricators

NGI Steel Ltd., Niugini Steel Corporation Ltd. and Markham Culverts Ltd. are steel bridge fabricators and suppliers of steel materials in PNG. The cost from and capability of these three companies are compared with those from fabricators in neighboring countries and the most reliable and economical quotation will be selected.

4) Secondary Steel Products

Atlas Steel Ltd., Markham Culvert Ltd. and several other companies in Lae are dealing with secondary steel products imported from the neighboring countries. Hence, these materials are to be procured locally for the Project.

5) Asphalt Concrete

At present, no asphalt batching plant exist along the Highlands Highway including the cities of Lae and Madang. For surfacing on the concrete deck, it is planned that cold asphalt mixture will be procured and transported for the Project.

(3) Applicable Technical Standards for Road and Bridge Designs

In PNG, the relatively simple Road Design Manual is available as a Geometric Design Standard, while no Bridge Design Standard is available. Hence, various funding agencies have applied their own standards in the projects. However, most of the bridges have been designed in accordance with Austroads (Australian Road & Bridge Standard) since aids packages from AusAID are dominant in PNG.

In this Study, the Road Design Manual and Austroads mentioned above were applied in principle with supplementation by the various Japanese Standards to design items where the standards available do not clearly cover the issues.

2-2-1-5 Policy for Utilization of Local Contractors

Based on information regarding the contractors that have undertaken previous Japan Grant Projects and the contractors recommended by DoW, a list of contractors likely to be capable to subcont for the Project has been prepared and those has been requested to submit company profiles, a list of similar project experiences, and a list of construction equipment owned by the company.

Those data received from some of them have been evaluated and it is consequently concluded that the following contractors will be capable to undertake a part of the Project as a subcontractor.

- Curtain Bros Papua New Guinea Limited
- Dekenai Constructions Limited
- Global Constructions Limited
- Flecher Morobe Construction Limited

Most of the contractors available in PNG are subsidiaries of companies in the neighboring

countries of Australia and New Zealand. They generally have common characteristics such as top management and field supervisors are foreigners, and experience in pre-cast construction methods. This could be beneficial considering the luck of local skilled labors, which in turn can induce high construction cost.

2-2-1-6 Policy for Operation and Maintenance Capability of the Implementing Agency

Over the past ten years, the Department of Works, the Implementing Agency of the Project, which was established on June 2000, has undergone significant change in organization i.e. amalgamation or separation with the Department of Transport. Such changes resulted in loss of key expertise and knowledge, severe decline in moral and dissolution of the work culture. In addition, the DoW has been continuously in shortage of budget resulting from the financial difficulty at the national level.

In order to ensure that the recipient country's obligation will be carried out on a timely manner, it is required to inform PNG of such obligation in writing including the detailed work items, estimated cost and duration of each work item and the deadline for completing the work and to closely monitor the implementation status of the work.

2-2-1-7 Policy of Grade Setting for Facility (Bridge) Improvement

(1) Policy for Selection of Improvement Methods and Scope

1) Cost Reduction by Reuse of Existing Bridges

Based on the assessment of the load carrying capacity of structural components in the study bridges under application of the present design standards, a rehabilitation method, including reinforcement or retrofitting of the existing members, will be studied as an alternative from the view point of maximum usage of the existing members and the most appropriate rehabilitation method will be selected from the economical aspect.

2) Economical Bridge Replacement Design

Most of the bridges selected for assistance are relatively small in size as their bridge lengths are not over 24m except Bena Bena and Dirty Water Bridges, which are in moderate size. Taking into account such small bridge sizes, low cost bridge types and construction methods will be selected in order to reduce the total construction cost.

3) Scope of Improvement for Approach Roads and Bank Protection

The improvement of the approach roads will be planned so as to connect with bridges by the most direct route. Bank protection provided will be limited to the area required to protect the improved bridges.

(2) Policy for Improvement with Dual Lane Bridges

The necessity of dual lane bridges, instead of single lane bridges studied at present, was assessed based on 1: quantitative evaluation of traffic volume and time required to cross each bridge, 2: the Government Policy on single lane bridges, plans or commitment for each bridge by other donors and traffic accident records for each bridge. Based on these assessments, it was decided that all the bridges selected for assistance should be improved to dual lane bridges. The reasons for this assumed need for dual lane bridges are explained as follows:

a) Evaluation of Traffic Volume and Crossing Time on a Bridge

Considering that the Highlands Highway is a sole arterial highway in PNG, it is, in principle, desirable that there be no waiting time to cross a bridge.

The necessity of dual lane bridges is assessed based on comparison of the average time

between oncoming vehicles calculated from the 24 hour traffic volume with the measured bridge crossing time for vehicles. Using a peak ratio of 15.8% and a direction ratio of 50.0 % from the 24 hr traffic counting surveys, peak traffic volume per hour is estimated at 66.9 vehicles per hour. Assuming average traffic speed of 35 km/hr, the average time required to cross a bridge and the average time between oncoming vehicles were calculated as shown in Table 2-9.

Table 2-9 Required Interval and Passing Time between Oncoming Vehicles

Daily Traffic Volume	847.0	vehicle
Peak Ratio	15.8	%
Direction Ratio	50.0	%
Peak Hour Traffic Volume /Direction	66.9	vehicle
Average Traffic Speed per hr.	35.0	km/hr
Average Traffic Speed per sec.	9.7	m/sec
Distance between each vehicle	523.1	m
Required Time To Pass Each other	53.8	sec
Time between Oncoming Vehicles	26.9	sec

From Table 2-9, it can be said that a vehicle can pass on a bridge without waiting if the crossing time on the bridge is less than 26.9 sec.

On the other hand, the crossing time on each study bridge (three sample vehicles taken in each direction) was measured at the site. Among the six crossing times measured at each site, the longest time is applied for comparison with the time between vehicles approaching from different directions. The survey results and comparison of these are tabulated in Table 2-10.

Table 2-10 Summary of Bridge Passing Time Surveys and Comparison

No.	Bridge Name	Location from Lae	Bridge Type	Distanc Between Stop Lines	Bridge Length	Direction	Passing Time on Bridge (sec)(1)	Speed (m/sec)	Passing Time of Each Vehicle (2)	Ratio (1)/(2)
0	Bitija	155.0	H steel girder bridge	98.0	49.2	From Lae	10.0	9.8	36.8	0.2
						For Lae	9.0	10.9		
1	Orompaka	218.8	H steel girder bridge	89.0	21.1	From Lae	15.0	5.9	26.9	0.6
						For Lae	16.0	5.6		
2	Nonompinka	219.0	H steel girder bridge	89.0	14.9	From Lae	15.0	5.9	26.9	0.6
						For Lae	16.0	5.6		
3	Honeranka	221.0	H steel girder bridge	74.0	18.1	From Lae	10.0	7.4	26.9	0.4
						For Lae	12.0	6.2		
4	Ofiga	221.3	H steel girder bridge	74.0	24.1	From Lae	10.0	7.4	26.9	0.4
						For Lae	12.0	6.2		
5	Umbaka	222.2	H steel girder bridge	82.0	12.0	From Lae	12.0	6.8	26.9	0.5
						For Lae	14.0	5.9		
6	Kingkio	232.3	H steel girder bridge	85.0	15.0	From Lae	12.0	7.1	26.9	0.4
						For Lae	12.0	7.1		
7	Dirty Water	255.4	Through truss bridge	105.0	49.0	From Lae	38.0	2.8	26.9	1.4
						For Lae	19.0	5.5		
8	Siguya	263.6	H steel girder bridge	73.0	18.0	From Lae	9.0	8.1	26.9	0.4
						For Lae	10.0	7.3		
9	Yasifo	269.0	H steel girder bridge	45.0	18.0	From Lae	8.0	5.6	26.9	0.3
						For Lae	7.0	6.4		
10	Parirosay	269.9	H steel girder bridge	74.0	24.0	From Lae	8.0	9.3	26.9	0.4
						For Lae	11.0	6.7		
11	Bena Bena	277.9	H steel girder bridge	165.0	96.0	From Lae	24.0	6.9	26.9	0.9
						For Lae	18.0	9.2		
12	Sunufamu	282.8	H steel girder bridge	64.0	12.0	From Lae	9.0	7.1	26.9	0.4
						For Lae	10.0	6.4		

As indicated in Table 2-10, a dual lane improvement for Dirty Water and Bena Bena Bridges is a high priority, while the priority of Yasifo Bridge is low.

It is noted that the necessity of widening Bitija Bridge is not technically justified since the crossing time on the bridge is 10.0 sec against the time between vehicles approaching from different directions being 36.8 sec (ratio 0.2); this indicates a very low priority.

b) DoW's Policy of Improvement with Dual Lane Bridges and Lane Number/Width of the Other Donor's Assistance Bridges

The Government of PNG has prioritized widening of single lane bridges along the National Highway as stated in the National Transport Development Plan: 2001-2010. In line with this policy, AusAID and Yumi Yet Project (UK) have provided assistance to the bridge widening project for single lane bridges along the Highlands Highway. Furthermore, it has been planned by the Donors that single lane bridges will be widened to dual lane bridges in the Highlands Highway Rehabilitation Project under World Bank, Bridge Replacement Project under AudAID, and Yumi Yet Project (UK).

c) Traffic Accident Records on the Highlands Highway at Single Lane Bridges

The traffic accident records over the past five years obtained from Goroka Highway Patrol Unit of the Royal Papua New Guinea Constabulary indicated that frequent accidents with casualties were seen at narrow single lane bridges.

d) Appropriateness of Two Lane Bridge Improvement

The bridge time analysis of oncoming traffic resulted in all the bridges selected for assistance, other than Dirty Water and Bena Bena Bridge, being sufficient with the single lane width based on the present traffic volumes. However, considering the above-mentioned facts i.e. that the DoW's policy was to improve to two-lane bridges, the bridge improvement projects on the Highlands Highway by other donors were already in progress with two lanes, and frequent traffic accidents were seen at narrow single lane bridges, it was concluded that all the bridges selected for assistance be improved with two lanes.

(3) Rehabilitation Plan for Bridges selected for Assistance

1) Assessment of Load Carrying Capacities and the Functions of Bridges selected for Assistance

Durability of the main components of existing bridges was assessed from a load carrying capacity aspect based on the detailed bridge survey of the 12 bridges selected for assistance.

