5. Result of Traffic Survey and Traffic Demand Forecast

5.1 Traffic Survey

The following traffic survey was carried out to grasp the current traffic condition and gather basic data for the future traffic demand forecast in Douala.

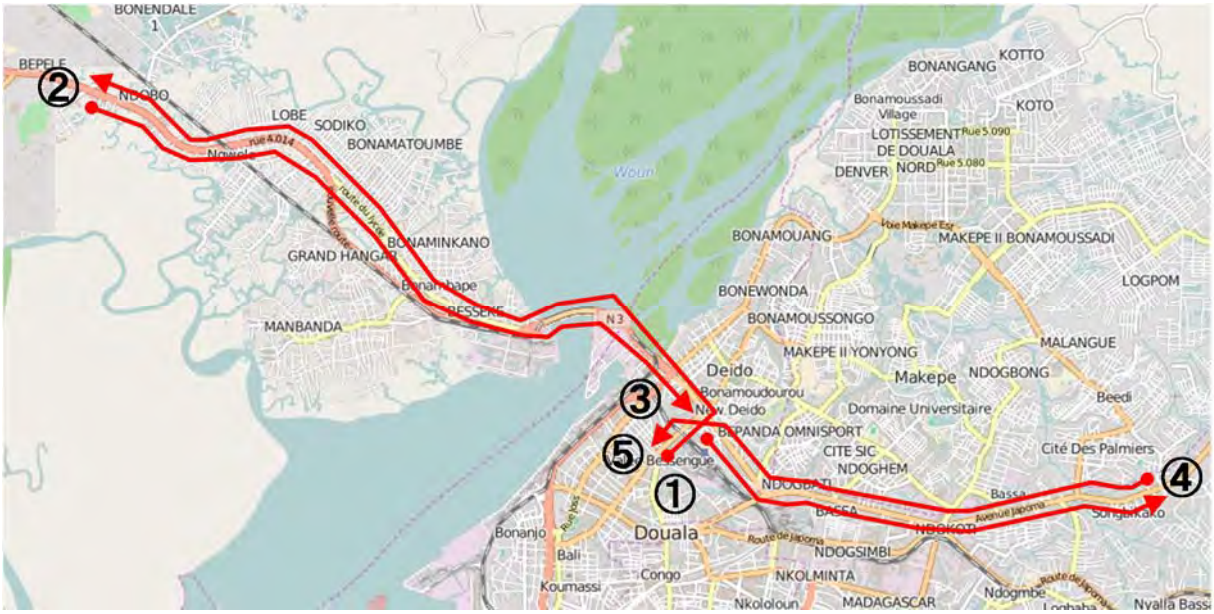
① Travel speed survey
② Traffic count survey
③ Roadside OD interview survey

5.1.1 Travel Speed Survey

In order to grasp traffic condition of Douala City, travel speed survey was conducted on the target routes as follows, which pass existing bridge crossing over Wouri River, an arterial road of the right bank (Route No.3) or another arterial road on the left bank passing urban area.

(1) Study Method

- The survey was conducted three times a day: at 8:00, 13:00 and 17:00 on weekdays and holidays along a travel route (①→②→③→④→⑤) that was approximately 41 kilometers long and their location, travel time and speed were recorded by the GPS logger.
- The traffic condition is ascertained from the driving speed, etc., measured at each point and the main bottlenecks were detected.



Source: JICA survey team

Figure 5.1 Travelling route in Travel speed survey 〔①→②→③→④→⑤〕

The travel speed survey was conducted for a total of five days — three days on weekdays and holidays in July and August and two days on a weekday and a holiday in November (15 times in total).

(2) Study Result

The following table below the result of the travel speed survey. The shaded area indicates significantly slow speeds below ten kilometers per hour.

Table 5.1 Travel Speed Survey Result

Survey Date	Weather	Start Time	①→② Travel Time [Speed]	②→③ Travel Time [Speed]	③→④ Travel Time [Speed]	④→⑤ Travel Time [Speed]	Total Travel Time [Average Speed]
Jul. 10, 2016 Sunday	☁	8:00	24 mints. [31km/h]	22 mints. [31km/h]	15 mints. [31km/h]	18 mints. [29km/h]	1h 20 mints. [30.7km/h]
	☁	13:00	25 mints. [29km/h]	23 mints. [29km/h]	15 mints. [31km/h]	21 mints. [24km/h]	1h 26 mints. [28.3km/h]
	☁	17:00	26 mints. [29km/h]	27 mints. [25km/h]	15 mints. [31km/h]	23 mints. [23km/h]	1h 32 mints. [26.6km/h]
Aug. 2, 2016 Thursday	☂	8:00	3h14 mints. [**4km/h**]	2h 22 mints. [**5km/h**]	36 mints. [13km/h]	43 mints. [13km/h]	6h 55 mints. [5.9km/h]
	☂	13:00	1h 34 mints. [**8km/h**]	1h 24 mints. [**8km/h**]	40 mints. [12km/h]	40 mints. [13km/h]	4h 20 mints. [9.5km/h]
	☂	17:00	1h 42 mints. [**7km/h**]	1h 53 mints. [**6km/h**]	40 mints. [12km/h]	21 mints. [25km/h]	4h 38 mints. [8.8km/h]
Aug. 7, 2016 Sunday	☂	8:00	38 mints. [20km/h]	25 mints. [28km/h]	15 mints. [32km/h]	19 mints. [27km/h]	1h 38 mints. [25.1km/h]
	☂	13:00	29 mints. [25km/h]	30 mints. [22km/h]	16 mints. [29km/h]	22 mints. [24km/h]	1h 39 mints. [24.8km/h]
	☂	17:00	54 mints. [14km/h]	1h 37 分 [**7km/h**]	16 mints. [29km/h]	20 mints. [27km/h]	3h 8 mints. [13.0km/h]
Nov. 12, 2016 Saturday	☁	8:00	26 mints. [28km/h]	24 mints. [28km/h]	16 mints. [30km/h]	18 mints. [29km/h]	1h 25 mints. [28.8km/h]
	☁	13:00	37 mints. [20km/h]	52 mints. [13km/h]	20 mints. [23km/h]	33 mints. [16km/h]	2h 24 mints. [17.0km/h]
	☂	17:00	31 mints. [24km/h]	24 mints. [28km/h]	20 mints. [24km/h]	1h 18 mints. [**7km/h**]	2h 35 mints. [15.8km/h]
Nov. 15, 2016 Tuesday	☁	8:00	29 mints. [26km/h]	28 mints. [24km/h]	48 mints. [10km/h]	38 mints. [14km/h]	2h 24 mints. [17.0km/h]
	☁	13:00	26 mints. [28km/h]	22 mints. [30km/h]	15 mints. [31km/h]	16 mints. [32km/h]	1h 21 mints. [30.1km/h]
	☀	17:00	32 mints. [23km/h]	1h 12 mints. [**9km/h**]	1h 17 mints. [**6km/h**]	17 mints. [31km/h]	3h 19 mints. [12.3km/h]

Source: JICA survey team

[Bottlenecks]

Bottlenecks in the target area were detected based on the travel speed survey result.

