National Roads Administration
The Republic of Mozambique

PREPARATORY SURVEY REPORT
(OUTLINE DESIGN STUDY)
ON
THE PROJECT FOR CONSTRUCTION OF BRIDGES
ON
THE ROAD BETWEEN ILE AND CUAMBA
IN
THE REPUBLIC OF MOZAMBIQUE

December 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

CHODAI CO., LTD.
EIGHT – JAPAN ENGINEERING CONSULTANTS INC.

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PREFACE

Japan International Cooperation Agency (JICA) conducted the Preparatory Survey (Outline Design Study) on the Project for Construction of Bridges on the Road between Ile and Cuamba in the Republic of Mozambique, and organized a survey team consisting of CHODAI CO., LTD. and EIGHT – JAPAN ENGINEERING CONSULTANTS INC. between Mar, 2011 to Dec, 2011.

The survey team held a series of discussions with the officials concerned of the Government of Mozambique, and conducted a field investigation. As a result of further studies in Japan, 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.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Mozambique for their close cooperation extended to the survey team.

December, 2011

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Director General,
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Japan International Cooperation Agency

SUMMARY

(1) Overview of Recipient Country

The Republic of Mozambique (hereinafter "Mozambique") is located in southern Africa, surrounded by Tanzania, Malawi, Zambia, Zimbabwe, Swaziland, and South Africa. Moreover, Madagascar and the Comoros are situated across Mozambique Channel.

The total land area is approximately 799,000 km^2, namely it is about twice as large as Japan. The country is extened from the south to north and its length of coastline facing the Indian Oceans is approximately 2,500km. The costal area and its hinterland are 44% of the total land area, 29% a plateau of the west side (200-600 m above sea level) and a highland of about 1,000 m above sea level occupies 27% of the total land area.

The number of the total population in Mozambique is 22,890,000. GDP per capita in Mozambique is 380 USD, and the rate of economic growth is 6.8% (2008). The economic growth has been increasing by 7-8% with the background of innovating infrastructure operations and strong foreign investment.

(2) Background of the Requested Japanese Assistance

The Mozambique government formulated the Action Plan for the Reduction of Absolute Poverty (PARPA) in 2001 aimed at the reduction of the poor up to 60% of the national, as the mid-long term national plan for the land reconstruction after the civil conflict. Later on, PARPA II (2006-2009) was also formulated. Its aim is to reduce the poverty ratio from 54% in 2003 to 45% in 2009, and it states 6 prioritized issues as follows; 1.Regional development, 2.Development of the legal amendment for production sector, 3.Improvement of the financial systems, 4.Supports for small and midsize firms, 5.Improvement of systems for collecting taxes, 6.Improvement of budgetary allocation. Infrastructure development included in regional development is essential for the realization of above items. In particular, the road and bridge development become a very important means to build the road network for encouraging the economics.

The National Roads Administration (hereinafter "ANE"), in cooperation with the Ministry of Public Works and Housing (hereinafter "MOPH") and the Road Funds (hereinafter "FE"), formulates the Road Sector Strategy (2007-2011: RSS) and it states that the road network development is an important agenda for socio-economic revitalization and supports for the regional development. Corridor development is encouraged to be focused and Route 103 including this bridge Project, as the target road, is one of the high prioritized roads necessary to be developed. Route 103 is the shortest route between Route 1 and the western Nacala corridor, which has a high potentiality for agriculture. It will also improve the logistic network in Nacala corridor. Additionally, the target roads are considered to be important in terms of the improvement in the logistic network from Quelimane which is the harbor city located in the Southern of Route 103 heading to Malawi.

The Islamic Development Bank (hereinafter "IDB") has a plan to develop the target roads but the target bridges are not included in this. These bridges are deteriorating and thus hinder smooth traffic flow. As a result of this situation, the Mozambique government made a request to the Government of Japan for a Grant Aid on the reconstruction the bridges between Ile and Cuamba. In response to the request, Japan International Cooperation Agency (hereinafter "JICA") carried out the Preparatory Survey (Preliminary Study) on the Project for Construction of Bridges on the Road between Ile and Cuamba from March 2010 to May 2010. In the Preliminary Study, it was concluded that there were some problems in both structure and width of the target bridges and that they should be improved urgently.

(3) Summary of the Study Findings and Project Contents

Based on the result of the Preliminary Survey, the Japanese Government decided to conduct the Preparatory Survey (Outline Design Study) on the Project for Construction of the Bridges on the Road between Ile and Cuamba, and JICA dispatched the Preparatory Survey Team to Mozambique from March to June of 2011. Based on the field survey and the study in Japan, the Team prepared the Summary Report. JICA dispatched the Team to Mozambique for the explanation of the Summary Report. Based on the discussions, the Mozambican Side and the Japanese Side confirmed and agreed on the contents of outline design and on the obrigations of the recipient country for this Project, and the Minutes of Discussion was signed by both sides on 2nd November, 2011.

In the field survey, the various surveys were carried out on the issues regarding the construction of the target bridges, such as traffic, topography, geology, meteorology, hydrology, environment, social and economic issues, procurement and costs for construction etc. Based on the results of these surveys, the main conditions of the facilities were determined and the outline of the bridges and the approach roads were determined as shown below.

No.	Bridge Name	Foundation Type	Superstructure Type	Width (m)	Bridge Length (m)	Approach Road (m)
1	Mutabasse	Spread footing	PC T-Girder	9.6	105	335
2	Muliquela	Spread footing	PC T-Girder	5.2	70	335
3	Matacasse	Pile foundation	RC hollow slab	9.6	15	345
4	Lua	Spread footing	PC T-Girder	5.2	50	530
5	Ualasse	Pile foundation	RC hollow slab	9.6	15	205
6	Licungo	Pile foundation	PC T-Girder	9.6	35	440
7	Nivaco	Spread footing & Pile foundation	RC hollow slab	9.6	30	330
8	Matsitse	Spread footing	RC hollow slab	9.6	15	325
9	Namisagua	Spread footing	RC hollow slab	9.6	15	285
10	Nuhusse	Spread footing	PC T-Girder	9.6	35	415
11	Lurio	Spread footing & Pile foundation	PC T-Girder	9.6	70	430
12	Muassi	Spread footing	RC hollow slab	9.6	15	265
13	Namutimbua	Spread footing	RC hollow slab	9.6	30	430

(4) Project Period and Estimated Project Cost

The planned overall project period is 41 months, consisting of 10.0 months for the detailed design work and 31.0 months for construction. The project cost reqired for fulfilling the undertakings to Mozambique is estimated to be 272 million JP yen.

(5) Evaluation of the Project

1) Relevance

This Project is requested in order to replace bridges urgently required in terms of human security as mentioned below.

- The Project target areas, Zambezia and Niassa Provinces, have many poor people and most of them are engaged in agriculture. Therefore, the development of road network is necessary to revitalize agriculture.
- The bridge development is necessary because inhabitants around the Project target areas have difficulty in commuting to school, visiting hospitals and delivering patients to the hospitals because of the undeveloped bridges.
- Traffic accidents often happened on bridges. In order to prevent such accidents, the expansion work of bridges (i.e. expanding the bridge width from one lane to two lanes) is urged.
- There are some bridges which might be collapsed, so they need to be replaced.
- The Project is considered to contribute the aims on MDGs.
- This Project collaborates with “The project for developing the Nacala Corridor”.

Through the field survey of the Project, these issues above have been examined and the validity of Project implementation by the Japanese grant aid has been found.

2) Effectiveness

a) Quantative Output

・Reduction in transit time and travel distance:

After improvement of the target bridges, the route becomes passable through the year. Moreover, the travel distance can be reduced about 55 km because the new route is the shortest way to Cuamba from Nampevo. Similarly, the transit time can be deducted between Napevo and Cuamba by about two hours.

・Reducing duration of road closed by heavy rain:

As a result of the interview to the local residents, the rainfall data and the hydrological analysis, it seems that the target road has been annually closed a few times during the rainy season due to storm water overflow. After constructing the target bridges designed with sufficient vertical clearance under the bridges, it is predicted that few road closure will happen by heavy rain on the target road.

・Reducing transportation cost:

Due to reducing the transit time and the travel distance and improving average driving speed, decrease in transportation cost can be expected. The deduction of annual transportation costs for this route in 2026 is estimated to be 2.7 million USD.

・Economic impact on the agricultural sector:

After improving the logistics capability on the target route, the economic impact to the agriculture sector, which is the main industry of the region, can be estimated to be 389 million USD over the next 20 years.

b） **Qualitative Output**

・Enhancement of the road network in the region

・Regional revitalization and life improvement

・Decrease in traffic accidents

・Mitigation of disaster risk

・Benefits for impoverished people

Hence the implementation of this Project is considered highly meaningful, relevant and effective.

PREPARATORY SURVEY REPORT (OUTLINE DESIGN STUDY)

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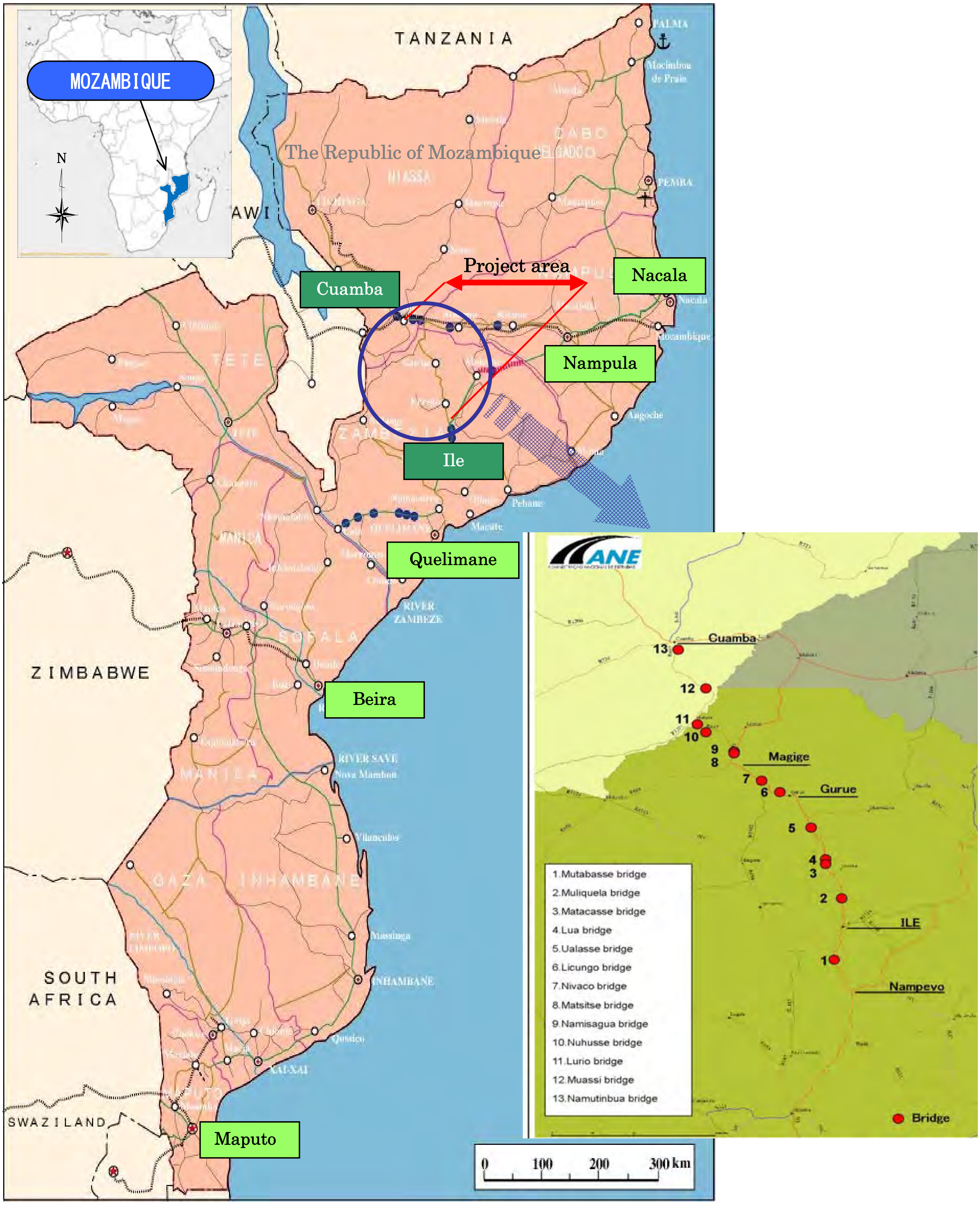
Project Location Map



Artist's Impression

No1. Mutabasse Bridge

No.8 Matsitse Bridge

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Abbreviations

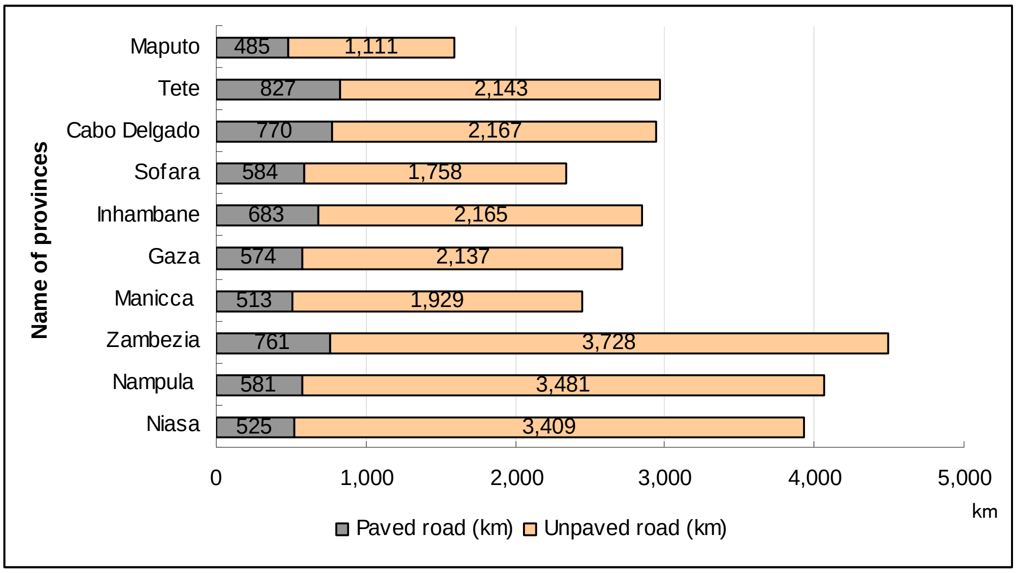
ANE	:National Roads Administration
AfDB	:African Development Bank
DNAIA	:Direcção Nacional de Avaliação de Impacto Ambiental
DPCA	:Direcção Provincial para a Coordenação da Acção Ambiental
EU	:European Union
EIA	:Environmental Impact Assessment
E/N	:Exchange of Notes
FE	:Road Fund
GAT	:Gabinete de Assuntos Transversais
GBS	:General Budget Support
GDP	:Gross Domestic Product
HEC	:Hydrologic Engineering Center
HIV/AIDS	:Human Immunodeficiency Virus /Acquired Immunodeficiency Syndrome
IDA	:International Development Association
IDB	:Islamic Development Bank
IEE	:Initial Environmental Examination
JICA	:Japan International Cooperation Agency
M/D	:Minutes of Discussions
MICOA	:Ministry for Coordination of Environmental Affairs
MOPH	:Ministry of Public Works and Housing
NGO	:Non-Governmental Organization
SADC	:Southern Africa Development Community
SATCC	:Southern Africa Transport and Communications Commission
PRISE	:Road Sector Integrate Plan
PARPA	:Action Plan for the Reduction of Absolute Poverty
RAP	:Resettlement Action Plan
RSS	:Road Sector Strategy 2007-2011
ROW	:Right of Way
TOR	:Terms of Reference
USAID	:United States Agency for International Development
USGS	:United States Geological Survey

Chapter 1. Background of the Project

1.1 Current Situation

In the Republic of Mozambique (hereinafter "Mozambique"), the Ministry of Public Works and Housing (hereinafter "MOPH") is in charge of the road administration, and the National Roads Administration (hereinafter "ANE") manages the maintenance works of major arterial roads.

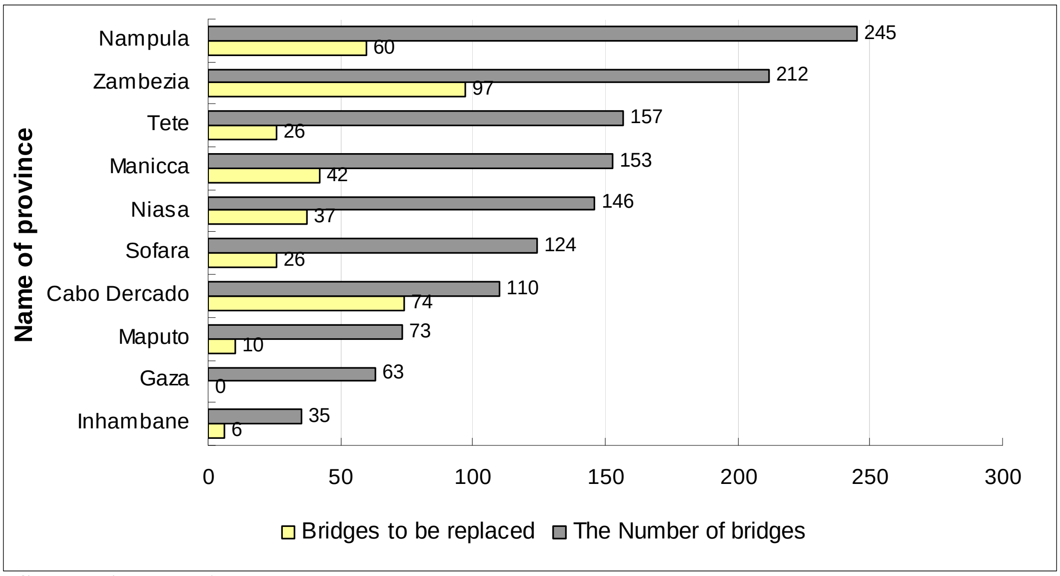
The overall length of roads in Mozambique is 32,348 km (RSS 2007-2011, Final Report, 2006), and the road density is greatly less than the average (214 km/1,000 km²) of Southern Africa Development Community (hereinafter "SADC"), and is 12th (38 km/1,200 km²) out of 14 South African countries. The road divisions are classified into five, namely primary roads, secondary roads, tertiary roads, neighboring streets and urban roads. ANE manages four types of roads except the urban roads, and the entire lengths of roads in Zambezia Province and Niassa Province are longer than that of the other provinces. As shown in Figure 1.1.1, Zambezia Province and Niassa Province have a low pavement ratio and are backward in terms of road network development.



Source: ANE Road Inventory 2010

Fig. 1.1.1 Length of paved and unpaved road

ANE conducts the periodic inspections of roads and bridges for maintenance. As shown in Figure 1.2.1, there are a large number of bridges in both Zambezia Province and Niassa Province in comparison with those of the other provinces. Moreover, there are a large number of bridges that need to be replaced in Zambezia Province, which causes difficulty in developing the road network. Due to this situation, those two provinces have slow economic revitalization even though they are major agricultural producers.



Source: ANE Bridge Inventory

Fig. 1.1.2 Numbers of bridges and bridges to be replaced in each province

The Mozambique government expects that Route 103, most of the target roads in this Project, is the shortest route between Route 1 and the western Nacala corridor, which has a high potentiality for agriculture. It will also improve the logistic network in Nacala corridor. Additionally, the target roads are considered to be important in terms of the improvement in the logistic network from Quelimane which is the harbor city located in the Southern of Route 103 heading to Malawi. The Islamic Development Bank (hereinafter "IDB") has a plan to develop the target roads but the target bridges are not included in this. These bridges are deteriorating and thus hinder smooth traffic flow. As a result of this situation, the Mozambique government hopes that new construction and replacement of the bridges between Ile and Cuamba can be urgently implemented.

1.2 Condition Surrounding the Project Sites

1.2.1 Environmental and Social Considerations

Environmental and social consideration study in this survey was focused on: 1. reviewing the report on the preliminary survey, 2. assisting ANE in order to obtain the environmental license for the project in Mozambique, 3. reflecting the results of environmental and social consideration study to the outline design.

The environmental study at IEE level for the Project was conducted in the preliminary survey carried out by JICA. The Project was categorized as category B in JICA Environmental Social Consideration Guideline (2004) and particularly serious impacts to the environment were not anticipated in the study.

(1) Reviewing the report on the preliminary survey

The environmental study at IEE level was conducted at the time of the preliminary study in 2010 because no environmental study had been conducted before. The study concluded that few serious impacts were anticipated because the Project mainly targeted only replacement/rehabilitation of the existing small and middle scale bridges. The following contents shown in Table 1.2.1 are some of the concerned environmental items raised in the environmental study at IEE level and confirmed in this field study.

Table 1.2.1 Review of the concerned environmental items in the preliminary study

No	Environmental Items	Description
1	Environmental Social Consideration process on the project	・Confirmation of preparatory status in ANE (Application and study of EIA, preparation of RRP): Official process requesting the categorization on the project by MICOA has made through the letter dated 16th March, 2011 from ANE to Environmental Action Directorate in Province (hereinafter; "DPCA"). ・DPCA made categorization of impacts based on the field survey. In Zambezia province, all 11 bridges were categorized as "C" (Official correspondence from Zambezia government on 24th April,2011). In Niassa province, 2bridges were categorized as "C" and 1 bridge (Br. Rurio) was categorized as "B" (Official correspondence from Niassa government on 26th May, 2011). The project of category B requires EAS study for Environmental license. ・The present environmental assessment procedure in Mozambique was confirmed to DNAIA in MICOA and DPCA. The Procedure had not changed since the last JICA study.
2	Confirmation of the information discloser to the PAPs (Schedule of stakeholder meeting, cut-off date on the land acquisition)	・The local peoples are generally explained about the project, because the road implementation project has been started at the area. ・Official announcement such as stakeholder meeting on the project might be planned within the scheme of the environmental assessment process after receiving official decision of MICOA on the categorization. The people's opinion will be feedback to the project implementation as much as possible. However, at the end of June, 2011, all resettlement related to bridge construction is expected to be avoided and it is not considered to be required particular meeting with PAPs. ・After finalizing the project affected area, the baseline survey for the land(for peoples, if necessary) will be conducted. Before commencement of the land survey on the RAP, the project activity (including cut-off date) shall be informed to the PAPs.

Source: JICA Study Team

(2) Assistance to obtain environmental license

1) Competent authority of the environmental assessment

The environmental assessment in Mozambique is supervised by the Ministry for Coordination of Environmental Action (hereinafter "MICOA") through the Direction of Environmental Impact Evaluation (hereinafter "DNAIA").

The Department of the Environmental Evaluation in DNAIA is mainly in charge of the environmental assessment procedure of projects categorized as "A". On the other hand, the Provincial Direction for coordination of environmental action (hereinafter "DPCA") in the provincial government is in charge of the procedure for projects categorized as "B" and "C".

2) Categorization and Procedure for the environmental license

In Mozambique, the projects that need environmental assessment were specified in Presidential Decree of No.45 in 2004. Moreover, projects that involve areas protected at domestic level and international level, urban areas with large resettlement & infrastructure, forestry development, agricultural development and industrial development, require environmental assessment.

The projects that need environmental assessment are divided into three categories; projects that will result in serious negative impacts in the region are categorized as “A”; projects that will result in some negative impacts in the region are categorized as “B”; and projects that result in little negative impacts are categorized as “C”. The category “A” requires environmental assessment at the level of EIA, “B” requires EAS, and “C” does not require either an EIA or SEA/SER (Simplified Environmental Assessment/ Simplified Environmental Report).

Regarding bridge construction projects, a bridge over 100m of the length is generally categorized as category A. Similarly, a bridge, whose length is less than 100m but has large scale of resettlement is categorized as “A”. In other cases, it is necessary to apply the environmental assessment as a category “B” or “C”.

Table 1.2.2 shows the required process for each category in the environmental assessment.

Table 1.2.2 Required process for each category in environmental assessment

Process on the EIA	Category “A”	Category “B”	Category “C”
Application	○	○	○
Pre-evaluation	×	○	×
Environmental Pre-Viability Report and Scope Definition	○	×	×
Terms of Reference	○	○	×
Environmental Impact Assessment (EIA)	○	×	×
Simplified Environmental Report (SER)	×	○	×
Public Participation Programme	○	△	×
Review by Technical Assessment Commission	○	○	×

Source: Handbook on Environmental assessment Legislation in the SADC Region (2007)

3) Environmental conditions in the region

① Social environment

The target bridges are located on Route 103. This route passes through three districts; Ile and Gurue in Zambezia Province, and Cuamba in Niassa Province. The major cities in these districts are Errego, Gurue and Cuamba, respectively. In these regions, tobacco, cotton, sugarcane, mais, soybean and rice are mainly cultivated. Although there are no particular communities around the bridge sites, the rivers are used by the villagers for washing, bathing and fishing. Table 1.2.3 shows the affected communities near bridge sites.

Table 1.2.3 Communities near bridge sites

No.	Name of Bridge	District	Communities (Localidad)
1	Mutabasse	Ile	Mutabasse
2	Muliquela	Ile	Muliquela
3	Matacasse	Ile	Matacasse/Socone
4	Lua	Ile/Gurue	Lua/Socone
5	Ualasse	Gurue	Casa Branca
6	Licungo	Gurue	Localidade Sede Gurue/ CMCG
7	Nivaco	Gurue	Nivago
8	Matsitse	Gurue	Sevene
9	Namisagua	Gurue	Sevene
10	Nuhusse	Gurue	Niuhusse/Ruasse
11	Lurio	Gurue/Cuamba	Rio Lurio/Ruasse
12	Muassi	Cuamba	Etatara/Cuamba
13	Namutimbua	Cuamba	Conselho Municipal de Cuamba

Source: JICA Study Team（Based on Information of ANE）

② Natural environment

The surrounding areas of the 13 bridges are mostly used for agriculture. Although a few residences are found around several bridges, no dense communities are established near those bridges.

There are no endangered faunal/floral species which require special conservation listed by the government in the target areas.

Original forest vegetation type in the areas is categorized as dry to wet Miombo vegetation both in Zambezia and Niassa Provinces. Only the Nivaco bridge is located approximately 100 m from the forest area as the nearest and none of the others are found close to the forest areas. Few negative impacts to the forest areas are anticipated through the Project.

4) Provision of project information to the local residents

It is necessary to provide the Project information to the local residents, based on legislation and the categorization. Projects categorized as category “A” are obliged to hold three stakeholder meetings at the environmental scoping, evaluation of the TOR for the study and review of the EIA report. On the other hand, projects categorized as category “B” require one stakeholder meeting depending on the requirement such as in the case of resettlement. ANE is supposed to hold a stakeholder meeting, based on the categorization approved by MICOA.

ANE has already provided some information to the local residents through the local governments. Moreover, thanks to the road projects on the target route which are divided into three sections (one has already completed, another is under construction, the other is still planning respectively), this bridge project is widely known by the local residents at the moment.

Incidentally, since there are some residences in the areas where the topographic surveys were carried out in this field survey, ANE had a meeting with the locals for showing the survey areas, giving the latest information and requesting cooperation for this Project.

Photo 1.2.1 Additional information provided by ANE to the local residents at Nuhusse bridge

Photo 1.2.2 Latest situation of Nufusse bridge

5) Involuntary resettlement and land acquisition

① Legislation related to land acquisition for the Project

Table 1.2.4 shows the legislation related to land acquisition in Mozambique.

Table 1.2.4 Legislation related to land acquisition in Mozambique

Legislation	Contents(tentative)
Land Act (No. 19/97). Lei de Terras	This Act aims at establishing the terms under which the creation, exercise, modification, transfer and termination of the right of land use and benefit operates. It regulates ownership of the land and public domain, the right of use and benefit of land, powers and responsibilities of the concerned public bodies. In particular, it defines obligations to be fulfilled by foreign or national entities, as well as fees to be paid in order to obtain a license for land exploitation.
Land Law Regulations 08 December 1998 Reglament	This Decree regulates Land Act No. 19/97 establishing right of use and conditions for exploiting public lands. It defines different land uses, listing obligations and rights of foreign or national entities, fees to be paid in order to obtain a license for land exploitation, etc. It concerns requirements to be met for obtaining the aforementioned license and regulates plans for land exploitation to be sent for approval to the competent authority. Technical Annex specifies requirements to be satisfied and limits (servitudes) of land areas.
Resolution No. 10/95 on the National Land Policy	This Resolution approves the National Land Policy. In particular, it identifies the national priorities, and provides a classification of land use for agricultural, industrial and mining purposes. Moreover, it defines an implementation strategy and requires for significant changes in the current basic legislation on land. Particular attention is devoted to the institution of a national land cadastre, as well as on tourism development and public works and infrastructures.
EIA Regulations and EIA Directives	Above in the legislation related to Environment Assessment-

Source: http://faolex.fao.org/

② Compensation practice by ANE for resettlement and land acquisition

i) Land tenure

The land tenure in Mozambique is stipulated in the Land Act (Lei de Terras, No. 19/97). All lands basically belong to the government and all citizens and companies have to apply to obtain the land use rights. Land alongside the public roads is managed by the government as a partly protected area. These areas are established on both sides within 30m from the shoulders of the primary roads and on both sides within 15m from the shoulders of the secondary road.

ii) Land acquisition

There is no particular legislation related to compulsory land acquisition for the public works. ANE prepares the draft of compensation framework based on the World Bank's safeguard. Table 1.2.5 shows the contents of resettlement policy framework for the road sectors in ANE (Draft).

Table 1.2.5 Resettlement policy framework for the road sectors in ANE (Draft)

	Items	Description
1	Analysis of legal framework related to resettlement	Right of way for the public road is stated in the Land Act(No. 19/97). However, there is no particular legislation for compulsory land acquisition/resettlement for public works. In case of this project, the RESETTLEMENT POLICY FRAMEWORK FOR THE ROADS SECTOR (draft) in ANE which was prepared based on the World Bank's guideline (policy 4.12) will be followed.
2	Necessity of resettlement	In case of this project, all 13 bridges are located at small to middle rivers in rural area and mainly reconstructed already existing bridges. There are no any newly affected people at the bridge itself. However, associate with the temporally detour / replaced road, some agriculture lands will be required. Also, at the time of project, adequate compensation should be completed by ANE for the precede road improvement project, especially Magige-Cuambe section.
3	Implementation of socio-economic study	After basic design survey which determines the actual construction site, socio-economic study may be conducted if it requires. However, any resettlement is not involved.
4	Compensation for asset loss, rehabilitation plan	Full replacement cost as compensation is described in the framework. However, in Mozambique, all lands are tenured by the government and compensation is mainly limited for right for land use and assets.
5	Relocation site development plan	When the resettlement is involved in the project, RRP (more than 200 affected person) or Abbreviated RRP(less than 200 AP) are required.
6	Grievance handling mechanism	At the compensation, if local residents have any grievance, the local residents complain to local leader first. Through local leader, the grievance is informed to local government administration (LGA) such as district when it is not solved locally. The Local Leaders shall maintain records where grievances and complaints, including minutes of discussions, recommendations and resolutions made, will be recorded. When it is not solved at the LGA level, the matter will be addressed higher level, finally at court. 1) The affected person should file his grievance in writing, to the Local Leader. (Where the affected person is unable to write, he should obtain assistance to write the note and emboss the letter with his thumbprint.) 2) The Local Leader should respond within 14 days during which any meetings and discussions to be held with the aggrieved person should be conducted. 3) If the aggrieved person does not receive a response or is not satisfied with the outcome within the agreed time he lodges his grievance to the LGA / the Municipal Council. 4) If no agreement is reached at this stage, then the complaint is taken to the Courts of Law.