The scope of the detailed bridge survey consists of measurement of the structural dimensions, rebar arrangement survey, and material strength survey. The measurement of the structural dimensions was carried out using a measurement tape to measure dimensions of the structural members. The rebar survey was conducted using a rebar detector and exposing by chipping the deck slabs and piers of major bridges such as Bena Bena. Consequently, it was detected that the size of the main rebars, spacing and concrete cover is respectively D 16 mm, 150 mm and 40 mm in the deck slabs, and D 16 mm, 150 mm and 75 mm in the piers. The material strength survey indicates that the concrete strength using a Schmidt hammer is estimated at 26 N/mm2 on average in the deck slab and at 21 N/mm2 on average in the piers. Tensile strength of the steel and rebars is 350 N/mm2 (yield strength) of H beams, 300 N/mm2 (yield strength) of deformed bars and 240 N/m m2 (yield strength) of round bars.

A structural analysis based on the above data was conducted in application of the present design criteria to estimate max. working stresses and safety factor (allowable stress divided by working

stress), i.e. a bridge member has enough durability if the safety factor is more than 1.0, but if not the member has inadequate load carrying capacity. The result of this analysis is shown in Table 2-11.

Table 2-11 Assessment Results of Bridge Capacity

No.	Bridge Name	Superstructure				Substructure			Abut.	Allowance of Bridge Clearance (m)
		Slab	H Beam	Truss		Abut	Pier		Nos of Piles	
				Chord	Dia. Chord	Pile	Column	Pile		
1	Orompaka	0.44	1.02	xxxx	xxxx	1.68	xxxx	xxxx	4	-0.2
2	Nonompinka	0.44	1.03	xxxx	xxxx	1.43	xxxx	xxxx	3	0.1
3	Honeranka	0.44	1.13	xxxx	xxxx	2.22	xxxx	xxxx	4	-0.3
4	Ofiga	0.44	1.19	xxxx	xxxx	0.22	xxxx	xxxx	2	3.2
5	Umbaka	0.44	1.59	xxxx	xxxx	0.22	xxxx	xxxx	2	1.7
6	Kingkio	0.44	1.03	xxxx	xxxx	1.68	xxxx	xxxx	4	2.3
7	Dirty Water	1.11	xxxx	0.85	0.55	1.54	xxxx	xxxx	8	1.8
8	Siguya	0.44	1.13	xxxx	xxxx	1.03	xxxx	xxxx	S. F.	3.0
9	Yasifo	0.44	1.13	xxxx	xxxx	1.68	xxxx	xxxx	4	1.6
10	Parirosay	0.44	1.15	xxxx	xxxx	1.03	xxxx	xxxx	S.F.	3.6
11	Bena Bena	0.44	1.19	xxxx	xxxx	1.54	0.70	0.91	4	0.3
12	Sunufamu	0.44	1.59	xxxx	xxxx	1.43	xxxx	xxxx	3	-1.0

Notes: Figures in above mean safety factor of member.
Colored column means inadequate capacity

As indicated in Table 2-11, all of the deck slabs, except that of Dirty Water, the chord members of Dirty Water, and the piers and foundation of Bena Bena are of inadequate load carrying capacity, and allowance of bridge clearance or channel clearance of Orompaka, Nonompinka, Bene Bena and Sunufamu is also insufficient. As such, countermeasures such as reinforcement or rehabilitation for these inadequate members and bridge functions are required.

2) Study on Rehabilitation Plans

Taking into account the design policy of widening bridges from single lane to dual lane and the assessment results of bridge capacity, rehabilitation plans for the 12 bridges selected for assistance was studied.

Dirty Water, Bena Bena and Sunufamu Bridges are of considerably inadequate durability or obviously insufficient channel clearance, so that extensive rehabilitation will be required. As such, rehabilitation alternatives, including total replacement or improvement are studied to select an optimum rehabilitation plan. On the other hand, the other study bridges, except those three bridges, are small scale with inadequate loading capacity of only a few members or with slightly insufficient channel clearance, so that a rehabilitation plan of widening of the existing single lane bridge with reinforcement will be mainly studied.

a) Study on the Rehabilitation Plan for the Bena Bena Bridge

Considering the defects in the Bena Bena Bridge including inadequate load carrying capacity of the deck slab, pier column and foundation and hydraulic problems (damming phenomenon at the upstream side due to topographic stricture and inadequate channel clearance), a comparative study of alternatives consisting of Alternative-1: Replacement with a dual lane bridge and Alternative-2: Improvement of the Existing Bridge plus Construction of a Single Lane Bridge was carried out. Resulting from this study as shown in Table 2-12, Alternative-1: Replacement with dual lane bridge was selected as the most suitable.

Table 2-12 Alternative Study on the Rehabilitation Plan for Bena Bena Bridge

Alternative		Evaluation Criteria							
		Construction Cost (60)	Structural Aspect (5)	Construction Aspect (10)	Construction Period (10)	Hydraulic Aspect (5)	Road Alignment (5)	Maintenance (5)	Overall Result (100)
Alternative-1 Replacement with Dual Lane Bridge Construction of Two Lane Bridge with 120 m beside existing.	Evaluation	The work is standard and this alternative is cheaper than Alt-2.	Proposed height is 1.3m higher than the original but aseismicity and structural aspect is superior to Alt-2.	Construction aspect is good.	About 14 months	Eliminating damming phenomenon induces sub critical flow.	S-curve in approach road.	Less maintenance than Alt-2	Selected
	Rating	60	5	10	10	5	2	5	97
Alternative-2 Reinforcement of Existing Bridge plus Construction of One Lane Bridge Raising of Grade、Extension of Bridge Length, Reinforcement of Substructure, plus Construction of One Lane Bridge	Evaluation	The work is very complicated and the cost is about 30 % higher than that of Alt-1	All substructures require reinforcement. Reliability and aseismicity is inferior to Alt-1.	Because of major reinforcement work, construction aspect is very poor.	Complicated and duplicate work takes longer period, about 18 months.	Damming phenomenon is eliminated. But severe hydraulic issues are remaining.	Same as existing.	Much maintenance for possible local scoring and expansion joints	Discarded
	Rating	45	0	2	7	2	5	2	63

Note：The figure in ( ) indicates weighted rating point.

b) Study on Rehabilitation Plan forDirty Water Bridge

The existing Dirty Water Bridge has inadequate load carrying capacity in the main truss chord members as established by the present loading standards. Comparative study of alternatives consisting of Alternative-1 Construction of a Dual Lane New Bridge and Alternative-2 Reinforcement of the Existing Bridge and Construction of a Single Lane Bridge was conducted as shown in Table 2-13. Based on this study, Alternative -1 is selected as the most suitable rehabilitation plan.

Table 2-13 Alternative Study on Rehabilitation Plan for Dirty Water Bridge

Alternative		Evaluation Criteria							
		Construction Cost (60)	Structural Aspect (5)	Construction Aspect (10)	Construction Period (10)	Hydraulic Aspect (5)	Road Alignment (5)	Maintenance (5)	Overall Result (100)
Alternative-1 Replacement with Dual Lane Bridge Construction of Two Lane Bridge with 60 m long beside Existing.	Evaluation	Alt-1 is cheaper than Alt-2.	Aseismicity and structural aspect is superior to Alt-2.	Construction aspect is good.	About 12 months	Channel clearance is inferior to Alt-2	Sharp curve in Lae side is improved.	Less maintenance than Alt-2	Selected
	Rating	60	5	10	10	3	5	5	93
Alternative-2 Reinforcement of Existing Bridge plus Construction of One Lane Bridge Reinforcement of Truss Chords, plus Construction of One Lane Bridge	Evaluation	The work is very complicated and the cost is about 50 % higher than that of Alt-1	Separated through type bridge has high possibility of member deformation by vehicle collision. Hence, structural aspect is inferior to Alt-1.	Because of complicated reinforcement work, construction aspect is very poor.	Complicated and duplicate work takes longer period, about 16 months.	No hydraulic problem because of single span.	No improvement in alignment	Much maintenance because of truss structure requiring more area of painting	Discarded
	Rating	45	2	2	8	5	3	2	62

Note：The figure in ( ) indicates weighted rating point.

c) Study on Rehabilitation Plan for Sunufamu Bridge

Considering the defects in Sunufamu Bridge including inadequate load carrying capacity of the deck slab and insufficient channel clearance, a comparative study of alternatives consisting of Alternative-1: Replacement with a dual lane bridge and Alternative-2: Improvement of the Existing Bridge plus Construction of a Single Lane Bridge was carried out. Resulting from this study as shown in Table 2-14, Alternative-1: Replacement with a dual lane bridge was selected as the most suitable option.

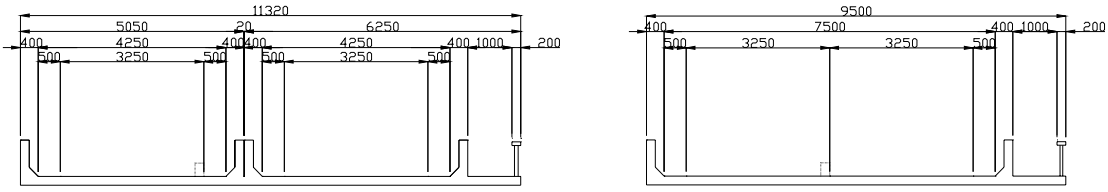
Table 2-14 Alternative Study on Rehabilitation Plan for Sunufamu Bridge

Alternative		Evaluation Criteria							
		Construction Cost (60)	Structural Aspect (5)	Construction Aspect (10)	Construction Period (10)	Hydraulic Aspect (5)	Road Alignment (5)	Maintenance (5)	Overall Result (100)
Alternative-1 <u>Replacement with Dual Lane Bridge</u> After provision of detour road, Construction of Two Lane Bridge 18 m long.	Evaluation	The work is standard and Alt-1 is cheaper than Alt-2.	Aseismicity and structural aspect is superior to Alt-2.	Construction aspect is good.	About 9 months	No problems because of single span.	Same as existing	Less maintenance than Alt-2	Selected
	Rating	60	5	10	10	5	5	5	100
Alternative-2 <u>Raising and Extension of Existing Bridge plus Construction of One Lane Bridge</u> Raising of Grade 、Extension of Bridge Length 4m, plus Construction of One Lane Bridge	Evaluation	The work is very complicated and the cost is about 30 % higher than that of Alt-1	Because of separated bridge and different span lengths, structural aspect is inferior to Alt-1.	Because of complicated work, construction aspect is very poor.	Complicated and duplicate work takes longer period, about 11 months.	Existing bridge becomes 2 span. Hence, not much improvement.	Same as existing.	Maintenance work load increase	Discarded
	Rating	40	2	2	8	2	3	3	60

Note：The figure in （ ） indicates weighted rating point.

d) Study on Rehabilitation Plan of Other Small Size Bridges

A common deficiency in the small scale bridges is inadequate load carrying capacity of the concrete deck slab against the present loading criteria. In principle, the rehabilitation plan for those bridges is widening i.e. improvement of the existing bridges and adding new single lane bridges. In this rehabilitation plan, two conceivable alternatives of Alt-1 Separated Type and Alt-2 Non Separated Type as shown in Figure 2-1 are considered in terms of jointing methods between the existing and new bridges.