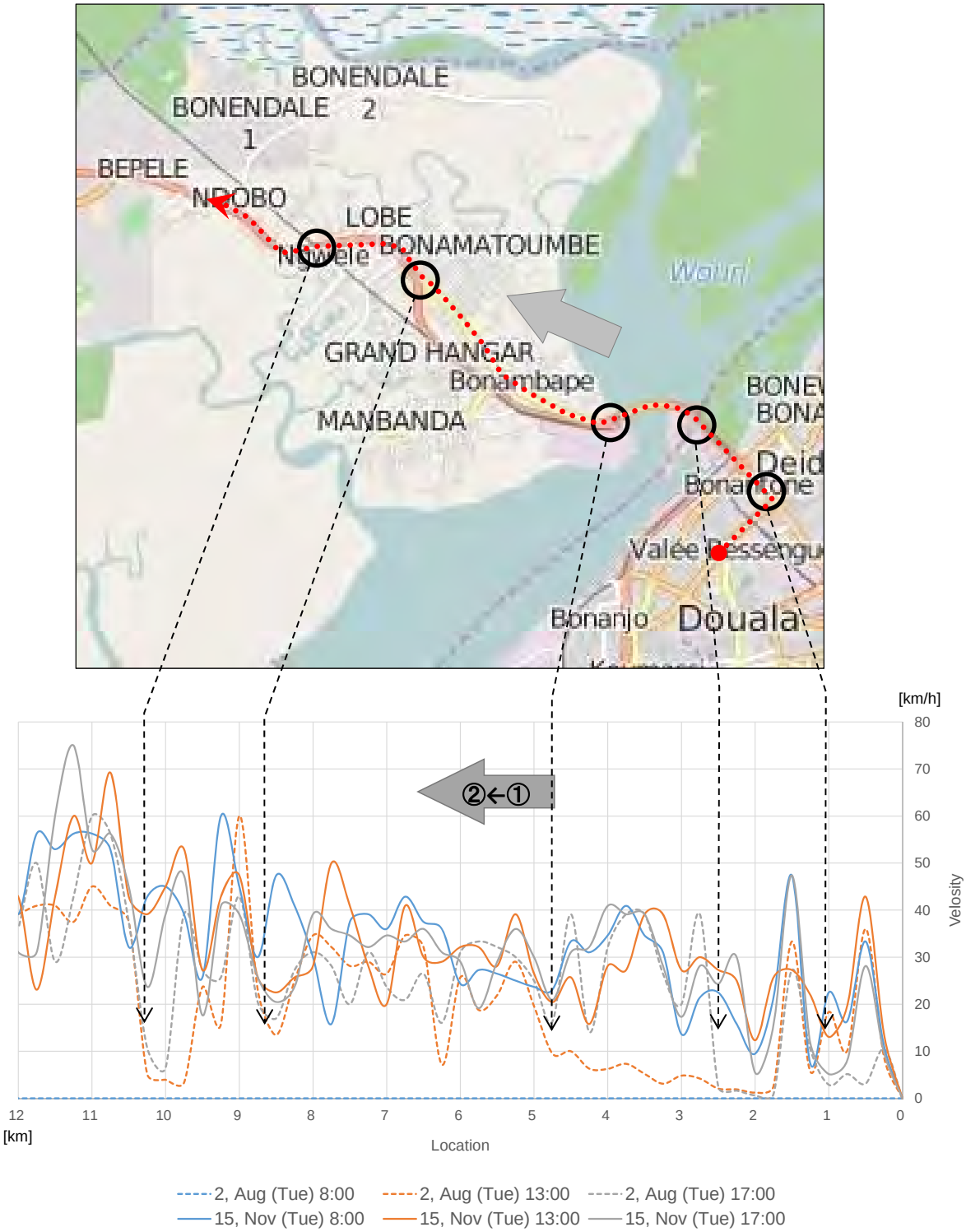
The speed fluctuations (weekday) of the segments, ①→②, ②→③, ③→④ and ④→⑤ of the travel route were put in graph form, occurrences of certain length of congestion below 15km/hr. were identified and their heads are shown with a circle as estimated bottlenecks.

It should be noted that conditions differ between July and August and November as described below.

Survey Date	Weekday/Holiday	Difference of Conditions
Jul. 10, 2016 (Sunday)	【Holiday】	・ Frequent occurrence of serious congestion affected by the improvement work of 2nd Bridge and NR 3 ・ Full-fledged wet season started in August, whereupon it rained almost every day. ・ Schools were closed in August for a long vacation.
Aug. 2, 2016 (Tuesday)	【Weekday】 * OD interview survey was conducted.	
Aug. 7, 2016 (Sunday)	【Holiday】	
Nov. 12, 2016 (Saturday)	【Holiday】	・ Although the above improvement work was still conducted, a replacement road around the 2nd Bridge improved traffic between Deïdo and the existing bridge. ・ The dry season started and it rarely rained.
Nov. 15, 2016 (Tuesday)	【Holiday】	

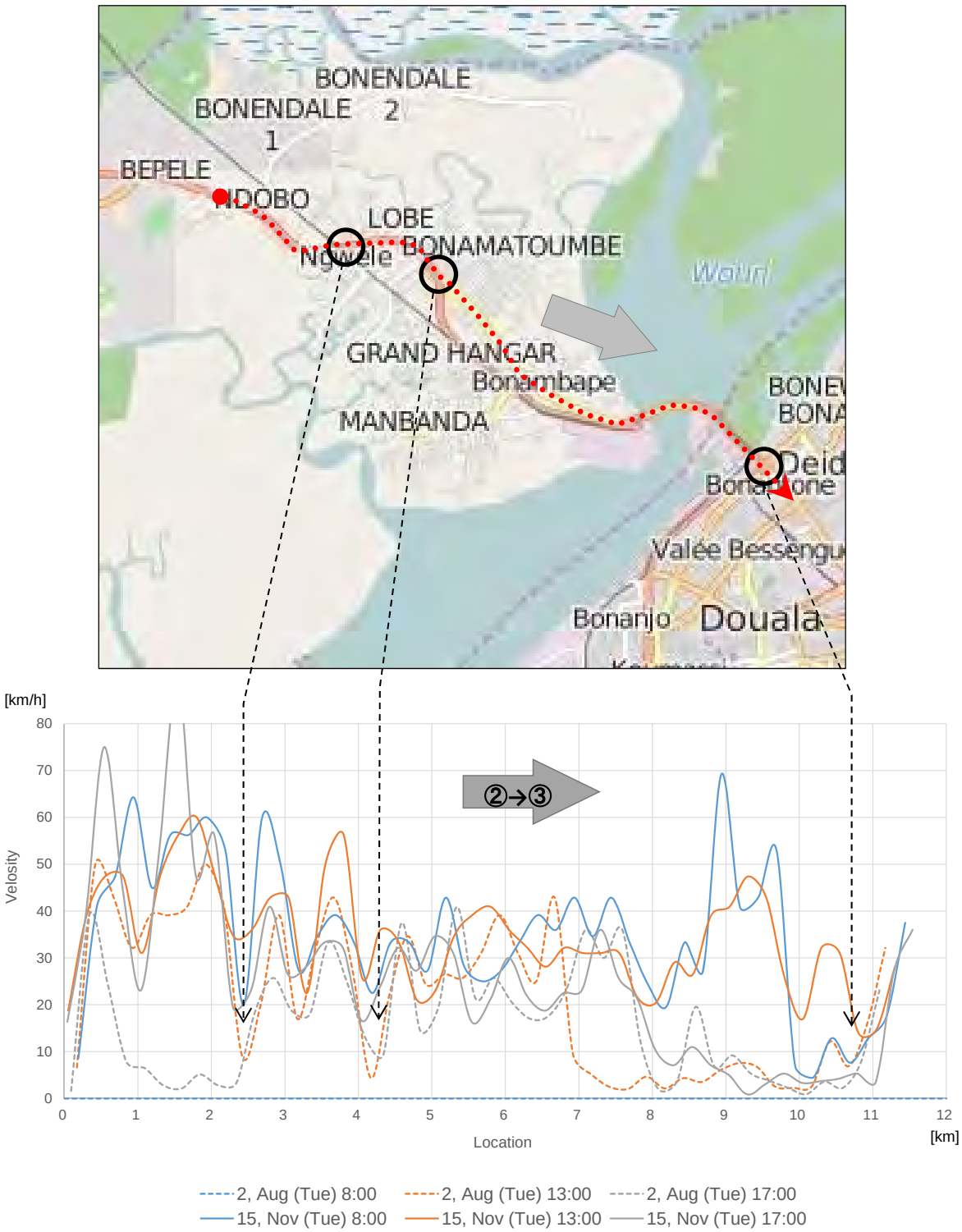
Improvement work of NR 3, that is part of the survey area, is conducted everywhere and causes serious congestion due to temporary detours during the work and unpaved sections.

The bottlenecks detected in the survey also include those of congestion caused by the traffic work. Although it is a key cause of congestion, the traffic at the bottlenecks will be improved significantly on completion of the work. However, new bottlenecks are still very likely.