	Items	Description
7	Organizational structure	If the resettlement and land acquisition are required, ANE implements study for RRP/Abbreviated RRP. Based on the RRP, actual compensation is implemented by districts. In case of this project, RRP is not required because there is no any resettlement at the time.
8	Implementation schedule	Compensation is implemented before project implementation.
9	Considering cost and budget	Based on the socio-economic survey, compensation is budgeted by ANE and compensation is paid through districts to the affected person.
10	Considering Monitoring・Evaluation Method at project completion	In case of resettlement, following items are planned to be monitored and evaluated in the draft framework (monitoring plan) in ANE, when those are involved in project. General success/acceptability of the compensation/resettlement process Project acceptance (or not) by the community Acceptance (or not), of the local residents by host community Restoration of Mashambas temporarily disrupted by construction Replacement of Mashamba /grazing land permanently displaced by access roads and building construction Quality of life compared with that before compensation/resettlement Productivity
11	Public participation	This project, all 13 bridges are located in the prospective route 13 which has been improved presently paving and expanding. The inhabitants alongside the road are well informed about the project. Also, at the ground survey, the project outline was informed to all relevant communities through districts.

Source: JICA Study Team based on RESETTLEMENT POLICY FRAMEWORK FOR THE ROADS SECTOR (draft) in ANE(2006)

6) Progress situation of obtaining the environmental license

The process on the environmental assessment in Mozambique was confirmed during this survey to the responsible section in ANE; Cabinet for Transversal Affair (hereinafter “GAT”), and MICOA.

Regarding this Project, ANE commenced the environmental process applying categorization process to Zambezia and Niassa Provinces on 16 March, 2011. Both DPCA in Zambezia and Niassa conducted field surveys for all bridges at ANE’s expense. In Zambezia Province, all 11 bridges were categorized as category “C” (official correspondence from Zambezia government on 24th April, 2011). In Niassa Province, two bridges were categorized as category “C” and one bridge (Br. Rurio) was categorized as category “B” (official correspondence from Niassa government on 26th May,2011).

The category “C” does not require particular specific environmental study after submitting the preliminary application which includes basic information of the Project. On the other hand, the category “B” requires the simplified environmental study (hereinafter “EAS”) for obtaining the environmental license from MICOA.

Table 1.2.6 shows the information required for EAS.

Table 1.2.6 Information required for EAS

A. **Information Required at Application and Screening** ・Description of the activity ・Need and desirability of the project ・Legal framework for the activity ・Brief description of the biophysical and socio-economic structure of the region ・Current land use on the proposed site ・Environmental information from the site ・Description of each stage of the EIA process ・Completion of the preliminary environmental information sheet(Appendix in 2004/45)
B. **Required Information at Pre-Assessment (the required only in category "B")** ・Number of affected people and communities ・Nature and type of affected ecosystems and species ・Extent of the area affected ・Probability, nature, duration, intensity and significance of potential impacts ・Direct and indirect impacts, global and cumulative effects ・The reversibility of impacts and the likelihood of compliance with Mozambican environmental quality standards ・Previous knowledge of the proposed site ・Checking whether the activity should be classified as a Category A, B or C project
C. **Required Information in the TOR of EAS for approval** ・ Name and location of proponent ・ Location of the project, its sphere of influence and current land use(Using maps in adequate scale and indicates limits of project affected area in it) ・ The compatibility of the project in the land use planning context ・ Description of reasonable alternatives which will be investigated at different project phases such as planning, construction and development ・ Description of the proposed public participation process
D. **Required Information in the EAS Report for approval** ・A non-technical summary covering the main issues and conclusions ・The location and description of the activity ・The legal and planning context of the activity ・A brief description of the baseline environmental situation ・Identification and assessment of the impacts ・An environmental management plan which includes the monitoring of impacts, environmental education and accident prevention and contingency plans ・Names of the multidiscipline team that carried out the study(nominated by DPCA/MICOA) ・A report on the public participation programme when it requires(associated with resettlement)

Source: Handbook on Environmental assessment Legislation in the SADC Region,
EIA regulations (No. 45/2004)

EAS is obligatory and needs to be conducted by a registered consultant in the MICOA, based on the legislation of 45/2004. ANE must appoint an adequate consultant in the list to carry out the study. The appointed consultant has to prepare the TOR and submit it to the provincial government. After obtaining the approval of the TOR from the provincial government, the study can commence. The flow of environmental impact assessment process in Mozambique is shown in Figure 1.2.1 and the tentative schedule for environmental process is shown in Table 1.2.7.

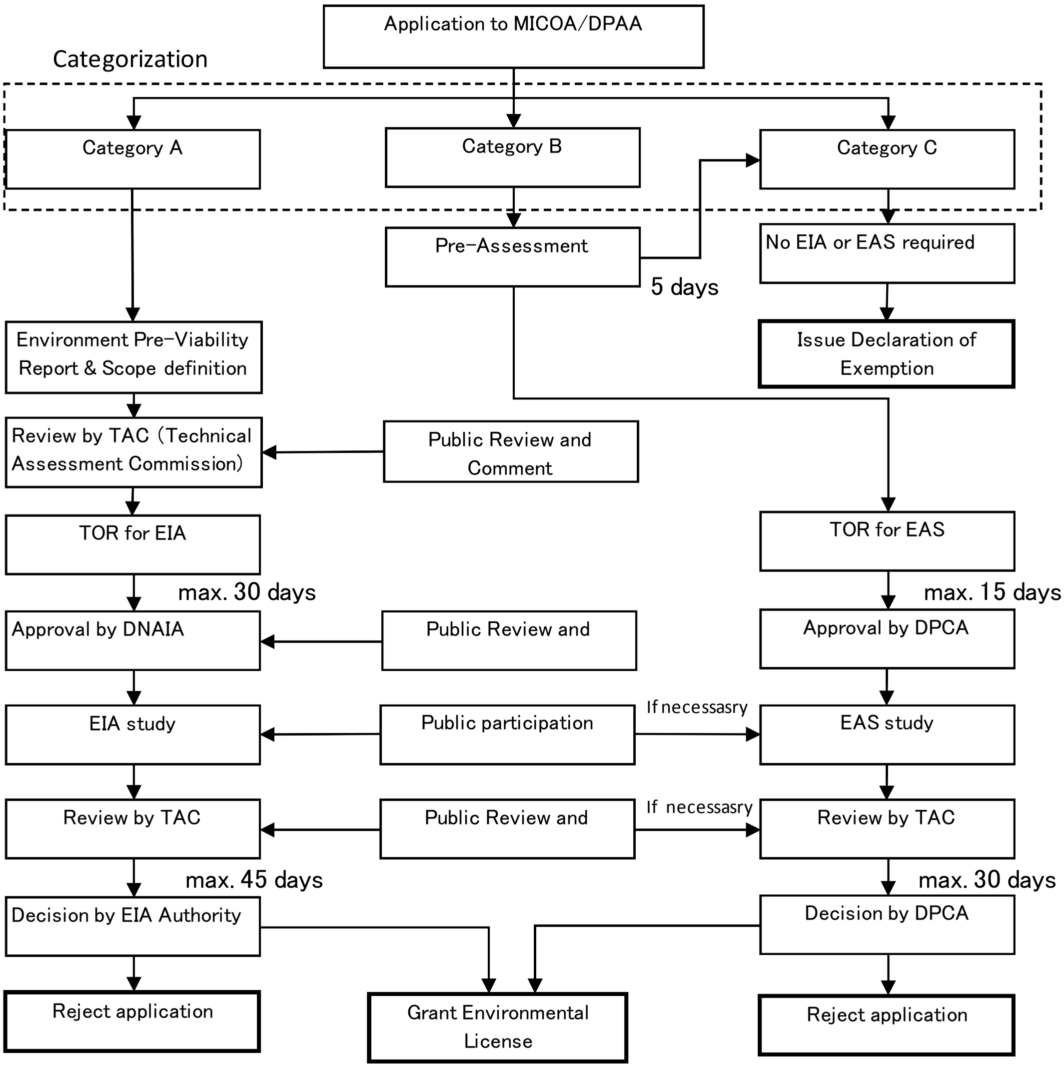


Fig. 1.2.1 Flow of environmental impact assessment process in Mozambique

Table 1.2.7 Tentative schedule for environmental process

Activities	Expected period	Main organization	Tentative target date
Tentative Application for categorization	-	ANE	3rd week in March
Tentative categorization by DPCA	8 Days max	DPCA	End of June
Preparation of TOR for Consultant	1 week	ANE	2nd week July
Consultant selection/contract	1-2 weeks	ANE	4th week July
TOR of ESA preparation to apply for the MICOA	1 week	Registered consultant	Early August
TOR approval (in case of category B)	15 days max	MICOA/DPCA	Late September
Implementation of ESA	2- 3 month	Consultant	Sep-Oct
Draft report submission to MICOA/DPCA and reviewing for approval	30 days max	MICOA/DPCA	Nov
Environmental License Application	5 days	ANE	Nov

Source: JICA Study Team (At April 2011)

(3) Reflecting results of the environmental study to the outline design

1) Basic policy

Concerning the environmental issues found in the previous study and this study, the design policy is planned in order to mitigate/ avoid the impacts to the environment. Especially, no involuntary resettlement is planned in this Project.

2) Environmental checklist

The environmental checklist for this Project is shown in Appendix 6.7.

3) Environmental monitoring plan (Tentative draft)

Tentative environmental monitoring plan is shown in Appendix 6.8. The contents should be updated, reflecting the results of EAS, the process of environmental license and implementation of land acquisition after this study.

1.2.2 Existing Bridges

The target 13 bridges are located on the 260 km section between Nampevo and Cuamba; five bridges out of 13 are located in the section between Nampevo and Gurue, two bridges are in between Gurue and Magige, six bridges are in between Magige and Cuamba. Moreover, the road between Nampevo and Gurue has been already paved except the target bridge sections, the road between Gurue and Magige is under construction supported by IDB and the road between Magige and Cuamba is in the planning stage.

Regarding structural types of the existing 13 bridges, five bridges out of 13 are reinforced concrete girder bridges, one bridge is reinforced concrete deck slab bridge, one structure is pipe culvert, and six bridges are temporary bridges namely bailey bridges.

All the target bridges are currently one-lane bridges and their widths range from 3.2 meter to 4.0 meter. On the section between Nampevo and Gurue, the completion of the roads paved with two lanes in 2004 resulted in an increase in the number of vehicles for passing the road and numerous traffic accidents which happened due to decreasing carriageway widths at the bridge points.

In addition, little maintenance of the bridges has been properly carried out, although several decades have passed since the completion of the existing bridges. Therefore, some target bridges have become seriously damaged and their load-carrying capacity has been decreasing. Others have risks of sinking down and collapsing due to scouring around piers and abutments caused by flood water.

The following tables show the existing conditions of the target 13 bridges.

Bridge Inspection Sheet 1.

18/Sep/2011

Bridge Name	No.1 Mutabasse	Route, Grade	N103, Primary Road
Province	Zambezia	Distance, Year built	Cuamba＋225km, 1938
Bridge Length	95m	Bridge Width	5.1m
Number of Span	10 Spans	Carriageway Width	3.25m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Mutabasse River

Vicinal Circumstance		The approach road at Cuamba side is curved sharply. There is no residence within approximately 200 meter from the bridge. Cassava, sugar cane and rice are cultivated along the road near the bridge. Some shrubs are scattered around the bridge. There is a primary school about 2 km from the bridge toward Cuamba.
Superstructure	Structural Type	Reinforcement concrete T-shaped girder birdge
	Present Condition	Some parts of cover concrete are fallen away from the underneath of main girder. After falling down cover concrete, the exposed steel plates have been corroded. The load-carrying capacity of the bridge has been gradually decreasing. In addition, not only the pavement & adjusting concrete, but also the deck slab has been seriously damaged. (See the following photos.)
Substructure	Structural Type	Abutment: Inverse-T type Pier: Wall type
	Present Condition	Rock layer is exposed on the riverbed. There is less scouring around piers & abutments. The existing pires have a risk of collapsing because of their weakness against horizontal force in case flood water or some obstacles hit the pires.
Approach Road	Present Situation	The approach road at Camba side is curved into S-shape. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the bridge & inclined at about 1 or 3%. The approach roads are two-lane, but the bridge is one-lane. Many traffic accidents happened due to decreasing carriageway width at the bridge.
Others	Present Situation	Optical fiber cable is hooked on lateral face of main girder.
Comment	The bridge should be reconstructed due to the risk of collapsing the existing structures. New bridge should have two lanes and be located at the downstream of the existing bridge due to smooth road alignment. Approach roads of the bridge should be smoothly connected to the existing road.	

Photos


Overview (from Cuamba Side)


Bottom Face of Main Girder (Stripping Cover Concrete)


Bridge Surface (Stripping Pavement & Ajusting Concrete)


Optical Cable on Lateral Face of Main Girder

Bridge Inspection Sheet 2.

18/Sep/2011

Bridge Name	No.2 Muliquela	Route, Grade	N103, Primary Road
Province	Zambezia	Distance, Year built	Cuamba＋192km
Bridge Length	66m	Bridge Width	5.1m
Number of Span	10 Spans	Carriageway Width	3.45m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Muliquela River

Vicinal Circumstance		There is no residence within approximately 200 meter from the bridge. Cassava, sugar cane and mais are cultivated along the road near the bridge. Some shrubs are scattered around the bridge. There is a primary school about 1 km from the bridge toward Cuamba. There is a rain gauge facility at the downstream side. There is a cemetery at the upstream side.
Superstructure	Structural Type	RC T-shaped girder birdge
	Present Condition	There is no visible serious damage on the main girders. No pavement on the deck slab. Some concrete handrail posts have been damaged.
Substructure	Structural Type	Abutment: Inverse-T type Pier: Two-post type
	Present Condition	Rock layer is exposed on the riverbed. There is less scouring around piers & abutments. The abutments & piers have no serious cracks and are in good condition.
Approach Road	Present Situation	The existing approach roads are straight. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the bridge & inclined at about 3 or 4%. The approach roads are two-lane, but the bridge is one-lane. Traffic accidents happened due to decreasing carriageway width at the bridge. There is the existing concrete side ditch at Cuamba side.
Others	Present Situation	The existing electrical cable & posts are located at about 40 meter from the bridge along the road. Optical fiber cable is hooked on lateral face of main girder. There is a water level gauge facility at the upstream side.
Comment		New one lane bridge should be constructed in order to avoid traffic accidents. New bridge should be located at the upstream of the existing bridge. The existing bridge is for Cuamba and the new bridge is for Nampevo. Sufficient traffic safe facilities such as traffic sigh should be installed due to safe traffic.

Photos

Overview (from Nampevo Side)

Overview of Bridge (from Nampevo Side)

Bridge Surface (Some Handrail Posts Damaged)

Side Ditch along the approach Road (Cuamba Side)

Bridge Inspection Sheet 3.

18/Sep/2011

Bridge Name	No.3 Matacasse	Route, Grade	N103, Primary Road
Province	Zambezia	Distance, Year built	Cuamba＋173km
Bridge Length	24.4m	Bridge Width	—
Number of Span	1 Span	Carriageway Width	4.2m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Matacasse River

Vicinal Circumstance		There are three houses with nine persons in the vicinal area of the birdge, but the project would not affect the area. Cassava, sugar cane, banana, mapira and mais are cultivated along the road near the bridge. Some shrubs are scattered around the bridge. In dry season, there is no water in the river but are reeds.
Superstructure	Structural Type	Bailey bridge
	Present Condition	The old bridge was collapsed because of flood water scouring under the abutments and became impassable. After the collapse, the bailey bridge was temporarily erected.
Substructure	Structural Type	Abutment: Gravity type Pier:
	Present Condition	Sand is sedimented on the river bed. The abutments have been gradually sinking down due to serious erosion. Moreover, scouring behind the abutments was also detected during the visual inspection.
Approach Road	Present Situation	The existing approach roads are straight. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the bridge & inclined at approximately 2 or 3%. The approach roads are two-lane, but the bridge is one-lane. Traffic accidents happened due to decreasing carriageway width at the bridge. There are two box culverts under the approach roads.
Others	Present Situation	Optical fiber cable is hooked on lateral face of deck slab.
Comment		The bridge should be reconstructed instead of the temporary one. New bridge should have two lanes and be located at the existing bridge position. Approach roads of the bridge should be smoothly connected to the existing road.

Photos


Overview (from Cuamba Side)


Bailey Bridge & Collapsed Existing Bridge


Overview (from Nampevo Side)


Sedimented Box Culvert under approach Road (Nampevo Side)

Bridge Inspection Sheet 4.

18/Sep/2011

Bridge Name	No.4 Rua	Route, Grade	N103, Primary Road
Province	Zambezia	Distance, Year built	Cuamba＋171km, 1955
Bridge Length	37m	Bridge Width	5.15m
Number of Span	4 Spans	Carriageway Width	3.45m
Attached Utilities	Optical Fiber Cable （Pipe:φ50mm）	River Name	Rua River

Vicinal Circumstance		The existing electrical cable & posts are located at about 80 meter from the bridge along the road. There are 2 houses with 11 persons at Nampevo side and 1 house with 4 persons at Cuamba side in the vicinal area of the birdge, but the project would not affect the area. Some shrubs are scattered around the bridge. Cassava, sugar cane, mapira and mais are cultivated along the road near the bridge. There is a washing place at the upstream of the existing birdge.
Superstructure	Structural Type	RC T-shaped girder birdge
	Present Condition	There is no visible serious damage on the main girders. No pavement on the deck slab. Some concrete handrail posts have been damaged.
Substructure	Structural Type	Abutment：Gravity type Pier：Wall type
	Present Condition	Rock layer is exposed on the riverbed. There is less scouring around piers & abutments. The abutments & piers have no serious cracks and are in good condition.
Approach Road	Present Situation	The existing approach road at Nampevo side is straight, but the approach road at Camba side is gently curved. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the bridge & inclined at approximately 2 or 3%. The approach roads are two-lane, but the bridge is one-lane. Traffic accidents happened due to decreasing carriageway width at the bridge.
Others	Present Situation	Optical fiber cable is hooked on underneath of deck slab.
Comment	New one lane bridge should be constructed in order to avoid traffic accidents. New bridge should be located at the upstream of the existing bridge. The existing bridge is for Cuamba and the new bridge is for Nampevo. Sufficient traffic safe facilities such as traffic sigh should be installed due to safe traffic. New washing place should be prepared during the construction period.	

Photos

Overview（from Nampevo Side）

Underneath of Existing Bridge near A1 Abutment

Overview（from Cuamba Side）

Overview of Bridge（from Cuamba Side）

Bridge Inspection Sheet 5. 18/Sep/2011

Bridge Name	No.5 Ualasse	Route, Grade	N103, Primary Road
Province	Zambezia	Distance, Year built	Cuamba＋155km
Bridge Length	24.4m	Bridge Width	—
Number of Span	1 Span	Carriageway Width	4.2m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Ualasse River
Vicinal Circumstance	There are swamp & rice field in the surrounding area of the bridge. In dry season, there is no water in the river. There is no residence within approximately 200 meter from the bridge. Banana and rice are cultivated along the road near the bridge.		
Superstructure	Structural Type	Bailey bridge	
	Present Condition	The old bridge was collapsed because of flood water scouring under the abutments and became impassable. After the collapse, the bailey bridge was temporarily erected.	
Substructure	Structural Type	Abutment: Gravity type Pier:	
	Present Condition	Sand is sedimented on the river bed. The abutment at Napevo side has been gradually sinking down due to serious erosion. Temporary abutment for bailey bridge at Cuamba side is made of gabions.	
Approach Road	Present Situation	The ambilateral access roads of the bridge are curved sharply. The ambilateral access roads are ascents from the bridge & inclined at approximately 3 or 4%. The bridge is located at the bottom of the valley. The approach roads are two-lane, but the bridge is one-lane. Traffic accidents happened due to decreasing carriageway width at the bridge.	
Others	Present Situation	Optical fiber cable is hooked on lateral face of deck slab.	
Comment	The bridge should be reconstructed instead of the temporary one. New bridge should have two lanes and be located at the existing bridge position. Approach roads of the bridge should be smoothly connected to the existing road.		

Photos


Overview (from Cuamba Side)


Overview (from Nampevo Side)


Bailey Bridge & Collapsed Existing Bridge (Nampevo Side)


Bailey Bridge & Existing River Protection (Cuamba Side)

Bridge Inspection Sheet 6.

18/Sep/2011

<table>
<tr><td colspan="2">Bridge Name</td><td>No.6 Licungo</td><td>Route, Grade</td><td>N103, Primary Road</td></tr>
<tr><td colspan="2">Province</td><td>Zambezia</td><td>Distance, Year built</td><td>Cuamba＋116km, 1953年</td></tr>
<tr><td colspan="2">Bridge Length</td><td>34m</td><td>Bridge Width</td><td>5.2m</td></tr>
<tr><td colspan="2">Number of Span</td><td>3 Spans</td><td>Carriageway Width</td><td>3.5m</td></tr>
<tr><td colspan="2">Attached Utilities</td><td>Optical Fiber Cable
（Pipe:φ50mm）</td><td>River Name</td><td>Licungo River</td></tr>
<tr><td colspan="2">Vicinal Circumstance</td><td colspan="3">There is a bamboo forest at Cuamba side.
Sugar cane and banana are cultivated at Napevo side and eucaliptus is planted at Cuamba side.
There is no residence within approximately 200 meter from the bridge.
Many pedestrian and bicycle are passing the bridge.
The bridge is located on approximately 1km from the foot of a mountain.
There is a tea plantation in the surrounding area of the bridge at Cuamba side, but the plantation will not affect the project.</td></tr>
<tr><td rowspan="2">Superstructure</td><td>Structural Type</td><td colspan="3">RC T-shaped girder birdge</td></tr>
<tr><td>Present Condition</td><td colspan="3">The existing superstructure is supported by the pires and a cantilever beam.
Nothing is loaded on the both Abutments.
There are some cracks and damaged parts on the deck slab.
Some re-bars in the deck might be seriously corroded.
No pavement on the deck slab.
Some concrete handrail posts & beams have been damaged.
The flood water has overflowed the bridge in recent years.</td></tr>
<tr><td rowspan="2">Substructure</td><td>Structural Type</td><td colspan="3">Abutment：Gravity type　　Pier：Wall type</td></tr>
<tr><td>Present Condition</td><td colspan="3">The embankment under the abutment at Cuamba side has been scoured.
Pier 1 & 2 have no serious damage and are in good condition.</td></tr>
<tr><td>Approach Road</td><td>Present Situation</td><td colspan="3">The existing approach roads are straight.
The bridge is located at the bottom of the valley.
The ambilateral approach roads are ascents from the bridge & inclined at approximately 1 or 3%.</td></tr>
<tr><td>Others</td><td>Present Situation</td><td colspan="3">The river is smoothly flowing through the year.
There are a water level gauge on the pier and a water gauge facility at the downstream side.
Optical fiber cable is hooked on underneath of deck slab.</td></tr>
<tr><td>Comment</td><td colspan="4">The bridge should be reconstructed due to the risk of overflowing the bridge in rainy season.
New bridge should have two lanes and be located at the existing bridge position.
Approach roads of the bridge should be smoothly connected to the existing road.</td></tr>
<tr><td rowspan="2">Photos</td><td colspan="2">
Overview（from Cuamba Side）</td><td colspan="2">
Overview（from Nampevo Side）</td></tr>
<tr><td colspan="2">
Overview of Bridge（from Cuamba Side）</td><td colspan="2">
Embankment Eroded under A2 Abutment（Cuamba Side）</td></tr>
</table>

Bridge Inspection Sheet 7. 18/Sep/2011

Bridge Name	No.7 Nivaco	Route, Grade	N103, Primary
Province	Zambezia	Distance, Year built	Cuamba＋104km
Bridge Length	6.2m	Bridge Width	7.1m
Number of Span	Pipe Culvert	Carriageway Width	–
Attached Utilities	Optical Cable Buried near Culvert	River Name	Nivaco River

Vicinal Circumstance		In dry season, there is no water in the river but are reeds. Sugar cane is cultivated along the road near the bridge. There are two big kapok trees at Cuamba side, but the trees would not affect the project. There is no residence within approximately 200 meter from the bridge.
Superstructure	Structural Type	Pipe culvert
	Present Condition	The scouring underneath the culvert is about 1.5 meters deep and getting worse. The flow goes underneath the culvert. There is a risk of collapse of the culvert. The flood water has overflowed the culvert in recent years.
Substructure	Structural Type	Abutment: Pier:
	Present Condition	The situation of scouring around the culvert has deteriorated.
Approach Road	Present Situation	The existing approach road at Cuamba side is straight, but the approach road at Nampevo side is gently curved. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the culvert & inclined at approximately 1 or 4%. There are two small pipe culverts under the approach road at Nampevo side.
Others	Present Situation	The river is smoothly flowing through the year. Optical fiber cable is buried along the roads.
Comment	The bridge should be urgently constructed due to the risks of overflowing & collapse of the culvert. New bridge should have two lanes and be located at the existing culvert position. Approach roads of the bridge should be smoothly connected to the existing road.	

Photos	 Overview (from Cuamba Side)	 Overview (from Nampevo Side)
	 Overview of Culvert (from Upstream Side)	 Overview of Culvert (from Downstream Side)

Bridge Inspection Sheet 8. 18/Sep/2011

Bridge Name	No.8 Matsitse	Route, Grade	N103, Primary Road
Province	Zambezia	Distance, Year built	Cuamba＋84km
Bridge Length	15.3m	Bridge Width	—
Number of Span	1 Span	Carriageway Width	4.2m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Matsitse River

Vicinal Circumstance		In dry season, there is no water in the river. There is a washing place at the upstream of the existing birdge. There is one houses with seven persons at Nampevo side in the surrounding area of the birdge, but the project would not affect the area. Cassava, sugar cane, banana, and mais are cultivated along the road near the bridge.
Superstructure	Structural Type	Bailey bridge
	Present Condition	The old bridge was collapsed because of flood water scouring under the abutments and became impassable. After the collapse, the bailey bridge was temporarily erected. The flood water has overflowed the bridge in recent years.
Substructure	Structural Type	Abutment: Gravity type Pier:
	Present Condition	Sand is sedimented on the river bed. The abutments have been gradually sinking down due to erosion.
Approach Road	Present Situation	The existing approach roads are straight. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the bridge & inclined at approximately 1 or 3%.
Others	Present Situation	Optical fiber cable is hooked on lateral face of deck slab. The existing electrical cable & posts are located at about 80 meter from the bridge along the road.
Comment	The bridge should be reconstructed instead of the temporary one. New bridge should have two lanes and be located at the existing bridge position. Approach roads of the bridge should be smoothly connected to the existing road. New washing place should be prepared during the construction period.	

Photos

Overview (from Cuamba Side)

Overview (from Nampevo Side)

Overview of Bridge (from Upstream Side)

Overview of Bridge (from Downstream Side)

Bridge Inspection Sheet 9.

18/Sep/2011

Bridge Name	No.9 Namisagua	Route, Grade	N103, Primary Road
Province	Zambezia	Distance, Year built	Cuamba＋83km
Bridge Length	18.3m	Bridge Width	—
Number of Span	1 Span	Carriageway Width	4.2m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Namisagua River

Vicinal Circumstance		In dry season, there is no water in the river. There is a washing place at the upstream of the existing birdge. Cassava, sugar cane, banana, mapira and mais are cultivated along the road near the bridge. There are a church and 1 house with 10 persons at Nampevo side in the vicinal area of the birdge, but the project would not affect the area. There also is 1 house with 4 persons at Cuamba side, but the project would not affect the area.
Superstructure	Structural Type	Bailey bridge
	Present Condition	The old bridge was collapsed because of flood water scouring under the abutments and became impassable. After the collapse, the bailey bridge was temporarily erected. The flood water has overflowed the bridge in recent years.
Substructure	Structural Type	Abutment: Gravity type Pier:
	Present Condition	Sand is sedimented on the river bed. The abutments have been gradually sinking down due to erosion.
Approach Road	Present Situation	The existing approach roads are straight. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the bridge & inclined at approximately 1 or 3%.
Others	Present Situation	Optical fiber cable is hooked on lateral face of deck slab. The existing electrical cable & posts are located at about 100 meter from the bridge along the road.
Comment	The bridge should be reconstructed instead of the temporary one. New bridge should have two lanes and be located at the existing bridge position. Approach roads of the bridge should be smoothly connected to the existing road.	

Photos		
	 Overview (from Cuamba Side)	 Overview (from Nampevo Side)
	 Bailey Bridge (from Upstream)	 Underneath of Bailey Bridge & A2 Abutment Collapsed

Bridge Inspection Sheet 10.