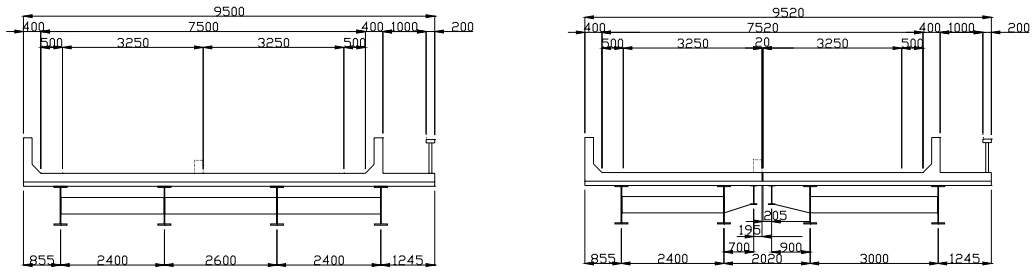


Alt-1 Separated Type　　Alt-2 Non Separated Type

Figure 2-1 Alternatives of Jointing Methods for Small Size Bridges

In comparison of Alt-1 and Alt-2 from the economical aspect, Alt-1 is about 20 % less expensive than that of Alt-1. Hence, Alt-2 Non Separated Type is selected from a cost aspect. The Non Separated Type is further subdivided into Alt-3 No Joint Type and Longitudinal Joint Type as shown in Figure 2-2. The latter may threaten traffic safety with the possibility

of accidents causing damage to the joint and requires much maintenance workload and carries a 30 % higher construction cost. Hence, Alt-3 No Joint Type was selected for the widening method.



Alt-3 No Joint Type　　Alt-4 With Longitudinal Joint Type

Figure 2-2　Alternatives of Non Separated Type for Small Size Bridges

2-2-1-8　Policy for Construction Method and Construction Period

(1)　Policy for Construction Method

The 12 bridges selected for assistance are broadly divided into two categories in terms of the rehabilitation plan. One category covers the Dirty Water Bridge, Bena Bena Bridge and Sunufamu Bridge requiring replacement with new dual lane bridges, the other category contains the 9 remaining bridges, which are all small scale bridges, to be rehabilitated by widening with improvement of the existing bridge and adding new single lane bridges.

The former is to construct new dual lane bridge either upstream or downstream beside the existing bridge, and the demolition of the existing bridge by PNG, after completion of the new bridge. The latter is to construct single lane new bridges just beside the existing bridges and subsequently to improve the existing bridges after traffic being diverted to the new single lane bridge, and finally the joint between edges of deck slabs is rigidly connected by special concrete. It is a basic policy in the detour plan during the construction in both cases to limit the work area to within the ROW available and to minimize the area of cash crops affected as much as possible.

For the three bridges that are to be replaced by new bridges, the existing bridges will be utilized as detour roads during the construction. On the other hand, except for Siguya Bridge and Parirosay Bridge, for small bridges requiring widening, a duplicate construction method is applied in principle. The sequence of that method is as follows:

First Step : Construction of a single lane bridge beside the existing bridge. During this step, the existing bridge will be used as a detour.
Second Step : After the traffic is diverted to the new bridge, the existing bridge is rehabilitated.
Final Step : Integration by installation of cross beams and joining the deck slab and approach road work will follow.

For joining the deck slab in the final step, jet concrete (which is a special concrete used to obtain 28 day concrete strength within 2-3 hours) will be used to integrate the deck slab, which must be done during periods without any vibration of the deck slab, so that this work will be carried out between midnight and 2:00 - 4:00 AM since there is no traffic at that time as per the traffic survey.

Siguya Bridge and Parirosay Bridge are small scale bridges of the spread footing type. The detour

roads will be constructed separately since large scale type sheathing will be required for construction of the new abutment. Because the bedrock is shallow and the creeks are of narrow width it will be more economical to construct the temporary detour of earth fill over a culvert. Table 2-15 shows measures for detouring traffic during construction for each bridge selected for assistance.

Table 2-15 Traffic Detouring Method during Construction

Bridge Name	Traffic Detouring Method
Orompaka	No Detour Provided, Application of Duplicate Construction Method
Nonompinka	No Detour Provided, Application of Duplicate Construction Method
Honeranka	No Detour Provided, Application of Duplicate Construction Method
Ofiga	No Detour Provided, Application of Duplicate Construction Method
Umbaka	No Detour Provided, Application of Duplicate Construction Method
Kingkio	No Detour Provided, Application of Duplicate Construction Method
Dirty Water	Existing Bridge Treated as Detour
Siguya	Provision of Embankment Detour with Pipe Culverts
Yasifo	No Detour Provided, Application of Duplicate Construction Method
Parirosay	Provision of Embankment Detour with Pipe Culverts
Bena Bena	Existing Bridge Treated as Detour
Sunufamu	Provision of Embankment Detour with Pipe Culverts

(2) Policy for Construction Period

The construction period and timing will be formulated considering the scale of the rehabilitation work, rainfall patterns, the number of workable days during the rainy season and Japan's Grant Aid system/Procedure. The construction period of small size bridge is about 7 months while the largest Bena Bena Bridge requiring replacement among the bridges selected for assistance will take 14 months for completion.

From the bridge location aspect of the 12 bridges selected for assistance, 5 small bridges consisting of Oronpaka, Nonompinka, Honeranka, Ofiga, Umbaka bridges are located within 4 km of each other near Kainantu, and the remaining 7 bridges are scattered over 50 km between Paroja Pass to Goroka through Henganofi.

Taking into account the such size and location of the bridges selected for assistance, it is planned that the construction will be divided into two phases: phase one covering the former 5 bridges in a construction period of 12 months, and phase two including the remaining 7 bridges in a construction period of 18 months.

2-2-2 Basic Plan

2-2-2-1 Overall Plan

(1) Applicable Design Conditions

In PNG, a relatively simple Road Design Manual is available as Geometric Design Standards, however, no Bridge Design Standard is available. Hence, various funding agencies have applied their own standards in the projects. However, most of the bridges have been designed in accordance with Austroads (Australian Road & Bridge Standard) since aids from AusAID are dominant in PNG.

In this Study, the Road Design Manual and Austroads mentioned above are applied in principle supplemented by the various Japanese Standards where the standards available do not clearly cover design items. Following are the main design criteria applicable to the Study.

1) Road Design Conditions

Applicable geometric design criteria in the Study are shown in Table 2-16.

Table 2-16 Road Design Conditions

Geometric Elements	Applicable Values	Remarks (Basis of Application)
-Road Classification	Rural National Road	As per Road Design Manual
-Design Speed	50 kph	Traffic Volume: More than 400, Train: Rolling
-Min. Horizontal Curve Radius	160 m recommended	Absolute Min. R=100m
-Max. Longitudinal Grade	6 %	As per Road Design Manual
-Cross slope	3 %	Surface dressing provided
-No's of Lane	Dual Lane	Refer to 2-2-1-7 (2) in this Report
-Carriageway Width	2*3.25 m=6.5 m	As per Road Design Manual / WB Rehabilitation Plan
-Shoulder Width	1.5 m	As per Road Design Manual / WB Rehabilitation Plan
-Sidewalk Width	1.0 m (Effective)	As per WB Rehabilitation Plan

2) Bridge Design Condition

Applicable bridge design criteria in the Study are shown in Table 2-17.

Table 2-17 Bridge Design Condition

Elements		Applicable Values	Remarks (Basis of Application)
-Design Flood Return Period		50 Years	PNG Manual specifies 100 years for bridges, but 50 years from Japanese Standard is applied considering scale of the study bridges.
-Clearance of Girder Soffit above Flood		0.5 m for flood less than 200 m3/sec 1.0 m for food less than 2000 but more than 500 m3/s	Traffic Volume: More than 400, Train: As per Japanese River Structure Standard
Design Load	Live Load	B Class Loading	As per Japanese Standard. B class load, which is about 10 % heavier than TL-44 loading in Austroads is suitable considering, overloaded trucks passing over the Highlands Highway.
	Seismic Load	Horizontal Seismic Coefficient	Refer to 2-2-1-2 (2) in the Report
	Thermal Load	+10 centigrade~ - 10 centigrade	As per Austroads
	Dead Load	Steel : 77 kN/m3 Reinforced Concrete : 24.5 kN/m3 Asphalts Concrete: 23.5 kN/m3	As per Austroads
Local Scoring		Dr. Suga's formula	As per Japanese Standard
Concrete Strength		Substructure : 21 N/mm2 Deck slab for non composite :24 N/mm2 Deck slab for composite :30 N/mm2	As per Japanese Standard

(2) Determination of Width

Determination of width applied in the Study is in accordance with the above criteria and further refers to the width proposed by the Highlands Highway Rehabilitation Project funded by the World Bank.

1) Applicable Bridge Width

Total width is 9.5 m consisting of carriageway of 7.5 m (subdivided into dual lanes of 3.25 m lane width and 0.5 m shoulder width), effective width of side walk 1.0 m, parapet width 0.4 m and handrail 0.2 m. The bridge width is shown in Figure 2-3. It is noted that the necessity and effective width of the sidewalk has been decided considering the number of villages and public facilities, if any, vicinity of the bridge site.

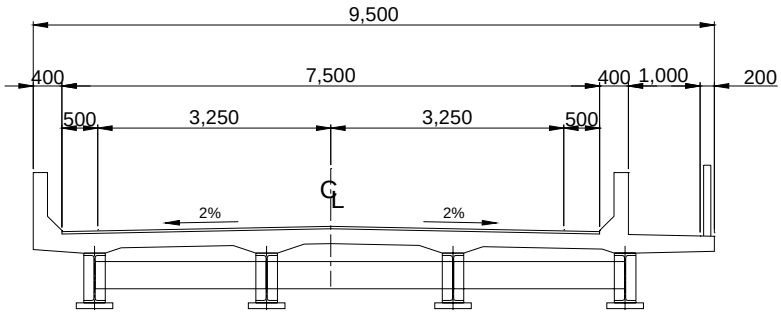


Figure 2-3 Typical Cross Section of Bridge

2) Applicable Roadway Width

Total roadway width is 9.5 m consisting of carriageway of 7.5 m (subdivided into dual lanes of 3.25 m) and shoulder width 1.5 m both sides. Figure 2-4 shows Typical Cross Section of Roadway.