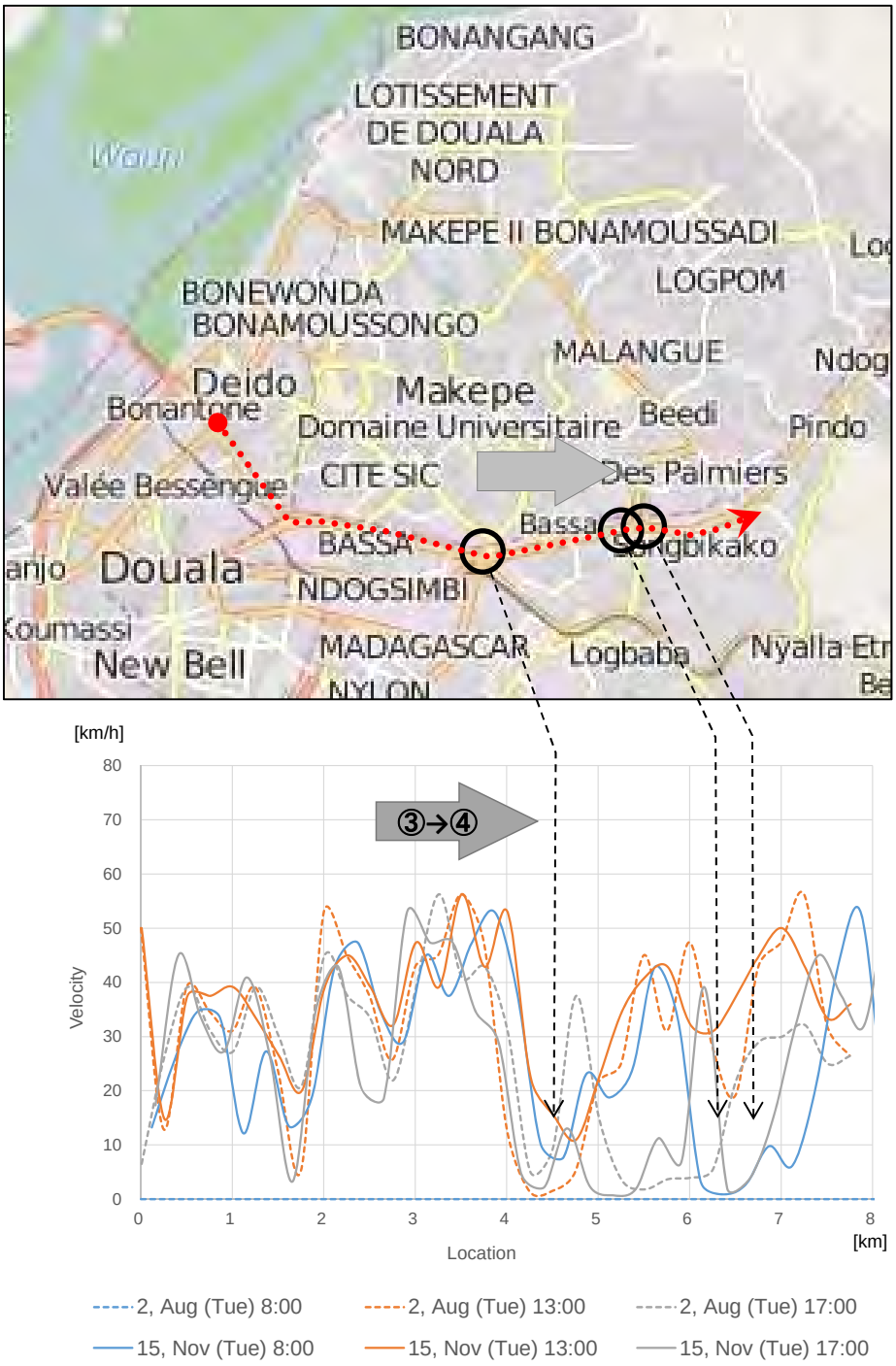
Source: JICA survey team

Figure 5.2 Bottlenecks in Section ①→② (Changes in Travel Speed)



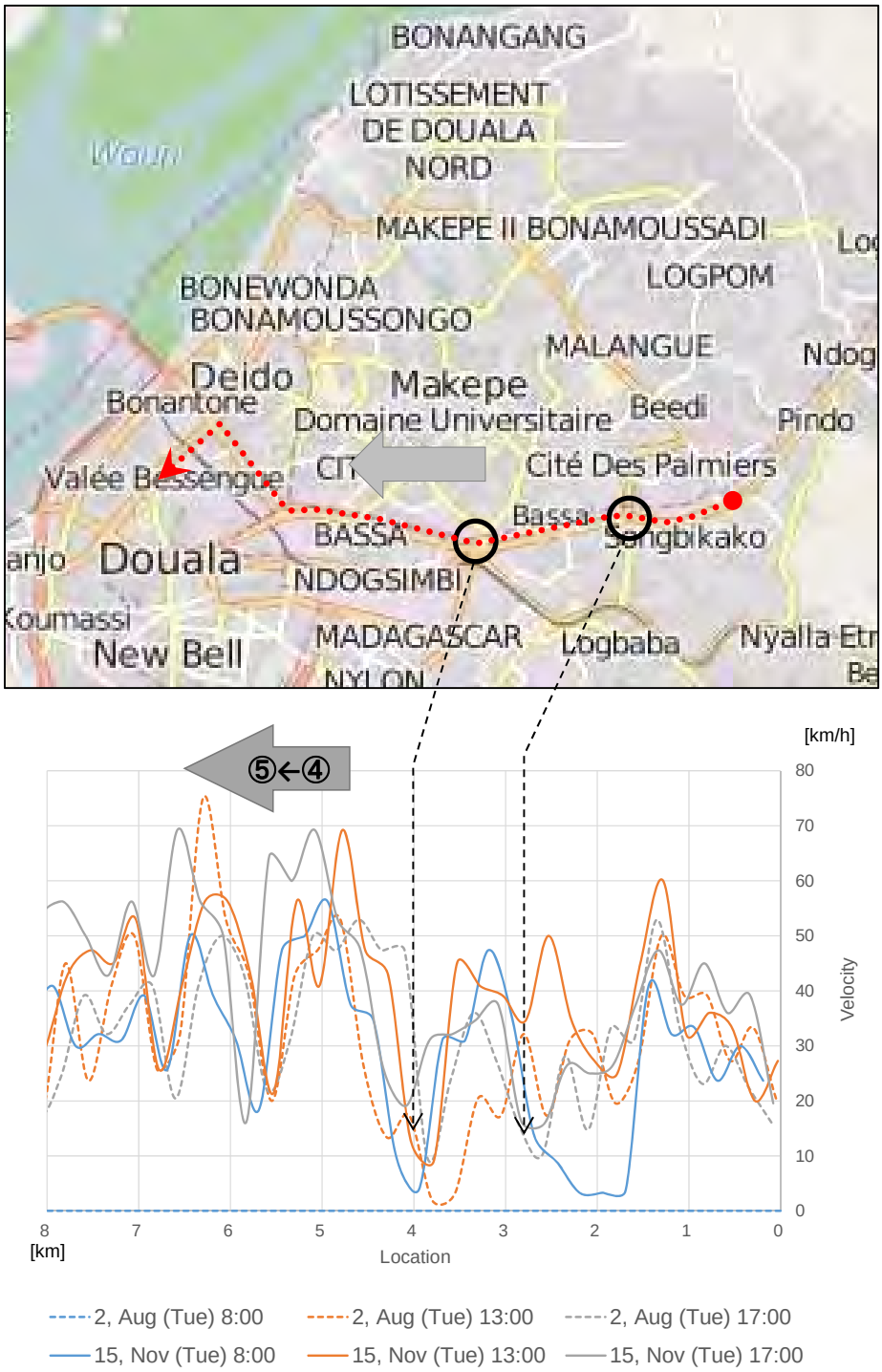
Source: JICA survey team

Figure 5.3 Bottlenecks in Section ②→③ (Changes in Travel Speed)



Source: JICA survey team

Figure 5.4 Bottlenecks in Section ③→④ (Changes in Travel Speed)



Source: JICA survey team

Figure 5.5 Bottlenecks in Section ④→⑤ (Changes in Travel Speed)

The traffic conditions and causes of congestion in Douala having emerged in the travel speed survey are summarized below.

【Traffic conditions in Douala】

- The biggest cause of the particularly severe congestion around the bridge crossing Wouri River is believed to be the NR3 improvement work. (The bridge point is not a bottleneck, but diverging /merging points of NR3, the old NR3 on the right bank and the bad pavement condition due to traffic work are the main bottleneck points.)

→ Future congestion forecasts require traffic analysis following the NR3 improvement work and completion of the 2nd bridge.

- Besides the area neighboring the bridge, chronic congestion was observed at intersections where the market is situated or used as taxi stands and areas with some structural network problems (near Marché PK 10).
- On holidays, there is far less congestion than weekdays. Rain is also likely to affect the traffic to some extent. (Congestion occurs when it rains, even during holidays.)

【Causes of congestion that are likely to improve with countermeasures】

- There is no compartment line at points such as intersections where the traffic flow needs to be straightened.

  (Vehicles sometimes enter the opposite lane to avoid traffic work and broken cars, which affects the vehicles coming from the opposite direction.)

- Intersections and roundabouts where people are more likely to gather are used as tax stands disorderly (although some intersections are officially designated as taxi stands with signs) and vehicles awaiting customers occupy considerable space, which affects the traffic capacity there.
- Traffic lights are installed on only a limited basis, and insufficiently. (Even when there are present, few drivers heed them, particularly motorbike riders.)
- The traffic demand flow is clearly opposite during the morning and evening peaks. However, the traffic sign cycles are fixed all day long. (no introduction of area-specific traffic light control)
- There is no traffic light facility book. (The CUD plans to prepare one.)
- Motorcycles that comprise the majority of traffic are ridden by unlicensed riders.
- The behavior of motorcycles that can travel more freely and faster than four-wheeled vehicles significantly affect the traffic and the riders ignore most of the traffic rules.

5.1.2 Traffic Count Survey and Roadside OD Interview Survey

In order to grasp characteristics of traffic of Douala City, particularly traffic crossing over Wouri River, traffic count survey: by vehicle type, time of day and directions, and roadside OD interview survey were conducted. The following figure and table show results of these surveys.