18/Sep/2011

<table>
<tr><td colspan="2">Bridge Name</td><td>No.10 Nuhusse</td><td>Route, Grade</td><td>R657、Third Road</td></tr>
<tr><td colspan="2">Province</td><td>Zambezia</td><td>Distance, Year built</td><td>Cuamba＋61km</td></tr>
<tr><td colspan="2">Bridge Length</td><td>24m</td><td>Bridge Width</td><td>—</td></tr>
<tr><td colspan="2">Number of Span</td><td>1 Span</td><td>Carriageway Width</td><td>4.2m</td></tr>
<tr><td colspan="2">Attached Utilities</td><td>Optical Fiber Cable
（Pipe:φ50mm）</td><td>River Name</td><td>Nuhusse River</td></tr>
<tr><td colspan="2">Vicinal Circumstance</td><td colspan="3">There is a washing place under the existing birdge.
There are dense vegetation and some trees in the surrounding area of the bridge.
Cassava, sugar cane, mapira and mais are cultivated along the road near the bridge.
There are a church and 2 houses with 9 persons at Nampevo side in the vicinal area of the birdge, but the project would not affect the area.
There also is 3 houses with 8 persons at Cuamba side, but the project would not affect the area.</td></tr>
<tr><td rowspan="2">Superstructure</td><td>Structural Type</td><td colspan="3">Bailey bridge</td></tr>
<tr><td>Present Condition</td><td colspan="3">The old bridge was washed away by flood water and became impassable.
After the collapse, the bailey bridge was temporarily erected.
The flood water has overflowed the bridge in recent years.</td></tr>
<tr><td rowspan="2">Substructure</td><td>Structural Type</td><td colspan="3">Abutment：Gravity type Pier：</td></tr>
<tr><td>Present Condition</td><td colspan="3">Rock layer is exposed on the riverbed. There is less scouring around piers & abutments.
The both abutments are made of stone masonry.</td></tr>
<tr><td>Approach Road</td><td>Present Situation</td><td colspan="3">The ambilateral access roads of the bridge are curved gently.
The bridge is located at the bottom of the valley.
The ambilateral access roads are ascents from the bridge & inclined at approximately 2 or 4%.</td></tr>
<tr><td>Others</td><td>Present Situation</td><td colspan="3">Two rivers meet at the bridge point and the width of the river become wider at downstream.
Optical fiber cable is hooked on lateral face of deck slab.
Some big trees which grow in the upstream have disturbed smooth flow.</td></tr>
<tr><td>Comment</td><td colspan="4">The bridge should be reconstructed instead of the temporary one.
New bridge should have two lanes and be located at the existing bridge position.
Approach roads of the bridge should be smoothly connected to the existing road.
New washing place should be prepared during the construction period.</td></tr>
<tr><td rowspan="2">Photos</td><td colspan="2">
Overview（from Cuamba Side）</td><td colspan="2">
Overview（from Nampevo Side）</td></tr>
<tr><td colspan="2">
Bailey Bridge & Piers Collapsed (from Napevo Side)</td><td colspan="2">
Bailey Bridge & Piers Collapsed (from Cuamba Side)</td></tr>
</table>

Bridge Inspection Sheet 11. 18/Sep/2011

Bridge Name	No.11 Lurio	Route, Grade	R657、Third Road
Province	Zambezia / Niassa	Distance, Year built	Cuamba＋54km, 2009年
Bridge Length	55.2m	Bridge Width	3.88m
Number of Span	5 Spans	Carriageway Width	3.2m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Lurio River

Vicinal Circumstance		The river is the natural border between Zambezia province and Niassa province. There is no residence within approximately 200 meter from the bridge. There is a washing place under the existing birdge. Cassava, sugar cane, mapira, banana and mais are cultivated along the road near the bridge. There are two big trees in the surrounding area of the bridge, but the trees would not affect the project.
Superstructure	Structural Type	RC T-shaped girder birdge
	Present Condition	Temporary concrete bridge was completed in 2009. Design calculation sheets & drwaings on the bridge do not exist. There is no visible serious damage on the main girders. There is a risk of overflowing the bridge in rainy season.
Substructure	Structural Type	Abutment: Stone Masonry Type Pier: Wall type
	Present Condition	Sand is sedimented on the river bed. The existing piers have no piles and some piers have been already inclined slightly.
Approach Road	Present Situation	The existing approach road at Cuamba side is straight, but the approach road at Nampevo side is sharply curved. The approach roads are longitudinally flat. As the bridge has no handrail, night time driving is extremely dangerous.
Others	Present Situation	The existing electrical cable & posts are located at about 20 meter from the bridge along the road. Optical fiber cable is hooked on lateral face of deck slab. There are some school in the surrounding area of the bridge and the road is crucial as a school-commuting path.
Comment	Flood water might overflow the bridge, since the planing & design were not carried out carefully. There is a risk of collapsing the bridge due to skewing existing pires. Therefore, the bridge should be urgently reconstructed. New bridge should have two lanes and be located at the upstream of the existing bridge due to smooth road alignment. Approach roads of the bridge should be smoothly connected to the existing road. New washing place should be prepared during the construction period.	

Photos

Overview (From Cuamba Side)

Overview (From Nampevo Side)

Overview of Bridge (From Cuamba Side)

Existing A1 Abutment & P1 Pier

Bridge Inspection Sheet 12.

18/Sep/2011

Bridge Name		No.12 Mussai	Route, Grade	R657、Third Road
Province		Niassa	Distance, Year built	Cuamba＋47km, 1999年
Bridge Length		12.1m	Bridge Width	5.15m
Number of Span		Pipe Culvert & 1 Span RC Bridge	Carriageway Width	—
Attached Utilities		Optical Fiber Cable (Pipe:φ50mm)	River Name	Muassi River
Vicinal Circumstance		In dry season, there is no water in the river but are reeds. There is no residence within approximately 200 meter from the bridge. Cassava, sugar cane, mapira, cotton and mais are cultivated along the road near the bridge.		
Superstructure	Structural Type	Pipe culvert & RC deck slab bridge		
	Present Condition	The exisiting culvert was constructed in 1999 and the one-span concrete bridge was additionally constructed in 2003 in order to increase the cross-sectional area of flow. The flood water has overflowed the bridge in recent years.		
Substructure	Structural Type	Abutment：Stone Masonry Type　　Pier：		
	Present Condition	Rock layer is exposed on the riverbed. The separated retaining wall has already skewed to the river and might collapse in the near future. The embankment behind the abutment has settled down.		
Approach Road	Present Situation	The existing approach road at Cuamba side is straight, but the approach road at Nampevo side is gently curved. The bridge is located at the bottom of the valley. The ambilateral approach roads are ascents from the bridge & inclined at approximately 1 or 3%.		
Others	Present Situation	In dry season, there is no water in the river but are reeds. Optical fiber cable is hooked on lateral face of deck slab.		
Comment	Flood water might overflow the bridge due to the lack of cross-sectional area of flow. There is a risk of collapse due to skewing & sinking the structure. Therefore, the bridge should be urgently reconstructed. New bridge should have two lanes and be located at the upstream of the existing bridge due to smooth road alignment. Approach roads of the bridge should be smoothly connected to the existing road.			
Photos	 Overview（From Cuamba Side）		 Overview（From Bridge toward Cuamba）	
	 Overview of Structure（From Upstream Side）		 Overview of Structure（From Downstream Side）	

Bridge Inspection Sheet 13. 18/Sep/2011

Bridge Name	No.13 Namutimbua	Route, Grade	R657、Third Road
Province	Niassa	Distance, Year built	Cuamba＋3km
Bridge Length	20.15m	Bridge Width	—
Number of Span	4 Spans	Carriageway Width	4.1m
Attached Utilities	Optical Fiber Cable (Pipe:φ50mm)	River Name	Namutinbua River
Vicinal Circumstance		There is no residence within approximately 200 meter from the bridge. Cassava, sugar cane, mapira and mais are cultivated along the road near the bridge. Many pedestrian and bicycles are passing the bridge. There are a facility for corn mill and 2 houses with 12 persons at Nampevo side in the vicinal area of the birdge, but the project would not affect the area.	
Superstructure	Structural Type	Temporary bridge	
	Present Condition	The old bridge was washed away by flood water and became impassable. After the collapse, the bailey bridge was temporarily erected. The flood water has overflowed the bridge in recent years.	
Substructure	Structural Type	Abutment: Stone Masonry Type Pier: Wall type	
	Present Condition	The existing pires are made of stone masonry. Therefore, the pires have a risk of collapsing because of their weakness against horizontal force in case flood water or some obstacles hit the pires. Scouring behind the abutments was detected during the visual inspection.	
Approach Road	Present Situation	The existing approach road at Cuamba side is straight, but the approach road at Nampevo side is gently curved. The approach roads are longitudinally flat. There are two small pipe culverts under the approach road at Cuamba side.	
Others	Present Situation	In dry season, there is no water in the river but are reeds. Most vicinal area of the bridge would cover with water when serious flood comes. Optical fiber cable is hooked on lateral face of deck slab.	
Comment	Flood water might overflow the bridge due to the lack of cross-sectional area of flow. There is a risk of collapse due to scouring behind the abutments. Therefore, the bridge should be urgently reconstructed. New bridge should have two lanes and be located at the upstream of the existing bridge due to smooth road alignment. Approach roads of the bridge should be smoothly connected to the existing road.		

Photos

Overview（From Bridge toward Cuamba）

Overview（From Bridge toward Nampevo）

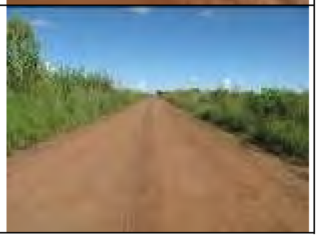
Overview of Bridge（From Nampevo Side）

Pipe Culvert under Access Road (Cuamba Side)

1.2.3 Current Situation of Existing Roads

The conditions of the existing road between Ile and Cuamba are as follows.

Table 1.2.8 Current situation of the existing road

Section	Pavement	Cross Section	Topographic	Photo
Ile - Gurue	Paved	W=8.8m (1.0+3.4+3.4 +1.0)	Rolling	
Gurue - Magige	Unpaved (Under Construction) (Financed by IDB)	W=8.0	Rolling	
Magige - Cuamba	Unpaved (Under Planning) (Financed by Portugal Gov.)	W=6.0	Flat and Rolling	

The unpaved sections mentioned above are advanced to upgrade by assistance of Portugal Government and Islamic Development Bank (hereinafter “IDB”). Gurue – Magige section financed by IDB is now under construction. The following table shows the applicable design standards for Gurue – Magige section.

Table 1.2.9 Design standards for Gurue – Magige section

Items	Applicable Standard	Remarks
Road Class	Primary Road (Type of Surfaced Road)	Geometric design parameters for surfaced road and asphalt road are different.
Design Speed	Desirable: 80km/h Absolute: 60km/h Urban Area: 50km/h	Standard design speed for Primary Road with surfacing is 60km/h, but TOR for design works stipulated the design speed of 80km/h. Finally, in case that it is difficult to use of design speed of 80km/h, use of design speed of 60km/h was agreed as absolute standard. Standard design speed for asphalt road is normally 100km/h.
Geometric Standard	ANE Standard (Draft)	From comparison with SATCC and ANE standard, ANE standard was applied because use of SATCC means a substantial increase in construction cost with the commensurate increment of earth work.

Items	Applicable Standard	Remarks
Cross Section	W=10.0m 0.5m: Protection Shoulder 1.0m: Surfaced Shoulder 3.5m: Carriageway	-
Pavement Composition	Surface: 13.2 & 6.7 mm (Double seal) Base: 15cm (Crushed Stone (G2)) Sub-base: 15cm Cement (Stabilized (C4)) Capping Layer: 20cm (CBR>15 (G7)) Sub-grade: CBR>7 (G9)	Applied Pavement Design Standard • TRH4 and/or 14 • Research Report R91/241 (South Africa Standard)
Earth Work	Standard Cut Slope: 1:2 Standard Embankment Slope: 1:3 Embankment>3m: 1:2	Cut slope has some variations base on soil type.
Safety Facilities	Guardrail	Embankment>3m and Curve Radius<750m

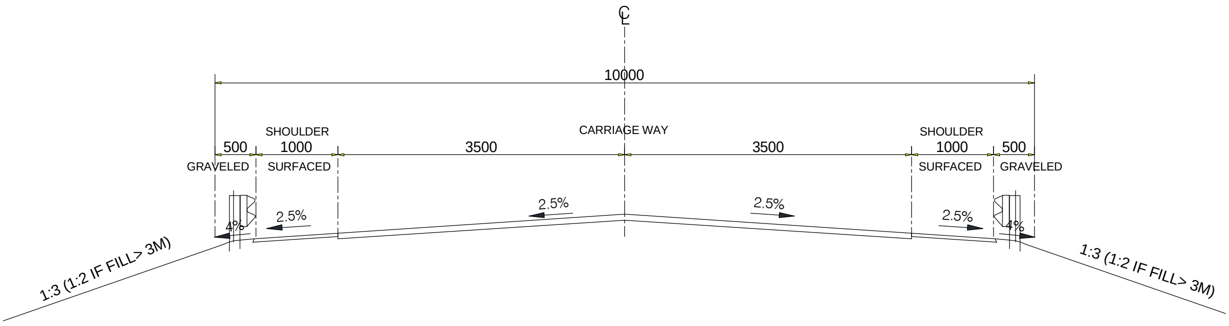


Fig. 1.2.2 Typical cross section on Gurue – Magige section

1.2.4 Ancillary Facilities

Some culverts as ancillary facility were identified through the site survey. These culverts should be replaced with bridge construction because length of all culverts is not sufficient for the new vertical plan of bridges.

Table 1.2.10 Culverts identified at sites

No.	Bridge Name	Culverts Location	Size and Number
1	Mutabasse	No	
2	Muliquela	No	
3	Matacasse	35m from bride to Ile side 33m from bridge to Cuamba side	W=1.5m,H=(Buried), N=1 W= 1.5m, H=0.9m, N=1
4	Lua	No	
5	Ualasse	No	
6	Licungo	No	
7	Nivaco	14m from bridge to Ile side 25m from bridge to Ile side	φ= 0.9m, N=1 φ= 0.9m, N=1
8	Matsitse	No	
9	Namisagua	No	
10	Nuhusse	No	

No.	Bridge Name	Culverts Location	Size and Number
11	Lurio	No	
12	Muassi	100m from bridge to Ile side	φ= 1.1m, N=1
13	Namutimbua	40m from bridge to Cuamba side 80m from bridge to Cuamba side	φ= 1.1m, N=1 φ=1.1m, N=1

As a general rule, replacement of culverts should be applied with equality or bigger capacity. The design should follow the ANE standard.

1.2.5 Existing Utilities

The optical fiber cables are buried along the road along the target route. They are used for telephone lines and are owned and controlled by the Telephone Public Corporation (hereinafter “TDM”). In the section of the target bridges, the cables are hooked on the lateral face of the deck slabs as shown in Photo 1.2.3 & 1.2.4. Therefore, it is necessary to relocate the cables before starting construction works. ANE has already agreed to their relocation at ANE’s own expense

Table 1.2.11 Location of cable buried near bridges

Bridge No.	Cable Position (Left Side)	Nampevo ↑	Cable Position (Right Side)
No.1		Existing Road	○
No.2			○
No.3			○
No.4			○
No.5			○
No.6			○
No.7			○ (Unconfirmed)
No.8	○		
No.9	○		
No.10	○		
No.11	○		
No.12	○		
No.13	○		
		↓ Cuamba	

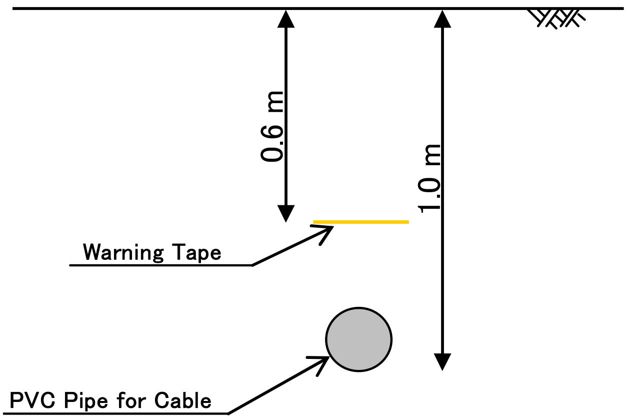


Fig. 1.2.3 General section view of the buried cable

Photo 1.2.3 Optical fiber cable at Br. Mutabasse

Photo 1.2.4 Optical fiber cable at Br. Namutinbua

Chapter 2. Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Project Aim

The Mozambique government formulated the Action Plan for the Reduction of Absolute Poverty (PARPA) in 2001 aimed at the reduction of the poor up to 60% of the national, as the mid-long term national plan for the land reconstruction after the civil conflict. Later on, PARPA II (2006-2009) was also formulated. Its aim is to reduce the poverty ratio from 54% in 2003 to 45% in 2009, and it states 6 prioritized issues as follows; 1.Regional development, 2.Development of the legal amendment for production sector, 3.Improvement of the financial systems, 4.Supports for small and midsize firms, 5.Improvement of systems for collecting taxes, 6.Improvement of budgetary allocation. Infrastructure development included in regional development is essential for the realization of above items. In particular, the road and bridge development become a very important means to build the road network for encouraging the economics.

ANE, in cooperation with MOPH and the Road Funds (hereinafter "FE"), formulates the Road Sector Strategy (2007-2011: RSS) and it states that the road network development is an important agenda for socio-economic revitalization and supports for the regional development. Corridor development is encouraged to be focused and Route 103 including this bridge project, as the target road, is one of the high prioritized roads necessary to be developed.

The Project aim is to organize the target thirteen bridges on Route 103 situated in the north part of the country, in order to secure safe year-round traffic on Route 103 which results in the stable and smooth logistics of Mozambique and the neighboring countries.

2.1.2 Outline of the Project

This Project is planned to reconstruct the target thirteen bridges on Route 103 in order to achieve the goals mentioned above. The scope of this Project is to reconstruct the target thirteen bridges and their approach roads. The success of the Project will bring safe year-round traffic on the route, decreasing traffic accidents and eliminating disaster risks. Furthermore, shortening transport time & distance, increasing transportation amount, benefits for the poor and regional development can be expected.

2.2 Outline Design of the Japanese Assistance

2.2.1 Design Policy

(1) Basic Concept

This is a Grant Aid Project to reconstruct bridges along an arterial road and thereby make a major contribution to economic development, lifestyle improvement and agricultural development in Mozambique. The target route contains numerous bridges that become inundated during the rainy season and narrow temporary bridges that hinder the road's functions as an arterial route. In this Survey, based on the policies described below, it has been decided to plan construction of 13 bridges and their approach roads based on the request from Mozambique government and the findings of field surveys and discussions with related agencies. In the Project, it is intended to rationalize design, execution and maintenance and reduce costs through grouping the bridges according to natural conditions and construction conditions, standardizing structures, and planning the common and divertible use of temporary materials and equipment. Concerning the approach roads, these will be planned to join with existing roads over the shortest distance possible while satisfying the curve radius and longitudinal profile stipulated in the road standards of Mozambique.

(2) Concept regarding Natural Conditions

1) Climate

Climate in the target area is divided into tropical savannah climate in the south and a climate of mild winters and light rainfall in the north. In both regions, the dry season lasts from May to November and the rainy season is from December to April. On the target route, vehicle passage is restricted during the rainy season because the section between Gurue and Cuamba is currently unpaved; the section between Gurue and Magige is currently under construction and the section between Magige and Cuamba is still busy with planning. In addition, there may be cases where river water flows over existing bridges and makes them impassable along the route. Accordingly, the construction plan will be appropriately determined upon giving sufficient consideration to water level during the rainy season. As for the dry season, since temperatures exceed 30℃ on many days, countermeasures against hot weather concreting will need for the quality control.

2) Hydrological conditions

In planning the bridges and roads, the clearance under girders and the locations of abutments will be decided according to design conditions upon taking the results of field surveys and hydraulic analysis into consideration.

3) Geological conditions

The geological makeup of the target area comprises granitic gneiss, schist and granite from the Cambrian to Precambrian eras. According to the results of boring survey, potential bearing strata in the respective bridge locations diversely comprise weathered rock layers (with an N value of around 50 and layer thickness of 5 m or more) around 20 m below the surface, rock strata outcrops in rivers and new rock at depths of 1~5 m. In the Project, it is planned that the spread foundations and the pile foundations will be supported by on such layers.

(3) Concept regarding social and economic conditions

The target area is located in the central-northern part of Mozambique, where poverty levels are extremely high even for that country. Locally available materials will be utilized as far as possible in order to contribute to the economic promotion of the local area. Moreover, regarding the employment of local residents, in addition to providing manual labor opportunities, relatively simple bridge designs will be adopted so that the local workers can also take part in the bridge construction. Furthermore, through standardizing the bridge structures, this will help improve the competence level of workers because the same works will be repeated.

There are washing places around the target bridges. In cases it is considered that the washing places are affected during the construction stage, the places are planned to be relocated in order not to endanger the livelihoods of the local residents.

(4) Concept regarding the situation and special conditions in the construction sector

1) Materials procurement

The materials available in Mozambique are cement for substructure, concrete aggregate, timber for formwork and fuel, etc. Upon considering past construction works, cement for superstructure will be procured from South Africa, while cement for low-strength concrete used in leveling and bridge substructures will be procured in Mozambique. Meanwhile, cement additives, reinforcing bars, bitumen and steel guardrails, etc. are generally procured from South Africa, while pre-stressing steel wire, elastic bearings and expansion joints are purchased from South Africa or Japan.

2) Procurement of construction machinery

Heavy machinery for road construction and general civil engineering works are available from local construction companies. However, numbers are limited and it is difficult to obtain such machines on time. Moreover, it is difficult to obtain heave construction machines such as large crane and vibrating hammer, etc. required for bridge construction in Mozambique. Accordingly, most of the important construction equipments will be procured from South Africa and so forth. Special machines such as for piling works will be procured from South Africa or Japan.

3) Procurement of workers

Workers can be procured from local construction companies in Mozambique, however, there are few skilled workers who have experience of bridge construction. Moreover, since the experienced workers tend to be concentrated in the metropolitan region, such workers' pay rates tend to become more expensive because it is necessary to consider additional allowances such as traveling one approximately 2,000 km to the construction sites. It will also be necessary to comply with Mozambique labor law (Lei Do Trabalho) when recruiting local workers.

(5) Concept regarding utilization of local contractors

Many of the large construction firms in Mozambique are local corporations of foreign affiliates that have their head offices in South Africa and Portugal, etc., and these foreign affiliated construction firms have been awarded the major public works. Such firms participated as subcontractors in past bridge construction projects under Japanese grant aid, and they can be utilized in this Project again.

(6) Concept regarding operation and maintenance

Since the target bridges in the Project will be concrete structures, the bridge structures will not require frequent maintenance work. The activities will mainly comprise periodic inspections of pavement, embankment and bridge handrails, etc. Since such work won't require any special technologies, it can be carried out with the conventional road maintenance works.

(7) Bridge design concept

1) Design criteria

The design of target bridges will basically comply with the Mozambique road design criteria (ANE's Design Standard (Draft)) and SATCC. However, if items do not be mentioned in these criteria, they will abide by the specifications for highway bridges stipulated by Japan Road Association. Table 2.2.1 shows the main bridge conditions to be applied in this basic design.

Table 2.2.1 Bridge design conditions

Items	Design condition	Description
Design discharge & Return period	50-year or 100-year return period based on hydrological analysis	Natural conditions, results of hydrological analysis, ANE's Standard
Vertical clearance under bridge	1.0 m	ANE's request
Live load	SATCC(NA,NB-24, 36), 60ton(Class-I)	SATCC standard
Seismic load	Seismic coefficient = 0.1	SATCC standard, Result of earthquake occurred in Manica
Thermal load	+49℃～0℃	SATCC standard
Number of traffic lane	One lane or two lanes	Refer Fig 2.1.2
Carriageway width	One lane: 3.6m, Two lane: 7.2m	Refer Fig 2.1.2
Sidewalk width	0.85-0.95m	Refer Fig 2.1.2

Based on the updated ANE's design standard, the live load will be updated to NB-36 from NB-24 at the detailed design stage.

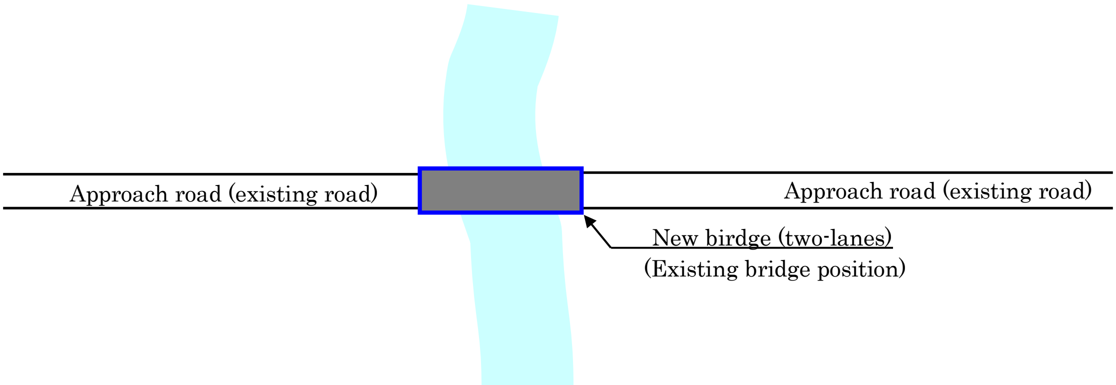
2) Utilization of existing bridges

The soundness on Muliquela and Lua bridges seems to be few problems regarding safety and durability. Therefore, those existing one – lane bridges will be utilized for only one direction. For the opposite direction, new bridges will be constructed with parallel to the existing ones. Furthermore, the new bridges will be constructed on the upstream side of existing bridges upon considering the road alignments and conditions of the target area. Moreover, efficient clearance between bridges and pier positions will be designed so that no negative impacts are raised on the structures and the flood flow line is not disturbed.

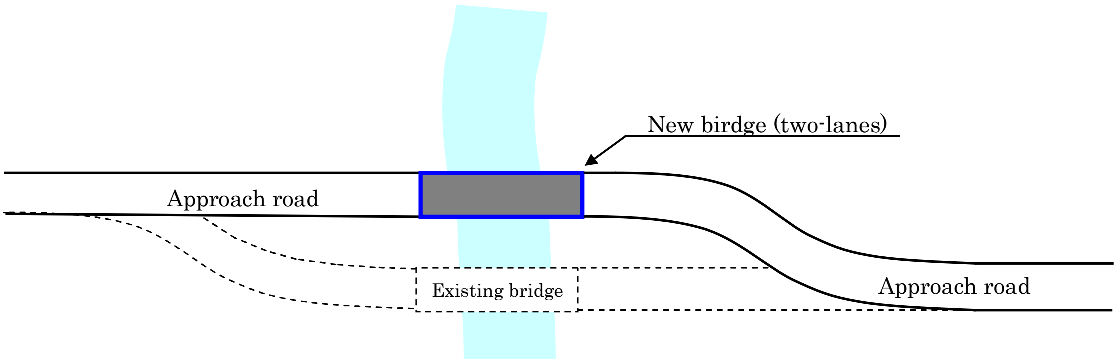
3) Bridge positions

The bridge positions will be divided into the following three types upon taking the existing bridge conditions, the existing road alignments and target area terrain into consideration.

Type A: Reconstruct the bridge at the existing bridge position.
(Br.Matacasee, Br.Ualasse, Br.Licungo, Br.Nivaco, Br.Matsitse, Br.Namisagua, Br.Nuhusse)



Type B: Construct new birdge upstream or downstream of the existing bridge.
(Br.Mutabasse, Br.Lurio, Br.Muassi, Br.Namutinbua)
The existing bridges will be removed by the Mozambique side after completion of new birdge, since the exisiting bridges are deemed to have problems regarding safety and/or durability.



Type C: Construct new one-lane bridge parallel to the existing bridge. (Br.Muliquela, Br.Lua)

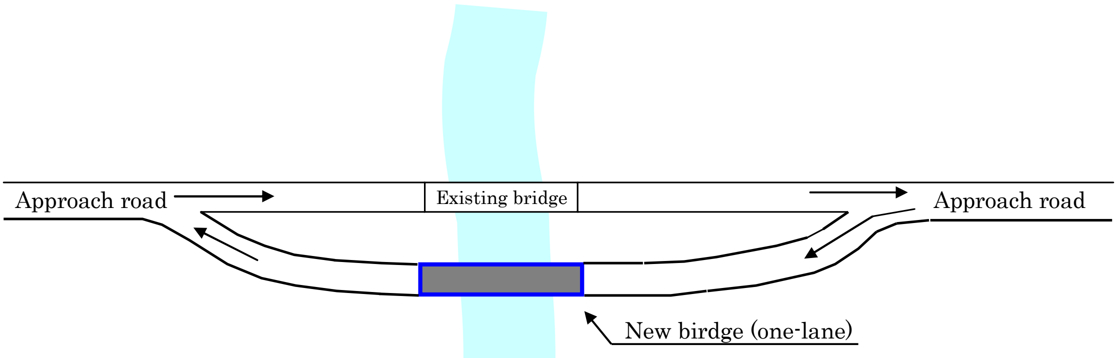


Fig. 2.2.1 Types of the target bridges

4) Width of roads and bridges

The width of approach roads is planned based on the standard width adopted on the road project between Gurue and Magige. On the other hand, the widths of the bridges are 9.6 m for two-lane bridges and 5.2 m for one-lane bridges respectively, following the bridge width on the Nakara Corridor and National Route 1 which was planned for the previous project.

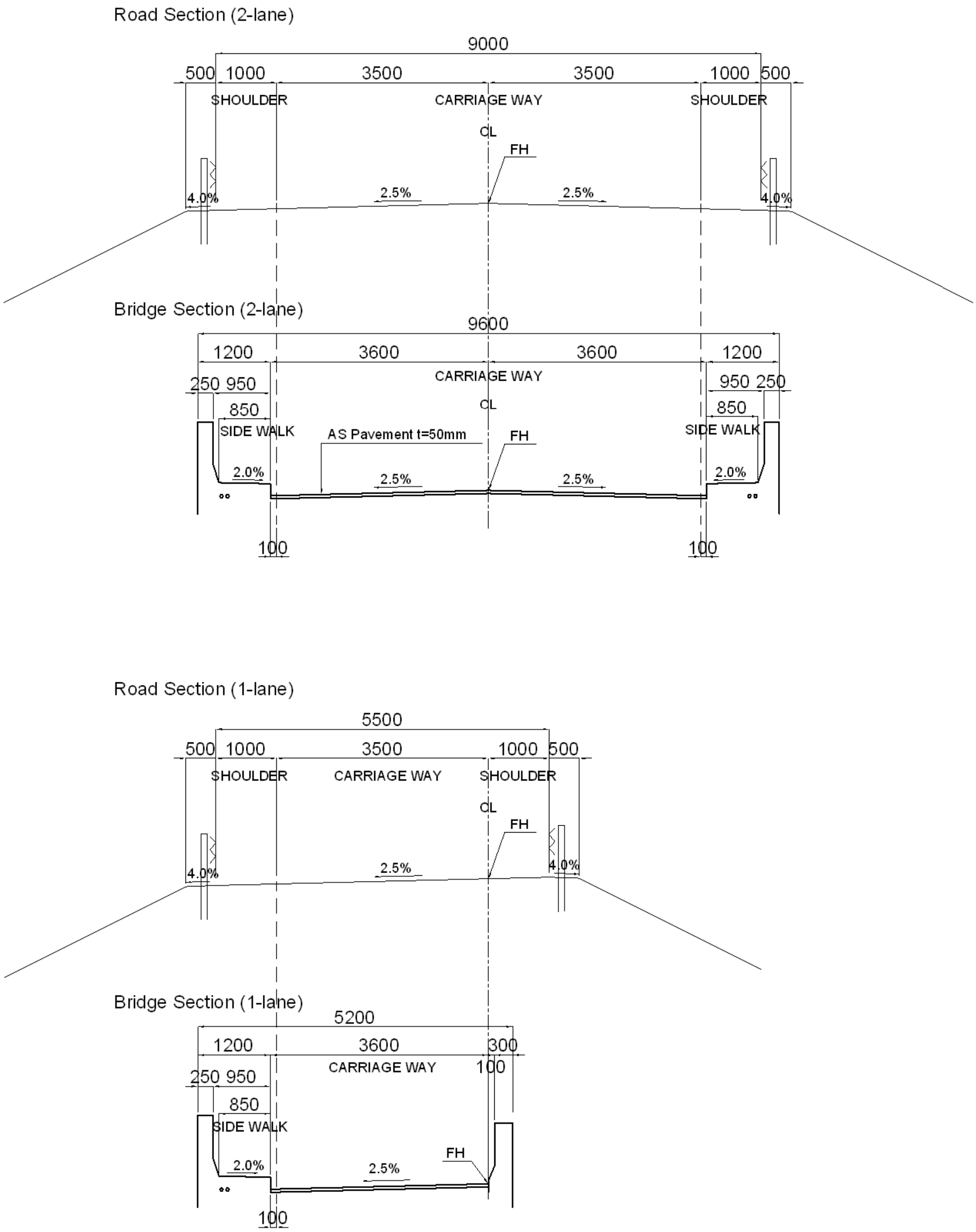


Fig. 2.2.2 Widths of approach roads and bridges

(8) Approach road design concept

1) Applicable design standard

The following manuals are mainly used for the road design in Mozambique. The approach road design is carried out based on these manuals.