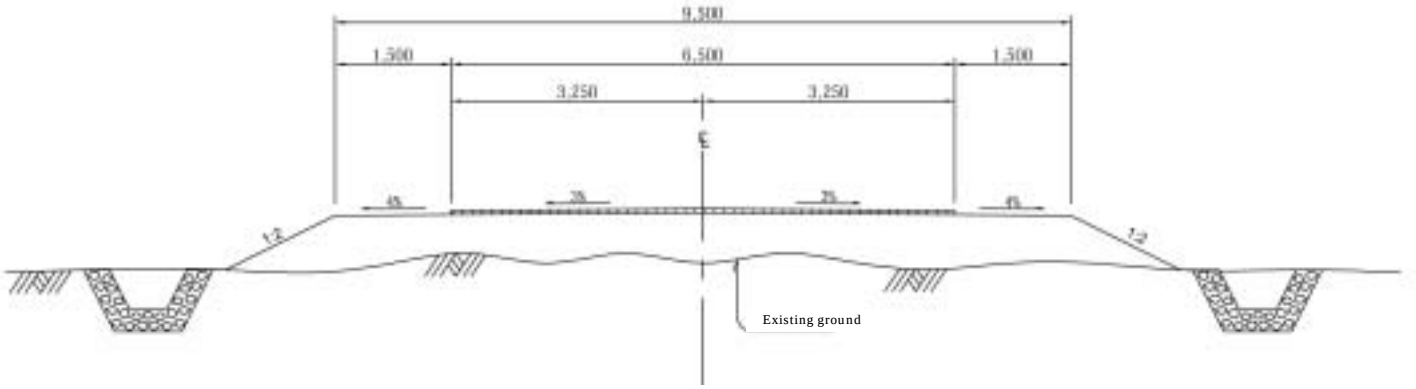


Figure 2-4 Typical Cross Section of Road

(3) Outline of Rehabilitation Plans

The outline of the rehabilitation plan for each bridge selected for assistance is tabulated in Table 2-18.

Table 2-18 Outline of Rehabilitation Plan for Each Bridges selected for Assistance

Bridge No.	Bridge Name	Rehabilitation Plan	Construction Method/Bridge Location
1	Orompaka	Widening by adding one lane new bridge, Raising and Improvement of Existing Bridge	Duplicate construction using existing and new bridge
2	Nonompinka	Widening by adding one lane new bridge, and Improvement of Existing Bridge	Duplicate construction using existing and new bridge
3	Honeranka	Widening by adding one lane new bridge, Raising and Improvement of Existing Bridge	Duplicate construction using existing and new bridge
4	Ofiga	Widening by adding one lane new bridge, and Improvement of Existing Bridge	Duplicate construction using existing and new bridge
5	Umbaka	Widening by adding one lane new bridge, and Improvement of Existing Bridge	Duplicate construction using existing and new bridge
6	Kingkio	Widening by adding one lane new bridge, and Improvement of Existing Bridge	Duplicate construction using existing and new bridge
7	Dirty Water	Replacement of existing bridge with new dual lane bridge, which is constructed in parallel with the existing. The existing bridge shall be removed by PNG side.	New bridge is located upstream due to availability of ROW.
8	Siguya	Widening by adding one lane new bridge, and Improvement of Existing Bridge	Installation of detour road with pipe culvert and widening work is carried out with open cut for foundation.
9	Yasifo	Widening by adding one lane new bridge, and Improvement of Existing Bridge	Duplicate construction using existing and new bridge
10	Parirosay	Widening by adding one lane new bridge, and Improvement of Existing Bridge	Installation of detour road with pipe culvert and widening work is carried out with open cut for foundation.
11	Bena Bena	Replacement of existing bridge with new dual lane bridge, which is constructed in parallel with the existing. The existing bridge shall be removed by PNG side.	New bridge is located downstream due to availability of ROW.
12	Sunufamu	Replacement of existing bridge with new dual lane bridge, which is constructed at the same location as the existing. The existing bridge will be removed in the civil work contract.	Due to difficulty in re-alignment of approach roads, new bridge is constructed at the same location as the existing after installation of detour road with pipe culverts.

2-2-2-2 Facility (Bridge) Rehabilitation Plan

The facilities covered in the Study is broadly divided into replacement of the one lane existing bridges with dual lane bridges, widening by adding a single lane bridge and improvement of the existing bridge, and installation of bank protection & approach road which are commonly applied in both cases. Hence, the facility design is described hereunder for those categories.

(1) Rehabilitation by Replacement with A New Two-Lane Bridge (for Dirty Water Bridge, Bena Bena Bridge and Sunufamu Bridge)

1) Study of Bridge Length and Span Length

The total bridge length and span length of new bridges for Dirty Water Bridge, Bena Bena Bridge and Sunufamu Bridge, are examined using following formulas:

- Desirable Total Bridge Length

The desirable total bridge length is examined using the following:

$L=0.5^{/1}\sim0.8^{/2}xQ\hat{}0.75$ -----Sabo Standard in Japan
$L=3.3^{/1}\sim4.9^{/2}xQ\hat{}0.5$ -----Lacey's formula
Where Q: Design Flood (m3/s)、L: Bridge Length (m)
/1: Applicable to rivers with stable flow
/2: Applicable to rivers with unstable flow

- Min. Span Length

The minimum span length is estimated using the following formula:

$L=20 + 0.005\ Q$ ----- Standard for River Structures in Japan
Where Q: Design Flood (m3/s)、L: Min. Span Length (m)

According to above formula, desirable total bridge length and min. span length are estimated as follows:

Items		Dirty Water	Bena Bena	Sunufamu
Bridge Length (m)	Sabo Standard	64.3～102.9	85.3～136.8	10.7～17.2
	Lacey's formula	84.1～124.9	101.6～150.9	25.5～37.9
Min. Span Length (m)		23m	24m	20.3m

The existing Dirty Water Bridge with a single span truss of 49 m is located at a curved portion of the river, so that severe erosion has been observed around the left side abutment. This indicates a left side abutment of the new bridge shall be setback into the Lae side, therefore, the new bridge needs longer bridge length. It is therefore desirable that the right side abutment will be situated just beside the existing and the left side abutment shall be set back into the Lae side as much as possible. Considering these situations and topographic conditions at the site, the bridge length of the new bridge is about 60 m with min. span length more than 23 m.

The existing Bena Bena bridge with a total span length of 100 m is located at a man made topographical bottleneck with a flood plain with more than 200 m wide upstream and downstream. Based on hydraulic analysis at the present situation, it has been reveled that critical flow with damming up phenomenon upstream and severe local scouring around the piers appear at the bridge crossing site. Extension of the bridge length therefore is required in order to mitigate such adverse effects.

As such, the river flow condition with varying bridge length is assessed using a non-uniform flow calculation up to steady flood flow, which indicates the desirable bridge length. A result of the assessment is summarized in Figure 2-5.

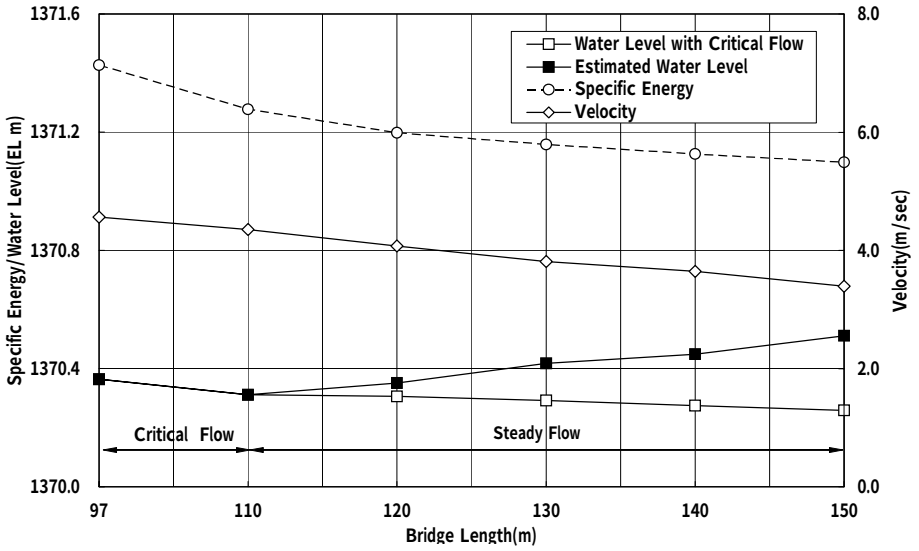


Figure 2-5 Relationship of Bridge Length and Water Level /Velocity

According to the result, river flow was made steadier with a length of more than 110 m. Specific flow was also gentler with a length of more than 110-120 m. Consequently, the bridge length of the new Bena Bena Bridge was proposed as 120 m.

Taking into account the considerable amount of flowing debris at the Sunufamu bridge site and required bridge length and minimum span length of the new Sunufamu Bridge, it is judged that at least 18 m of total bridge length is required for the new Sunufamu Bridge.

2) Study of Superstructure Types

In order to select a suitable superstructure type, elements that should be considered are a) Superstructure shall be light and continuous having high ductility because of PNG belonging to a strong earthquake zone, b) Sources for fabrication and erection of PC girders are not available in PNG, and c) Field works need to be minimized because of the inadequate number of skilled labors.

Considering those elements, steel structures are mainly considered in formulating alternatives for the superstructure.

a) Dirty Water Bridge

Considering the requirements of the New Dirty Water Bridge, which has a total bridge length of about 60 m and minimum span length more that 23 m, two alternatives consisting of Alt-1: 2 Span Continuous Steel Plate Girder of 2@30m = 60 m and Alt-2: Single Span Length of 1@60 m= 60 m are formulated and compared from various aspects as shown in Table 2-19. Consequently Alt-1: 2 Span Continuous Steel Plate Girder of 2@30m = 60 m is selected as an optimum type.

Table 2-19 Comparison Study of Superstructure Types for Dirty Water Bridge

Comparing Superstructure Types		Evaluation Items						
		Construction Cost (60)	Structural Aspect (5)	Construction Aspect (10)	Construction Period (10)	Hydraulic Aspect (5)	Maintenance (10)	Overall Result (100)
Alternative-1 2 Span Continuous Plate Girder 2@30 m =60 m	Evaluation	Unit weight of steel is about 170 kg/m2, which is 30 % cheaper than that of Alt-2.	Because of continuous girder, aseismicity and structural aspect is superior to Alt-2.	River pier construction during rainy season will cause difficulty of construction.	About 16 months	Because of installation of river pier, river flow is obstructed.	Less maintenance work load than Alt-2	Selected
	Rating	60	5	8	8	3	5	89
Alternative-2 Single Span Steel Truss Bridge 1@60 m=60 m	Evaluation	350 kg/m2 of steel unit weight causes higher cost.	Because of single span bridge aseismicity is inferior to Alt-1. Moreover, through type bridge has a potential problem of bridge members deformation due to vehicle collision.	Complicated work in election of superstructure.	Because no river pier is needed, the period is shorter, say 15 months	No hydraulic problems.	Maintenance work load is heavier than Alt-1	Discarded
	Rating	42	0	6	10	5	3	65

Note：The figure in ( ) indicates weighted rating point.

b) Bena Bena Bridge

Considering the requirements of the New Bena Bena Bridge, which has a total bridge length of about 120 m and minimum span length more that 24 m, two alternatives consisting of Alt-1: 4 Span Continuous Steel Plate Girder of 4@30m = 120 m and Alt-2: 3 Span Continuous Steel Plate Girder of 3@40m = 120 m are formulated and compared from various aspects as shown in Table 2-20. Consequently Alt-1: 4 Span Continuous Steel Plate Girder of 4@30m = 120 mm is selected as an optimum type.