(1) Survey Method

- Six roadside OD interview survey spots, five intersection survey spots and two additional spots for the traffic count survey were selected on main arterial roads in the Douala road network following discussions with the CUD. (See Figure 5.6.)
- During the six roadside OD surveys, a 24-hour traffic count survey was conducted at the same spot to expand the daily OD table. At the remaining five intersections and two additional spots for the traffic count survey, the survey was conducted for 17 hours (7:00 to 24:00) excluding nighttime, when there was very little traffic. (See Table 5.2.)
- The traffic count survey was conducted manually based on the following vehicle types, directions and time zones.

					
① Motorcycle	② Passenger vehicle	③ Taxi	④ Mini-bus	⑤ Bus	⑥ Light truck
					
⑦ Truck (2 axle)	⑧ Truck (3 axle)	⑨ Trailer (4 axle)	⑩ Trailer (5 axle)	⑪ Trailer (6 axle)	

- The local police accompanied the roadside OD interview survey. The survey team stopped vehicles on the road to ask drivers the following questions:

① departure point,
② destination,
③ purpose of the trip,
④ number of passengers, and
⑤ goods to be transported (cargo vehicles only)

Table 5.2 Outline of the Traffic Count Survey and Roadside OD Interview Survey

Survey Type	Place	Time Date: Aug. 2, 2016 (Tuesday)	Survey Spots
Traffic Count Survey	Basic road section	7:00 to 7:00 (24 hours)	6 spots
		7:00 to 24:00 (17 hours)	2 spots
	Intersection	7:00 to 24:00 (17 hours)	5 intersections (each direction)
Roadside OD Interview Survey	Basic road section	7:00 to 24:00 (17 hours)	6 spots * same point as 24-hour traffic count survey

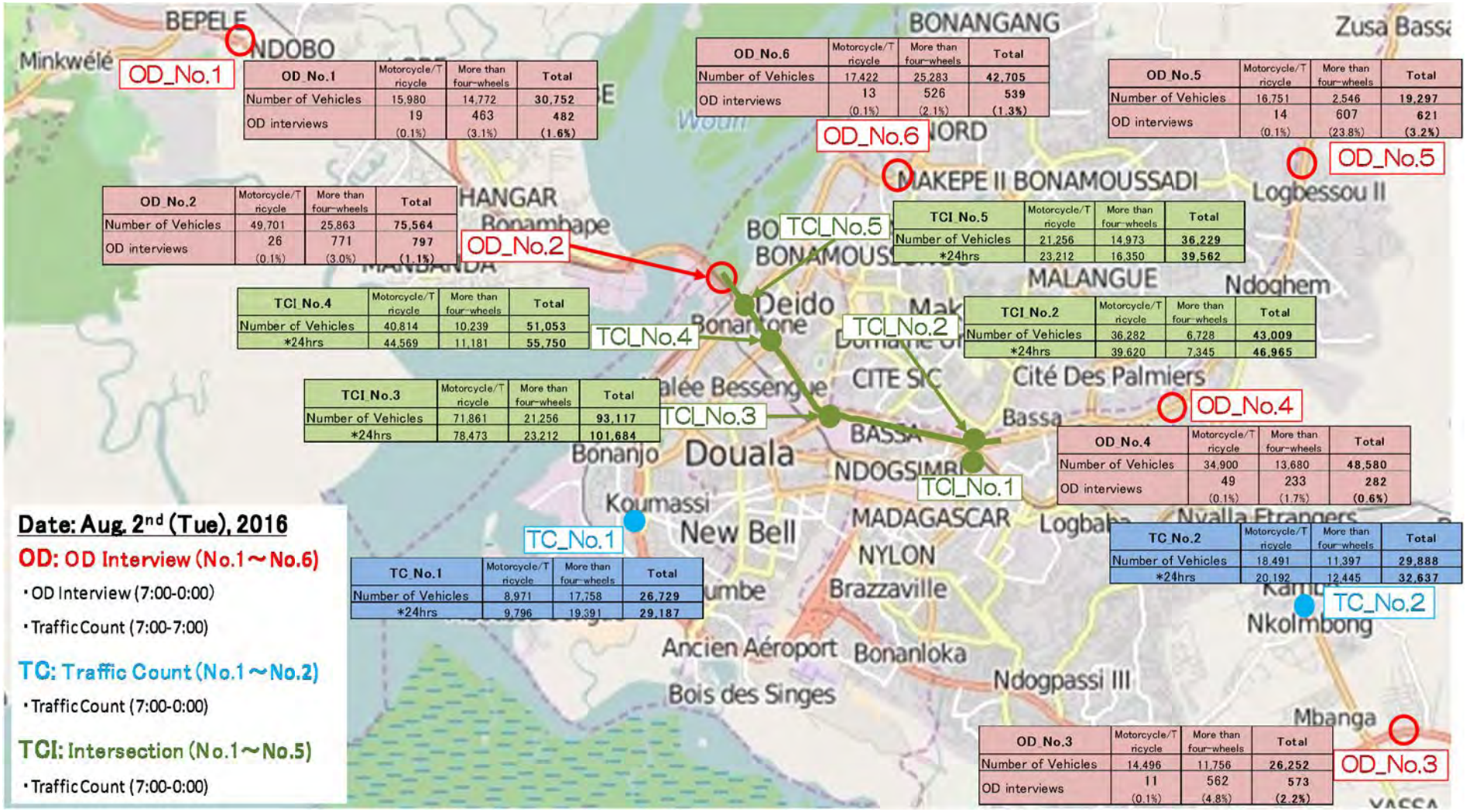
Source: JICA survey team

		
Survey method briefing session	Traffic count survey	Roadside OD interview survey

Source: JICA survey team

Photo 5.1 Scenes of the Traffic Survey

The traffic count survey and roadside OD interview survey spots and traffic volume (PCU) are summarized on the next page.

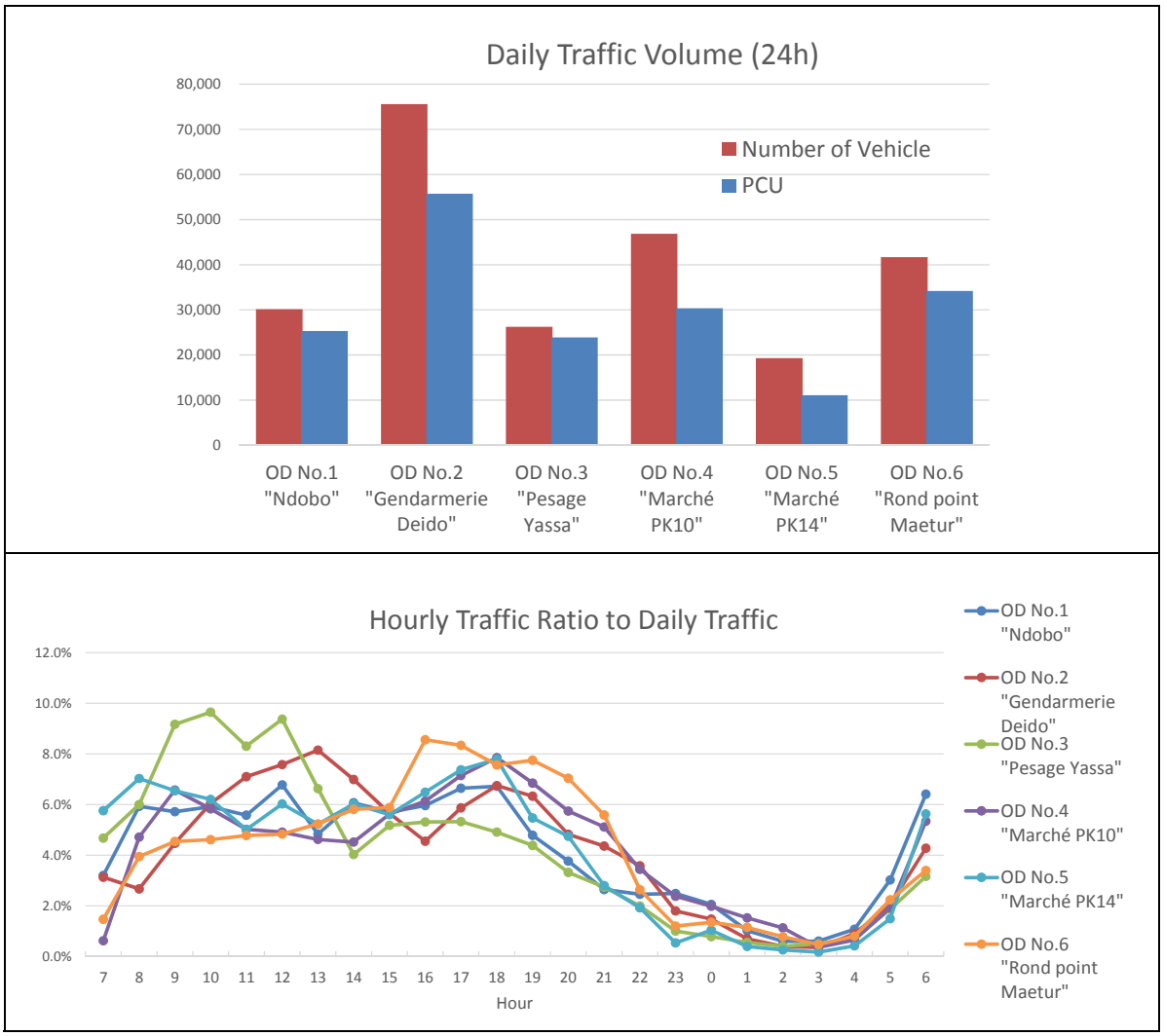


Source: JICA survey team

Figure 5.6 Summary of Survey Results: Traffic Count Survey and Roadside OD Interview Survey

(2) Traffic survey result [survey on August 2, 2016 (Tue)]

The survey result of the six spots where the 24-hour survey was conducted is shown in the following figure.