- ANE's Design Standard (Draft): Road Classification, Geometric Design
- SATCC Standard: Pavement, Bridges and Culverts, Traffic Sign, Specification
- South Africa Standard: Hydrology and Drainage

2) Alignment plan

The alignment is basically connected to existing road with the shortest length in accordance with the bridge design policy and geometric design standard. Moreover, the road surface level is decided not to be covered with flood water in return period of 3-year. In addition, considering social impacts such as house relocation, no resettlement is planned in this Project.

3) Typical cross section

Following typical cross sections which are used for the road project on Gurue – Magige are applied for this Project.

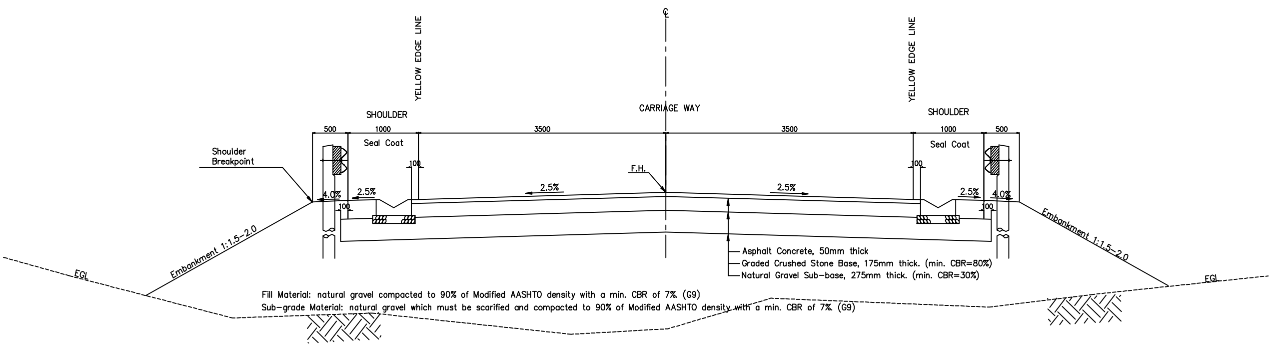


Fig. 2.2.3 Typical cross section for two-lanes

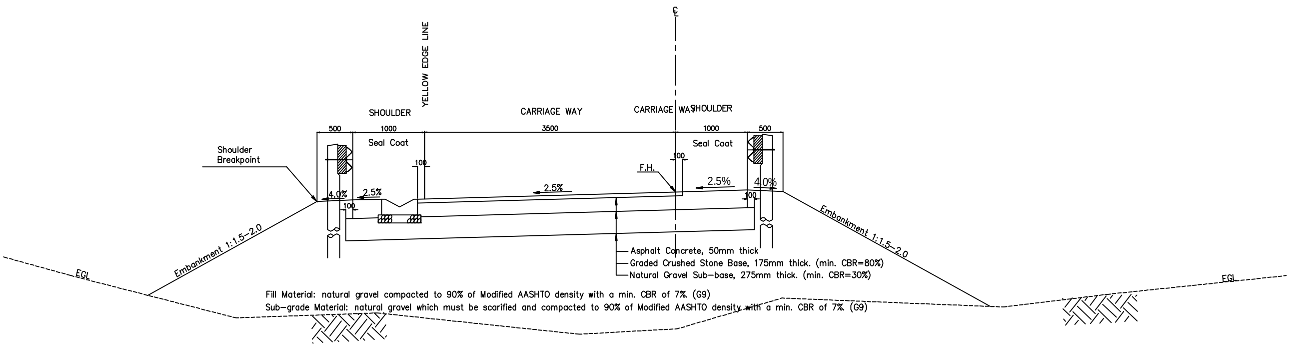


Fig. 2.2.4 Typical cross section for one-lane

4) Pavement design

Double seal pavement is applied to Gurue – Magige road based on the theoretical methods such as multi layer elasticity method, but considering reliability for middle or long term period, asphalt concrete pavement is superior and is therefore applied to this Project based on the result of past Japanese assistance projects.

However as mentioned before, a part of target sections are not paved. Thus asphalt pavement will be applied in accordance with the following concepts.

Table 2.2.2 Application policy of asphalt pavement

Section	Pavement	Bridge No.	As Pavement Area	Remarks
Ile-Gurue	Paved	No.1,2,3,4,5	Whole Project Length	Shoulder: Seal Coat
Gurue-Magige	Unpaved (Under Construction)	No.6,7	Whole Project Length	Shoulder: Seal Coat
Magige-Cuamba	Unpaved (Under Planning)	No.8,9,10,11, 12,13	50m of bridge approaches	Remaining road section and Shoulder: Seal Coat

As to the section Magige and Cuamba, the asphalt pavement area on each bridge will be updated at the detailed design stage, considering the progress of the project on the section between Magige and Cuamba financed by the government of Portugal.

5) Drainage facilities

The existing transversal drainage structures are mostly blocked up with soil. Therefore, existing traversal drainage should be replaced to new structure with adequate capacity in consideration of easy maintenance.

In addition, gutters are installed on the road shoulder for protection of embankment slop. Theses gutters are connected to adequate outlet via U-type ditch.

6) Safe traffic facilities

Safe traffic facilities such as traffic sigh should be installed in accordance with the SATCC manuals. Setting of guardrails is also including in this Project as safe traffic facilities. Guardrails are set based on the same standard (curve radius < 750m and Height of embankment > 3m) as Gurue – Magige road.

(9) Concept regarding construction method and period

- During the rainy season, it is anticipated that the road conditions will deteriorate and that it is difficult to transport equipments, materials and workers around the bridge sites. Therefore, sufficient construction period including transport blockage days will be planned, considering the local conditions and safety matters.

- Since it is extremely difficult and dangerous to construct foundations and substructures in rivers of high water flow, it is basically planned to complete foundations and substructures during the dry season.

- The Analytic Hierarchy Process (hereinafter AHP) is used as one of the resources for compiling the construction plan to determine the order of priority for reconstructing bridges. The AHP, which was developed in the United States, is a hierarchical analysis technique for determining the order of priority. In this Project, the field surveys were conducted upon setting six assessment items, i.e. (1) degree of clearance under bridge girders, 2) degree of damage, 3) bridge structural type, 4) load bearing capacity, 5) pedestrian safety, and 6) road alignment, and the order of priority indicated in Table 2.1.3 was obtained. Considering not only the result but also grouping the bridges according to dimensions, shape and construction method, geographical conditions and safety, the economical and efficient order of construction is planned.

Table 2.2.3 Order of priority bridges based on AHP technique

Priority	Bridge name
1	7.Nivaco
2	3.Matacasse, 5.Ualasse, 8.Matsitse, 9.Namisagua, 10.Nuhusse
3	11.Lurio
4	13.Namutinbua
5	12.Muassi
6	6.Licungo
7	1.Mutabasse
8	4.Lua
9	2.Muliquela

(10) Concept regarding clearing UXO's and Land mines

Before start this study, ANE already carried out the survey & clearing of land mines in March and June, 2011. The cleared area at each bridge is shows in Figure 2.2.5. Additional areas, which need to be cleared by the results of this study, have to be demined by ANE before the tendering. Moreover, after the tendering, if the contractor request to demine other lands not cleared yet and ANE accepts the mine clearing to be necessary for the Project, the mine-clearing will be carried out by ANE.

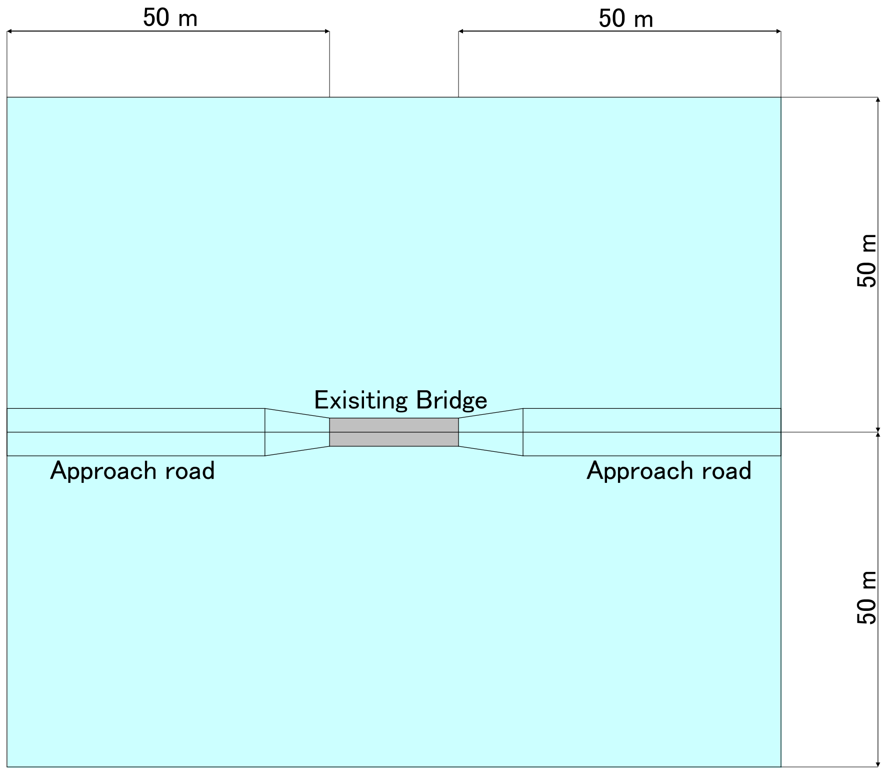


Fig. 2.2.5 Area where land mines cleared

2.2.2 Basic Plan

(1) Hydrological analysis

1) Rainfall intensity

Daily rainfall data were supplied as below from three rainfall stations. The statistical rainfall at Gurue and Ile are not supplied with a high confidence due to the short records. The calculated design rainfall may prove to be more conservative than necessary. Hence an average of the design rainfall experienced at Cuamba may prove sufficient for the purposes of the survey.

Table 2.2.4 Rainfall data suppied

Station	Requested data	Supplied data	Missing records
Cuamba	1981-2010	1981-2010	-
Gurue	1981-2010	1981-1983, 2004,2005,2007	1994-2003, 2006, 2008-2010
Ile	1981-2010	1981-1988, 1990	1989, 1991-2010

A statistical analysis is done on the rainfall data at station of Cuamba. Two statistical distribution methods, Gumbel Method and Log Pearson III, are applied to the observed rainfall records. As a result, Log Pearson III shows highly-compatible.

Table 2.2.5 Calculation of rainfall intensity

Method	Gumbel								
SLSC (99%)	X-COR	P-COR							
0.028	0.991	0.992							
Return Period	200	100	50	30	20	10	5	3	2
Rainfall intensity	165	152	140	130	123	109	96	85	75

Method	LogP3								
SLSC (99%)	X-COR	P-COR							
0.028	0.992	0.994							
Return Period	200	100	50	30	20	10	5	3	2
Rainfall intensity	**172**	**157**	**142**	**132**	**123**	**109**	**95**	**84**	**75**

2) Design discharge

Design discharge is derived by the Rational method (Drainage Manual 5th Edition: SA National Road Agency). In addition, 5% of calculated volume is added in consideration of depositional work of soil. Followings are Japanese Standard for the facilities of sand erosion control. The project sites are not so serious erosion area. Thus 5% is applied.

- Under construction of facilities for soil erosion control (50% completed to the design discharge) or protection of inflection and turbulent flow: 10%
- Completed construction of facilities for soil erosion control: 5%

Applicable return periods are stipulated in ANE's Design Manual as follows. According to this manual, the return period should be decided by discharge volume of 20-year return period and importance of structures.

Table 2.2.6 Standard for decision of return period

Discharge for 20-year	Applied Return Period			
	Pipe	Box	Structure (Importance: Low)	Structure (Importance: High)
$20m^3/s > Q$	5	10	10	20
$20m^3/s < Q < 250m^3/s$	10	20	20	50
$Q > 250m^3/s$	30	30	30	100

Source: ANE's Design Standard

The calculation results for each river are shown in Table 2.2.7. Design discharge for return period of 3-year is also calculated for construction stage.

Table 2.2.7 Calculation results for design discharge on each river

Bridge Name		Discharge 20-years (m^3/s)	Design Discharge (m^3/s)		
			1/3 (for construction)	1/50	1/100
No.1	Mutabasse	532.6	227.9	739.1	896.4
No.2	Muliquela	274.2	106.2	511.1	619.9
No.3	Matacasse	57.0	22.1	106.3	128.8
No.4	Lua	423.0	163.8	788.4	956.2
No.5	Ualasse	100.8	43.2	139.9	169.6
No.6	Licungo	699.4	299.1	970.4	1177.1
No.7	Nivaco	270.9	115.9	375.9	455.9
No.8	Matsitse	90.1	38.5	125.1	151.6
No.9	Namisagua	95.8	41.0	132.9	161.3
No.10	Nuhusse	361.7	140.1	674.1	817.6
No.11	Lurio	482.8	187.0	899.9	1091.5
No.12	Muassi	53.9	20.9	100.5	121.8
No.13	Namutimbua	167.3	64.8	312.0	378.3

3) Flood level estimation for bridges

The software used to model for the flood level calculation is HEC-Ras in which primary input is cross-sectional data, Manning's roughness, the flood peaks and types of pier. This software was developed as the River Analysis System by Hydrologic Engineering Center (HEC) of America.

Cross sections are extracted from the topographic survey. The following table shows the results of the flood level calculation by the HEC-Ras, which is based on the calculation for non-uniform flow.

Table 2.2.8 Suggested flood water level for return period of 3-years, 50-years and 100-years

Bridge Name		Location of New Br. from existing Br.	H.W.L(m) : Upstream side			Results of hearing (m)
			Temporary	New bridge	Existing	
No.1	Mutabasse	Downstream	327.14	329.88	Removal	331.09
No.2	Muliquela	Upstream	408.88	411.59	411.39	409.56
No.3	Matacasse	Same position	495.76	498.25	Removal	497.74
No.4	Lua	Upstream	507.74	511.76	510.43	509.87
No.5	Ualasse	Same position	566.32	568.02	Removal	569.45
No.6	Licungo	Same position	625.47	630.04	Removal	626.50
No.7	Nivaco	Same position	701.63	704.62	Removal	702.15
No.8	Matsitse	Same position	719.29	721.04	Removal	721.21
No.9	Namisagua	Same position	707.19	708.82	Removal	708.94
No.10	Nuhusse	Same position	598.76	603.97	Removal	602.65
No.11	Lurio	Upstream	580.87	585.86	Removal	584.51
No.12	Muassi	Upstream	580.74	582.58	Removal	582.32
No.13	Namutimbua	Upstream	564.07	567.29	Removal	565.76

Table 2.2.9 Velocity and Froude number by each bridge

Bridge Name		Downstream side		Upstream side	
		Velocity (m/s)	Froude number	Velocity (m/s)	Froude number
No.1	Mutabasse	2.16	0.32	2.15	0.32
No.2	Muliquela	3.15	0.57	3.08	0.55
No.3	Matacasse	4.25	0.82	3.56	0.65
No.4	Lua	3.07	0.37	3.06	0.37
No.5	Ualasse	4.18	0.82	3.56	0.66
No.6	Licungo	4.63	0.52	4.57	0.51
No.7	Nivaco	4.01	0.60	3.84	0.56
No.8	Matsitse	3.92	0.83	3.28	0.65
No.9	Namisagua	2.23	0.41	2.18	0.40
No.10	Nuhusse	4.33	0.57	4.23	0.55
No.11	Lurio	2.28	0.27	2.28	0.27
No.12	Muassi	3.51	0.73	3.20	0.63
No.13	Namutimbua	2.32	0.32	2.30	0.32

(2) Design seismic coefficient

According to the SATCC bridge design standards, the seismic intensity in the target area is estimated to be MM6 (modified Mercali intensity 6) as shown in Figure 2.2.6. However, concerning bridges targeted in this survey, in response to the request from ANE, the design seismic intensity is set to reflect the magnitude 7.0 earthquake that occurred in Manica Province in February 2006.

Modified Mercalli Intensity at epicentre (MM)	Maximum ground acceleration (A) at epicentre (g)
ii - iii	0.003
iv - v	0.01
vi	0.03
vii - viii	0.1
ix	0.3
x - xi	1.0

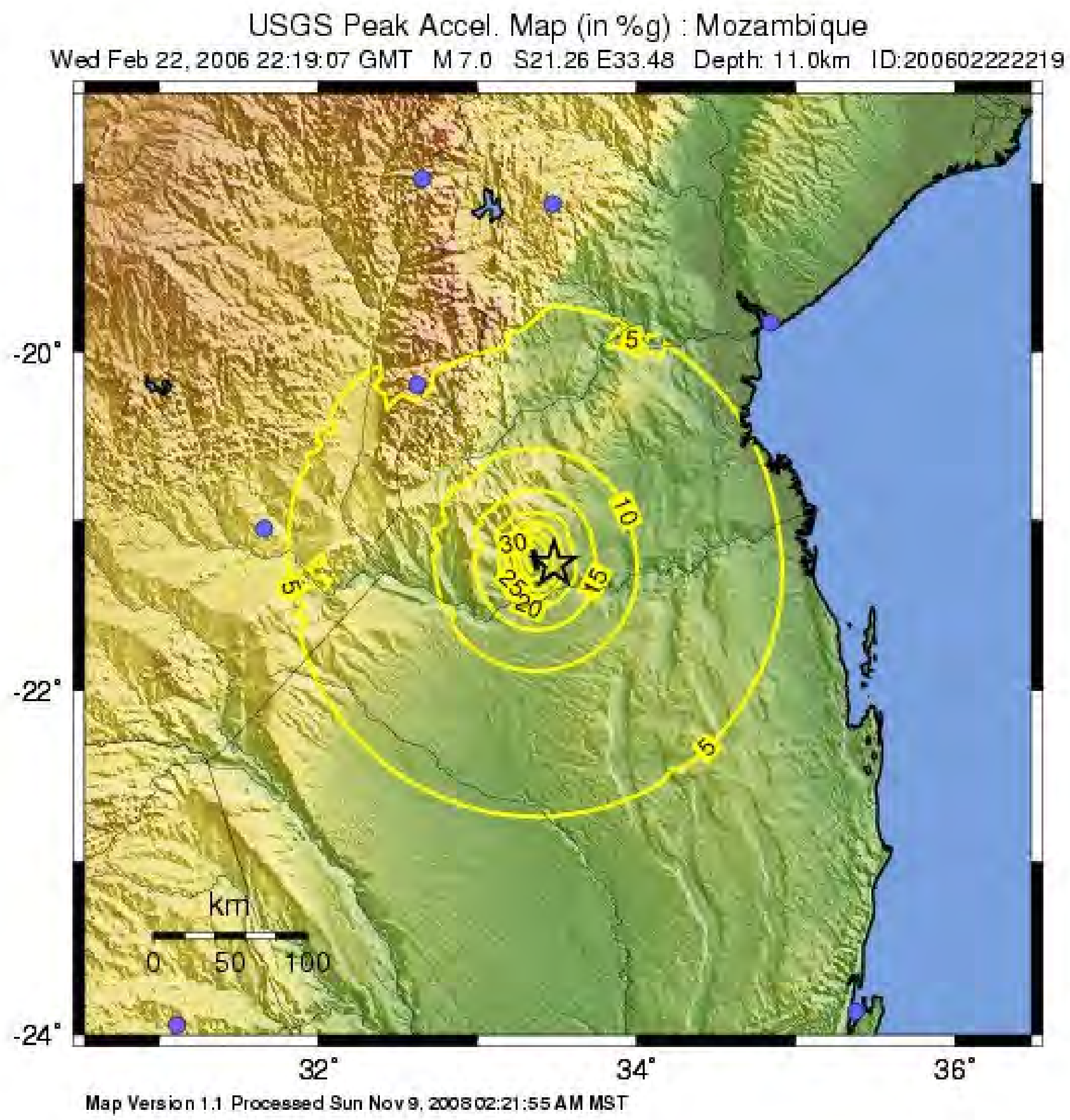
Source: Code of Practice for the Design of Road Bridges and Culverts (2001)

Fig. 2.2.6 Seismic intensity divisions according to the modified mercali hierarchy in SATCC standard

The United States Geological Survey (hereinafter USGS) has published a distribution chart of peak ground acceleration for the aforementioned Manica magnitude 7.0 earthquake as shown in Figure 2.2.7. This survey target area is located approximately 780 km in terms of epicentral distance from the center of earthquake, and from this distribution map it may be inferred that maximum ground acceleration in the target area when the quake occurred was no higher than 5%. As is indicated above, the peak ground acceleration for the target area according to SATCC standard is 3%g, however, considering the uncertainty of a natural phenomenon such as earthquakes and the fact that this quake occurred in Manica Province, 5%g is adopted as the maximum ground acceleration for this area to be on the safe side.

Regarding the design horizontal seismic coefficient for bridges, it is necessary to consider amplitude caused by structural response. Therefore, generally speaking, peak acceleration at the top of piers is approximately twice as large as that on the ground.

Accordingly, the design seismic coefficient in this Project is planned to be as follows: kH = 0.05 x 2 = 0.10.



Source: United States Geological Survey (USGS)

Fig. 2.2.7 Peak ground acceleration distribution map of Manica earthquake

(3) Bridge design

1) Design load

Design loads are based on ANE's Bridge Design Manual and the SATCC standard. If no specific values are given in these manuals, refer to the design specification for highway bridges issued by Japan Road Association.

①Dead load

The dead load complies with the SATTC standard.

②Live load

The live load complies with the SATCC standard. Similarly, consideration is given to the Portuguese standard, which has been requested by ANE. According to the SATCC standard, it is stipulated that NA load and NB load should always be considered in the design for highway bridges. Hence this is complied with in this design.

➢ SATCC standards

i) Design number of lanes

According to the SATCC standard, when the carriageway width is 4.8 m or more, the design number of lanes should be as indicated in Table 2.2.10, but when the carriageway is less than 4.8 m, the design number of lanes should be derived by dividing the width by 3. The design number of lanes in this case can be a number with a decimal point.

Table 2.2.10 Carriageway width and design number of lanes

Carriageway width (m)	Number of notional lanes*
4.8 up to and including 7.4	2
above 7.4 up to and including 11.1	3
above 11.1 up to and including 14.8	4
above 14.8 up to and including 18.5	5
above 18.5 up to and including 22.2	6
* notional lanes are imaginary lanes for the application of the design loading and should not be confused with traffic lanes on the roadway	

Source : SATCC standards

The Project targets one-lane bridges (carriageway width: 3.6 m) and two-lane bridges (carriageway width: 7.2 m). According to the above table, the two-lane bridges have two lanes, whereas the one lane bridges have 1.2 lanes as their width is less than 4.8 m (3.6 / 3 = 1.2).

ii) NA load

NA load is a combination of lane load and concentrated load. The lane load intensity Qa (kN/m) is determined from the loaded length as shown in Figure 2.2.8.

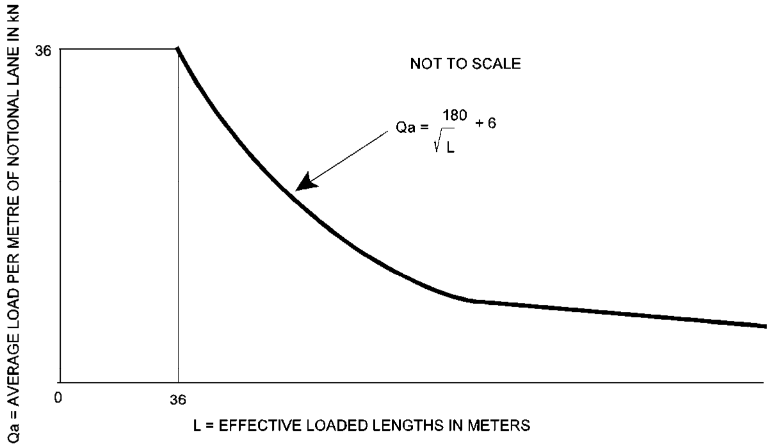


Fig. 2.2.8 Relationship between loaded length and lane load intensity (NA load)

In the case where there are multiple design lanes, the load intensity is changed according to each lane based on the above Qa.

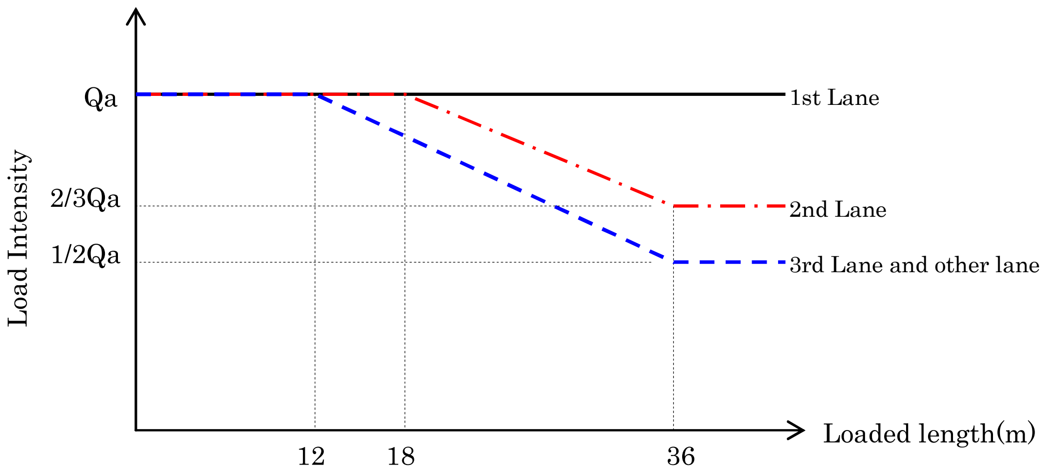


Fig. 2.2.9 Load intensity by lane

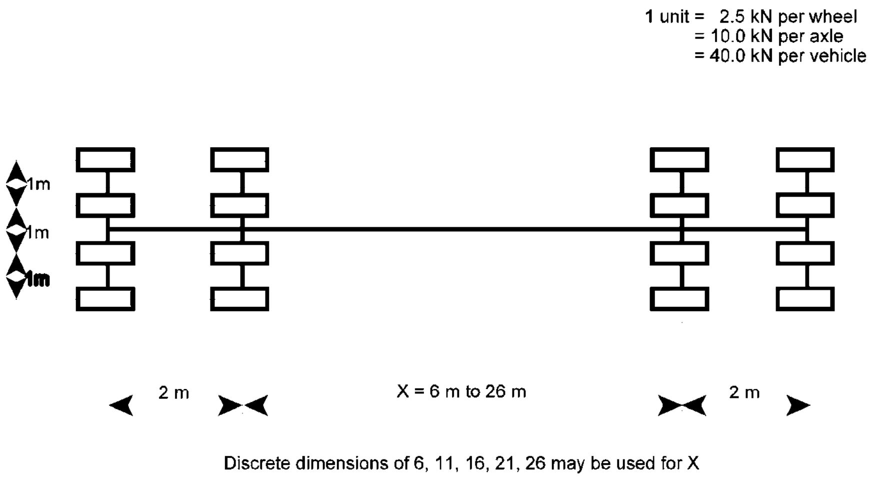
Regarding concentrated load, $144/\sqrt{(n)}$ is placed on the most critical position for each lane. Incidentally, n indicates the lane number.

Table 2.2.11 Concentrated load on each lane

First lane	144.0 kN
Second lane	$144/\sqrt{2}$=101.8 kN
Third lane	$144/\sqrt{3}$= 83.1 kN

iii) NB load

Concerning NB load, it is permissible to consider as many vehicles as possible in the direction perpendicular to the bridge axis, however, only one vehicle may be loaded in the bridge axis direction. The basic position for loading in the perpendicular direction is 0.6 m away from the kerb, however, in cases where the clearance between the kerb and the bridge handrail is more than 0.6 m, the position is 0.15 m from the kerb.



Source: SATCC standards

Fig. 2.2.10 NB load

Table 2.2.12 NB loading conditions

Class	Loaded area / wheel	Wheel load	Weight / vehicle
NB24	0.245m x 0.245m	60kN/wheel	960kN / vehicle
NB36	0.300m x 0.300m	90kN/wheel	1,440kN / vehicle

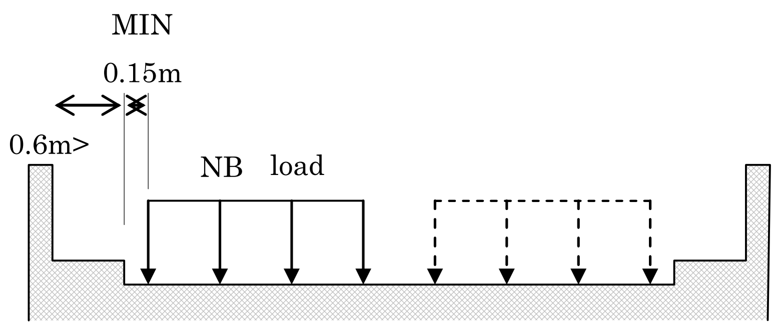


Fig. 2.2.11 Loading method in the direction perpendicular to the bridge axis

iv) Sidewalk live load

In cases where the loaded length is less than 25 m, the sidewalk live load is 5.0kN/m^2, and when loaded length is more than 25 m, the load is $25/\sqrt{L}$ (where L is loaded length). However, the load must not be less than 1.5kN/m^2.

➢ **Portuguese standards**

i) Decision of bridge class

Live load differs according to the bridge class. Based on the request from the government of Mozambique, Class I is adopted in this Project.

Table 2.2.13 Bridge class

Class I	High traffic volume and heavy traffic. For national routes and urban roads.
Class II	Low traffic volume and no heavy traffic. For agricultural roads and forest roads.

ii) Loading method for live load and its intensity

Live load comprises the following two types that are considered separately.

a) Wheel load

In Class I, the following wheel loads are placed in the most critical position. Incidentally, Q=200kN, a=0.20m, b=0.60m.

※Q is the load per axis, and the load per wheel is 100 kN.

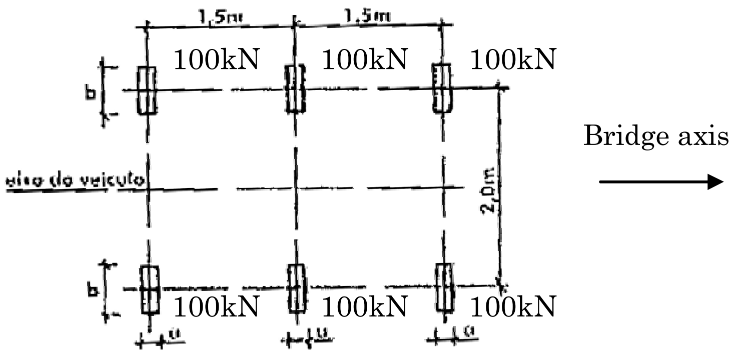


Fig. 2.2.12 Wheel load arrangement and load intensity

b) Concentrated load + Distribution load

In Class I, the following concentrated load and distribution load are placed in the most critical position.