Table 2-20 Comparison Study of Superstructure Types for Bena Bena Bridge

Comparing Superstructure Types		Evaluation Criteria						
		Construction Cost (60)	Structural Aspect (5)	Construction Aspect (10)	Construction Period (10)	Hydraulic Aspect (5)	Maintenance (10)	Overall Result (100)
Alternative-1 4 Span Continuous Plate Girder 4@30 m =120 m	Evaluation	Unit weight of steel is about 160 kg/m2 and one more pier is required. This is 15% cheaper than Alt-2.	Because of continuous girder, aseismicity and structural aspect is superior.	Most common erection by truck crane with bents	About 18 months	Adverse hydraulic effects are solved	Almost same as Alt-2	Selected
	Rating	60	5	10	10	3	10	98
Alternative-2 3 Span Continuous Plate Girder 3@40 m =120 m	Evaluation	Heavier unit weight causes higher cost.	Same as Alt-1	Same as Alt-1	Almost same as Alt-1	No hydraulic problems.	Almost same as Alt-1	Discarded
	Rating	50	5	10	10	5	10	90

Note：The figure in ( ) indicates weighted rating point.

c) Sunufamu Bridge

Considering the requirements of the New Sunufamu Bridge, which has a total bridge length of about 18 m, two alternatives consisting of Alt-1: Single Span Composite H Shape Beam of 1@18m = 18 m and Alt-2: Single Span Non Composite H Shape Beam of 1@18 m=18m are formulated and compared from various aspects as shown in Table 2-21. Consequently Alt-1: Single Span Composite H Shape Beam of 1@18m = 18 m is selected as an optimum type.

Table 2-21 Comparison Study of Superstructure Types for Sunufamu Bridge

Comparing Superstructure Types		Evaluation Criteria						
		Construction Cost (60	Structural Aspect (5)	Construction Aspect (10	Construction Period (10)	Hydraulic Aspect (5)	Maintenance (10)	Overall Result (100)
Alternative-1 Single Span Composite H Shape Beam 1@18m = 18 m	Evaluation	Unit weight of steel is lighter than that of Alt-2. This is 20% cheaper than Alt-2.	Aseismicity and structural aspect is superior.	Both alternatives are the same.	About 6 months	Because of single span, no hydraulic problems	In case of replacement of deck slab, detour road is required	Selected
	Rating	60	5	10	10	5	8	98
Alternative-2 Single Span Non Composite H Shape Beam 1@18 m=18m	Evaluation	Heavier unit weight causes higher cost.	More deflection is caused.	Same as Alt-1	Almost same as Alt-1	No hydraulic problems.	Superior to Alt-1	Discarded
	Rating	48	4	10	10	5	10	87

Note：The figure in ( ) indicates weighted rating point.

3) Study of Foundation Types

Considering subsoil conditions and the magnitude of the dead loads, an optimum type of foundation was selected. Conceivable alternatives are steel tubular pipe, cast in place RC pile and open caisson for Dirty Water Bridge and Bena Bena Bridge that have similar subsoil conditions and magnitude of dead loads i.e. span length of 30 m and sand & gravel with a gravel size less than 20 cm and bearing stratum located less than 15 m in depth. Steel tubular pipe with a diameter of 600 mm is selected as an optimum type considering the economic aspect.

Steel H shape pile is selected for the most suitable foundation type of Sunufamu Bridge considering subsoil condition that is similar to and supports less dead load compared with the above two major bridges.

(2) Rehabilitation by Repairing of Existing Bridge and Widening with A New One-Lane Bridge

It is a basic concept for widening and improvement of the existing single lane small bridges to add a single lane bridge with side walk of the same type of superstructure and substructure as the existing type and to rectify defects such as inadequate load carrying capacity and insufficient channel clearance by replacement of such members, raising of bridge grade, installation of additional piles, and adding cover plates on the beams.

Table 2-22 shows defects in the existing bridges and specific works for the existing and widening portions.

Table 2-22 Rehabilitation Methods for Small Bridges selected for Assistance

Bridge Name	Defects to be Improved	Rehabilitation Methods	
		For Existing Bridge	For Widening Bridge
Orompaka	-Narrow roadway width. -Insufficient under clearance against flood. -Inadequate load carrying capacity of piles. -Inadequate edge distance of bridge seat -Inadequate load carrying capacity of girders. -Inadequate load carrying capacity of deck slab.	-Raise girder level. -Add piles. -Widen bridge seat. -Repair and repaint girders -Replace deck slab.	- Construction of a one-lane widening bridge.
Nonompinka	-Widening of bridge -Inadequate width of bridge seat -Inadequate load carrying capacity of deck slab	-Widening bridge seat -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.
Honeranka	-Widening of bridge -Raising of bridge grade -Inadequate width of bridge seat -Inadequate load carrying capacity of deck slab	-Raising abutment -Widening bridge seat -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.
Ofiga	-Widening of bridge -Inadequate load carrying capacity of piles -Inadequate width of bridge seat -Inadequate load carrying capacity of deck slab	-Widening bridge seat -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.
Unbaka	-Widening of bridge -Severe cracks in pile head -Inadequate load carrying capacity of deck slab	-Demolition of abutment -Additional piles -Installation of abutment -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.
Kingkio	-Widening of bridge -Severe cracks in pile head -Inadequate load carrying capacity of deck slab	-Demolition of abutment -Additional piles -Installation of abutment -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.
Siguya	-Widening of bridge -Inadequate width of bridge seat -Inadequate load carrying capacity of deck slab	-Widening bridge seat -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.
Yasifo	-Widening of bridge -Inadequate width of bridge seat -Inadequate load carrying capacity of deck slab	-Widening bridge seat -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.
Parirosay	-Widening of bridge -Inadequate width of bridge seat -Inadequate load carrying capacity of deck slab	-Widening bridge seat -Repair of beams -Replacement of deck slab	- Construction of abutment and superstructure for one lane and integration with the existing.

(3) Study of River Bank and River Bed Protection Work

It is necessary to install bank protection around abutments and riverbed protection around river piers considering possible local scoring and erosion by flood flow and flowing debris and weakening bank and riverbed by installation of the structure. These river protection structures are wire mesh gabions which are widely and commonly used in PNG and difficulty of installation is minimul as described below:

1) Extent of Bank Protection Work

It is, in principle, to install bank protection in an extent as shown in Figure 2-6, which indicates the area covered by flood up to an intersection point between the High Water Level and ground line. Filter fabric (geo-textile) is installed at the back of the gabions in order to prevent sucking backfill material.

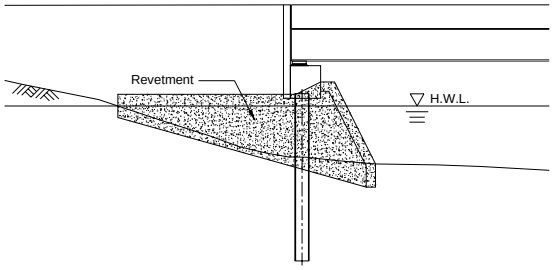


Figure 2-6 Extent of Bank Protection Work

2) Extent of River Bed Protection Work

Extent of installing riverbed protection was determined based on extent of local scouring estimated by Dr. Suga's formula. Consequently, the extent of riverbed protection for Dirty Water Bridge and Bena Bena Bridge is 13 m * 13 m and 11 m * 6 m respectively.

(4) Study of Approach Road

Pavement composition of the approach road is sub-base course with a thickness of 25 cm, base course with a thickness of 20 cm and surface dressing by double bituminous surface treatment (DBST), which is a commonly applied pavement composition of the Highlands Highway including the Highlands Highway Rehabilitation Project by World Bank.

Embankment slope is 1 vertical :2 horizontal and at the toe of the embankment side-ditch stone masonry is provided.

(5) Summary of Facility (Bridge) Rehabilitation Plan

The overall scheme of the facilities planned is shown in Table 2-23.

Table 2-23 Summary of Rehabilitation Plan for 12 Bridges selected for Assistance

Bridge Name	Improvement Method	Project Length (m)	Bridge Length (m)	Span Length (m)	Superstructure Type	Abutment Type ( ) indicates existing	Pier Type	Approach Road Length (m)
Orompaka	Widening and Improvement of Existing	95.0	21.4	20.8	Single Span Composite H Shape Beam	Pile Bent Type, Steel H Pile 250*250, L=4.5, n=12(4)	Not Applicable	Lae side：35.0 Goroka side :38.6
Nonompinka	Widening and Improvement of Existing	110.0	15.3	14.7	Single Span Composite H Shape Beam	Pile Bent Type, Steel H Pile 250*250, L=5.5, n=6(2)	Not Applicable	Lae side：60.0 Goroka side：34.7
Honeranka	Widening and Improvement of Existing	100.0	18.6	18.0	Single Span Composite H Shape Beam	Pile Bent Type, Steel Pile 250*250, L=10.5, n=10(4)	Not Applicable	Lae side：40.0 Goroka side：41.4
Ofiga	Widening and Improvement of Existing	90.0	24.5	23.9	Single Span Composite H Shape Beam	Pile Bent Type, Steel H Pile 250*250, L=2.5, n=22(2)	Not Applicable	Lae side：40.0 Goroka side：25.5
Umbaka	Widening and Improvement of Existing	50.0	12.3	11.7	Single Span Composite H Shape Beam	Pile Bent Type, Steel H Pile 250*250, L=7.0, n=22(2)	Not Applicable	Lae side：20.0 Goroka side：17.7
Kingkio	Widening and Improvement of Existing	80.0	15.3	14.7	Single Span Composite H Shape Beam	Pile Bent Type, Steel H Pile 250*250, L=8.0, n=12(4)	Not Applicable	Lae side：20.0 Goroka side：44.7
Dirty Water	Replacement with dual lane bridge	310.0	60.0	2@29.62	2 Span Continuous Plate Girder	Pile Bent Type Steel Tubular Pile Dia. 600、L=8.0、n=10	T shape Pier on steel pile Dia. 600、L=7.0、n=12	Lae side：131.5.0 Goroka side：118.5
Siguya	Widening and Improvement of Existing	85.0	18.3	17.7	Single Span Composite H Shape Beam	Spread footing	Not Applicable	Lae side：25.0 Goroka side：41.7
Yasifo	Widening and Improvement of Existing	80.0	18.4	17.8	Single Span Composite H Shape Beam	Pile Bent Type, Steel H Pile 250*250, L=3.5, n=12(4)	Not Applicable	Lae side：35.0 Goroka side：26.6
Parirosay	Widening and Improvement of Existing	105.0	24.0	23.8	Single Span Composite H Shape Beam	Spread footing	Not Applicable	Lae side：50.0 Goroka side：31.0
Bena Bena	Replacement with dual lane bridge	340.0	120.0	28.62+2@29.0+32.62	4 Span Continuous Plate Girder	Pile Bent Type Steel Tubular Pile Dia. 600、L=12.0 、n=10～8	Wall type pier on steel pile Dia. 600、L=10.0, n=12	Lae side：110.5 Goroka side:109.5
Sunufamu	Replacement with dual lane bridge	195.0	18.0	17.34	Single Span Composite H Shape Beam	Pile Bent Type, Steel H Pile 250*250, L=6.0, n=10	Not Applicable	Lae side：72.0 Goroka side:105.0

2-2-3 Basic Design Drawing

The basic design drawings are provided in the Appendix–6.