Source: JICA survey team

Figure5.7 24-Hour Traffic Volume (number of vehicles, PCU) at each Survey Point and Hourly Ratio in 24-Hour Traffic Volume

The value used in French road design standards (ICTAVRU) is used to convert the passenger-car units (PCUs) in the traffic volume survey.

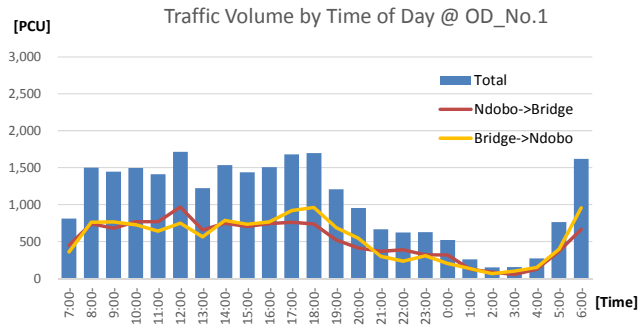
Table 5.3 Passenger Car Conversion Factor in the Survey

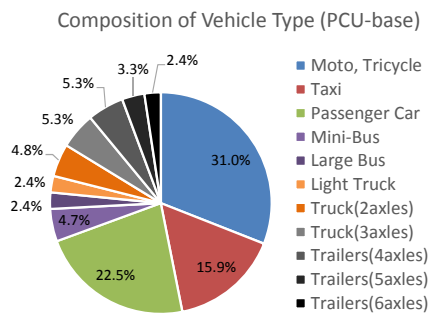
Motorcycle	Passenger car and taxi	Mini-bus	Large bus	Light truck	Truck (2 axle)	Truck (3 axle)	Trailer (4 or more axle)
0.5	1.0	1.0	2.0	1.0	2.0	2.0	2.0

Source: Compiled by the JICA Survey Team based on ICTAVRU

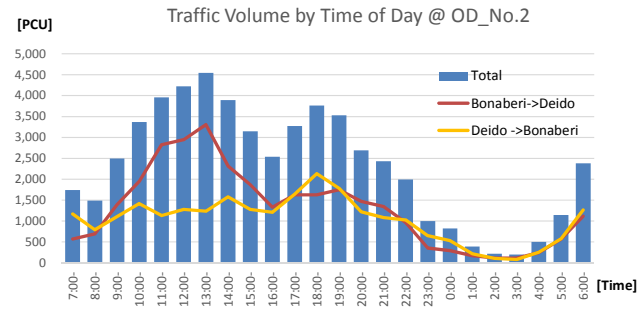
The survey results at each survey spot are shown in the following figure.

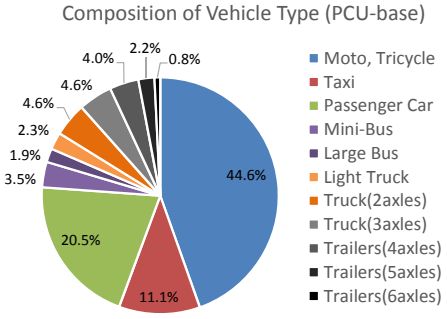
【OD No.1 “Ndobo”】Basic Road Section (24 Hours)



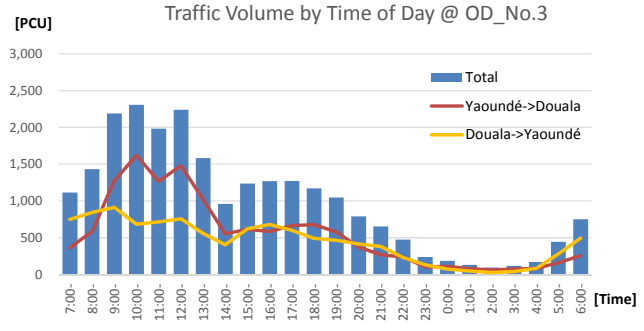


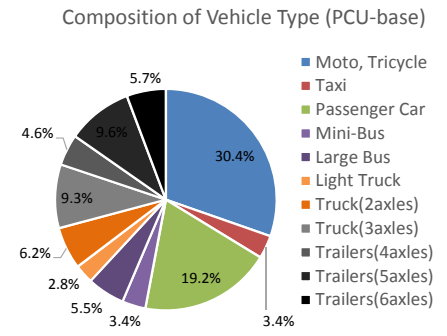
【OD No.2 “Deïdo” River Crossing Point】Basic Road Section (24 Hours)



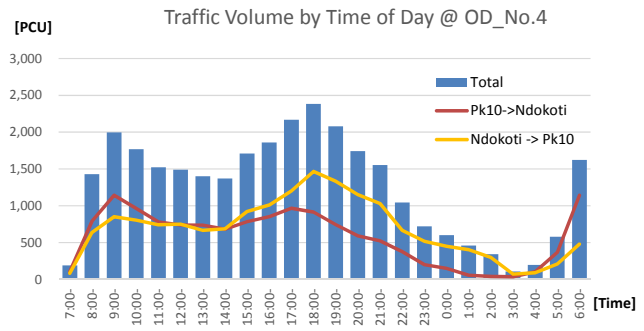


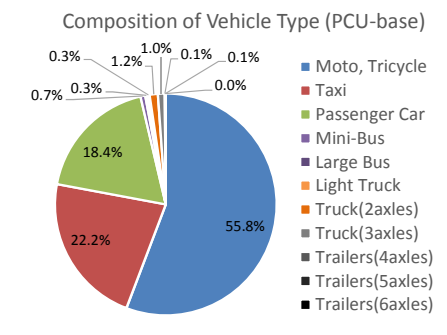
【OD No.3 “Yassa”】Basic Road Section (24 Hours)





【OD No.4 “PK10 Marché”】Basic Road Section (24 Hours)

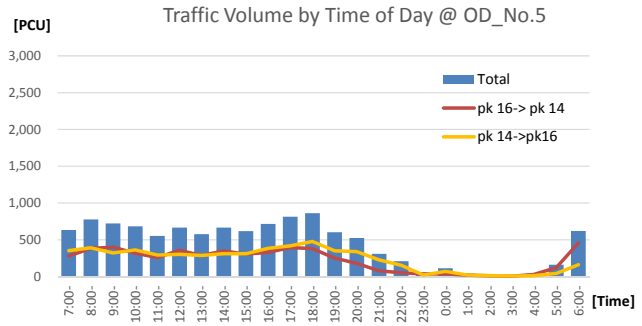


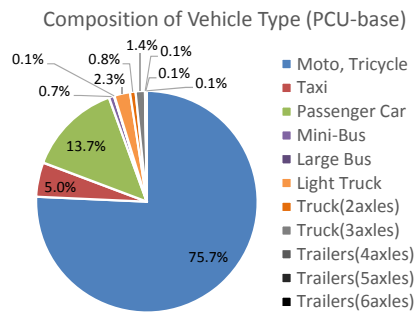


Source: JICA survey team

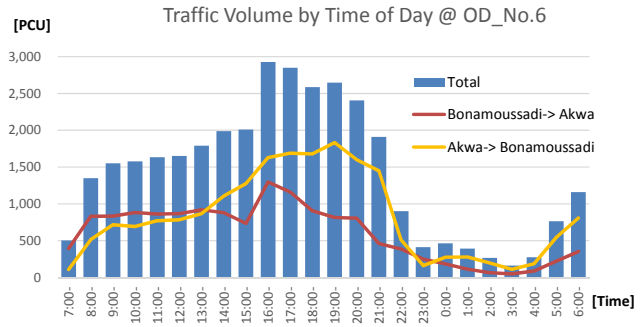
Figure 5.8 Traffic Volume and Ratio by Vehicle Type by Direction and Time at Each Survey Spot (1/2)

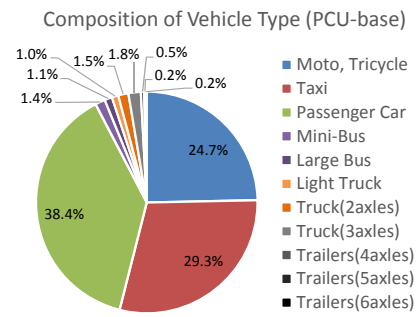
【OD No.5 “PK14 Marché”】Basic Road Section (24 Hours)