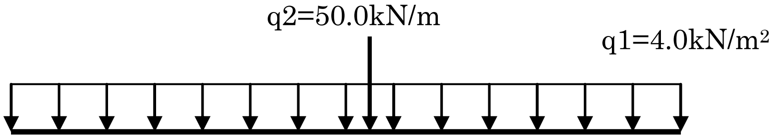


Fig. 2.2.13 Loading method of concentrated load and distribution load

iii) Impact load

Impact load is viewed as equivalent to 10 kN/m.

iv) Sidewalk live load

The most disadvantageous out of the distribution load of 3.0 kN/m² or the concentrated load of 20 kN is loaded.

➢ Other loads to consider

In addition to the aforementioned loads, the following loads are considered as necessary:

i) Pre-stressing load
ii) Creep, drying shrinkage
iii) Earth pressure
iv) Water pressure
v) Buoyancy or uplift
vi) Seism

2) Material strength

The design strength of concrete is set upon considering actual performance values on the previous projects in Mozambique. Similarly, the strength of reinforcing bar to be used in this Project is shown in Table 2.2.15.

Table 2.2.14 Design strength of concrete

Item	Design strength (N/mm^2)	Note
Post tension T girder	40 (Main girder), 30 (Cross beam)	
RC hollow slab	24	
Pier	30	
Abutment	24	
Cast-in-situ pile	24(30)	
Handrail	24	
Leveling concrete	18	

Table 2.2.15 Design strength of reinforcing bar

Item	Yield strength (N/mm^2)	Note
Post tension T girder	450 (SABS920-1985)	Considering results of the previous project
RC hollow slab	Ditto	ditto
Pier	Ditto	ditto
Abutment	Ditto	ditto
Cast-in-situ pile	Ditto	ditto

3) Vertical clearance under bridge girder

The design flood water levels (hereinafter HWL) at each bridge location are shown in the hydrological analysis results mentioned above. Based on request from ANE, 1.0 m from these design flood levels are be secured as the allowable clearance under bridge girders.

4) Selection of bridge length and span length

① Design Policy

Most of the river widths at each bridge location with the HWL calculated in the hydraulic analysis are far wider than the existing bridge lengths. Considering conditions of the landforms around the bridges, moving abutments back to the river width positions at the HWL would be extremely uneconomical and entail over-elaborate planning. Accordingly, it is only necessary to satisfy the following conditions when determining the bridge length and span length of bridges. Similarly, the standard span lengths are set according to each river size in order to optimize the project costs.

- Adopt bridge lengths in excess of the existing bridge lengths.
- Secure sufficient vertical clearance under bridge to allow the flood water flow to pass.
- Secure standardization by adopting the same length for each span.

Figure 2.2.14 shows the flow for determining bridge length and span length.

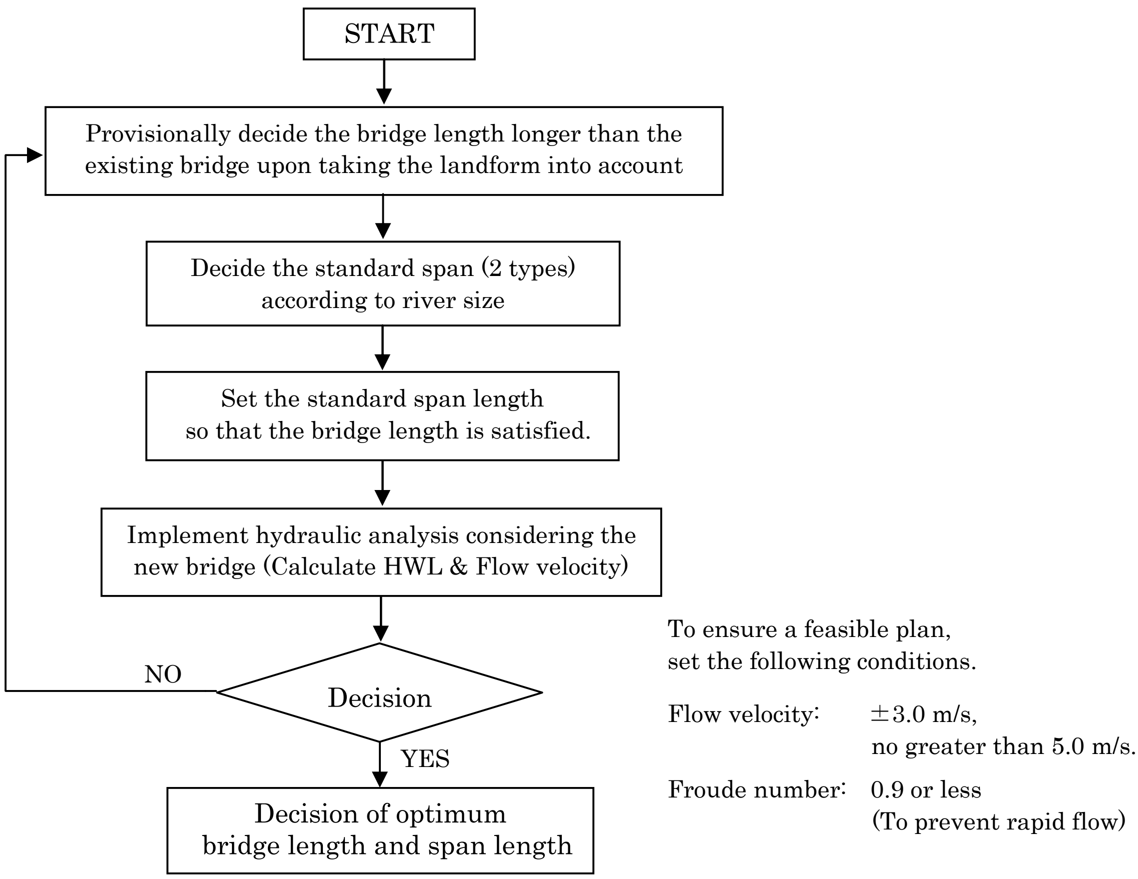


Fig. 2.2.14 Flow chart for deciding bridge length and span length

② Necessary Bridge Length

The bridge lengths are set according to the aforementioned policy. Basically, the existing bridge lengths are secured, however, in cases where the bridge needs to be further extended due to the landform, the bridge length is set accordingly. Concerning bridges for which the overflow height is high (more than 0.5 m) according to the findings of the hearing surveys, the bridge lengths are set by adding some allowance to the present lengths.

Table 2.2.16 Necessary bridge length

Bridge name		Existing bridge		New bridge		
		Type	Bridge length	Overflow height (hearing results)	Necessary bridge length	Reason
No.1	Mutabasse	RC T-girder	95m		95m	Existing bridge length
No.2	Muliquela	RC T-girder	66m		66m	Existing bridge length
No.3	Matacasse	Bailey	24m (old bridge: 10m)		15m	Surrounding landform
No.4	Lua	RC T-girder	37m		45m	Surrounding landform
No.5	Ualasse	Bailey	24m (old bridge: 10m)		15m	Surrounding landform
No.6	Licungo	RC T-girder	34m	0.3m	34m	Existing bridge length
No.7	Nivaco	Pipe culvert	6m+4m	1.0m	30m	Surrounding landform + allowance
No.8	Matsitse	Bailey	15m	0.5m	15m	Surrounding landform
No.9	Namisagua	Bailey	18m	0.5m	15m	Surrounding landform
No.10	Nuhusse	Bailey	24m	1.0m	30m	Surrounding landform + allowance
No.11	Lurio	RC T-girder	55m	2.0m	66m	Existing bridge length + allowance
No.12	Muassi	Pipe culvert & RC deck slab	12m	0.7m	15m	Surrounding landform + allowance
No.13	Namutimbua	Bailey	20m	0.5m	25m	Surrounding landform

Note: Old bridge means a bridge which had already destroyed by past floods.

③ Standard span length

In determining span length, all 13 bridges are classified into two types according to the river discharges, and the bridge types and span lengths are standardized as shown in Table 2.2.17.

Class 1: Maximum discharge: less than 500m^3/s
(Br.3, 5, 7, 8, 9, 12, 13)

On rivers with maximum discharge of less than 500m^3/s, it is possible to divert river flow by building a temporary channel. Therefore it is relatively easy to execute foundation works, substructure works and supporting works for deck slab inside river because the ground is in nearly dry condition.

Moreover, since temporary cofferdam and temporary jetty for constructing substructures are not required, the span length can be shortened by using the piers. However, in order to aver a risk of blocking the river caused by driftwood, etc, reasonable span length should be planned for this Project. Hence, the standard span length of 15 m that is prescribed in the Japanese river structural code is adopted as the optimum standard span length.

Considering the above conditions, it is concluded that cast-in-situ reinforced concrete bridge is the most appropriate for this class.

Class 2: Maximum discharge: 500m^3/s or more
(Br.1, 2, 4, 6, 10, 11)

On rivers with maximum discharge of 500m^3/s or more, it is difficult to divert river flow by building a temporary channel. Therefore, all bridge construction works need to be carried out while the river flows as it is. In this case, precast girders are most effective because the erection method of precast girders is not affected by the weather and the ground condition under the superstructure.

Similarly, since temporary cofferdam and temporary jetty for constructing piers are expensive, it is desirable to lengthen the span length in order to reduce the number of piers in the river. The longest span length of precast girders in the central northern area of Mozambique is 35 m on the Lugela Bridge in Zambezia Province.

Therefore, it is concluded that pre-stressed concrete precast girder bridge is the most appropriate for this class and that the standard span length is 35 m.

Table 2.2.17 Standard span length

Bridge name		New bridge			
		Maximum discharge (m^3/s)		Bridge type	Standard span length
No.1	Mutabasse	896.4(100y)	>=500	Pre-stressed concrete bridge	35m
No.2	Muliquela	619.9(100y)	>=500	Pre-stressed concrete bridge	35m
No.3	Matacasse	106.3(50y)	<500	Reinforcing concrete bridge	15m
No.4	Lua	956.2(100y)	>=500	Pre-stressed concrete bridge	35m
No.5	Ualasse	139.9(50y)	<500	Reinforcing concrete bridge	15m
No.6	Licungo	1171.1(100y)	>=500	Pre-stressed concrete bridge	35m
No.7	Nivaco	455.9(100y)	<500	Reinforcing concrete bridge	15m
No.8	Matsitse	125.1(50y)	<500	Reinforcing concrete bridge	15m
No.9	Namisagua	132.9(50y)	<500	Reinforcing concrete bridge	15m
No.10	Nuhusse	817.6(100y)	>=500	Pre-stressed concrete bridge	35m
No.11	Lirio	1091.5(100y)	>=500	Pre-stressed concrete bridge	35m
No.12	Muassi	100.5(50y)	<500	Reinforcing concrete bridge	15m
No.13	Namutimbua	312.0(50y)	<500	Reinforcing concrete bridge	15m

Note: (**y) shows the return period stipulated by ANE's Standard

④ Determination of bridge length and span length

Based on the necessary bridge lengths and standard span lengths, the bridge and span lengths are determined as shown in Table 2.2.18. Regarding No. 4 Lua Bridge, since adopting the standard span length would result in the bridge becoming 15 m longer, this has been modified to the optimum span length due to economic reason.

For all bridges, the hydraulic analysis was carried out, assuming that the bridges of the designed bridge length and span length have been constructed at the planned locations. As a result of the hydraulic analysis, it is found that the flow velocities and Froude numbers around the bridges are no greater than the appropriate guide values of 5.0 m/s and 0.9, respectively.

Table 2.2.18 List of bridge lengths and span lengths

Bridge name		New bridge				
		Location	Necessary bridge length	Bridge type	Span length	Bridge length
No.1	Mutabasse	Downstream side	95m	Pre-stressed concrete bridge	35m	3 spans x 35m = 105m
No.2	Muliquela	Upstream side	66m	Pre-stressed concrete bridge	35m	2 spans x 35m = 70m
No.3	Matacasse	Same position	15m	Reinforcing concrete bridge	15m	1 span x 15m = 15m
No.4	Lua	Upstream side	45m	Pre-stressed concrete bridge	25m	2 spans x 25m = 50m
No.5	Ualasse	Same position	15m	Reinforcing concrete bridge	15m	1 span x 15m = 15m
No.6	Licungo	Same position	34m	Pre-stressed concrete bridge	35m	1 span x 35m = 35m
No.7	Nivaco	Same position	30m	Reinforcing concrete bridge	15m	2 spans x 15m = 30m
No.8	Matsitse	Same position	15m	Reinforcing concrete bridge	15m	1 span x 15m = 15m
No.9	Namisagua	Same position	15m	Reinforcing concrete bridge	15m	1 span x 15m = 15m
No.10	Nuhusse	Same position	30m	Pre-stressed concrete bridge	35m	1 span x 35m = 35m
No.11	Lirio	Upstream side	66m	Pre-stressed concrete bridge	35m	2 spans x 35m = 70m
No.12	Muassi	Upstream side	15m	Reinforcing concrete bridge	15m	1 span x 15m = 15m
No.13	Namutimbua	Upstream side	25m	Reinforcing concrete bridge	15m	2 spans x 15m = 30m

5) Selection of foundation type

① Geological conditions

As a result of the geological survey, the soil property along the target route was found to be broadly composed of four types, that is, from the surface, embankment, riverbed sediment, residual soil, and basement rock (granitic gneiss). The residual soil referred here, which was created by weathering of the basement rock granitic gneiss, differs in origin from riverbed sediment created by river action. According to the results of standard penetration test (hereinafter SPT), the residual soil layer can be classified into two types; i.e. a layer with N-value of 15~50, and a hard layer with N-value far greater than 50. The residual soil layer with N-value more than 50 is regarded as weathered soft rock, in determining the soil modulus used in design.

The following layers can be considered as a bearing layer for bridge.

- Residual soil layer with N value of 30 or higher
- Hard residual soil layer (weathered soft rock)
- Basement rock

Concerning the vertical location of the bearing layer, although there is some variation depending on the bridge position, it generally exists at depths in the range of 0.0~20.0 m. Figure 2.2.15, 2.2.16, 2.2.17 show typical examples of the envisioned soil profile.

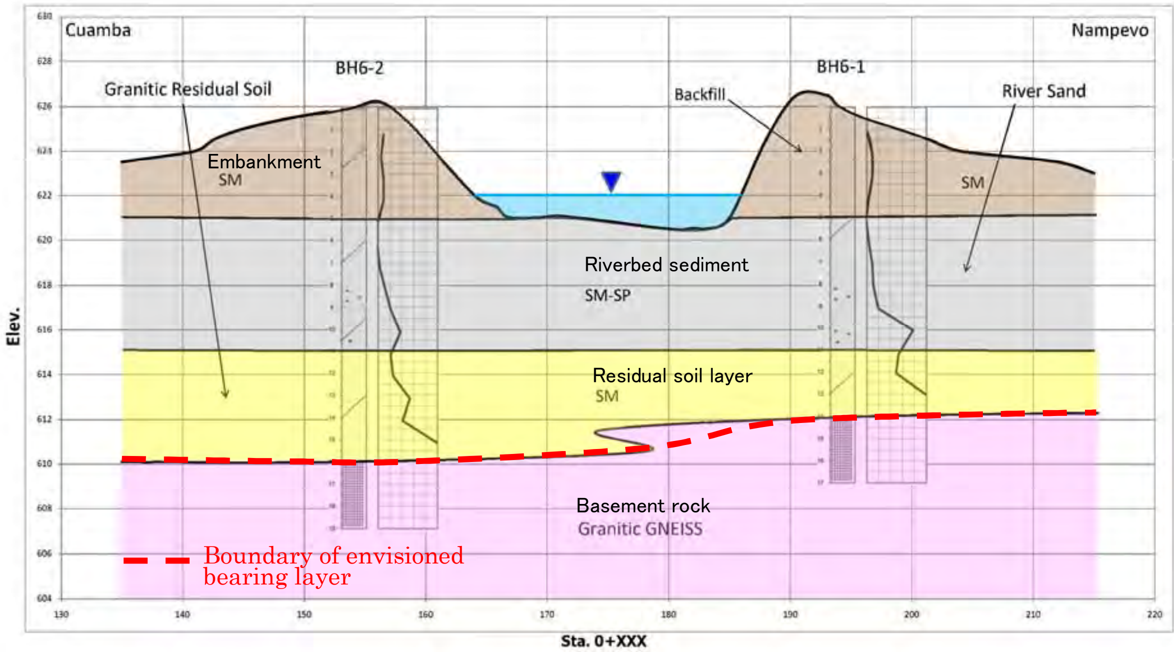


Fig. 2.2.15 Example of soil profile with deep bearing layer (Basement rock)

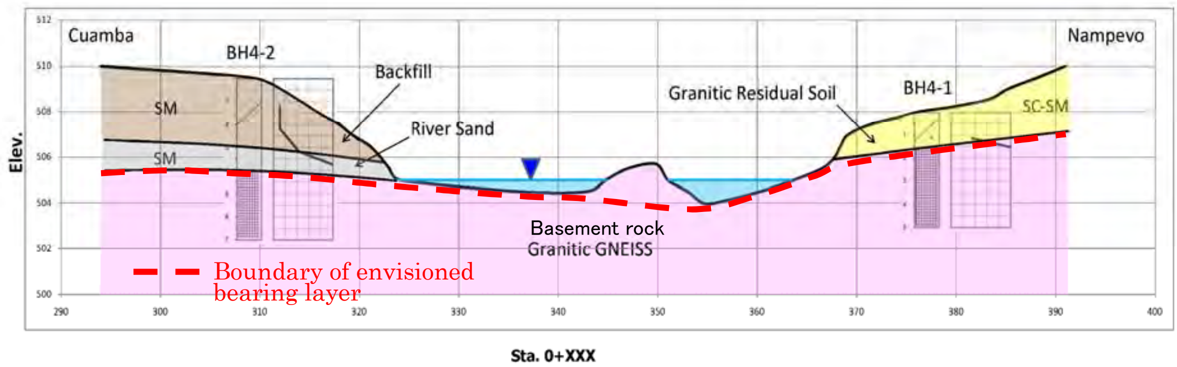


Fig. 2.2.16 Example of soil profile with shallow bearing layer (Basement rock)

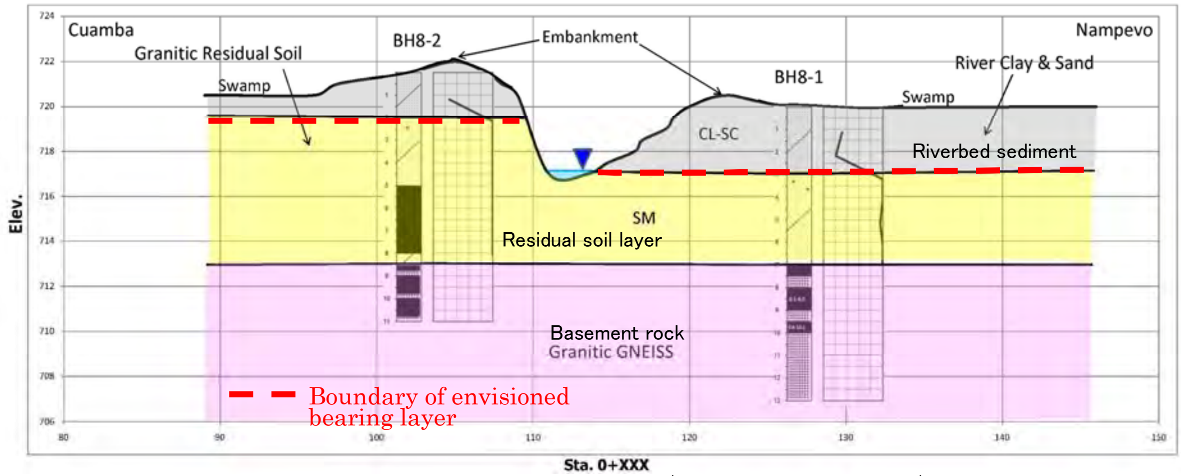


Fig. 2.2.17 Example of soil profile with hard residual soil (Weathered soft rock) as bearing layer

Table 2.2.19 Bearing layer estimation results

Br No.	Bridge length	Substructure	Obtained information from soil survey					Bearing stratum applied to bridge design			
			Boring Number	Distance (a structure center to a borehole)	Depth of bearing stratum applicable (EL. m)	Ground type of bearing stratum	Current ground elevation (EL. m)	**Elevation of bearing stratum for bridge design (EL. m)**	**Depth of bearing stratum (m)**	**Ground type of bearing stratum**	Process of bearing stratum assumption
No.1	3@35 =105m	A1	BH1-2	6.0 m	326.347	B.Rock	329.092	**326.347**	**2.7**	**B.Rock**	Referring BH1-2 B.Rock EL. Assumption of horizontally stratum distribution.
		P1	BH1-4	5.0 m	324.831	B.Rock	325.679	**324.831**	**0.8**	**B.Rock**	Referring BH1-4 B.Rock EL. Assumption of horizontally stratum distribution.
		P2	BH1-5	5.0 m	321.700	B.Rock	324.977	**321.700**	**3.3**	**B.Rock**	Referring BH1-5 B.Rock EL. Assumption of horizontally stratum distribution.
		A2	BH1-1	11.0 m	324.797	B.Rock	327.786	**323.500**	**4.3**	**B.Rock**	Referring BH1-1B.Rock EL. Assumption of sloping stratum distribution.
No.2	2@35 =70m	A1	BH2-2	2.0 m	407.723	B.Rock	411.077	**407.723**	**3.4**	**B.Rock**	Referring BH2-2 B.Rock EL. Assumption of horizontally stratum distribution.
		P1	BH2-3	7.0 m	406.296	B.Rock	406.837	**406.296**	**0.5**	**B.Rock**	Referring BH2-3 B.Rock EL. Assumption of horizontally stratum distribution.
		A2	BH2-1	2.0 m	406.124	B.Rock	412.456	**406.124**	**6.3**	**B.Rock**	Referring BH2-1 B.Rock EL. Assumption of horizontally stratum distribution.
No.3	1@15 =15m	A1	BH3-2	15.0 m	485.204	B.Rock	493.493	**485.204**	**8.3**	**B.Rock**	Referring BH3-2 B.Rock EL. Assumption of horizontally stratum distribution.
		A2	BH3-1	10.0 m	485.108	B.Rock	498.641	**485.108**	**13.5**	**B.Rock**	Referring BH3-1 B.Rock EL. Assumption of horizontally stratum distribution.
No.4	2@25 =50m	A1	BH4-2	12.0 m	505.843	B.Rock	506.780	**505.000**	**1.8**	**B.Rock**	Referring BH4-2 B.Rock EL. Assumption of decline toward riverbed.
		P1	BH4-1	33.0 m	506.486	B.Rock	504.925	**504.000**	**0.9**	**B.Rock**	Referring BH4-1 to 3 B.Rock EL., and considering connection to riverbed EL.
		A2	BH4-1	8.0 m	506.486	B.Rock	506.858	**505.000**	**1.9**	**B.Rock**	Referring BH4-1 B.Rock EL. Assumption of decline toward riverbed.
No.5	1@15 =15m	A1	BH5-2	10.0 m	552.417	Sand	570.019	**552.417**	**17.6**	**Sand**	Referring BH5-2 sand EL. (deeper than GL-17.5m). N=33.
		A2	BH5-1	9.0 m	552.957	Sand	568.875	**552.957**	**15.9**	**Sand**	Referring BH5-1 sand EL. (deeper than GL-17.0m). N=34.
No.6	1@35 =35m	A1	BH6-2	4.0 m	610.000	B.Rock	626.500	**610.000**	**16.5**	**B.Rock**	Referring BH6-2 B.Rock EL. Assumption of horizontally stratum distribution.
		A2	BH6-1	6.0 m	611.273	B.Rock	626.472	**611.273**	**15.2**	**B.Rock**	Referring BH6-1 B.Rock EL. Assumption of horizontally stratum distribution.
No.7	2@15 =30m	A1	BH7-2	7.0 m	694.284	R. Soil	701.023	**694.284**	**6.7**	**R. Soil**	Referring BH7-2 hard R.Soil EL (deeper than GL-6.0m)
		P1	BH7-2	14.0 m	694.284	R. Soil	700.871	**694.110**	**6.8**	**R. Soil**	Referring BH7-2 R.Soil EL. Assumption of sloping stratum distribution.
		A2	BH7-1	4.0 m	693.940	B.Rock	700.823	**693.940**	**6.9**	**B.Rock**	Referring BH7-1 B.Rock EL. Assumption of horizontally stratum distribution.
No.8	1@15 =15m	A1	BH8-2	7.0 m	719.500	R. Soil	721.208	**716.500**	**4.7**	**R. Soil**	Referring BH8-2 hard R.Soil EL., and considering connection to riverbed EL.
		A2	BH8-1	7.0 m	716.700	R. Soil	720.500	**716.700**	**3.8**	**R. Soil**	Referring BH8-1 hard R.Soil EL. (deeper than GL-3.0m)
No.9	1@15 =15m	A1	BH9-2	9.0 m	701.915	B.Rock	708.272	**701.915**	**6.4**	**B.Rock**	Referring BH9-2 B.Rock EL. Assumption of horizontally stratum distribution.
		A2	BH9-1	10.0 m	705.000	R. Soil	706.777	**705.000**	**1.8**	**R. Soil**	Referring BH9-1 hard R.Soil EL. (deeper than GL-2.5m).
No.10	1@35 =35m	A1	BH10-2	15.0 m	600.572	B.Rock	601.569	**597.500**	**4.1**	**B.Rock**	Referring BH10-2 B.Rock EL. Assumption of decline toward riverbed.
		A2	BH10-1, 3	18.0 m	596.323	R. Soil	601.762	**596.400**	**5.4**	**R. Soil**	Referring BH10-1&3 hard R.Soil Assumption of sloping stratum distribution.
No.11	2@35 =70m	A1	BH11-2	4.0 m	573.200	Sand	580.499	**573.200**	**7.3**	**Sand**	Referring BH11-2 sand EL.(deeper than GL-7.0m). N=45.
		P1	BH11-6	0.0 m	573.700	R. Soil	578.577	**573.700**	**4.9**	**R. Soil**	Referring BH11-6 hard R.Soil EL. (deeper than GL-5.0m).
		A2	BH11-5	0.0 m	572.100	R. Soil	580.972	**572.100**	**8.9**	**R. Soil**	Referring BH11-5 hard R.Soil EL. (deeper than GL-9.0m)
No.12	1@15 =15m	A1	BH12-2	4.0 m	578.856	B.Rock	581.018	**578.856**	**2.2**	**B.Rock**	Referring BH12-2 B.Rock EL. Assumption of horizontally stratum distribution.
		A2	BH12-1	7.0 m	576.752	B.Rock	581.011	**576.752**	**4.3**	**B.Rock**	Referring BH12-1 B.Rock EL. Assumption of horizontally stratum distribution.
No.13	2@15 =30m	A1	BH13-3	4.0 m	559.320	B.Rock	564.156	**559.000**	**5.2**	**B.Rock**	Referring BH13-3&1 B.Rock EL. Assumption of sloping stratum distribution.
		P1	BH13-1	8.0 m	557.400	B.Rock	559.635	**557.400**	**2.2**	**B.Rock**	Referring BH13-1 B.Rock EL. Assumption of horizontally stratum distribution.
		A2	BH13-1	7.0 m	557.400	B.Rock	563.632	**557.400**	**6.2**	**B.Rock**	Referring BH13-1 B.Rock EL. Assumption of horizontally stratum distribution.

B. Rock = Basement Rock **R. Soil = Residual Soil**

② Soil modulus

i) Basement rock

Most of the basement rocks discovered in this geological survey are found to be granitic gneiss, which is a type of metamorphic rock, and since this has gneissic surface structure, it foliates in the direction of schistosity plane, which is a factor in deterioration of rock strength. However, the results of the unconfined compression test indicate that the rocks are extremely hard with an average value of 71 MPa (Max: 126 MPa, Min: 14 MPa) and that there is no close relationship between the core fracture morphology and schistosity plane. It is therefore inferred that the rocks do not have high fissility.

Although the basement rocks detected in this survey, in engineering terms, are classed as hard rock, it is concluded that the basement rocks are regarded as soft rock rather than hard rock for deciding the soil modulus in this design due to the following reasons; 1) the geological surveys were not conducted at exact points where the abutments and the piers would be constructed. Therefore, hard rock layers might not be detected at the depths planned in actual construction. 2) it is inherently difficult to accurately estimate strength characteristics of rocks.

ii) Hard residual soil

The residual soil layers around bridge positions are soil derived from the weathering of basement rock. In cases where the hard residual soil layers with N value of 50 or more are continuously distributed in the vertical direction, it is decided to treat the layer as weathered soft rock in terms of the soil modulus in design. In addition, since the characteristics of above-mentioned granitic gneiss are deemed to be similar to granite, it is treated as plutonic rock type.

iii) Policy for determining soil modulus

The soil modulus used for this design is set, according to the following policy.

- Unit weight of soil or rock γ (kN/m^3) :

・Concerning sand & soil, the values are set, based on the laboratory test results and the values proposed in the existing literature.

・Concerning weathered soft rock and basement rock, the values are estimated by the existing literature.

- Angle of shear resistance ϕ (deg) :
  - Concerning sandy soil, weathered soft rock and basement rock, the angles are estimated by the results of SPT and the values proposed in the existing literature.
  - Concerning cohesive soil, the angles are assumed to be zero, in order to be on the safe side.
- Adhesion c (kN/m^2) :
  - Concerning cohesive soil, residual soil and basement rock, the values are estimated by the results of SPT and the values proposed in the existing literature.
  - Concerning sandy soil, no adhesion is adopted, in order to be on the safe side.
- Elastic modulus Eo(kN/m^2) :
  - The elastic modulus is estimated, based on the laboratory test results, the N values and the values proposed in the existing literature.

iv) Results of soil modulus

Table 2.2.20 shows the soil modulus used in design.