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The implementation policies are introduced, taking into account that the project would have to be implemented under the Japan's Grant Aid Scheme, as described below:

To maximize the procurement of local labor, materials and equipment in PNG so as to increase employment opportunities, to facilitate technology transfer and to provide positive impact to the local economy.

To prevent disputes related to land tenure systems, all the facilities have been designed within the right of way (ROW) shown in the Government survey map. It is, however, possible for such issues to arise if land acquisition in the past was not perfectly settled or there is un-satisfactory compensation for cash crops affected by the work. Hence, it is strongly suggested to PNG that they assign a co-ordination officer from the Provincial Work Office to work with the local residents.

To establish a practical communication network between the Government of PNG, Embassy of Japan, JICA PNG Office, the consultant and a contractor for the project implementation to be as smooth as possible and for emergency cases considering the aggravated security in PNG.

A detailed implementation schedule with budget required for each of the undertakings to be implemented by PNG in a timely manner will be furnished to the PNG side in writing and monitoring will be closely carried out to prevent delay and non-fulfillment.

A portion of the works proposed in the Study consists of rehabilitation or improvement of the existing structures. It is possible that some difference between the design and actual conditions will be discovered. Therefore a procedure for design change and reporting to PNG side will be formulated during the construction supervision stage.

To prepare a practical construction plan taking into account the local rainfall pattern, period required for materials and equipment procurement and application of appropriate construction methods.

It is a goal of the construction schedule not to interrupt the present traffic flow and to minimize incontinences during one lane traffic flow on detour roads and bridges.

Technology transfer to PNG engineers through on the job training and strengthening of maintenance and operation systems in DoW are covered in the project, including practical recommendations for methods and timing of inspection, maintenance and repairs after completion of the facility.

2-2-4-2 Implementation Conditions

Special considerations in the project implementation are as follows:

(1) Respect for Local Traditions

Peoples in PNG pay special attention to the traditional land tenure systems and cash crop compensation because of little opportunity to earn money. In order to implement the Project smoothly, a contractor should respect prevailing Government laws and local traditions with regard to construction and hiring local laborers and should make every effort to minimize disputes with laborers and local residents.

(2) Environmental Considerations

In accordance with the Environmental Impact Assessment (EIA) and Environmental Monitoring Plan (EMP) to be carried out by the PNG side, an environmental specialist to be assigned to the Project shall monitor environmental aspects during the construction period. If environmental problem is detected, the contractor will be requested to rectify such item immediately.

Countermeasures against possible adverse effects derived from the construction, such as waste materials from demolition of the existing structures, water pollution from excavation in the rivers and dust from pavement work shall be specified in the Specification, and the actual works shall be supervised in accordance with the Specification.

In addition, AIDS has become a critical social issue in PNG. Laborers and staff related to the construction shall be enlightened by an environmental expert periodically in order to prevent the spread of AIDS.

(3) Tight Security at Job Sites

The project sites have been relatively well populated compared with the sites in the previous Japan's Grant Aid packages and it has been reported that vehicles/supermarkets are frequently infested with criminals. Special security measures shall be provided by the PNG side to secure safety of project personnel and property at campsites, each bridge site and during transportation.

(4) Custom Clearance

All the project equipment and materials imported from Japan and the third countries will be unloaded at Lae Port. Thus construction plans should be established taking into consideration sufficient time for unloading, customs clearance, inland transportation, etc.

(5) Maximum Usage of Dry Season

In order to reduce the construction cost, it has been planed that timing of river pier construction and the period of use of detour roads with pipe culverts are in the dry season. Hence, these conditions shall be clearly specified in the Tender Documents and contractors will be instructed to follow such conditions during the implementation.

(6) Public Traffic Diversion during Construction

As the Project is to rehabilitate single lane bridges in some cases through replacement with a dual lane bridge while using the existing bridge as a detour road, widening /replacement with provision of a detour road or widening under the duplicate scheme on single lane bridges, one way traffic at bridge sites may take place during the construction period.

Under such conditions, public traffic control such as measure to control the direction of vehicles and pedestrians, notices of detour roads, assignment of traffic policemen, and necessary lighting facilities shall be provided in order to prevent traffic accidents and congestion during the construction stage.

(7) Transportation of Steel Members

Since the works will require special transportation of steel bridge members, the sizes and weights of the members should be appropriate for existing road geometry and loading capacity.

2-2-4-3 Scope of Works

The scope of works to be undertaken by the Japanese Government as well as by the PNG side is as follows:

Works and Facilities to be provided by the Japanese Government	Works and Facilities to be provided by PNG side
- Construction of Facilities - Rehabilitation construction works of the 12 bridges selected for assistance as per Section 2-2-2 "Facility (Bridge) Rehabilitation Plan" of this report. - Installation and removal of temporary facilities (plant, equipment/material yards, site offices, quarters, etc.) required in execution of construction works. - Removal of Existing Sunufamu Bridge and transport of steel girders to DoW Provincial Office and disposal of waste materials to the disposal areas designated by PNG side. - Safety measures required in execution of construction works. - Safety measures for public traffic in construction area during construction. - Prevention measures for environmental pollution in execution of construction works. - Procurement, import and transport of equipment/materials required for the rehabilitation works as per Section "2-4-6 Procurement Plan" of this report, and re-export of imported equipment. - Consulting Services for detailed design, preparation of tender documents, assistance to PNG side for tender proceedings, and construction supervision as per Section "2-4-4 Consultant Supervision" of this report, including environmental control plan.	- Free provision of sites for construction, temporary facilities and other construction activities required in execution of construction works. - Loss compensation for farm crops affected in execution of construction works. - Removal and relocation of existing utilities and facilities that obstruct execution of construction works at the sites (electric wires, telephone lines, etc.) before commencement of construction works. - Removal of both existing super- and sub-structures of Dirty Water and Bena Bena Bridge and a part of Bena Bena Bridge approach roads after completion of new bridges. - Free provision of disposal areas required for waste materials from construction. - Assignment of a full-time official from DoW Provincial Office to construction site for coordination with local residents. - Security of construction sites and temporary facilities (disposition of full-time police officers). - Arrangement for visas, certificates and other privileges to Japanese nationals and third country personnel related to and required in execution of construction works. - Exemption of consultants and contractors from taxes, customs duties and other levies charged in PNG for execution of construction works. - Payment of bank services charges for banking arrangements and authorization to pay.

2-2-4-4 Consultant Supervision

(1) Schedule of Consulting Services

The project shall be implemented under two phases, phase one covers Orompaka, Nonompinka, Honeranka, Ofiga Umbaka bridges under a single year scheme and phase two includes Kingkio, Dirty Water, Siguya, Yashifo, Parirosay, Bena Bena, Sunufamu Bridges under a multi year scheme.

Prior to commencement of the Project, the Exchange of Notes (E/N) for Phase I will firstly be signed between the two Governments (Japan and PNG). After the E/N, JICA will issue a recommendation letter to DoW and then the contract for the consulting service for the detailed design and construction supervision shall be concluded between DoW and the Japanese consultant. After completion of the detailed design, a contractor will be procured and construction supervision will follow. In addition to this, the Exchange of Notes (E/N) for Phase II will also be signed between the two Governments (Japan and PNG) and the detailed design will follow after contracting with DoW and a Japanese consultant. After the detailed design of Phase II, E/N concerned with the construction shall be concluded and the contract for the services of the tender stage and construction supervision stage shall also be concluded between DoW and the consultant. The consultant will provide the following consulting services within the limits of Japan's Grant Aid:

1) Detailed Design and Preparation of Tender Documentation Stage

Detailed design, which includes the following outputs, should be conducted for the facilities based on the Basic Design Study Report. Finally, tender documents will be prepared for approval by DoW.

- Design report
- Drawings
- Tender documents

2) Tender (Pre-construction) Stage

DoW, with assistance from the consultant will select a successful tenderer and conclude the construction contract through a competitive tender method among Japanese construction firms. Representative(s) from the Government of PNG attending tender opening and signing the contract with a wining contractor should be legal representative(s) responsible for this procedure. The consultant should assist the Representative to conduct the following:

- Bid announcement
- Pre-qualification of contractors
- Tender and tender evaluation, and
- Contract negotiation

3) Construction Supervision Stage

After obtaining the verification of the construction contract from the Ministry of Foreign Affairs of the Government of Japan, the consultant will issue a Notice to Proceed to the contractor and then construction supervision shall begin.

The consultant within his capacity as the Engineer should directly report to DoW, the Embassy of Japan and JICA PNG office about the various field activities, and should issue field memoranda or letters to the contractor, if necessary, regarding the various matters including progress, quality, safety and payment for the Project.

The defects liability period expires on the date one year after the completion of the Project. At the end of the defects liability period, defects liability inspection will be conducted as the final work of the consulting services.

(2) Staffing

The required staff and their responsibilities in the detailed design, tender (pre-construction) and construction stages are described below:

1) Detailed Design

The detailed design of the 12 bridges will be conducted by the consultant team headed by the Project Manager.

- Project Manager : Responsible for superintending all technical and managerial aspects of consultancy services for detailed design
- Bridge Engineer (Superstructure) : Responsible for field investigation, structural calculations and stability analysis, detailed design drawings and quantities calculation for superstructures

- Bridge Engineer (Substructure) : Responsible for field investigation, structural calculations and stability analysis, detailed design drawings and quantities calculation for substructures
- Construction Planer and Cost Estimator: Responsible for construction planning and updating cost estimates based on the latest work quantities and unit prices.
- Document Specialist: Responsible for preparation of tender documents.