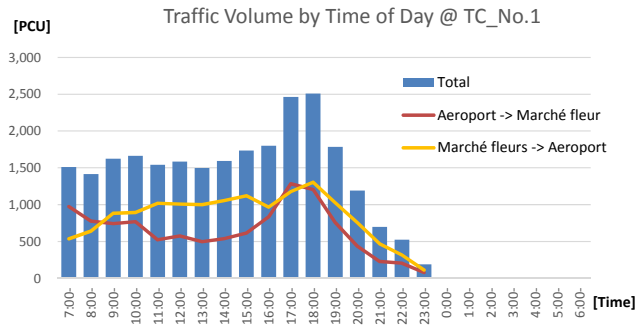


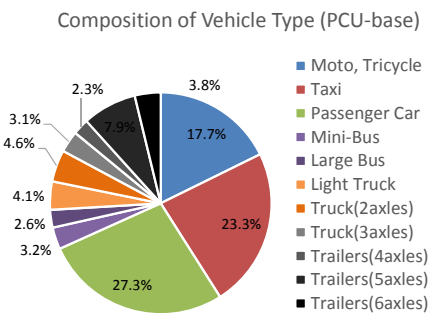
【OD No.6 “Maëtur Roundabout”】Basic Road Section (24 Hours)



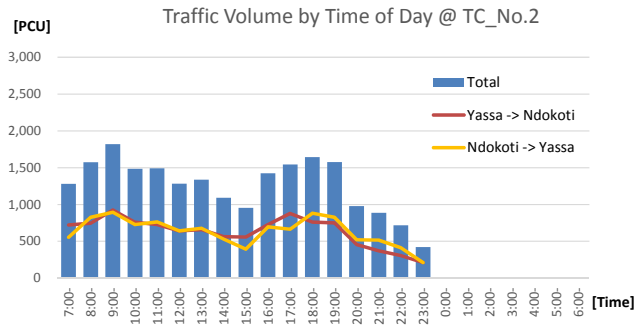


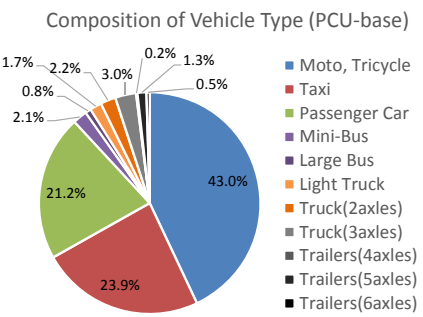
【TC No.1 “In front of Douala Airport”】Basic Road Section (17 Hours)





【TC No.2 “Nyalla”】Basic Road Section (17 Hours)





Source: JICA survey team

Figure 5.9 Traffic Volume and Ratio by Vehicle Type by Direction and Time at Each Survey Spot (2/2)

Observations from the survey results are described below.

- The daily traffic volume at each survey spot increases gradually from 3 a.m., its lowest point, until peaking at 8 a.m. (Figure 5.7) at most spots. However, it continues to increase until 10 a.m. at the river crossing point of the existing bridge (OD No. 2) where the traffic volume peaked in the survey and is maintained until shortly after noon. Particularly severe congestion occurred at the roundabout near the bridge. There is some time lag between the traffic demand peaking and the time of crossing the bridge and it is possible that there some unusual factors applied (roadworks, passing of trains or vehicle failure, etc.).

- In the traffic volume by time and direction, as illustrated in the line graph, the red and yellow lines indicate the direction toward the bridge (inbound) and in the opposite direction (outbound), respectively. There is more inbound traffic in the morning in most spots and outbound traffic increases from evening to night. The area (Akwa) around the bridge on the left bank is the business center of Douala and the concentrated traffic volume there is mainly commuting traffic, whereupon the above traffic flow occurs.

- At OD No. 3 and TC No.1 on NR 3, cargo vehicle traffic comprises 25 to 30%, which exceeds the figure for other roads. It reflects the trend whereby large cargo vehicles tend to use NR3; avoiding the inland city center.

- Motorcycles comprise 25 to 75% in most spots, excluding TC No. 1 and are the most frequent mode of transport in terms of PCU, with a particularly high ratio around such markets as OD Nos. 4 and 5. They include many motos-taxis. Motos-taxis await customers around the market, including Ndokotti, which shows the considerable demand for a common means of transportation among citizens. (Markets and intersections are designated as 4- and 2-wheeled taxi stands.)

- The overall traffic, as well as traffic of motorcycles and cargo vehicles at the bridge traversing the river (OD No. 2), predominates because it is the only road traversing the Wouri River.

- The volume of passenger-car taxis clearly differs by area. Of the entire passenger-car volume, the ratio used as taxis is relatively high, slightly less than the ratio of total passenger cars. Bad driving manners of taxi drivers and ignoring traffic rules are common, which adversely affects smooth traffic to some extent.

The roadside OD interview survey result at the six survey spots is summarized below.

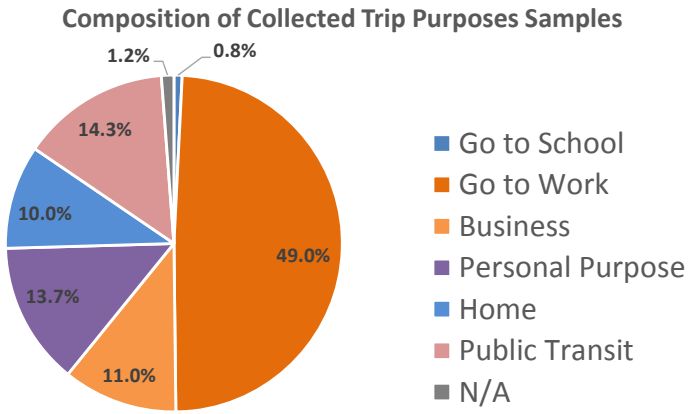
The data obtained in the survey is used to forecast the traffic demand in the next section.

Table5.4 Effective Sample Size by Survey Spot

OD No.1 Ndobo	**OD No.2** Deïdo	**OD No.3** Yassa	**OD No.4** Marché PK10	**OD No.5** Marché PK14	**OD No.6** Maëtur Roundabout	**Total**
482	798	573	282	621	539	3,295

Source: JICA survey team

The roadside OD survey samples were gathered to ensure unbiased time zone or vehicle type. As a result, the effective sample size was 3,295.



Source: JICA survey team

Figure 5.10 Composition of Trip Purposes

In terms of trip purpose, approx. 50% is for commuting. Partly because the survey was conducted during the school summer vacation (on August 2, 2016, Tuesday), the stated purpose of commuting to school was believed to be far less than during other months.

Table 5.5 Average Number of Passengers by Vehicle Type

Motorcycle	Passenger Car	Taxi	Mini-bus	Large bus	Truck/Trailer	Overall Average
1.8	2.4	3.8	11.1	41.1	2.4	5.3

Source: JICA survey team

Taxi passengers going in the same direction often share a ride as a means of public transportation and the average passenger total was 3.8. The number of passengers taking other means of public transportation (mini and large buses) was also very high.

There were many motos-taxis, most of which had more than two people riding with an average of 1.8.

5.2 Traffic Demand Forecast

5.2.1 Review of Existing Report on Traffic Demand Forecast

(1) Review of traffic demand forecast of the 2nd Bridge

In the study concerning the 2nd Bridge, in 2002 and 2007 traffic volume survey and OD survey were conducted on the crossing-river-traffic via existing bridge. To the traffic volume by vehicle type resulted from these surveys, predicted future growth of traffic demand and component ratio of vehicle type, along with establishing scenario were set, then the traffic volume crossing Wouri River in 2030 has been estimated as in the following table.

【Setting growth rate of future traffic demand】

- The future traffic volume is estimated using the future population growth rate on the right and left river banks.

→Apply the population of each area as an indicator that correlates with the traffic in the area because the main purpose of the traffic is as an everyday means of transportation for commuting to and from work and school.

- Apply the future GDP growth rate of Cameroon to indicate the growth of traffic passing Douala or with an origin and destination outside it.

→National GDP is used as an indicator that correlates with the traffic with origin and destination outside Douala. Because the main purpose of long-distance trips is cargo transportation, GDP that highly correlates with it is used.