Table 2.2.20 List of soil modulus

Boring No.	Soil Type			N-blow	Unit weight γ (kN/m^3)	Angle of Shear Resistance ϕ (deg)	Adhesion c (kN/m^2)	Elastic Modulus E_0 (kN/m^2)
Summary Br. No1 Spread Footing	Embankment (Silty soil)		B	12	17.5	0.0	70.0	8,400
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–
		Sandy soil 1	Fs1	–	–	–	–	–
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–
		Sandy soil 1	As1	–	–	–	–	–
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–
		Sandy soil 1	Rs1	22	18.0	30.0	0.0	15,400
		Sandy soil 2	Rs2	–	–	–	–	–
		Weathered soft rock	Rs3	–	–	–	–	–
	Basement rock		RB	–	21.0	37.0	100.0	200,000
Summary Br. No2 Spread Footing	Embankment (Silty soil)		B	5	17.5	0.0	30.0	3,500
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–
		Sandy soil 1	Fs1	0	18.0	25.0	0.0	0
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–
		Sandy soil 1	As1	–	–	–	–	–
	Residual soil	Cohesive soil 1	Rc1	12	18.0	0.0	70.0	8,400
		Sandy soil 1	Rs1	25	18.0	30.0	0.0	17,500
		Sandy soil 2	Rs2	–	–	–	–	–
		Weathered soft rock	Rs3	–	–	–	–	–
	Basement rock		RB	–	21.0	37.0	100.0	200,000
Summary Br. No3 Pile Foundation	Embankment (Silty soil)		B	16	17.5	0.0	95.0	11,200
	Bed sediment	Cohesive soil 1	Fc1	2	15.5	0.0	45.0	2,500
		Sandy soil 1	Fs1	–	–	–	–	–
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–
		Sandy soil 1	As1	–	–	–	–	–
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–
		Sandy soil 1	Rs1	18	17.0	30.0	0.0	12,600
		Sandy soil 2	Rs2	–	–	–	–	–
		Weathered soft rock	Rs3	–	–	–	–	–
	Basement rock		RB	–	21.0	37.0	100.0	200,000
Summary Br. No4 Spread Footing	Embankment (sandy soil)		B	6	17.0	0.0	0.0	4,200
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–
		Sandy soil 1	Fs1	22	17.0	30.0	0.0	15,400
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–
		Sandy soil 1	As1	–	–	–	–	–
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–
		Sandy soil 1	Rs1	18	17.0	30.0	0.0	12,600
		Sandy soil 2	Rs2	–	–	–	–	–
		Weathered soft rock	Rs3	–	–	–	–	–
	Basement rock		RB	–	21.0	37.0	100.0	200,000
Summary Br. No5 Pile Foundation	Embankment (Sandy soil)		B	7	18.0	25.0	0.0	4,900
	Bed sediment	Cohesive soil 1	Fc1	2	14.0	0.0	10.0	1,400
		Sandy soil 1	Fs1	4	18.5	25.0	0.0	2,800
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–
		Sandy soil 1	As1	–	–	–	–	–
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–
		Sandy soil 1	Rs1	17	17.0	30.0	0.0	11,900
		Sandy soil 2	Rs2	34	18.5	35.0	0.0	23,800
		Weathered soft rock	Rs3	117	19.5	35.0	70.0	71,000
	Basement rock		RB	–	–	–	–	–
Summary Br. No6 Pile Foundation	Embankment (sandy soil)		B	3	17.0	25.0	0.0	2,100
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–
		Sandy soil 1	Fs1	8	17.0	25.0	0.0	5,600
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–
		Sandy soil 1	As1	–	–	–	–	–
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–
		Sandy soil 1	Rs1	24	17.0	30.0	0.0	16,800
		Sandy soil 2	Rs2	–	–	–	–	–
		Weathered soft rock	Rs3	–	–	–	–	–
	Basement rock		RB	–	21.0	37.0	100.0	200,000

Summary Br. No7 Abutment: Pile Foundation Pier: Spread Footing	Embankment (Sandy soil)		B	2	17.0	25.0	0.0	1,400	
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–	
		Sandy soil 1	Fs1	1	17.0	25.0	0.0	700	
	Alluvial deposit	Cohesive soil 1	Ac1	6	16.0	0.0	35.0	4,200	
		Sandy soil 1	As1	–	–	–	–	–	
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–	
		Sandy soil 1	Rs1	15	17.0	30.0	0.0	10,500	
		Sandy soil 2	Rs2	–	–	–	–	–	
		Weathered soft rock	Rs3	93	19.0	35.0	60.0	60,600	A1,P1
	Basement rock		RB	–	21.0	37.0	100.0	200,000	A2
Summary Br. No8 Spread Footing	Embankment (Silty soil)		B	–	–	–	–	–	
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–	
		Sandy soil 1	Fs1	–	–	–	–	–	
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–	
		Sandy soil 1	As1	–	–	–	–	–	
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–	
		Sandy soil 1	Rs1	13	18.5	25.0	0.0	9,100	
		Sandy soil 2	Rs2	–	–	–	–	–	
		Weathered soft rock	Rs3	87	19.0	35.0	60.0	57,900	
	Basement rock		RB	–	–	–	–	–	
Summary Br. No9 Spread Footing	Embankment (Silty soil)		B	–	–	–	–	–	
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–	
		Sandy soil 1	Fs1	11	18.5	25.0	0.0	7,700	
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–	
		Sandy soil 1	As1	–	–	–	–	–	
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–	
		Sandy soil 1	Rs1	28	17.0	35.0	0.0	19,600	
		Sandy soil 2	Rs2	–	–	–	–	–	
		Weathered soft rock	Rs3	137	19.5	35.0	70.0	79,200	A2
	Basement rock		RB	–	21.0	37.0	100.0	200,000	A1
Summary Br. No10 Spread Footing	Embankment (Silty soil)		B	–	–	–	–	–	
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–	
		Sandy soil 1	Fs1	–	–	–	–	–	
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–	
		Sandy soil 1	As1	–	–	–	–	–	
	Residual soil	Cohesive soil 1	Rc1	17	17.0	0.0	100.0	11,900	
		Sandy soil 1	Rs1	22	17.0	30.0	0.0	15,400	
		Sandy soil 2	Rs2	–	–	–	–	–	
		Weathered soft rock	Rs3	87	19.0	35.0	60.0	57,900	A2
	Basement rock		RB	–	21.0	37.0	100.0	200,000	A1
Summary Br. No11 Abutment: Pile Foundation Pier: Spread Footing	Embankment (not exist)		B	–	–	–	–	–	
	Bed sediment	Cohesive soil 1	Fc1	6	16.5	0.0	40.0	3,400	
		Sandy soil 1	Fs1	8	17.0	25.0	0.0	5,600	
	Alluvial deposit	Cohesive soil 1	Ac1	5	16.0	0.0	30.0	3,500	
		Sandy soil 1	As1	–	–	–	–	–	
	Residual soil	Cohesive soil 1	Rc1	14	18.5	0.0	80.0	9,800	
		Sandy soil 1	Rs1	25	18.5	30.0	0.0	17,500	
		Sandy soil 2	Rs2	45	19.0	35.0	0.0	31,500	A1
		Weathered soft rock	Rs3	179	20.0	35.0	80.0	95,300	A2,P1
	Basement rock		RB	–	–	–	–	–	
Summary Br. No12 Spread Footing	Embankment (Silty soil)		B	–	–	–	–	–	
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–	
		Sandy soil 1	Fs1	–	–	–	–	–	
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–	
		Sandy soil 1	As1	–	–	–	–	–	
	Residual soil	Cohesive soil 1	Rc1	–	–	–	–	–	
		Sandy soil 1	Rs1	9	17.0	25.0	0.0	6,300	
		Sandy soil 2	Rs2	–	–	–	–	–	
		Weathered soft rock	Rs3	77	18.5	35.0	60.0	53,200	
	Basement rock		RB	–	21.0	37.0	100.0	200,000	
Summary Br. No13 Spread Footing	Embankment (Silty soil)		B	–	–	–	–	–	
	Bed sediment	Cohesive soil 1	Fc1	–	–	–	–	–	
		Sandy soil 1	Fs1	5	17.0	25.0	0.0	2,000	
	Alluvial deposit	Cohesive soil 1	Ac1	–	–	–	–	–	
		Sandy soil 1	As1	–	–	–	–	–	
	Residual soil	Cohesive soil 1	Rc1	50	17.0	0.0	200.0	35,000	
		Sandy soil 1	Rs1	–	–	–	–	–	
		Sandy soil 2	Rs2	–	–	–	–	–	
		Weathered soft rock	Rs3	–	–	–	–	–	
	Basement rock		RB	–	21.0	37.0	100.0	200,000	

③ Foundation

i) Classification of foundation types

Bridge foundations are basically divided into spread foundations and pile foundations, depending on the depth of the bearing layer. Generally speaking, spread foundations are more economical if the bearing layer is down to around 5 m from the surface. On the other hand, pile foundations tend to become more advantageous at levels deeper than that. Table 2.2.21 shows the foundation types for the bridges and the bearing layers in the Project.

Concerning a case where the bearing layer is too deep to adopt spread foundations but too shallow to adopt pile foundations, the feasibility of adopting replacing foundations; i.e. replacing soft layers underneath a spread foundation with poor concrete, is examined.

Table 2.2.21 Foundation types and the bearing layers

Br No.	Bridge Length	Substructure	Soil type of bearing stratum		Depth of bearing stratum	Foundation type		
			Basement rock	Residual soil	GL−(m)	Spread footing	Replacement foundatio	Pile foundation
No.1	3@35 =105m	A1	○		2.7	○		
		P1	○		0.8	○		
		P2	○		3.3	○		
		A2	○		4.3		○	
No.2	2@35 =70m	A1	○		3.4	○		
		P1	○		0.5	○		
		A2	○		6.3		○	
No.3	1@15 =15m	A1	○		8.3			○
		A2	○		13.5			○
No.4	2@25 =50m	A1	○		1.8	○		
		P1	○		0.9	○		
		A2	○		1.9	○		
No.5	1@15 =15m	A1		○	17.6			○
		A2		○	15.9			○
No.6	1@35 =35m	A1	○		16.5			○
		A2	○		15.2			○
No.7	2@15 =30m	A1		○	6.7			○
		P1	○		6.8	○		
		A2	○		6.9			○
No.8	1@15 =15m	A1		○	4.7	○		
		A2		○	3.8	○		
No.9	1@15 =15m	A1	○		6.4	○		
		A2		○	1.8	○		
No.10	1@35 =35m	A1	○		4.1	○		
		A2		○	5.4	○		
No.11	2@35 =70m	A1		○	7.3			○
		P1		○	4.9	○		
		A2		○	8.9			○
No.12	1@15 =15m	A1	○		2.2	○		
		A2	○		4.3	○		
No.13	2@15 =30m	A1	○		5.2		○	
		P1	○		2.2	○		
		A2	○		6.2		○	

:Pile foundation

:Spread footing

ii) Selection of pile type and diameter

In selecting the pile type used in this Project, the compatibility with soil conditions on each site, the past experience of construction in this region and the market availability; i.e. the procurement situation and the transportation method and distance, are taken in consideration. Regarding the compatibility with soil conditions, attention should be given to the hard intermediate layers and some boulders existed in the middle layer detected by the geological survey. Regarding the past experience of construction in this region and the market availability, the findings of hearings conducted in this preparatory survey should be reflected in the selection. Table 2.2.22 shows the judgments for selecting pile type based on these above basic conditions. The selection of more specific pile types, based on the pile selection chart shown in Table 2.2.23, is carried out. As the result of the selection, it is concluded that cast-in-place piles (all-casing method) is the most appropriate for this Project. Regarding the casing installation of all-casing method, two methods are available, i.e. the swaying press-in method and the rotating press-in method. In this Project, the rotating press-in method is adopted because it allows sure execution on hard intermediate layers and some boulders.

Incidentally, for constructing cast-in-place piles, the reverse circulation drill method is relatively widely adopted in Mozambique, however, there is a risk that the drilling speed will decline greatly if large particle gravels or rock masses are encountered. Moreover, there may be cases where drilling itself is not possible. In such cases, since it would be necessary to newly procure alternative methods, it leads to greater risk in terms of delay in the construction schedule. Therefore, it is decided not to adopt the reverse circulation drill method for this Project.

iii) Replacing foundation

In case of spread foundations on a bearing layer of basement rock, where the overlying layer from the top of the abutment footing to the surface (river bed) becomes extremely thick, the section from underneath the abutment footing to the bearing layer will be replaced with poor concrete (ground improvement). In this case, the reaction force received underneath the abutment footing is conveyed to the basement rock via the replaced concrete. Incidentally, in consideration of workability of the works and quality uniformity, the thickness of replacement concrete is planned to be a minimum of 1.5 m and maximum of 3.0 m.

Table 2.2.22 Basic conditions for selecting pile type and judgment

Conditions for selecting pile type		Judgment
Soil conditions	Hard layer or some boulders exists in the intermediate layers.	The driven pile method is not applicable, because the penetration into such hard layers may be impossible. The pile installation by inner excavation method is not applicable, because gravel and rock masses may be irremovable by the machine.
	The bearing layers are situated at depth of 5-20 m.	The reverse circulation drill method is not applicable, because some boulders exist in the intermediate layers and its pile length are not economical for this method.
Procurement conditions	Steel materials such as steel pipes and the transportation charge are expensive.	Steel pipe piles, steel pipe soil cement piles or steel cement piles are not applicable.
Construction method	Special construction method is not needed.	Pre-boring piles or steel pipe soil cement piles is not applicable because of no construction experience of these methods in Mozambique in the past.
Other	Caisson, steel pipe sheet pile foundations, Soil mixing wall foundations	These methods are not applicable, because they are uneconomical, considering the scale of the target bridges.

Table 2.2.23 Foundation type selection chart

Conditions		Foundation Type	Spread Footing	Percussion Pile Foundation: RC Pile	Percussion Pile Foundation: PHC Pile & SC Pile	Percussion Pile Foundation: Steel Pipe Pile, Percussion Method	Percussion Pile Foundation: Steel Pipe Pile, Vibro-hammer method	Inner excavation Method, PHC·SC Pile: Percussion treatment	Inner excavation Method, PHC·SC Pile: Cement-milk mixing Treatment	Inner excavation Method, PHC·SC Pile: Casting concrete Treatment	Inner excavation Method, Steel Pipe Pile: Percussion treatment	Inner excavation Method, Steel Pipe Pile: Cement-milk mixing Treatment	Inner excavation Method, Steel Pipe Pile: Casting concrete Treatment	Hybrid pile of steel pipe and soil cement	Pre-boring Pile	Cast-in-place pile: All casing	Cast-in-place pile: Reverse circulation	Cast-in-place pile: Earth drill method	Cast-in-place pile: Caisson type pile	Caisson Foundation: Pneumatic caisson	Caisson Foundation: Open caisson	Steel Sheet Pipe Pile	Continuous mix-in-place wall
Soil Conditions	Intermediate layer	Existence of extremely weak layer	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○	○
		Existence of extremely hard layer	○	×	△	△	△	○	○	○	○	○	○	○	○	△	○	△	○	○	△	△	○
		Existence of gravel: Dia. ≦ 5cm	○	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Existence of gravel: 5cm ＜Dia≦10cm	○	×	△	△	○	△	△	△	△	△	△	○	○	○	○	△	○	○	○	△	○
		Existence of gravel: 10cm ＜Dia≦50cm	○	×	×	×	×	×	×	×	×	×	×	×	×	△	×	×	○	○	△	×	△
		Existence of liquefaction layer	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Bearing Stratum	Depth of Bearing Stratum: 5m ＜	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	○	×	×	×	×
		Depth of Bearing Stratum: 5～15m	△	○	○	○	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	△	△
		Depth of Bearing Stratum: 15～25m	×	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Depth of Bearing Stratum: 25～40m	×	×	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
		Depth of Bearing Stratum: 40～60m	×	×	△	○	○	△	△	△	○	○	○	○	○	△	○	×	×	△	○	○	○
		Depth of Bearing Stratum: ≦ 60m	×	×	×	△	△	×	×	×	×	×	×	△	△	×	△	×	×	×	△	△	△
		Soil Type: Cohesive soil (20≦N)	○	○	○	○	○	○	×	△	○	×	△	△	×	○	○	○	○	○	○	○	○
		Soil Type: Sand/Sand gravel (30≦N)	○	○	○	○	○	○	○	×	○	○	×	○	○	○	○	○	○	○	○	○	○
		Inclination (over approx. 30 degree)	○	×	△	○	○	△	△	△	○	○	○	△	△	○	△	△	○	○	△	△	△
		Markedly uneven surface	○	△	△	○	○	△	△	△	○	△	△	△	△	○	○	○	○	○	△	△	○
	groundwater condition	Ground water level close to ground level	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
		Large amount of spring water	△	○	○	○	○	○	○	○	○	○	○	○	△	○	○	△	×	○	○	○	△
		Confined ground water pressure ≧2m	×	○	○	○	○	×	×	×	×	×	×	○	×	×	×	×	×	△	△	○	×
		Flow rate more than 3m/min	×	○	○	○	○	○	×	×	○	×	×	×	×	×	×	×	×	○	△	○	×
Structural Features	Magnitude of Working Load	Vertical Reaction: Small (Span L <20m)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	△	×	×
		Vertical Reaction: Normal (span L <50m)	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Vertical Reaction: Large (span L >50m)	○	×	△	○	○	△	△	△	○	○	○	○	△	○	○	△	○	○	○	○	○
		Smaller horizontal load comparing with vertical load	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△
		Larger horizontal load comparing with vertical load	○	×	△	○	○	△	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○
	Bearing Type	Bearing Pile	/	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	/	/	/	/
		Friction Pile	/	○	○	○	○	/	/	/	/	/	/	○	○	○	○	○	/	/	/	/	/
Construction Conditions	On water construction	Water depth is less than 5m	○	○	○	○	○	△	△	△	△	△	△	△	×	×	○	△	×	△	△	○	×
		Water depth is 5m or deeper	×	△	△	○	○	△	△	△	△	△	△	△	×	×	△	×	×	△	△	○	×
		Narrow working space	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	○	△	△	×	△
		Use of batter piles	/	△	○	○	○	×	×	×	△	△	△	△	×	△	×	×	×	/	/	/	/
		Possibility of noxious fume	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	×	○	○	○
	impact to neighbor	Low vibration and noise	○	×	×	×	△	△	○	○	△	○	○	○	○	△	○	○	○	○	○	△	○
		Low impact to adjacent structures	○	×	×	△	△	△	○	○	△	○	○	○	○	○	○	○	△	△	△	△	○

○:High applicability △:Applicable ×:Low applicability

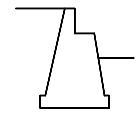
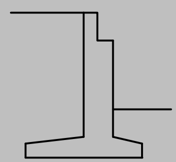
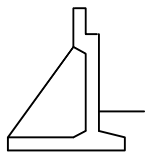
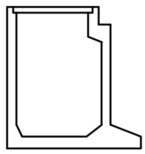
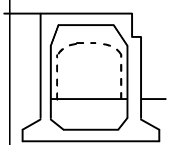
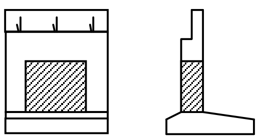
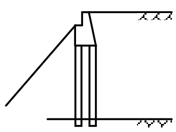
Reference: SPECIFICATIONS FOR HIGHWAY BRIDGES / Part IV (Japan Road Association)

6) Selection of substructure type

① Selection of abutment type

In consideration of the bridge sizes and the structural heights, the inverted T type is applicable for the target bridges. Table 2.2.24 shows the selection chart of abutment type.

Table 2.2.24 Selection chart of abutment type

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

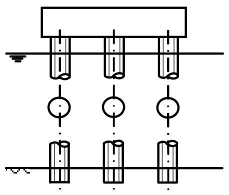
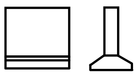
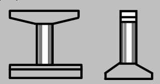
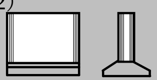
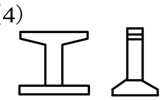
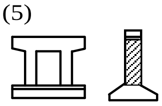
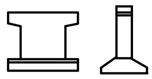
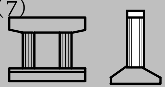
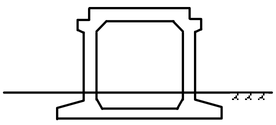
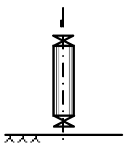
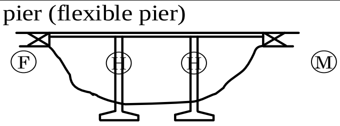
② Selection of pier type

Inverted T type, which is the common type, is applicable as the pier type for this Project.

Moreover, as most of target bridges are located on sections where the rivers suddenly expand and contract as well as converge and curve, the characteristic features of the flows are complicated and the directions of the center line of the flows are uncertain. In such case, cylindrical pier, which has no particular direction with respect to flow, is applicable, although oval-shaped pier, which may cause obstruction of the stream in the event of unexpected direction of flow, is not appropriate.

Therefore, it is concluded that the inverted T type cylindrical piers are planned for this Project. Table 2.2.25 shows the selection chart of pier type.

Table 2.2.25 Selection chart of pier type

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

③ Structural height

i) Abutments

- Positional relation of footing and riverbed in elevation

  ・In cases where the basement rock is exposed on the riverbed and cases where the depth from the riverbed to the basement rock is shallow, the top of the abutment footings is planned to be aligned close to the elevation of the basement rock.

  ・In cases where the riverbed comprises sediment or weathered soft rock, the top of the abutment footing is planned to be aligned with the forecast deepest riverbed elevation, or to be set at sufficient height to secure overlying layer of 1.0 m from the current deepest riverbed.

- Embedding of spread foundation into bearing layer

  ・In case the bearing layer is a rock layer, the footings are planned to be set on the layer horizontally and securely. In case the bearing layer is a hard sandy soil layer or a weathered soft rock layer, the footings are planned to be embedded with 0.5 m deep into the bearing layer.

- Other points

  ・Concerning pile foundations, in case where the height of the abutment exceeds the applicable range of structural height of inverted T type, the pile cap is planned to be set with the ground level. In such case, bank protection works are planned around abutments in areas where there is a risk of piles being exposed by scouring.

ii) Piers

In order to prevent the footings of piers from blocking the river flows, the top of footings are basically planned to be embedded into the riverbed.

- Vertical position of pier on riverbed

  ・In cases where the basement rock is exposed on the riverbed and cases where the depth from the riverbed to the basement rock is shallow, the top of the pier footings is planned to be aligned close to the elevation of the basement rock.

  ・In cases where the riverbed comprises sediment or weathered soft rock, the top of the abutment footing is planned to be aligned with the forecast deepest riverbed elevation, or to be set at sufficient height to secure overlying layer of 1.0 m from the current deepest riverbed.

  ・In cases where the estimated scouring depth is large and it is difficult to secure sufficient embedding, riverbed protection works around piers are planned to prevent scouring. Furthermore, the top of the pier footings needs not be aligned with the forecast deepest riverbed elevation.

iii) Piles

The pile lengths are determined according to the following policy.

- Embedding length of pile into bearing layer
  - In cases where the bearing layer is a hard sandy soil layer or a weathered soft rock layer, the minimum embedding length is planned to be the pile diameter or more. Moreover, if the bearing capacity is insufficient, the embedding length is planned to be extended up to three times the pile diameter, considering workability of the works.
  - In cases where the bearing layer is rock, the embedding length is planned to be the pile diameter.
- Embedding length into pile cap
  - Pile heads are planned to be embedded into the pile cap by 0.1 m deep.
- Pile length
  - Pile length, comprising the length that includes embedded pile in pile cap, is set in units of 0.5 m. (e.g. 10.0m, 10.5m, 11.0m, 11.5m, 12.0m)

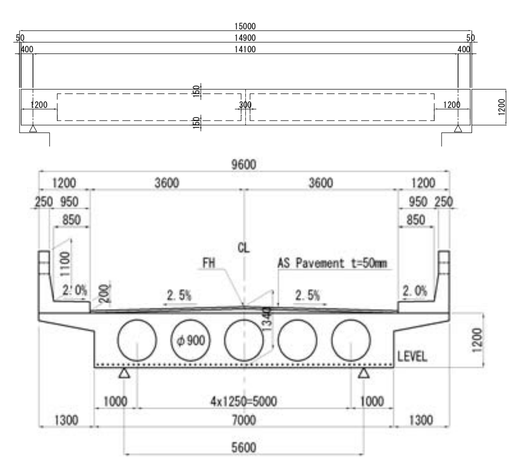
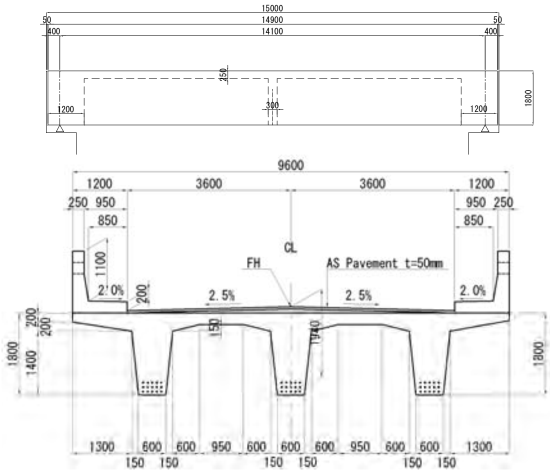
7) Selection of superstructure type

① Reinforced concrete bridge

Reinforced concrete bridges with span length of 15 m are planned over rivers with maximum discharge of less than 500m^3/s. On such rivers, it is possible to divert river flow by building a temporary channel and keep the sites in dry condition. Accordingly, cast-in-place reinforced concrete bridges using supports from the ground underneath the bridge are inexpensive and advantageous in such cases. The bridge type is ultimately selected out of the following two types following comparative examination. Table 2.2.26 shows the comparison chart of the following reinforced concrete bridges with span length of 15m.

Alternative 1: Reinforced concrete hollow slab bridge
Alternative 2: Reinforced concrete three-girder bridge

Table 2.2.26 Comparison chart of reinforced concrete bridges with span length of 15m

	Alternative-1 : RC Hollow Slab (Cast in Place)		Alternative-2 : RC 3-Girders (Cast in Place)	
Side View Girder Section				
Bridge outline	This type of bridge has high efficiency of section and light weight characteristics due to arrangement of hollows in girder section. Concrete casting is performed on scaffolding set under the superstructure.		This type of bridge is girder type bridge and do not have hollows. Arrangement of 3 girders is suitable for the bridge which has road width approx. 10m. Concrete casting is performed on scaffolding set under the superstructure.	
Structural standpoint	・ Lower girder height (high efficiency of girder section) ・ Shorter approach road ・ Some construction experience in Mozambique (this type is the same as a past project)	○	・ Higher girder height ・ Longer approach road ・ No construction experience in Mozambique	△
Construction	・ Excellent workability in the point of casting concrete (1-layer of D32 is arranged on lower side) ・ Excellent workability (the shape of section is simple) ・ Countermeasure against floating of form is required.	○	・ Good workability in the point of casting concrete (3-layer of D32 is arranged on lower side) ・ Good workability (the shape of section is more complex)	△
Influence on substructure and foundation	Smaller reaction and design loads of substructure and foundation Reaction force from superstructure : 1,600kN(1.00)	○	Larger reaction and design loads of substructure and foundation Reaction force from superstructure: 1,900kN(1.19)	△
Economical standpoint	Little lower cost of construction (Cost of superstructure is approx. same as Althernative-2, but cost of substructure is a little lower than Alternative-2.)	○	Little higher cost of construction (Cost of superstructure is approx. same as Alternative-1, but cost of substructure is a little higher than Althernatve-1.)	○
Conclusion	Alternative-1: RC hollow slab is adopted as RC bridge in this project because of some experience of construction, shorter approach road and small reaction.			

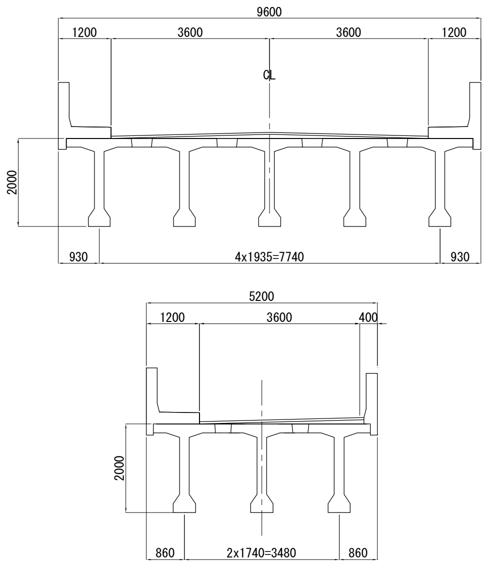
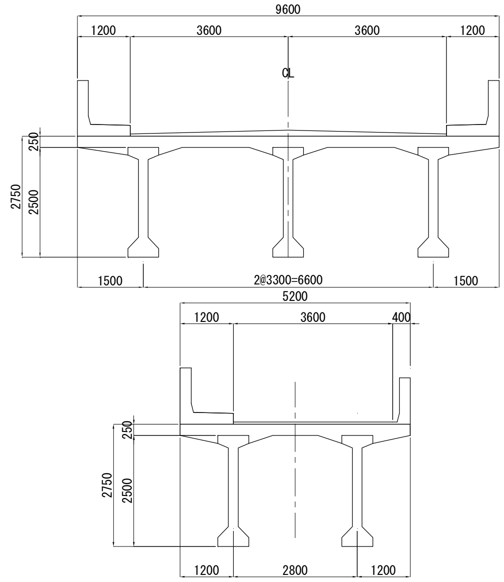
As a result of the comparative examination, the reinforced concrete hollow slab bridge is adopted. Reasons for this decision are as follows: ① As girder height is low, work quantities can be reduced in the approach roads, ② Reactive force of superstructure is small, thereby enabling load on substructure to be reduced, and ③ This type of bridge has been already constructed in the previous projects in Mozambique.

② Pre-stressed concrete bridge

Pre-stressed concrete bridges with span length of 35 m are planned over rivers with maximum discharge of 500m^3/s or greater. On such rivers, it is impossible to divert river flow and to keep the sites in dry condition. Accordingly, precast girder bridges, which can be built any time throughout the year with using erection girder system; i.e. without using space under the girders, are more advantageous. The bridge type is ultimately selected out of the following two types following comparative examination. Table 2.2.27 shows the comparison chart of the following pre-stressed concrete bridges with span length of 35m.

Alternative 1: Post-tension T girder bridge
Alternative 2: Pre-stressed concrete composite girder bridge

Table 2.2.27 Comparison chart of pre-stressed concrete bridges with span length of 35m

	Alternative-1: PC Post Tension T Girder		Alternative-2: PC Composite Girder	
Arrangement of girder				
Bridge outline	This type is same as bridges constructed in a past project in Mozambique. This bridge is constructed by the method that connected post-tension T girders by tendons in slab.		This bridge consist of components which combined post-tension I girders and RC slab by dowel. Concrete casting of slab is performed on scaffolding set under the superstructure.	
Structural standpoint	・ Lower girder height ・ Shorter approach road ・ Some construction experience in Mozambique (this type is the same as a past project)	○	・ Higher girder height ・ Longer approach road ・ No construction experience in Mozambique	△
Construction	・ No problem about stability of girder at erection ・ At slab work, tensioning work of tendons in slab is required because of PC slab, but no scaffolding is needed. ・ Slight influence from weather	○	・ Countermeasure against stability of girder at erection is required. ・ At slab work, scaffolding between girders is required because of RC slab, but no tensioning work is needed. ・ Weather condition have an influences on concrete casting of slab	△
Influence on substructure and foundation	Smaller reaction and design loads of substructure and foundation Reaction force from superstructure For 1 lane bridge: 1,900kN(1.00) For 2 lane bridge: 3,200kN(1.00)	○	Larger reaction and design loads of substructure and foundation Reaction force from superstructure For 1 lane bridge: 2,100kN(1.10) For 2 lane bridge: 3,600kN(1.13)	△
Economical standpoint	Total construction cost is almost same as Alternative-2: More girders are required than Alternative-2, but banking height can be low because of low girder height.	○	Total construction cost is almost same as Alternative-1: The number of girders are smaller than Alternative-1, but banking height becomes high.	○
Conclusion	Alternative-1: Post Tension T Girder is adopted as PC bridge in this project because of some experience of construction, shorter approach road and small reaction.			

As a result of the comparative examination, the post-tension T girder bridge is adopted. Reasons for this decision are as follows: ① As girder height is low, work quantities can be reduced in the approach roads, ② Reactive force of superstructure is small, thereby enabling load on substructure to be reduced, and ③ This type of bridge has been already constructed in the previous projects in Mozambique.