2) Pre-construction Stage

Tasks assigned to the Consultant are to assist the Government of PNG in advertisement of PQ notice, issuance of PQ documents and tender documents, evaluation of PQ and tender documents and other activities related to tendering.

- Project Manager: Responsible for all the aspects of consulting services during the pre-construction stages.

3) Construction Stage

- Project Manager: Responsible for all the aspects of consulting services during the construction stages.
- Resident Engineer: Responsible for all the aspects of construction supervision at the sites and coordination with and reporting to DoW, Embassy of Japan and JICA PNG Office.
- Bridge Engineer: Responsible for design changes, especially of substructures.
- Environmental Specialist: Responsible for observation of the environmental monitoring plan and disseminating prevention measures to curb the spreading of AIDS.

2-2-4-5 Quality Control Plan

The design of the Project was carried out according to the relevant standards available in PNG and supplementary Japanese standards applied. However there is no specific Quality Control Manual in PNG. For this reason, the quality control plan was formulated on the basis of the design concept as shown in Table 2-24.

Table 2-24 Quality Control Tests Plan

Item			Test Method	Frequency
Crushed Rock Base	Mixed Material		Liquid Limit, Liner Shrinkage	Every mixing
			Sieve Gradation	
			Abrasion Loss	
			Aggregate Density	
			Maximum Dry Density	
	Paving		Field Density (Compaction)	Daily
Prim Coat & Tack Coat	Material	Bitumen	Quality Certificate	
			Applied Volume /Weight	Every 500 m2
Cold Mix Asphalt Concrete	Material	Bitumen	Quality Certificate & Chemical Analysis	Every material
		Aggregate	Sieve Gradation	Every mixing
			Water Absorption	Every material
			Abrasion Loss	
	Mix Requirements		Marshall Stability	Every mixing
			Marshall Flows	
			Air Voids	
			Voids in Mineral Aggregate	
			Indirect Tensile Strength	
			Immersion (Strength) Index	
			Bitumen Content	
DBST	Material	Bitumen	Applied Volume /Weight	Every 500 m2
		Aggregate	Applied Volume /Weight	Every 500 m2
Concrete	Material	Cement	Quality Guarantee, Chemical & Physical Analysis	Every material
		Water	Chemical Analysis	Every material
		Admixture	Quality Guarantee, Chemical Analysis	Every material
		Fine Aggregate	Bulk Specific Gravity Dry	Every material
			Sieve Gradation, Finesse Modulus	
			Clay and Friable Particles	
		Coarse Aggregates	Bulk Specific Gravity Dry	Every material
			Flakiness Index	
			Sieve Gradation	
			Sodium Sulfate Soundness	
	Mixing Test		Compressive Strength at 7 days & 28 days	Every mixing
	Pouring		Slump (Concrete)	Daily
			Concrete Temperature before Pouring	Daily
	Strength		Compressive Strength at 7 days & 28 days	Daily or >50m^3
Re-bar	Material		Quality Certificate	Each lot
Structural Steel	Material		Mill sheet	Each lot
Welding			X Ray Test	Each Member
High Tensile Bolt	Material		Quality Certificate, Torque Value	Each lot
Paint	Material		Quality Certificate	Each lot
Bearing	Material		Quality Certificate, Mechanical Tests	Each lot

2-2-4-6 Procurement Plan

(1) Procurement of Construction Materials

Most of the construction materials for roads and bridges which mostly have been imported from the neighboring countries are available in PNG, with the exception of special items such as bearings, expansion joints, jet cement with admixtures, testing instruments and so on which are mainly imported from Japan.

Plate girders and H shape beams are to be procured from Indonesia in consideration of the cost comparison with those in PNG.

The off shore transport routes from Japan and Indonesia are Yokohama to Lae and Jakarta to Lae

respectively and inland transport from Lae to the sites.

An indicative procurement schedule of major materials is shown in Table 2-25.

Table 2-25 Indicative Procurement Schedules of Materials

Item	PNG	Japan	Third Countries
H shape beams			O
Plate girder			O
High Tensile Bolts	O		
Painting material	O		
Hand rails			O
Bearings		O	
Drain Pile, etc.	O		
Scaffold	O		
Asphalt	O		
Aggregates	O		
Asphalt Mixture	O		
Cement	O		
Expansion Joint		O	
Jet Cement		O	
Admixture		O	
Re-bar	O		
Form	O		
Paint for Road Maker	O		
Lubricant	O		
Fuel, Gasoline, others	O		
Laboratory Equipment		O	

(2) Procurement of Construction Equipment

There is only one company in PNG renting construction equipment and only of very limited type and capacity. The other option is to rent equipment from local contractors that have their own equipment, but rent is expensive because of unbalance of demand and supply. Hence, procurement place of equipment was decided from economical aspect based on cost comparison between rental cost in PNG and operation cost of equipment transported from Japan. A list of major construction equipment to be procured in the Project is listed in Table 2-26.

Table 2-26 Indicative Procurement Schedule of Construction Equipment

Item	Capacity Spec.	PNG	Japan
Bulldozer	15t		O
Power Shovel	1.4 m^3		O
Dump Truck	10.0t		O
Backhoe	0.6 m^3		O
Truck Crane	35 t	O	
Jamb Breaker	600-800 kg		O
Vibration Roller	0.8t~1.1t		O
Load Roller	10.0t		O
Motor Grader	3.1m		O
Piling Machine	Diesel Hammer 2.5 t		O
Asphalt Spray	4,000 ltr		O
Concrete Mixer	0.5 m^3	O	
Concrete Plant	30 m3/hr	O	
Lane Maker	2.0lit/min		O
Asphalt Finisher	2.5~4.5m	O	

2-2-4-7 Implementation Schedule

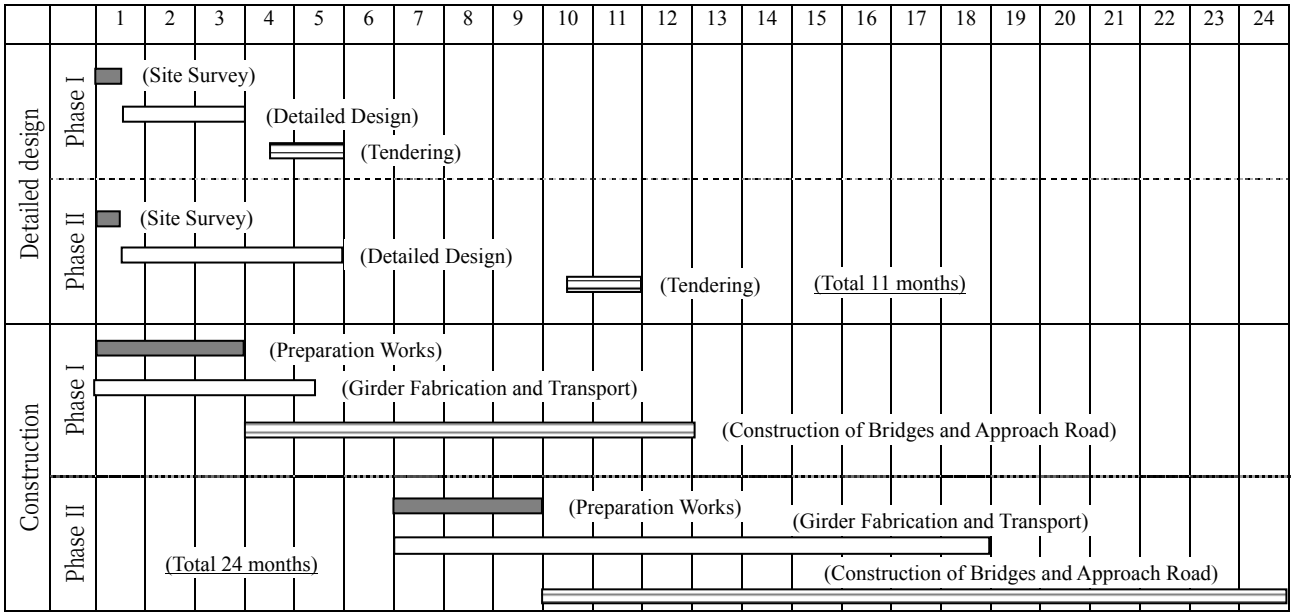
Considering the number of the bridges scattered along the Highlands Highway and assuming the project will be implemented under the Japan's Grant Aid System, it is desirable to phase the Project consisting of Phase I covering 5 small bridges (Orompaka, Nonompinka, Honeranka, Ofiga Umbaka) located near Kainantu under the Japanese single fiscal year scheme and Phase II including the remaining 7 bridges (Kingkio, Dirty Water, Siguya, Yashifo, Parirosay, Bena Bena, Sunufamu) situated between Henganofi and Goroka under the Japanese multi fiscal year scheme.

Consequently the Consulting Services will be commenced under the Grant Aid Project only after the Exchange of Notes (E/N) covering the detailed design, tendering, construction supervision and civil work for Phase I have been signed. At the beginning of the Services, the Consultant will carry out site surveys within a two week period and the detailed design including preparation of the tender documents will follow. The tendering activities such as prequalification of contractors, tender evaluation, selection of a contractor and etc. will be carried out as an assistance concept, and it will take about three months. After selection of a contractor through the competitive biding, the Government of PNG will sign the civil work contract with the selected contractor and the contract will be verified by the Government of Japan. The notice to proceed will be issued to the contractor after verification of the contract. The construction will be officially commenced with a construction period of 12 months for Phase I.

On the other hand, the Exchange of Notes (E/N) for the detailed design of Phase II is signed between the two Governments and the detailed design will follow after contracting with DoW and a consultant. It will take 4.5 months to complete the design. After the design, the Exchange of Notes (E/N) for the tendering, construction supervision and civil work of Phase II will be singed, and after that, the tendering to select a contractor for Phase II will follow. Signing the contract with the selected contractor and verification of the contract by the Government of Japan will be carried out and the construction of Phase II will be commenced with a contract period of 18 months.

The tentative implementation schedule for the project is depicted in Table 2-27 taking into account the procedure of the Japan's Grant Aid Scheme.

Table 2-27 Tentative Implementation Schedule



2-3 Obligations of Recipient Country

The following measures will need to be undertaken by the Government of PNG as conditions of the Grant Aid being extended for the Project by the Government of Japan.