Table 5.6 Component Ratio of Trip Generation Rate from OD Survey

	Daily Average Traffic Volume (More than 4 wheeled)	Ratio
From inner to inner of city	24,714	77%
From inner to outside of city	6,751	21%
From outside to outside of city	693	2%
Total	32,158	100%

Table 5.7 Future Component Ratio of Vehicle Type

Mode	2007	2015	2030
Taxi	30%	20%	15%
Minibus	26%	30%	35%
Coach	6%	30%	35%
Bike taxi	38%	20%	15%
Total	100%	100%	100%

Table 5.8 Estimated Value of Explanatory Variables on Future Growth of Traffic Demand

Explanatory Variables	High Prediction		Low Prediction	
	2007-2015	2015-2030	2007-2015	2015-2030
Population growth rate * On right bank (Bonaberi) * On left bank	4% *1.80% *4.30%	2.3% *0.80% *2.35%	3% *1.50% *3.10%	2% *0.50% *2.10%
Mobility (Number of trips per capita	2%	2%	1%	1%
GDP growth rate	6.0%	4.5%	3.20%	1.50%

Table 5.9 Estimated Future Growth Rate of Traffic Demand

Future Growth Rate of Traffic Demand	High Prediction		Low Prediction	
	2007-2015	2015-2030	2007-2015	2015-2030
(Traffic demand from inner to inner city)	3.80%	2.80%	2.50%	1.50%
*On right bank	6.30%	4.35%	4.10%	3.10%
*On left bank	**5.05%**	**3.58%**	**3.30%**	**2.30%**
Integrated growth rate (From inner to outside of city/ From outside to outside of city)	**6.0%**	**4.5%**	**3.20%**	**1.50%**

All Sources Above: DEUXIEME PONT DU WOURI A DOUALA, Ministère des Travaux Publics

Table 5.10 Estimated Future Traffic Demand Crossing the Wouri River in *the 2nd Bridge Study*

Mode	2007	High Prediction		Low Prediction	
		2015	2030	2015	2030
Passenger vehicle	14,649	22,099	38,725	18,960	25,989
Pick-up truck	2,674	4,034	7,069	3,461	4,744
Taxi	9,417	9,561	12,566	8,203	8,433
Minibus	3,442	6,038	12,345	5,181	8,285
Large Bus	119	911	1,862	781	1,249
Large truck	1,911	2,717	5,258	2,458	3,073
Total (vehicles)	32,211	45,360	77,825	39,044	51,775
Bike taxi	24,377	19,122	25,131	16,406	16,866
Traffic volume (PCU)	**46,429**	**58,549**	**97,511**	**50,486**	**64,530**
Growth rate		2.94%	3.46%	1.05%	1.65%

Source: DEUXIEME PONT DU WOURI A DOUALA, Ministère des Travaux Publics

The above demand forecast shows an increase of approx.70% for high prediction and approx. 30% for low prediction over 2015.

(2) Review of traffic demand forecast of the 3rd Bridge

For the Study concerning the 3rd Bridge, primary research was conducted, but quantitative traffic demand forecast has not been considered. For qualitative analysis, even though the traffic capacity will be increased with the construction of the 2nd Bridge and the improvement of NR3, issues are raised, such as remaining congestion as ever along with economic growth and urban development, and lack of redundancy for drivers' route choices which is limited to using the NR3.

5.2.2 Traffic Demand Forecast: *Basic Idea of this work*

(1) Study Method

Future traffic demand at the 4th Bridge and relevant roads forecasted by the following procedures will estimate change of traffic flows in Douala City such as change of traffic demand of access roads on the both banks by the construction of the 4th Bridge, then present impact analysis.

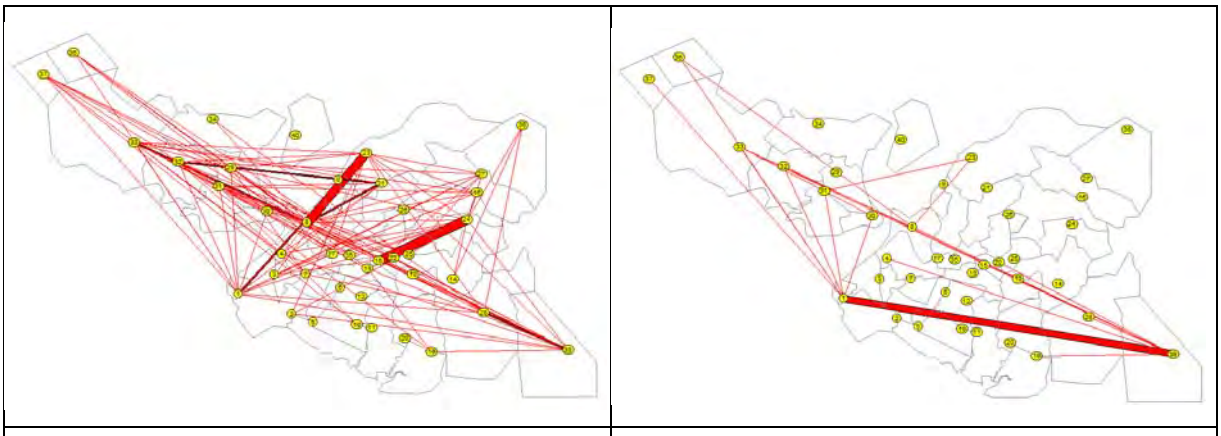
A) Estimate OD table of current vehicle traffic in the objective areas from the Roadside OD interview survey (of 40 zones assumed)
B) Set current road-network conditions of major arterial roads
C) Assign current traffic demand with the data above
D) Set growth rate of future traffic demand, then estimate OD table of future vehicle traffic
E) Set future road-network conditions of major arterial roads
F) Assign traffic volume in the future with the data of future OD table and future network conditions
G) Conduct quantitative analysis of the changes in demand factors between current and future condition of target intersections, congestion level of major routes, reduction of travel time, etc.

(2) Estimated OD table of current vehicles

The traffic survey (traffic count survey and roadside OD interview survey) result was used to estimate the CD table of current vehicles that indicates the daily traffic volume. The magnification factor is set in the two vehicle types based on the total traffic volume traversing each zone and obtained from the roadside OD survey to prepare the OD table for each vehicle type.

Vehicle OD Table by Vehicle Type	Vehicle Type
OD table of passenger car, etc. (human trips)	Motorcycle, passenger car, taxi, mini- and large buses
OD table of cargo vehicle, etc. (goods trip)	Light truck, truck and trailer

The desire-line diagram based on the estimated OD table of the current vehicles is provided below.



OD Table of Passenger Cars, etc. (human trip)	CD Table of Cargo Vehicles, etc. (good trip)

Source: JICA survey team

Figure 5.11 Desire-Line Diagram based on the Current OD Table

The traffic volume of passenger cars for commuting, business, personal and other purposes is mainly concentrated in Akwa, Ndokotti and NR 3 (toward Yaoundé). Although the traffic volume concentration of cargo vehicles has the strongest connection of direction toward the Douala Port and Yaoundé, a certain level of connection with the direction toward the right bank is also observed.

(3) Conditions of future traffic volume forecast

An OD table of the future traffic volume with the following matters taken into consideration is prepared from the table of the current one.

Considerations	Idea
Future traffic volume increase	The rate of increase in population and economic growth rate of Cameroon are reflected in the OD table of passenger cars (human trips) and cargo vehicles (goods trips), respectively, to express the future increase in demand. ・ Future population increase: BUCREP estimates the annual rate of increase in population to be approx. 2.2% until 2035 and it is used as the growth rate for the OD table of passenger cars. ・ Economic growth rate: That of Cameroon was around 5 to 6% recently. Annual rates of 5% and 2.5% apply until 2025 and thereafter, respectively, for the OD table of cargo vehicles.
Land development on right bank	Population increase (approx. 11,245 persons) by the Bonamatoumbe development is reflected in the concentrated traffic volume in the zone in future.
Impact of the new port development in Kribi	According to an interview with the Kribi Port public company, the port development plan is as follows: ・ Opening of operation of Phase 1 in 2016 (annually 350,000TEU) ・ Opening of operation of Phase 2 by 2022 (additionally annually 600,000TEU) ・ Opening of operation of Phase 3 by 2035 (cargo handling volume yet to be decided) * As the annual capacity of the Douala Port is 530,000TEU, it will exceed it in Phase 2. The cargo handling volume at the Douala Port has increased at an annual rate of 8 to 12% since 2010 according to statistical data (Transtat 2014) of the MINT. The traffic demand at ports and harbors will continue to increase at a similar rate based on the future national economic growth forecast and most of the growth is likely to be handled by the Douala and Kribi ports. There is an idea of expanding the Douala Port and new demand may emerge even when the demand at the existing Doula Port moves after Kribi Port development. Against this backdrop, the traffic demand of the Douala Port is set to increase up to 1.5times as much as that of current demand in accordance with the growth rate. The converted traffic from the Douala to Kribi ports will have little impact on the traffic volume crossing the Wouri River as both ports are situated on the left bank.