(4) Approach road design

1) Applicable geometric design parameter

ANE's Design Standard is basically followed for this Project. However, only normal cross fall is changed from 2.0% to 2.5% as well as Gurue – Magige road. The design speed of 60km/h is applied because the field survey indicated that the target bridges are existed in hilly and/or mountainous area. Table 2.2.28 shows the applicable geometric design parameters for this Project.

Table 2.2.28 Applicable geometric design parameter

Road Class: Primary Road					
Design Speed: V=60km/h					
Design Items		Unit	ANE's Standard	Gurue - Magige	This Project
Min. Stop Sight Distance		m	85	115	85
Min. Passing Sight Distance		m	410	410	410
Min. Radius for Curve	Desirable	m	250	250	250
	Absolute	m	115	210	115
Max. Gradient	Flat	%	6.0	6.0	6.0
	Rolling	%	7.0	7.0	7.0
	Mountainous	%	8.0	7.85	8.0
Min. Gradient		%	0.0	0.0	0.3
K Value	Crest	k	18	N/A	18
	Sag	k	17	N/A	17
Min. Curve Length		m	40	140	40
Max. Super Elevation		%	10.0	6.0	6.0
Normal Cross Fall	Gradient > 0.5%	%	2.0	2.5	2.5
	Gradient < 0.5%	%	3.0	2.5	2.5
Normal Cross Fall	Unpaved Shoulder	%	4.0	4.0	4.0

2) Pavement design

As discussed in the design policy, asphalt concrete pavement is adopted for this Project. However, essential design parameters for asphalt concrete pavement are not stipulated in ANE's Design Standard. It is therefore SATCC Pavement Design Standard is used for the pavement design.

Design conditions for the pavement design are as follows:

- Design Standard: SATCC Draft Code of Practice for the Design of Road Pavements
- Design Period: 15-years (from detail design of Gurue-Magige road)
- Traffic Class: Class T4 (1.7million) (from detail design of Gurue-Magige road)
- Sub-grade Class: S3 (CBR=7%) (from detail design of Gurue-Magige road)
- Climate: Wet
- Pavement Composition: As follows:

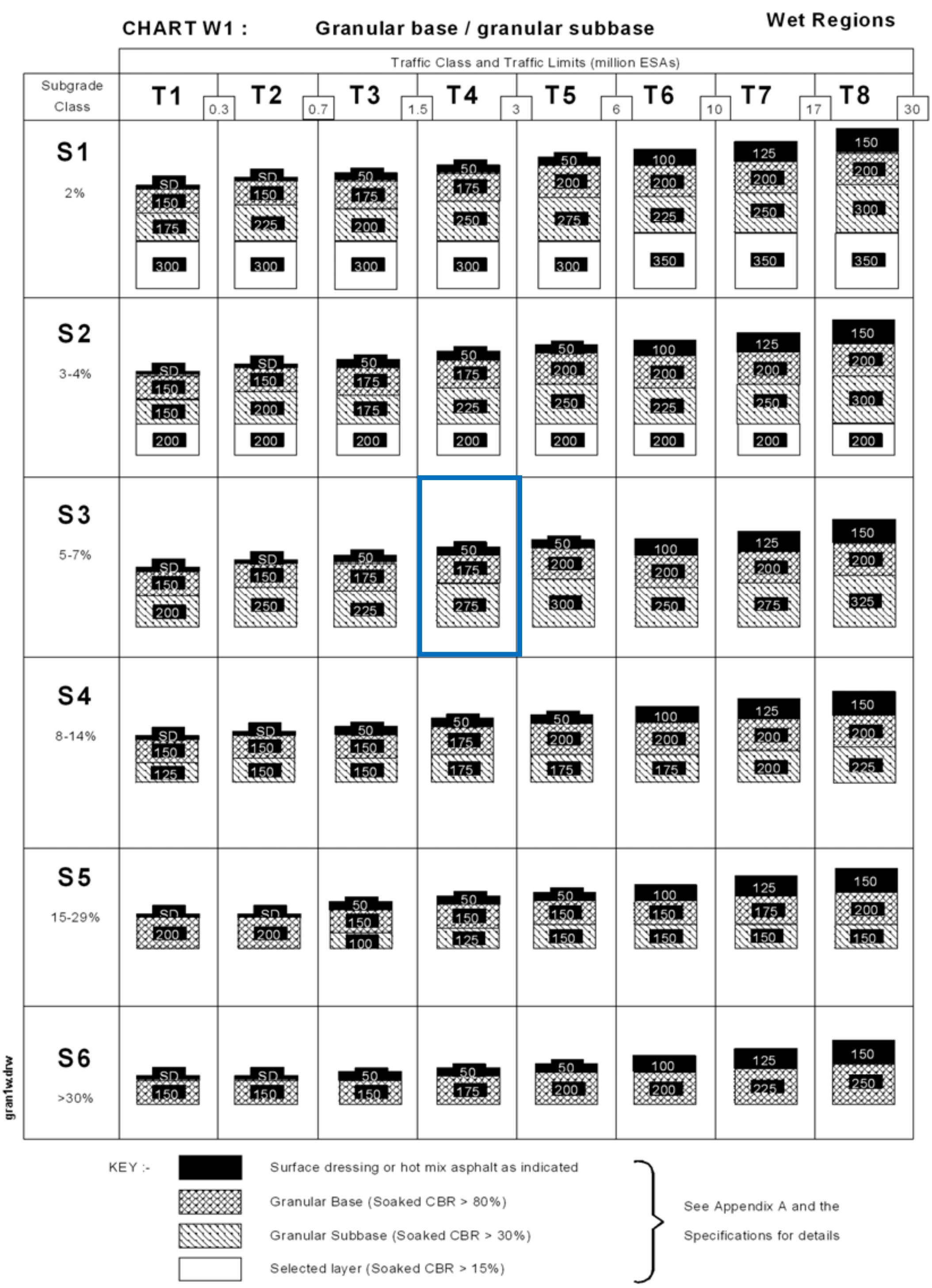


Fig. 2.2.18 Applicable pavement composition from SATCC pavement design

Incidentally, Table 2.2.29 shows that the pavement composition for this Project is superior to the recommended pavement composition of Gurue - Magige road.

Table 2.2.29 Comparison of pavement composition

Gurue - Magige	Pavement Composition	Asphalt Sealing	Base (Crushed Stone) CBR=80	Sub-base (Cemented) C4: 0.75-1.5MPa	S/N
	Coefficient	0	0.14	0.20	
	Thick (m)	0.030	0.150	0.250	**0.071**
This Project	Pavement Composition	Asphalt Concrete	Base (Crushed Stone) CBR=80	Sub-base (Granular) CBR=30	S/N
	Coefficient	0.4	0.14	0.11	
	Thick (m)	0.050	0.175	0.275	**0.075**

3) Center line and Vertical alignment plan

As mentioned in previous sub-chapter, both horizontal and vertical alignment is connected to existing road with the shortest length possible in accordance with the geometric design standard. Table 2.2.30 shows the project length; i.e. bridge length, road length for target bridges. As a result, relocation of houses is not necessary for this Project. Table 2.2.31 shows the relation between to the road surface level and estimated flood level. As a result, all target sections will be not covered with water in return period of 3-year. However, bridges of No.6, No.11, No.12 and No. 13 may be covered with water at return period between 4-years to 100-years or 50-years, respectively.

Table 2.2.30 Bridge length & Approach road length

No	Bridge Name	Bridge Length (m)	Width (m)	(A) Approach road at Napevo side (m)	(B) Approach road at Cuamba side (m)	(A)+(B) Total Road Lengh (m)	(A)+(B)+(C) Project Lengh (m)
Br.1	Mutabasse	105	9.6	160	175	335	440
Br.2	Muliquela	70	5.2	170	165	335	405
Br.3	Matacasse	15	9.6	178	167	345	360
Br.4	Lua	50	5.2	335	195	530	580
Br.5	Ualasse	15	9.6	76	129	205	220
Br.6	Licungo	35	9.6	217	223	440	475
Br.7	Nivaco	30	9.6	150	180	330	360
Br.8	Matsitse	15	9.6	135	190	325	340
Br.9	Namisagua	15	9.6	135	150	285	300
Br.10	Nuhusse	35	9.6	185	230	415	450
Br.11	Lurio	70	9.6	256	174	430	500
Br.12	Muassi	15	9.6	99	166	265	280
Br.13	Namutimbua	30	9.6	225	205	430	460

Table 2.2.31 Possibility of water covering by each approach road

Bridge Name		Bottom of road (m)	Flood Level (m)		Possibility of Covering with Water
			1/3	Return Period	
No.1	Mutabasse	333.02	327.14	329.88 (100)	No flooding at 100-years return period
No.2	Muliquela	414.66	408.88	411.59 (100)	No flooding at 100-years return period
No.3	Matacasse	500.47	495.76	498.25 (50)	No flooding at 50-years return period
No.4	Lua	513.20	507.74	511.76 (100)	No flooding at 100-years return period
No.5	Ualasse	570.37	566.32	568.02 (50)	No flooding at 50-years return period
No.6	Licungo	628.74	625.47	630.04 (100)	Possibility of flooding at 100-years return period
No.7	Nivaco	706.76	701.63	704.62 (100)	No flooding at 100-years return period
No.8	Matsitse	622.91	719.29	721.04 (50)	No flooding at 50-years return period
No.9	Namisagua	711.14	707.19	708.82 (50)	No flooding at 50-years return period
No.10	Nuhusse	605.98	598.76	603.97 (100)	No flooding at 100-years return period
No.11	Lurio	585.54	580.87	585.86 (100)	Possibility of flooding at 100-years return period
No.12	Muassi	582.40	580.74	582.58 (50)	Possibility of flooding at 50-years return period
No.13	Namutimbua	565.98	564.07	567.29 (50)	Possibility of flooding at 50-years return period

2.2.3 Outline Design Drawings

The outline design drawings for this Project are shown in Appendix 6.6.

2.2.4 Implementation Plan

(1) Implementation policy

- Through grouping the project construction sites according to the site characteristics and bridge types, each group can works simultaneously and the construction period can be shortened. Moreover, it is planned to improve work efficiency through sharing the site offices and concrete plants.
- The types of superstructure, substructure and foundation for the target 13 bridges are possibly unified. Moreover, unifying the temporary works and erection girder methods and sharing construction equipments are planned for cost reduction.
- Sufficient safety measures are planned, since the public safety in the region is unstable. For example, security guards are planned to be assigned to the site offices and dormitories.

(2) Implementation Conditions

1) Works in river

Most of the target bridge sites are sometimes damaged by flooding during the rainy season. Therefore, no work inside rivers in the rainy season is basically planned. However, if it is absolutely necessary, sufficient safety control such as setting an appropriate danger water level has to be planned. Moreover, the work efficiency during the rainy season is carefully considered in order to make an adequate construction planning.

2) Traffic safety measures

It is planned to pave the target road on two lanes over the route. On the section between Nampevo and Gurue, the project has already been completed and the entire road is paved on both lanes except for the bridge sections. There are five target bridges on the section between Nampevo and Gurue, and since the road narrows to one lane over these bridges, numerous traffic accidents occur on them. During the construction period, in order to prevent accidents, sufficient number of traffic controllers and safety signs are planned to be allocated on sites.

3) Tax exemption and refund measures

Concerning taxes on imported equipment and materials in Mozambique, rather than exemption, ANE pays the customs duties on behalf of the contractor. As the procedure for this, it is necessary for a contractor to prepare the necessary documentation and submit it to ANE at least one month in advance of the importation. Moreover, since ANE needs to secure sufficient budget to cover the cost of customs duties in this Project, it is necessary for the Japanese side to give the necessary information to calculate the budget to ANE when giving outline explanation of this Project in Mozambique.

Similarly, concerning IVA (value added tax), rather than exemption, ANE provides a refund of IVA. Accordingly, the Japanese side also needs to inform ANE of the rough target amount when giving outline explanation of this Project in Mozambique so that the necessary budget can be secured.

(3) Scope of Works

Table 2.2.32 shows the general scope of works on the Japanese side and the Mozambique side in this Project. The Mozambique side is responsible for all matters concerning the securing of construction sites; e.g. camp yards, fabrication yards, and borrow pits, etc. Moreover, since the area of 30 m from the road center is the right of way, it is confirmed that the lands in this scope can be used for construction if necessary.

Table 2.2.32 Scope of obligations on the Japanese side and the Mozambique side

the Japanese Side	the Mozambique Side
- Reconstruction of the target 13 bridges and approach roads connecting with existing road - Establishment & removal of temporary facilities such as site offices and work yards, etc. - Procurement, import, export and transportation of construction equipments & materials, based on the construction plan - Detailed design, preparation of tendering and construction supervision	- Acquisition of environmental licenses - Survey and removal of landmines - Provision of quarries and disposal areas - Securing of construction sites and land for site offices - Compensation for the lands to be used in this project - Bank commissions (opening of a bank account (B/A), procedures for the authorization to pay (A/P)) - Exemption and refund of taxes placed on the import and purchase of works equipments and materials in Mozambique - Provision of the bailey bridges (temporary facilities) - Removal and transfer of public facilities such as optical fiber cable - Removal of temporary bridges and existing bridges if necessary - Provision of preventive education of HIV/AIDS to local people - Maintenance of the facilities constructed in this project

(4) Construction supervision

Resident engineer and bridge engineers are planned to be assigned to carry out quality control, schedule control and safety control during the construction period.

The quality control comprises inspection of the construction materials and execution accuracy of structures, based on certificates from the suppliers, laboratory test results and site inspections.

Regarding the schedule control, critical work items will be grasped via weekly progress inspections and improve with taking appropriate countermeasures in order to ensure that all the works are completed within the construction period.

Concerning the safety control, contractor has to provide monthly safety education to all local workers, and the engineers have to check whether necessary measures for safety are taken on sites or not. In case the measures are not enough, the engineers have to request the contractor to improve the things immediately.

(5) Quality control plan

Table 2.2.33 shows the quality control plan in this Project.

Table 2.2.33 Quality control plan

	Item	Content	Frequency
Material Inspection	Aggregate	Particle, Specific gravity, Hardness, Stability	Every 250m^3 at each quarry and borrow pit
	Cement	Particle, Specific gravity, Strength	Every 30 tons for each supplier
	Rebar	Strength, Bending	Every diameter from each lot
	Pre-stressed cable	Strength	Each lot
	Asphalt	Needle penetration, Viscosity, Softening	Each lot
	Embankment soil	Particle, Specific gravity, Consolidation, Moisture content, Plastic/Liquid limit, CBR	Every 500m^3 at each borrow pit
Product Inspection	Fresh concrete	Slump, Temperature	Every 5m^3 at site
	Hardened concrete	Compression strength, Unit weight	Every 30m^3
	Asphalt mix	Asphalt content, Temperature	Every 30 tons at site
	Base course, Sub-base course	Site density, Moisture content	Every 20m
	Girder	Dimensions, Straightness	Each girder
	Foundation, Substructure	Dimensions, Location, Elevation	Each structure
	Superstructure	Dimensions, Location, Elevation	Every 5m along the alignment
	Asphalt pavement	Thickness, Flatness, Elevation	Thickness: Every 100m^2, Flatness & Elevation: Every 5m along the alignment

(6) Procurement plan

Most of the construction equipments and materials are planned to be imported from foreign countries to Mozambique due to lack of domestic productions as well as low quality of local products. Table 2.2.34 shows the procurement sources of equipments & materials.

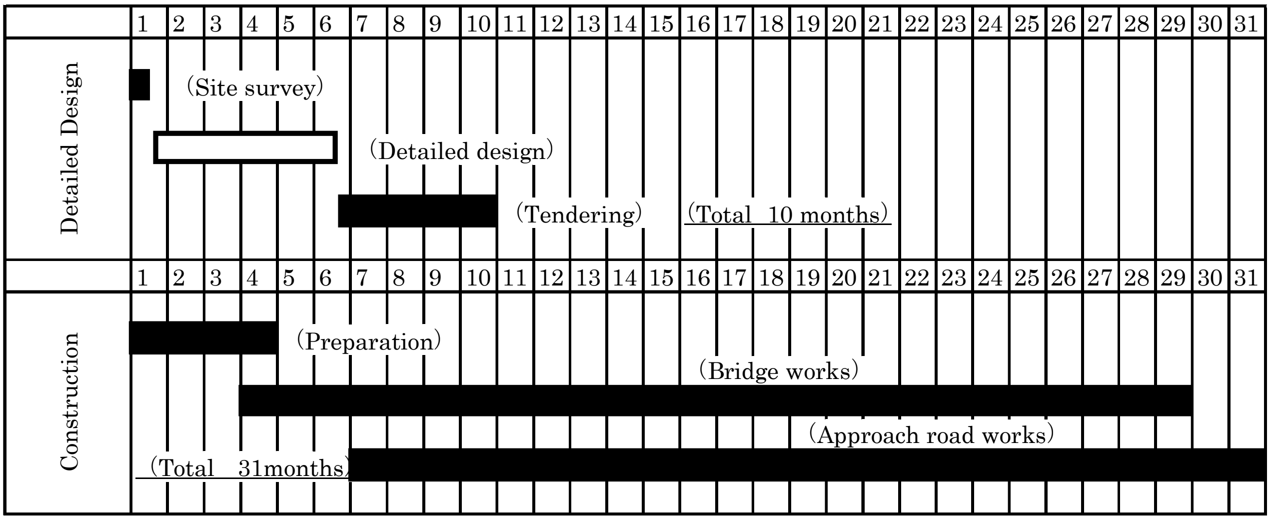
Table 2.2.34 Procurement sources for major construction equipments & materials

Item	Source			Remarks
	Mozambique	Japan	Third country	
［Materials］				
Portland cement	○		○	For substructure: Mozambique For superstructure: South Africa
Aggregate	○			
Pre-stressed cable			○	Not available in Mozambique
Steel plate			○	Ditto
Concrete Admixture			○	Ditto
Reinforcing bar			○	Ditto
Plywood	○			
Asphalt bitumen			○	Difficult procurement in Mozambique
Fuel, Oil	○			
Elastic bearing		○		Difficult procurement in Third country
Guardrail			○	Difficult procurement in Mozambique
[Heavy equipment]				
Bulldozer			○	Difficult procurement in Mozambique
Tipper truck			○	Ditto
Excavator			○	Ditto
Crawler crane			○	Ditto
Truck crane			○	Ditto
Giant breaker			○	Ditto
Drilling machine for pile		○		Difficult procurement in Third country
Vibration hammer			○	Difficult procurement in Mozambique
Compaction machine			○	Ditto
Blade grader			○	Ditto
Asphalt distributor			○	Ditto
Concrete mixer			○	Ditto
Asphalt finisher			○	Ditto

(7) Implementation schedule

Table 2.2.35 shows tentative implementation schedule.

Table 2.2.35 Tentative implementation plan



2.3 Obligations of the Recipient Country

2.3.1 General Conditions for Japan's Grant Aid

- To award the contract and implementation of the Project,
- To secure the lands necessary for implementation of the Project,
- To manage resettlement of the residents necessary to implement the Project and compensation for those residents,
- To open bank account in the name of the government of the recipient country in Japan (B/A) and issue the authorization to pay (A/P) and bearing of the costs thereof,
- To ensure all the expenses and prompt execution for unloading, custom clearance,
- To exempt Japanese nations from customs duties, domestic taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of goods and services under the Project,
- To provide supports for Japanese personnel to carry necessary products & services into Mozambique under the verified contracts,
- To ensure proper maintenance management of the facilities constructed by Japan's Grant Aid Project

2.3.2 Special Conditions for the Project

- To relocate or dismantle existing utilities such as optical fiber cable at project sites,
- To detect, discriminate and clear UXO's and land mines in the requisite lands on the project implementation,
- To provide temporary facilities such as existing bailey bridge,
- To remove or demolish obstacles and existing bridges,
- To obtain environmental licenses for the project implementation,
- To secure sites for borrow pit and disposal area,
- To conduct public announcement if there will be a traffic interrupt by the Project
- To Provide preventive education for HIV/AIDS

2.4 Project Operation Plan

The maintenance work necessary to operate and maintain the facilities constructed in this Project are recommended as shown in Table 2.4.1.

The structural mechanics of the target bridges and those approach roads is not complicated and the methodology and items for the maintenance work is quite general. Moreover, ANE has already maintained similar type of bridges constructed by Japan's Grant Aid Project and is familiar with those bridges and the maintenance work.

Table 2.4.1 Maintenance work for the facilities

Item	Frequency	Check Point	Description of Works
Visual inspection	Often	All facilities	Inspection & Maintenance work based on "Bridge Maintenance Manual" prepared in the project.
Bridge maintenance	Once every six months	Expansion joints	Cleaning of expansion joints. Any damage shall be photographed and recorded.
		Drainage system	Cleaning of drainage clogged with rubbish, soil or sand. Any damage shall be photographed and recorded.
		Bearings	Cleaning of bearings. Checking on displacement and deterioration of bearings.
		Handrail	Checking on if there is any damage caused by traffic accident. Any damage shall be photographed and recorded.
		Main girder	Checking on if there is any damage. Any damage shall be photographed and recorded.
	Once every six months (Particularly after rainy season)	Bridge deck and pavement	Checking on deck surface. If there are any potholes or damages, they shall be repaired.
	Once every six months (Particularly after rainy season)	Abutments and Piers	Checking on if there are any scours around structures and settling of structures. Any scours and settling shall be photographed and recorded.
Access roads maintenance	Once every six months (Particularly after rainy season)	Road surface	Checking on road surface. If there are any potholes or damages, they shall be repaired.
		Shoulders & slopes	Checking on any deformations and cracks. Weeding and repairing damaged sections.
		Side ditch and catch pits	Cleaning of ditch and pits clogged with rubbish, soil or sand. Any damage shall be photographed and recorded.
	Once every six months (Particularly after rainy season)	Guard rail and traffic sign	Checking on if there is any corrosion or damage on guard rail and traffic sign. Any damage shall be photographed and recorded.
Riverbank protection	Once every six months (Particularly after rainy season)	Gabions	Checking on if there are any scours around structures and damages of gabions. Any scours and damages shall be photographed and recorded.

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

The cost of the Project to be borne by Mozambique side is estimated at 3.25 million USD as summarized in Table 2.5.1. These costs are estimated under the following conditions as shown in Table 2.5.2.

(1) Project cost to be borne by Mozambique Side

Table 2.5.1 Project cost to be borne by Mozambique side

Items	Cost (Thousand USD)	Equivalent (Million JPY)
1. Removal of existing bridges	172.0	14.4
2. Removal of bailey bridges	6.5	0.5
3. Compensation for crop fields	67.8	5.7
4. Removal and transfer of public facilities (e.g. Optical cable)	78.0	6.5
5. Survey and removal of landmines	718.2	60.1
6. Custom duty & Value added tax (IVA)	2,164.0	181.2
7. Payment of bank service charges for bank arrangement (B/A) and Authorization to pay (A/P)	47.8	4.0
Total	3,254.3	272.4

(2) Conditions of cost estimation

Table 2.5.2 Conditions of cost estimation

Items	Condition
1. Estimate time	May, 2011
2. Exchange Rate	1 USD = 83.73 JPY 1 MT = 2.579 JPY
3. Construction Period	31 months

2.5.2 Operation and Maintenance Cost

Annual operation and maintenance cost after the completion of the Project are estimated as shown in Table 2.5.3.

Table 2.5.3 Annual operation & maintenance cost

Item	Frequency	Check point	Description of work	Annual cost (USD)
Inspection for bridge and approach road	Once per 6 months	Deck slab Expansion joints Drainage pipes Bearings Handrail Main girders Abutments & Piers Slopes Side ditch Guardrail and Traffic signs	Inspection & cleaning	4,620
Repairing pavement	Once per 5 years	Road surface	Overlay	44,900
Repairing riverbank protection	Once per 2 years	Riverbed in front of abutments	Repairing gabions	42,000
	Once per 2 years	Slopes around abutments	Repairing gabions & re-panting	58,200
Repairing shoulder and slope	Once per 2 years	Road shoulder and slopes	Weeding & repairing damaged area	33,700
Total cost for annual operation & maintenance cost				183,420

Chapter 3. Project Evaluation

Direct and indirect effects have been evaluated as benefit effects expected through the Project implementation. Evaluation methods through PDM are utilized for the evaluation. Indicators have been selected to evaluate objectively the Project effects.

Table 3.1.1 Tentative PDM evaluation items

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal ： To stabilize and facilitate logistics with other countries and inside Mozambique	・Increase on road expantion developed ・Increase on road density ・Improvement of cursoriality on local roads ・Increase on local products	・Road overall plan such as PRISE ・Provincial industry statistics	・Continuous implementation of road plan in Mozambique ・Continuous supports by other donors ・Stable growth on economic in Mozambique
Project purpose ： To secure travelable roads through the year by the development of bridges and roads in the Northern Mozambique, Nampepo / Ile on Route 103 andCuamba in Niassa province on Naccala Corridor	・Increase of the traffic volume on the target roads ・Increase of large cargo traffic ・Shortening the traffic time required ・Increase on income of inhabitants around the project site ・Decrease on days of traffic shut off during the rainy season	・ Result of the traffic vokume census by automobiles(the end of the project・defect examination） ・Research for time required（the end of the project) ・Poverty ratio	・
Output : 13 Bridge construction and replacement from Nampepo/Ile-Cuamba are implemented	・Bridges are constructed just as the operation ・Bridges as applicable are constructed	・Monthly construction work report ・Result of final completion examination ・Defect examination	・E/N and G/A execution
Activities ： 1) Planning for 13 Bridge construction and replacement, Work of construction. 2）Work distribution for the counterpart, Formulation of implementation plan	**Inputs：Japanese side** ・Examination concerning basic and details designing and project implementation ・Technology transfer to ANE	**Mozambique side** ・Participation of counterparts ・Implementation of the project covered by the partner country	**Pre-conditions** : ・Cooperation with counterparts and related agencies ・Acquision of environrmenatl approval ・Securement of safe construction work ・Agreement with inhabitants

3.1 Preconditions

The preconditions for the implementation of the Project are described below.

1) Compensation for crops

Acquisition of private lands and resettlement are not required in this Project. However, adequate compensation for crops in the Project area has to be carried out.

2) Obtainment of Environmental License

The environmental license needs to be obtained for implementation of this Project. Regarding this Project, 12 bridges out of 13 were categorized as “C” and one bridge was categorized as “B”. The category “C” does not require further environmental study. However, the category “B” requires the simplified environmental study for obtaining the license from MICOA.

3) Clearing UXO's and Landmines

The Project areas are planned in this study. All the areas have to be demined before the tendering.

4) Relocation of Existing Utilities

The optical fiber cables are buried along the road along the target route and are hooked on the target bridges. Therefore, the cables have to be relocated, before starting the construction stage.

3.2 Important Assumptions

As the Project agenda, unlike projects about bridge development on arterial roads, i.e. "The project for reconstructing the arterial road and bridge" and "The project for reconstructing the secondary road and bridge", this Project focuses on the bridge development on a secondary road, so the pavement ratio of the target road is low. Not only the bridge development but also the development of road pavement will be considered to strengthen the aid effectiveness, and the early completion of the project for paving Niassa Corridor implemented by other donors is a precondition to achieve the Project purpose.

3.3 Project Evaluation

3.3.1 Relevance

This Project is requested in order to replace bridges urgently required in terms of human security as mentioned below.

1) The Project target areas, Zambezia and Niassa Provinces, have many poor people and most of them are engaged in agriculture. Therefore, the development of road network is necessary to revitalize agriculture.
2) The bridge development is necessary because inhabitants around the Project target areas have difficulty in commuting to school, visiting hospitals and delivering patients to the hospitals because of the undeveloped bridges.
3) Traffic accidents often happened on bridges. In order to prevent such accidents, the expansion work of bridges (i.e. expanding the bridge width from one lane to two lanes) is urged.
4) There are some bridges which might be collapsed, so they need to be replaced.
5) The Project is considered to contribute the aims on MDGs.
6) This Project collaborates with "The project for developing the Nacala Corridor".

Through the field survey of the Project, these issues above have been examined and the validity of Project implementation by the Japanese grant aid has been found.

3.3.2 Effectiveness

1) Quantitative Outputs

- Reduction in transit time and travel distance:
  After improvement of the target bridges, the route becomes passable through the year. Moreover, the travel distance can be reduced about 55 km because the new route is the shortest way to Cuamba from Nampevo. Similarly, the transit time can be deducted between Napevo and Cuamba by about two hours.

- Reducing duration of road closed by heavy rain:
  As a result of the interview to the local residents, the rainfall data and the hydrological analysis, it seems that the target road has been annually closed a few times during the rainy season due to storm water overflow. After constructing the target bridges designed with sufficient vertical clearance under the bridges, it is predicted that few road closure will happen by heavy rain on the target road.

- Reducing transportation cost:
  Due to reducing the transit time and the travel distance and improving average driving speed, decrease in transportation cost can be expected. The deduction of annual transportation costs for this route in 2026 is estimated to be 2.7 million USD.

- Economic impact on the agricultural sector:
  After improving the logistics capability on the target route, the economic impact to the agriculture sector, which is the main industry of the region, can be estimated to be 389 million USD over the next 20 years.

2) Qualitative Outputs

- Enhancement of the road network in the region
- Regional revitalization and life improvement
- Decrease in traffic accidents
- Mitigation of disaster risk
- Benefits for impoverished people

Hence the implementation of this Project is considered highly meaningful, relevant and effective.