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

Common items of undertakings by PNG were already discussed as per Annex-4 of the Minutes of Discussions dated on January 22, 2004. Hence, general items in the same Annex-4 are reproduced in the following for reference purposes:

- To secure land necessary for the sites of the Project and to clear, level and reclaim the land prior to commencement of the construction,
- To provide facilities for the distribution of electricity, water supply and drainage and other incidental facilities in and around the sites,
- To secure buildings prior to the procurement for the installation of the equipment,
- To ensure provision of all the expenses and prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid,
- To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which could be imposed in the recipient country with respect to the supply of the products and services under the verified contracts,
- To accord Japanese nationals, whose services may be required in connection with supply of the products and services under the verified contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.
- To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities as well as for the transportation and installation of the equipment.

2-3-2 Special Items of the Project

- Basic agreement with local residents concerning crops affected by the work by July 2004 and compensation payment for crops affected by the works at the sites for Phase I by January 2005, and for Phase II by August 2005.
- Relocation of utility poles affected by the works at sites for Phase I by January 2005, and for Phase II by August 2005.
- Provision and clearance for main camp yard and temporary yard at each bridge site for Phase I by January 2005, and temporary yard at each bridge site for Phase II by August 2005.
- Provision of spoil bank and disposal yard for bridges of Phase I by January 2005, and for Phase II by August 2005.
- Assignment of a Coordination Officer to deal with local residents during the period from February 2005 to March 2007.
- Assignment of Traffic Policy for traffic management at each bridge site for Phase I from February 2005 to March 2006 and for Phase II from September 2005 to March 2007.
- Assignment of Four Security Policemen on a full time basis at the main camp yard from February 2005 to March 2007.
- Complete demolition of the existing Dirty Water Bridge and Bena Bena Bridge after March 2007.

2-4 Project Operation Plan

The Provincial Work Manager, the head of the DoW Provincial Office, is responsible for maintenance and operation of roads and bridges in PNG. In the Project, that is the DoW Eastern Highlands Provincial Office.

The operation and maintenance works, such as cleaning of side ditches and culverts, cutting of grass and pothole repair as was carried out on a force account basis by Kassam Pass Maintenance Office (located 165 km from Lae) and Watabung maintenance Office (located 325 km from Lae) which are sub offices of DoW Eastern Highlands Provincial Office. It is however reported that such works are subcontracted with private firms at present.

The operation and maintenance works for the bridges after completion of the Project shall be carried out in accordance with the work schedule shown in Table 2-28.

Table 2-28 Operation and Maintenance Schedule

Interval	Content of works
Every Year	Cleaning and removal of deposit around bridge seat and in cross drainage and side ditch.
	Repainting of lane mark and repair of incidental facility for traffic safety.
	Cutting and removal of grass.
	Inspection and repair of bank protection and river bed protection.
Periodical	Patching or overlay of surface layer on bridge and approach at every 5 year
	Repainting of railings and bridges at every 10 year

It should be noted that bank protection and river bed protection by wire mesh gabions are not permanent structures and may collapse due to failure of wires by wear and tear. It is therefore strongly recommended to DoW that inspection shall be carried out after every flood and repair work shall be conducted if partial collapse is observed, otherwise cave in at approach roads will be caused due to wash out of backfill materials.

2-5 Cost Estimate

2-5-1 Project Cost to be borne by Japan's Grant Aid

The total cost of the Project by the Japan's Grant Aid is estimated at Japanese Yen 1,278 million consisting of 375 million for Phase I and 903 million for Phase II as summarized in Table 2-29 and 2-30.

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

Table 2-29 Project Cost for Phase I to be borne by Japan's Grant Aid

(for 5 bridges of Orompaka, Nonompinka, Honeranka, Ofiga and Umbaka with total length of 92.1 m)

Items			Amount (Million Japanese Yen)	
Facilities	Bridge Works (Total Length; 92.1m)	Superstructures	100	313
		Substructures	85	
		Bank Protection	59	
		Approach Roads	69	
Detailed design and Construction supervision		62		

Table 2-30 Project Cost for Phase II to be borne by Japan's Grant Aid

(for 7 bridges of Kingkio, Dirty Water, Siguya, Yashifo, Parirosay, Bena Bena and Sunufamu with total length of 274 m)

Items			Amount (Million Japanese Yen)	
Facilities	Bridge Works (Total Length; 274m)	Superstructures	316	792
		Substructures	226	
		Bank Protection	104	
		Approach Roads	146	
		Removal of Existing Sunufamu Bridge	0.4	
Detailed design and Construction supervision		111		

Condition of Cost Estimate

Exchange rate : US$ 1.0 = J. Yen 110.21 (6 month average before February 29, 2003)
: Kina 1.0 = J. Yen 33.06
The above-mentioned Exchange Rate is to be reviewed by the Government of Japan.

Construction period : 12 months for Phase I and 18 months for Phase II
Others : On condition that the Project is implemented under the Japan's Grant Aid Scheme.

2-5-2 Project Cost to be borne by PNG Side

The Project costs required for the undertakings by PNG side are shown in Table 2-31.

Table 2-31 Project Cost to be borne by PNG Side

Work Items		Cost (Kina)	Yen Equivalent
(1)	Compensation for Crops	58,700	1,940,600
(2)	Relocation of Utility poles	56,000	1,851,360
(3)	Land Preparation for Temporary Facilities Yards	2,340	77,360
(4)	Removal of Existing Dirty Water and Bena Bena Bridges	490,100	16,202,700
	TOTAL	607,140	20,072,020

2-5-3 Maintenance Cost

Based on the Project Operation Plan recommended in Chapter 4 of this report, the periodical maintenance schedule and cost are estimated as shown in Table 2-32.

Table 2-32 Maintenance Cost Estimation

Classification	Frequency	Component	Work	Approximate Cost	
				Kina	Yen Equivalent
Drainage	Twice a year	Bridge surface	Cleaning	5,200	172,000
		Side ditch	Cleaning	1,400	46,000
Traffic Safety	Once a year	Lane Making	Repainting	20,000	661,000
Road	Twice a year	Shoulder & Slope	Cutting grass	3,700	122,000
Annual cost for maintenance				30,300	1,001,000
Bank Protection	Once a year	Bank and River Bed	Inspection	165,000	5,455,000
Pavement	Every 5 year	surfacing	Repair, patching, or overlay	30,000	992,000
Girder and Beam	Every 10 year	Surface of steel members	Repainting	10,000	331,000

Notes: Exchange rate Kina 1.0 = J. Yen 33.06
Indirect cost is estimated at 30% of direct cost.

From Table 2-32, DoW is required to bear the maintenance costs of about 30,300 Kina (1,001 thousand Yen) annually as well as 30,000 Kina (992 thousand Yen) every 5 years and 10,000 Kina (331 thousand Yen) every 10 years. These maintenance costs are averaged out at about 120,000 Kina (3,960 thousand Yen) a year.

On the other hand, the annual maintenance budget for roads and bridges of DoW was recently 31 million Kina (1,024 million Yen) in total. Hence, the above-estimated annual maintenance cost for the rehabilitated bridges by this Project corresponds to only 0.38 % of the total DoW‘s annual maintenance budget, so that it is judged financially possible for DoW to continue the maintenance of the rehabilitated bridges.

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

Chapter 3 Project Evaluation and Recommendations

3-1 Project Effects

As a result of the socio-economic and field surveys and the basic design in the Study, the impact and effects generated by the Project Implementation are as follows:

1) Direct Impacts and Effects

Present Status and Issues	Countermeasures taken by the Project	Direct Impact and Effects
Because of all the study bridges having a single lane with narrow carriageway of 3.65 m, vehicles passing the bridge are forced to reduce running speed so that the bridges become a traffic bottleneck.	Those bridges are replaced with or widened to dual lane bridges having standard carriageway width of 7.5 m.	The project solves traffic bottlenecks so that both time and operation cost saving are generated. It is also expected to reduce the number of traffic accidents, even though 1.65 accidents on a single lane bridge (1.31persons death and 7.12 persons injury) happen every year at present.
Because all the study bridges were designed by old live load of T33 ton, some of the structural members are of inadequate load carrying capacity and a few of the bridges have insufficient channel clearance. It is therefore possible to cause the bridge collapse or the bridge being washed out.	The bridges are rehabilitated with consideration of B Loading in Japan which is slightly heavier that T44 Loading in PNG and raising of the bridge grade to accommodate the flood discharge with 50 years return period.	Prolongation of the bridge life with 50 years decreases maintenance cost and the bridge collapse probability, which in turn generates socio-economic stability in the Highlands regions.
In the absence of the sidewalk in the existing bridges, the pedestrians suffer danger in crossing the bridges.	Provision of a sidewalk with 1.0 m width at one side is incorporated in the design.	It is expected to reduce accidents resulting in injury and death.

The area and extent where the project benefit covers are six highland provinces consisting of Morobe, Southern Highlands, Chimbu, Western Highlands, Southern Highlands and Enga Provinces with total population of 2,511 thousand in 2000 Census (which is about 48% of 5,190 thousand total population in PNG).

2) Indirect Impacts and Effects

The indirect impacts and effects derived from the project are likely improvement of transportation schedules, acceleration of the agriculture and mining development, correction of regional disparities and expansion of market spheres. Furthermore, it is expected to improve the stabilization of people's livelihood and national consciousness in the area where the public security is being aggravated.

3-2 Recommendations

In order to generate the project effects and impacts with sustainability, it is requisite to demolish the existing bridges (Bena Bena and Dirty Water) and to conduct proper inspection and maintenance of the bridges immediately after the completion of the project. In addition, the following four items are strongly recommended to be taken into account.

- Strict Traffic Control for Compliance of Traffic Rules: Due to rehabilitation of a single lane bridge to a dual lane bridge, traffic bottlenecks are solved but it is possible to increase the number of severe traffic accidents because of increasing vehicle running speed. It is therefore required to strictly control vehicles running over speed by traffic policy and conduct enlightenment activities for pedestrians with regard to bridge passing and road crossing.

- To Secure Enough Maintenance Budget: DoW is suffering a shortage of the road and bridge maintenance budget because of chronic national budget constraints. Hence it is expected that the Government shall complete the structural reform initiated by IMF at the earliest possible time and implement taxation reform to ensure tax revenue for a part of the road maintenance budget.
- Need of Close Cooperation among Donors: Taking into account the importance of the Highlands Highway, International Funding Agencies such as World Bank, Asian Development Bank and Technical Cooperation Agencies such as AusAID and JICA are assisting the Government of PNG with implementation of various Highlands Highway Projects. In order to utilize local resources and generate the project benefit on a timely manner as much as possible in the project implementation, it is desirable to closely coordinate among all the donors in terms of assistance strategy, implementation policy and other technical matters.
- To Ensure ROW under State Land: The traditional land tenure system is one of the reasons causing delayed development of infrastructures in PNG. This system has a long history beginning in the 1950s and continues up to date. Nevertheless, the Government of PNG should spend every effort to ensure ROW along National Highways be under State Land.