Appendices

1． Member List of the Study Team

1.1 1st Site Survey (08/Mar/2011～28/Jun/2011)

	Position		Name	Organization	Period
(1)	Leader	:	Masahiko SUZUKI	Japan International Cooperation Agency (JICA)	3/10 – 3/25
(2)	Project Coordinator	:	Daisuke FUKUZAWA	Japan International Cooperation Agency (JICA)	3/10 – 3/25
(3)	Chief Consultant／Bridge Designer I	:	Junji YASUI	Chodai Co., Ltd	3/08 – 4/21
(4)	Road Designer／Transport Survey	:	Koichi ISHII	Eight-Japan Engineering Consultants Inc. (Pegasus Engineering Corporation)	3/08 – 4/21
(5)	Bridge Designer II／Natural Condition Survey I	:	Yukikazu KOBAYASHI	Chodai Co., Ltd	3/08 – 4/21, 6/14 – 6/28
(6)	Natural Condition Survey II	:	Koji TAKAHASHI	Eight-Japan Engineering Consultants Inc.	4/05 – 5/19
(7)	Environmental & Social Consideration	:	Kazuo IIYAMA	Chodai Co., Ltd (Nippon Koei Co., Ltd)	3/08 – 4/21
(8)	Construction & Procurement Planning／Cost Estimation	:	Jun MORISHITA	Chodai Co., Ltd	3/08 – 4/06
(9)	Interpreter	:	Kyoko TAMAI	Chodai Co., Ltd (Pioneer Translation Ceter)	3/10 – 3/25

1.2 2nd Site Survey (Explanation of DOD) (26/Oct/2011～04/Nov/2011)

	Position		Name	Organization	Period
(1)	Leader	:	Masahiko SUZUKI	Japan International Cooperation Agency (JICA)	10/29 – 11/04
(2)	Project Coordinator	:	Daisuke FUKUZAWA	Japan International Cooperation Agency (JICA)	10/29 – 11/04
(3)	Chief Consultant／Bridge Designer I	:	Junji YASUI	Chodai Co., Ltd	10/26 – 11/04
(5)	Bridge Designer II／Natural Condition Survey I	:	Yukikazu KOBAYASHI	Chodai Co., Ltd	10/26 – 11/04

2. Study Schedule

2.1 1st Site Survey (08/Mar/2011～28/Jun/2011)

	Date		JICA		Consultant						
			Leader (Mr. Masahiko SUZUKI)	Project Coordinator (Mr. Daisuke FUKUZAWA)	Chief Consultant / Bridge Designer I (Mr. Junji YASUI)	Road Designer / Transport Survey (Mr. Koichi ISHII)	Bridge Designer II / Natural Condition Survey I (Mr. Yukikazu KOBAYASHI)	Natural Condition Survey II (Mr. Koji TAKAHASHI)	Environmental & Social Consideration (Mr. Kazuo IIYAMA)	Construction & Procurement Planning / Cost Estimation (Mr. Jun MORISHITA)	Interpreter (Ms. Kyoko TAMAI)
1	8-Mar-11	Tue.			Travel to Mozambique				Travel to Mozambique		
2	9-Mar-11	Wed.			Meeting with ANE				Meeting with ANE		
3	10-Mar-11	Thu	Travel to Mozambique								Travel to Mozambique
4	11-Mar-11	Fri	Visit to JICA Maputo and ANE						Visit to JICA Maputo and ANE		
5	12-Mar-11	Sat	Travel to Quelimane				Preparation for tender for survey company		Travel to Quelimane		
6	13-Mar-11	Sun	Bridge inspection			Site investigation			Site investigation		Bridge inspection
7	14-Mar-11	Mon									
8	15-Mar-11	Tue	Travel to Maputo								Travel to Maputo
9	16-Mar-11	Wed	Explanation on Inception report to ANE, and Discussion on M/D								Explanation on Inception report to ANE, and Discussion on M/D
10	17-Mar-11	Thu									
11	18-Mar-11	Fri									
12	19-Mar-11	Sat			Data collection	Travel to Maputo			Travel to Maputo		
13	20-Mar-11	Sun	Signing of M/D, Reporting to EOJ and JICA Maputo		Data analysis				Data analysis		
14	21-Mar-11	Mon			Discussion on M/D with ANE				Discussion on M/D with ANE		
15	22-Mar-11	Tue									
16	23-Mar-11	Wed			Signing of M/D, Reporting to EOJ and JICA Maputo				Signing of M/D		
17	24-Mar-11	Thu	Travel to Japan		Data collection		Preparation for tender for survey company		Data collection	Data collection	Travel to Japan
18	25-Mar-11	Fri									
19	26-Mar-11	Sat									
20	27-Mar-11	Sun			Data analysis						
21	28-Mar-11	Mon			Data collection		Preparation for tender for survey company				
22	29-Mar-11	Tue									
23	30-Mar-11	Wed			Travel to Quelimane	Data collection	Travel to Quelimane				
24	31-Mar-11	Thu			Site investigation		Site investigation				
25	1-Apr-11	Fri									
26	2-Apr-11	Sat									
27	3-Apr-11	Sun				Travel to Quelimane			Travel to Quelimane		
28	4-Apr-11	Mon			Site investigation			Travel to Maputo	Site investigation		
29	5-Apr-11	Tue								Travel to Japan	
30	6-Apr-11	Wed									
31	7-Apr-11	Thu						Data collection			
32	8-Apr-11	Fri						Travel to Quelimane			
33	9-Apr-11	Sat						Site investigation			
34	10-Apr-11	Sun									
35	11-Apr-11	Mon									
36	12-Apr-11	Tue									
37	13-Apr-11	Wed									
38	14-Apr-11	Thu			Travel to Maputo				Travel to Maputo		
39	15-Apr-11	Fri			Technical meeting with ANE				Technical meeting with ANE		
40	16-Apr-11	Sat			Data collection				Data collection		
41	17-Apr-11	Sun			Data analysis				Data analysis		
42	18-Apr-11	Mon			Technical meeting with ANE				Technical meeting with ANE		
43	19-Apr-11	Tue			Reporting to JICA Maputo, Visit to ANE				Reporting to JICA Maputo		
44	20-Apr-11	Wed			Travel to Japan				Travel to Japan		
45	21-Apr-11	Thu									
46	22-Apr-11	Fri									
47	23-Apr-11	Sat									
48	24-Apr-11	Sun									
49	25-Apr-11	Mon									
50	26-Apr-11	Tue									
51	27-Apr-11	Wed									
52	28-Apr-11	Thu									
53	29-Apr-11	Fri									
54	30-Apr-11	Sat									
55	1-May-11	Sun									
56	2-May-11	Mon									
57	3-May-11	Tue									
58	4-May-11	Wed									
59	5-May-11	Thu									
60	6-May-11	Fri									
61	7-May-11	Sat									
62	8-May-11	Sun									
63	9-May-11	Mon									
64	10-May-11	Tue									
65	11-May-11	Wed									
66	12-May-11	Thu									
67	13-May-11	Fri									
68	14-May-11	Sat						Travel to Maputo			
69	15-May-11	Sun						Data collection			
70	16-May-11	Mon									
71	17-May-11	Tue									
72	18-May-11	Wed						Travel to Japan			
73	19-May-11	Thu									
74	14-Jun-11	Tue					Travel to Mozambique				
75	15-Jun-11	Wed									
76	16-Jun-11	Thu					Travel to Quelimane				
77	17-Jun-11	Fri					Site inspection				
78	18-Jun-11	Sat									
79	19-Jun-11	Sun									
80	20-Jun-11	Mon									
81	21-Jun-11	Tue									
82	22-Jun-11	Wed									
83	23-Jun-11	Thu					Travel to Maputo				
84	24-Jun-11	Fri					Technical meeting with ANE				
85	25-Jun-11	Sat					Data analysis				
86	26-Jun-11	Sun									
87	27-Jun-11	Mon					Travel to Japan				
88	28-Jun-11	Tue									

2.2 2nd Site Survey (Explanation of DOD) (26/Oct/2011～04/Nov/2011)

Date			JICA		Consultant	
			Leader (Mr. Masahiko SUZUKI)	Project Coordinator (Mr. Daisuke FUKUZAWA)	Chief Consultant / Bridge Designer I (Mr. Junji YASUI)	Bridge Designer II / Natural Condition Survey I (Mr. Yukikazu KOBAYASHI)
1	26-Oct-11	Wed.			Travel to Mozambique	
2	27-Oct-11	Thu			Visiting and Meeting with JICA Maputo	
3	28-Oct-11	Fri			Explanation on DFR to ANE	
4	29-Oct-11	Sat	Travel to Mozambique		Data analysis	
5	30-Oct-11	Sun	Team meeting			
6	31-Oct-11	Mon	Visit to JICA Maputo, Explanation on DFR to ANE			
7	1-Nov-11	Tue	Visiting and Meeting with FE, Discussion on M/D with ANE			
8	2-Nov-11	Wed	Travel to Maputo			
9	3-Nov-11	Thu	Signing of M/D, Reporting to EOJ and JICA Maputo			
10	4-Nov-11	Fri	Travel to Japan			

3． List of Parties Concerned

Organization	Position / Occupation	Name
National Roads Administration (ANE)	General Director	Mr. Cecilio Grachane
	Director of Planning	Mr. Calado Ouana
	Director or Projects	Mr. Ismael Sulemane
	Bridge Engineer	Mr. Evaristo Mussupai
	Traffic Department	Mr. Anival Nuvunga
	Environmental Department	Ms. Emilia Tembe
	Delegate of ANE Zambezia	Mr. Andre Chachine
	ANE Project Office (Gurue – Magige Road Project)	Mr. Fransisco Simbini
	ANE Zambezia	Mr. Roberto
Road Fund (FE)	Chairman	Mr. Elias Paulo
	Lawer, Dep. of External Relationship	Mr. Frederico Chipuale
	Economist	Mr. Mr. Joao Mutombene
Gurue District Office	Infrastructure Department	Mr. Walien Jenuce
Gurue Municipally Office	Mayer	Mr. Anisetoue Guile
	Infrastructure Department	Mr. Soaji
Ile District Office	Infrastructure Department	Mr. Paulo Nacomaka
Zambezia Traffic Police	Director	Mr. Chimene
Quelimane Port Authority	Executive Director	Mr. Domingos Muzeia
Quelimane Customs	Gestor de Operacoes	Mr. Custodio Macamo
Quelimane Statistics Office	Director	Mr. Armando Terenhes
Zambezia Agriculture Office	Agriculture Department	Mr. Jesus Gunia
	Timber Department	Mr. Bastique
Zambezia Planning Department	Planning / Finance	Mr. Gracidijp Francer
Cha Gurue	Manager	Mr. Almeida Lee
Agua Gurue	Factory Manager	Mr. Aslam Vahoro
ENGLOB	Resident Engineer	Mr. Jose Marin
TECNICA	Resident Engineer	Mr. Moniero
Hoyo hoyo	Resident Engineer	Mr. Zewi
MICOA	Director	Ms. Rosa Benedito
Department for Environmental Impact Evaluation (Zambezia)	Head of Department	Ms. Fatima Mudanisie
Forest & Wildlife Section, Department for Agriculture	Director	Mr. Antonio Chibite
Cuamba Municipally Office	Advisor	Mr. Mario Lazaro
Governo Distrito de Cuamba	Public Works Department	Ms. Lueiana
Embassy of Japan	Ambassador	Mr. Susumu Segawa
	Ambassador	Mr. Eiji Hashimoto
	Counsellor	Mr. Keiji Hamada
	Second Secretary	Ms. Yuka Iwanami
JICA Mozambique Office	Resident Representative	Mr. Masami Shukunobe
	Deputy Resident Representative	Mr. Hitoshi Matsumoto
	Assistente do Representante Residente	Mr. Akihiro Miyazaki
	Assesor de Formulasao de Projectos	Ms. Harumi Maruyama

4 . Minutes of Discussions

4.1 1st Site Survey (23/Mar/2011)

**MINUTES OF DISCUSSIONS
ON THE PREPARATORY SURVEY (OUTLINE DESIGN STUDY)
ON THE PROJECT FOR CONSTRUCTION OF BRIDGES ON THE ROAD
BETWEEN ILE AND CUAMBA
IN THE REPUBLIC OF MOZAMBIQUE**

In response to a request from the Government of the Republic of Mozambique (hereinafter referred to as "Mozambique"), the Government of Japan decided to conduct a Preparatory Survey for Outline Design (hereinafter referred to as "the Survey") on the Project for Construction of Bridges on the Road between Ile and Cuamba (hereinafter referred to as "the Project"), and entrusted the study to Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent the Preparatory Survey Team for Outline Design (hereinafter referred to as "the Team") to Mozambique. The Team is headed by Mr. Masahiko SUZUKI, Senior Transport Sector Advisor, JICA and is scheduled to stay in the country from March 9 to June 5, 2011.

The Team held a series of discussions with the officials of Mozambique and conducted a field survey at the Project area. In the course of the discussions, both sides have confirmed the main items described in the attached sheets. The Team will proceed to further works and prepare the Preparatory Survey Report.

Maputo, March 23, 2011

鈴木 正彦

Suzuki Masahiko
Leader
Preparatory Survey Team
Japan International Cooperation Agency
Japan

Cecílio Grachane

Mr. Cecílio Grachane
Director General
National Road Administration
The Republic of Mozambique

ATTACHMENT

1. Objective of the Project

The objective of the Project is to secure smooth transport between Ile/Nampevo and Cuamba through the construction/rehabilitation of bridges.

2. Project Sites

The Project sites locate in Zambezia and Niassa Provinces which are shown in Annex 1.

3. Responsible and Implementing Organizations

The responsible ministry of the Project is the Ministry of Public Works and Housing. (hereinafter referred to as "MOPH"). The implementing organization of the Project is the National Road Administration (hereinafter referred to as "ANE"). The organization charts are shown in Annex 2 and 3 respectively.

4. Items requested by the Government of Mozambique

4-1. As a result of the discussions, the bridges described below were requested by the Mozambican side to be reconstructed or rehabilitated.

- Mutabasse bridge
- Muliquela bridge
- Matacasse bridge
- Lua bridge
- Ualasse bridge
- Licungo bridge
- Nivaco bridge
- Matsitse bridge
- Namisagua bridge
- Nuhusse bridge
- Lurio bridge
- Muassi bridge
- Namutimbua bridge

4-2. JICA will assess the appropriateness of the request through the Survey and will report the findings to the Government of Japan. Implementation and components of the Project will be decided by the Government of Japan.

4-3. Both sides confirmed that there is a possibility that the Project would be divided into several phases or that not all the requested bridges could be the component of the Project based on the prioritization of the bridges as shown in Annex 4.

5. Japan's Grant Aid Scheme

5-1. The Mozambican side has shown a full understanding to the Japan's Grant Aid Scheme explained by the Team, as described in Annex 5 and 6.

5-2. The Mozambican side will take the necessary measures, as described in Annex 7, for smooth implementation of the Project, as a condition for the Japanese Grant Aid to be implemented.

6. Environmental and Social Considerations

6-1. Both sides confirmed that the Mozambican side shall conduct the necessary procedure concerning the environmental assessment (including stakeholder meetings, EIA survey etc.) and make EIA report of the Project. The EIA approval shall be received from the responsible authorities and submitted to JICA Mozambique office before November 2011.

6-2. The Mozambican side agreed to arrange the budget allocation for EIA study, land acquisition, resettlement and compensation for the Project Affected Persons (PAPs) and to take necessary measures for PAPs and secure the land before the commencement of pre-qualification under the contractor bidding procedure.

7. Schedule of the Study

7-1. The Team will proceed with further studies in Mozambique until June 5, 2011.

7-2. JICA will prepare a draft final report in English and dispatch a mission to Mozambique in order to explain its contents around October 2011.

7-3. When the contents of the report is accepted in principle by the Mozambican side, JICA will complete the final report in English and send it to Mozambique around February 2012.

8. Other Relevant Issues

8-1. The Mozambican side confirmed that the following undertakings should be taken by the Mozambican side at the Mozambican expenses under the Project.

(1)To provide tax exemption for construction materials and equipment for the Project

(2)To provide land necessary for the Project including detour, camp yard and temporary construction yard

(3)To remove existing obstacles including optical fiber cables and electric cables

(4)To detect, discriminate and clear UXO's and land mines in the areas shown by the Japanese side before the commencement of the construction

(5)To provide temporary facilities such as bailey bridge

(6)To provide preventive education for HIV/AIDS

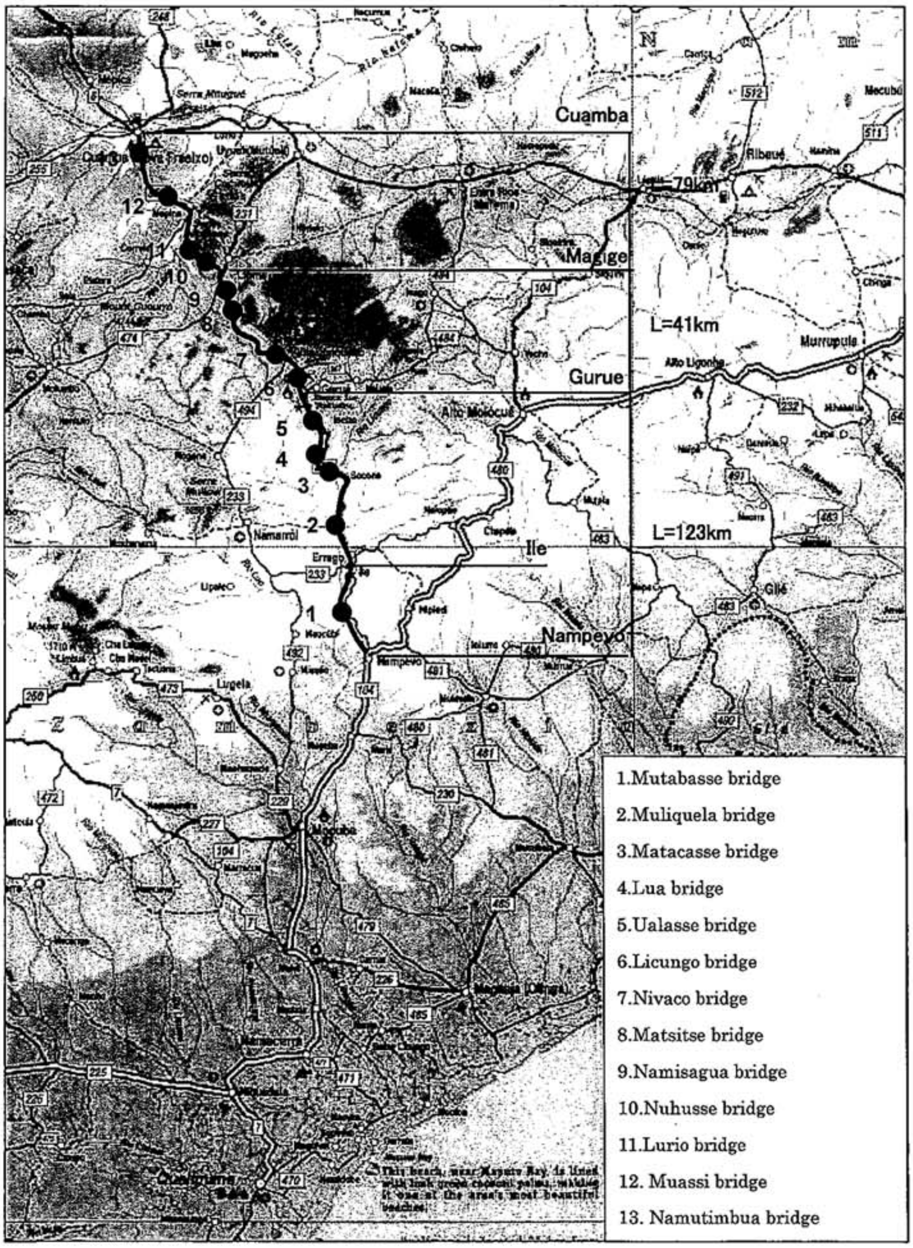
(7)To conduct public announcement if there will be a traffic interrupt by the Project
(8)To secure site for borrow pit and disposal area

8-2. The road between Ile/Nampevo to Cuamba is currently or planned to be rehabilitated by other donors. The Mozambican side confirmed that no bridge of the Project is overlapped with the components of other donor projects.

8-3. The Mozambican side shall secure enough budget and personnel necessary for the operation and maintenance of the road and bridges constructed by the Project, including the periodical maintenance work after the completion of the Project.

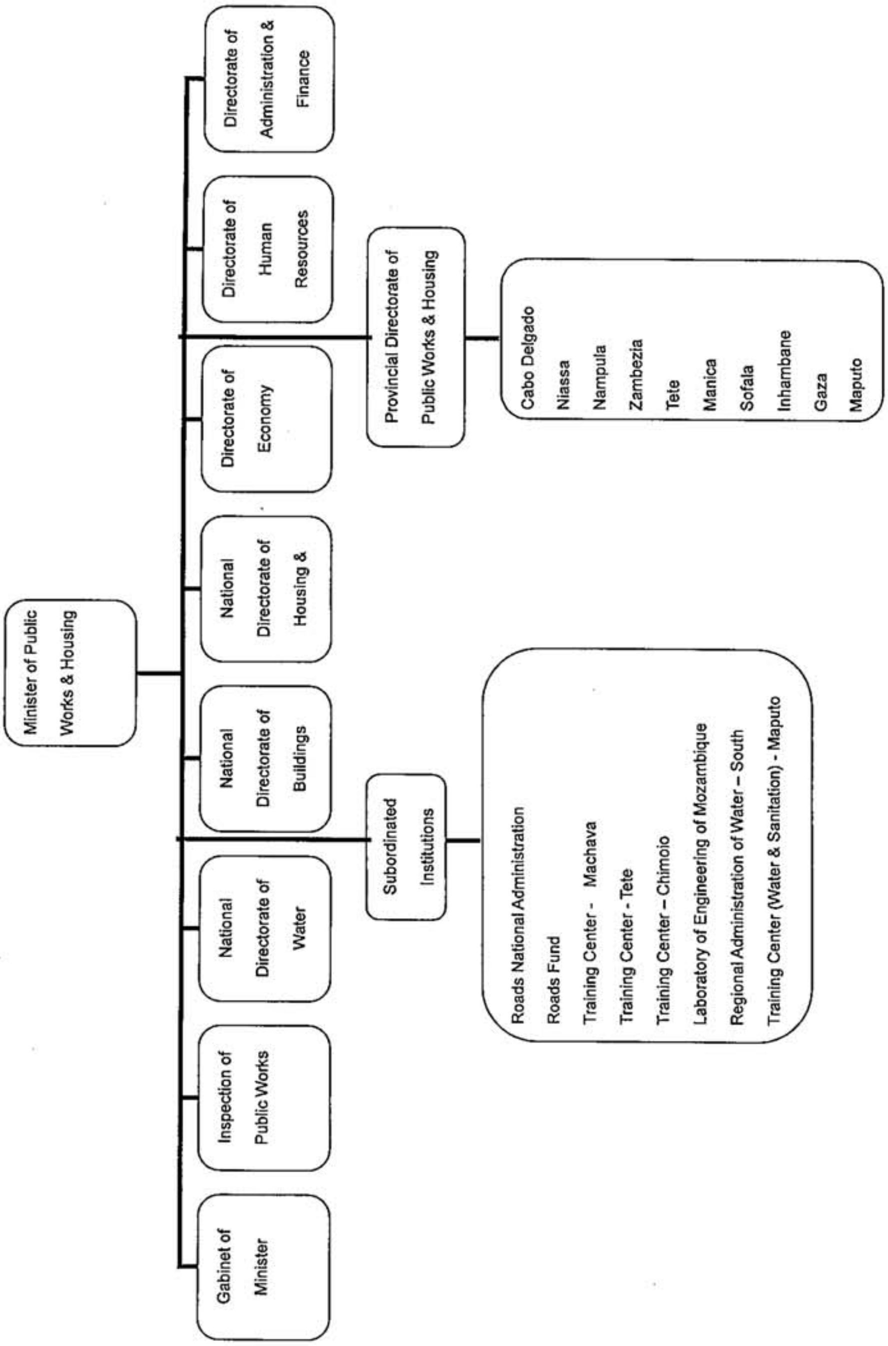
Annex-1	Project Site
Annex-2	Organization Chart of MOPH
Annex-3	Organization Chart of ANE
Annex-4	Prioritization of the requested bridges
Annex-5	Japan's Grant Aid
Annex-6	Flow Chart of Japan's Grant Aid Procedures
Annex-7	Major Undertakings to be taken by Each Government

Annex-1



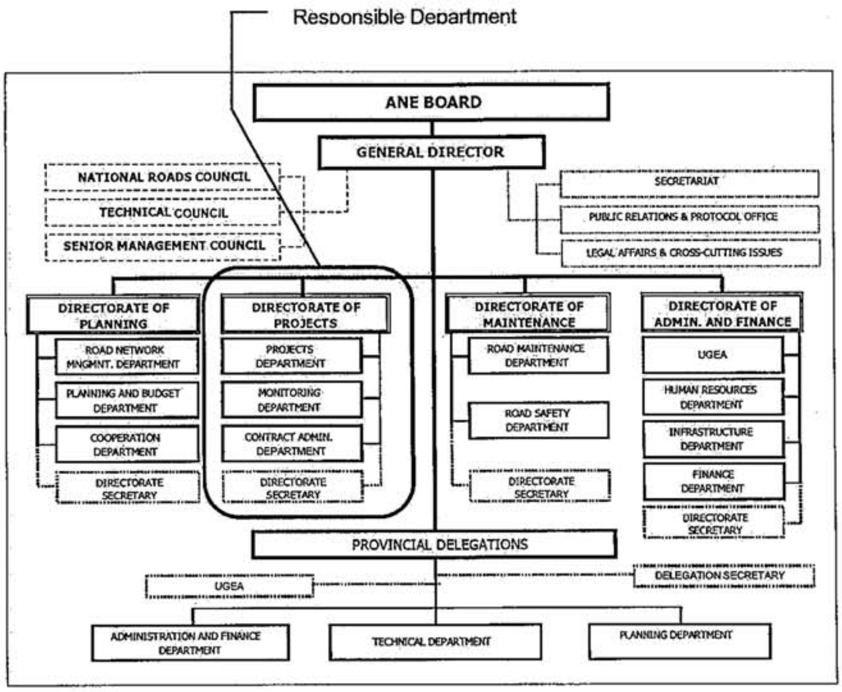
Project Site

Annex-2



Organizational Chart of MOPH

Annex-3



Organization Chart of ANE

Annex-4

Prioritization of the requested bridges

Priority	Bridge
1	Nivaco Bridge
2	Matacasse Bridge Ualasse Bridge Matsitse Bridge Nuhusse Bridge Namisagua Bridge
3	Lurio Bridge
4	Namutimbua Bridge
5	Muassi Bridge
6	Licungo Bridge
7	Mutabasse Bridge
8	Lua Bridge
9	Muliquela Bridge

Annex-5

JAPAN'S GRANT AID

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as a part of this realignment, a new JICA law was entered into effect on October 1, 2008. Based on this law and the decision of the GOJ, JICA has become the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc.

The Grant Aid is non-reimbursable fund provided to a recipient country to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedures

The Japanese Grant Aid is supplied through following procedures :

・Preparatory Survey

- The Survey conducted by JICA

・Appraisal &Approval

-Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet

・Authority for Determining Implementation

-The Notes exchanged between the GOJ and a recipient country

・Grant Agreement (hereinafter referred to as "the G/A")

-Agreement concluded between JICA and a recipient country

・Implementation

-Implementation of the Project on the basis of the G/A

2. Preparatory Survey

(1) Contents of the Survey

The aim of the preparatory Survey is to provide a basic document necessary for the appraisal of the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of relevant agencies of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of a outline design of the Project.

- Estimation of costs of the Project.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Outline Design of the Project is confirmed based on the guidelines of the Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization of the recipient country which actually implements the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA employs (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the Report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the appropriateness of the Project.

3. Japan's Grant Aid Scheme

(1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the Exchange of Notes(hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the recipient country to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the recipient country to continue to work on the Project's implementation after the E/N and G/A.

(3) Eligible source country

Under the Japanese Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals".

(4) Necessity of "Verification"

The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to fulfill accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as Annex.

(6) "Proper Use"

The Government of the recipient country is required to maintain and use properly and effectively the facilities constructed and the equipment purchased under the Grant Aid, to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Grant Aid.

(7) "Export and Re-export"

The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account under the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

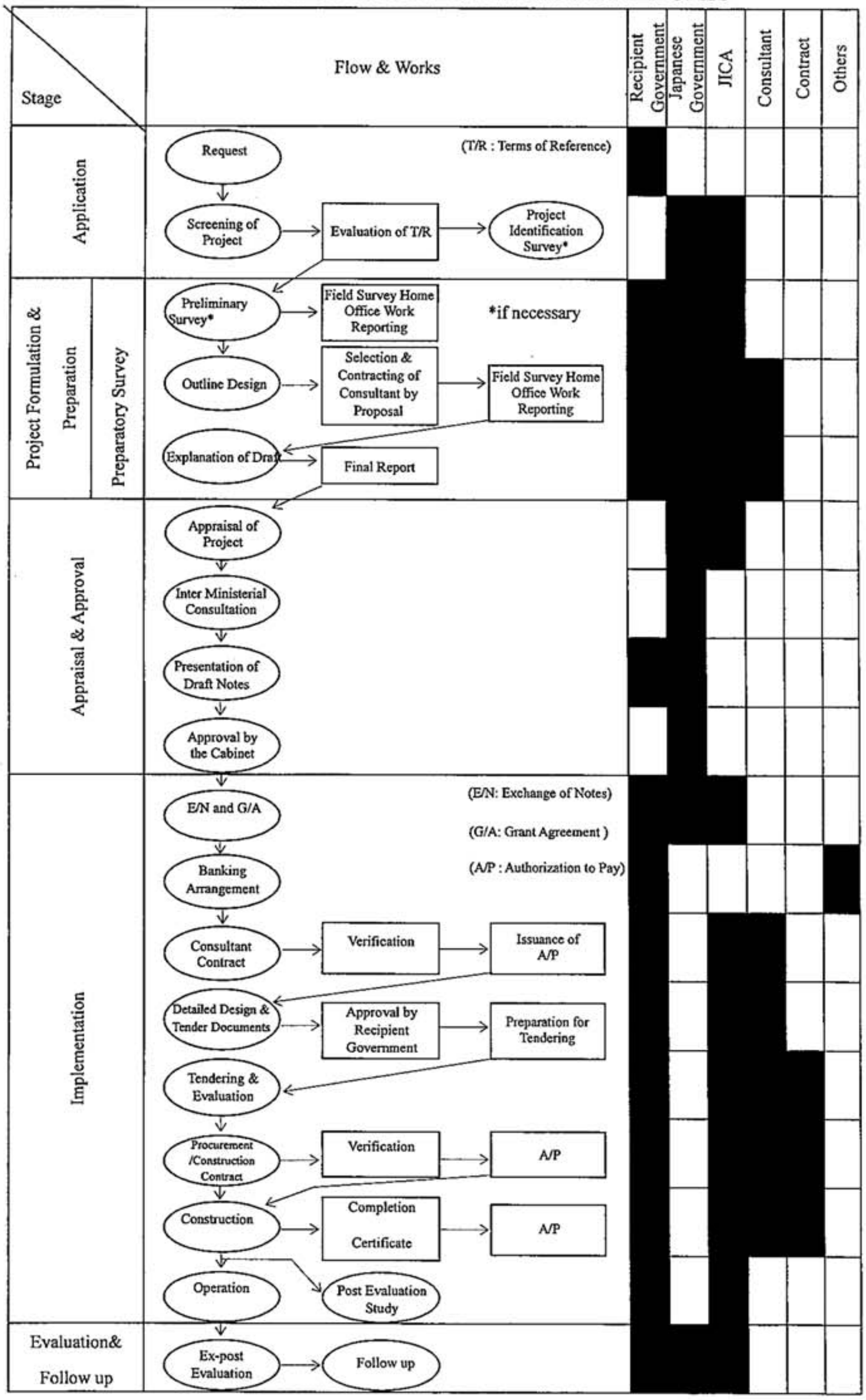
The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions paid to the Bank.

(10) Social and Environmental Considerations

A recipient country must carefully consider social and environmental impacts by the Project and must comply with the environmental regulations of the recipient country and JICA socio-environmental guidelines.

Annex-6

FLOW CHART OF JAPAN's GRANT AID PROCEDURES



Annex-7

Major Undertakings to be taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	to secure a lot of land necessary for the implementation of the Project and to clear the site;		●
2	To ensure prompt unloading and customs clearance of the products at ports of disembarkation in the		
	1) Marine (Air) transportation of the Products from Japan to the recipient country	●	
	2) Tax exemption and custom clearance of the Products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	(●)	(●)
3	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the		●
4	To accord Japanese nationals whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		●
5	To ensure that [the Facilities and the products]/[the Facilities]/ [the products] be maintained and used properly and effectively for the implementation of the Project		●
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project		●
7	To bear the following commissions paid to the Japanese bank for banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
8	To give due environmental and social consideration in the implementation of the Project.		●

(B/A : Banking Arrangement, A/P : Authorization to pay)