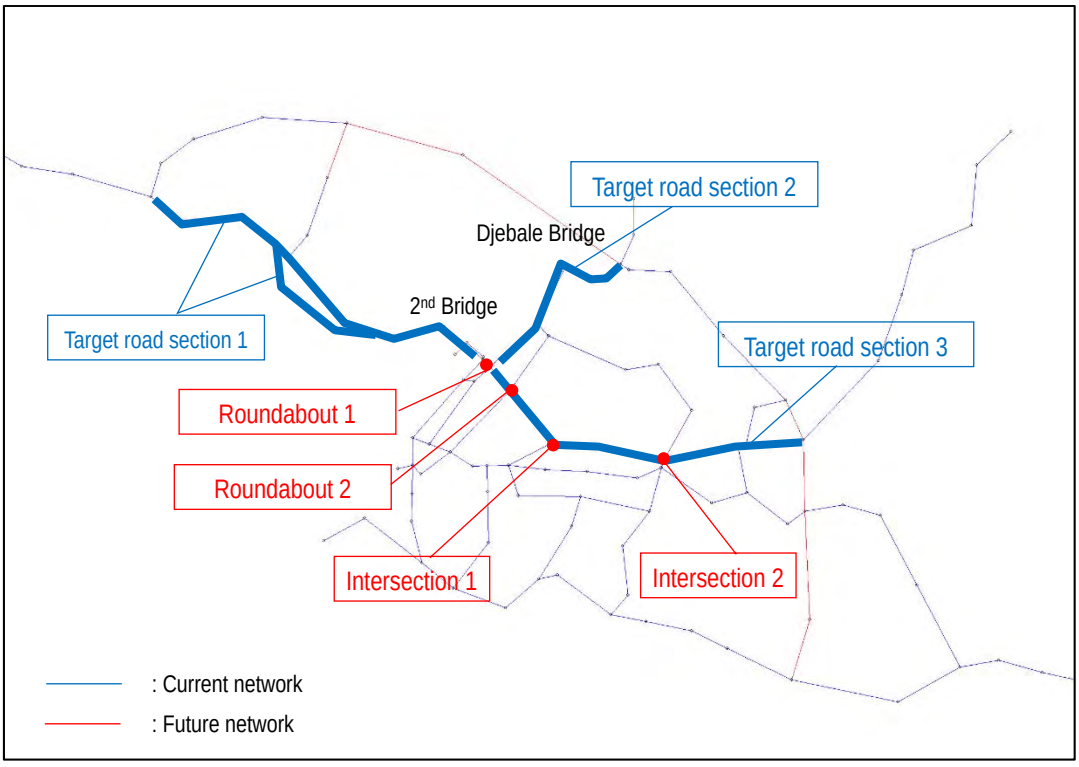
Table 5.11 provides a list of study cases in the survey. A comparative analysis of traffic in Douala is conducted in two cases, with and without Djebale Bridge, for each year. The traffic in the case of an access road built temporarily on the right bank (Case_1-2) is also analyzed for 2025.

Table 5.11 Study Cases of Future Traffic Demand Forecast

		Case_0	Case_1-0	Case_1-1	Case_1-2	Case_2-0	Case_2-1
Year		2016	2025			2035	
Study		Confirmation of reproducibility of current condition of traffic volume distribution	Study of traffic condition with no Djebale Bridge 9 years later from now (NR 3 improvement is reflected)	Study of traffic condition with the Djebale Bridge 9 years later from now (4-lane access road development on right bank)	Study of traffic condition with the Djebale Bridge 9 years later from now (However, development of temporary 2-lane access road on the right bank)	Study of traffic condition with no Djebale Bridge 19 years later from now	Study of traffic condition 10 years after the starting of use of the Djebale Bridge 19 years later from now
Network Condition	2nd Bridge Improvement of NR3	-	○	○	○	○	○
	Djebale Bridge	-	-	○	○	-	○
	Access road on right bank	-	-	○	-	-	○
	Improvement of relevant roads on the left bank	-	○	○	○	○	○

Source: JICA survey team

The roads and intersections for which traffic conditions are analyzed are shown in the figure below.



Source: JICA survey team

Figure 5.12 Traffic Distribution Network and Traffic Analysis Locations

(4) Traffic analysis based on future traffic demand forecast

The traffic volume distribution calculation results in each case above are summarized in the table below.

Table 5.12 Traffic Condition based on Traffic Volume Distribution Result

	Case_0	Case_1-0	Case_1-1	Case_1-2	Case_2-0	Case_2-1
Year	2016	2025			2035	
Total Travel Vehicle-Kilometer (2016=100)	100	129	124	123	166	156
Average Length of All Trips	12.5km	16.2km	12.3km	12.2km	13.3km	12.6km
Average Speed of All Trips (2016=20)	20	27	29	28	11	12
① Traffic Volume of 2nd Bridge * Case_0 is 1st Bridge	55,700 PCU/day	71,600 PCU/day	46,400 PCU/day	47,100 PCU/day	88,600 PCU/day	57,500 PCU/day
② Traffic Volume of Djebale Bridge	—	—	25,200 PCU/day	24,500 PCU/day	—	31,100 PCU/day
Of which traffic volume converted when 3rd bridge is constructed	—	—	1,700 PCU/day		—	2,300 PCU/day
Total ①+②	55,700 PCU/day	71,600 PCU/day			88,600 PCU/day	
Traffic Volume of Access Road on Right Bank	—	—	20,500～22,200 PCU/day	11,500～13,100 PCU/day	—	27,900 - 30,000 PCU/day
Congestion on surrounding roads						
Target Road Section 1	1.32	1.54	1.10	1.21	1.90	1.33
Target Road Section 2	1.71	1.45	1.19	1.17	1.74	1.41
Target Road Section 3	1.15	0.94	0.88	0.88	1.08	0.97
Roundabout 1	1.77	2.13	1.57	1.57	2.61	1.78
Roundabout 2	1.63	1.73	1.41	1.42	2.00	1.58
Demand Rate of Intersection 1	0.77	0.72	0.83	0.85	0.74	0.80
Demand Rate of Intersection 2	0.95	0.65	0.62	0.58	0.91	0.75

Source: JICA survey team

(5) Future traffic analysis

- Although the traffic condition a decade from now (as of 2025) is expected to improve as a result of development of the 2nd bridge, improvement work of NR 3, the road between Bonamoussadi and Akwa and roads around PK 10, demand is also expected to soar (approx. 26% increase from 2016), which is likely to further exacerbate congestion around Akwa in central Douala. (Congestion in target road section 2 will deteriorate from 1.32 to 1.54.)
- The traffic demand a decade from then (in 2035) is forecast to increase by 58% from 2016 and the traffic condition in Douala is forecast to deteriorate significantly when road improvement is limited to that currently underway or studied concretely.
- Djebale Bridge development will significantly improve the traffic condition around Akwa, including Deïdo where the roundabout is situated, a decade from now (in 2025). The improvement work will also result in further improvement of areas around Ndokotti and NR 3 in addition to the area around the bridge for the below reasons.
  - There is only one route that traverses the Wouri River and developing the Djebale Bridge will fuel traffic demand, since the new route will be the shortest.
  - The new route also functions as a beltway and some traffic will move to the Djebale Bridge route as an alternative route, even though it is not the shortest, which will result in traffic being distributed across the city.
- The traffic demand a decade from then (in 2035) is forecast to increase by over 50%, so Djebale Bridge development is the minimum necessity. Drastic measures to improve the urban structure and traffic convenience, including the development of public transportation and review of land use plans, are also needed. Unless such measures are implemented, road traffic in Douala is likely to deteriorate badly from the current condition.
- As the road to be developed by the SAD is connected with NR 3, two lanes suffice as the access road on the right bank for the time being. However, a four-lane road will also be needed to accommodate further increase in demand.
- Traffic of the Intersection 2 (Ndokotti) that is congested with the intersection demand rate exceeding 0.9 will improve and go below 0.9 in future when the Djebale Bridge is constructed.
- The above traffic analysis is the result of calculation based on the road traffic capacity observed under the current condition and is expected to improve further if traffic lights are installed, traffic control tightened and traffic safety awareness raised.

6. Approaches Necessary to Improve the Traffic Situation

6.1 Development of a new road network

Currently, the existing bridge is the only one crossing the Wouri River and the concentration of traffic causes serious congestion on bridge and surrounding roads. In response, the 2nd Bridge, which will have six lanes, is under construction. According to MINTP, on completion of the 2nd Bridge, the bridges will be used for separate purposes – the existing bridge will accommodate pedestrians and light vehicles and the 2nd Bridge will be used for vehicles.

As described in Table 5.12 of the previous section, in case the 2nd Bridge handled all the traffic set to cross the river, the demand will be 71,600 PCU/day in 2015 and 88,600 PCU/day in 2035, largely exceeding the daily traffic capacity of a six-lane road of 40,500 PCU/day. If the east-west traffic demand is concentrated on the 2nd Bridge, congestion on the surrounding roads is expected to intensify severely.

Based on the above, there is a need to establish a new road network crossing the Wouri River to respond to ever-increasing traffic demand. Constructing a new bridge crossing the river is also crucial from the perspectives of securing an alternative route during an emergency such as a traffic accident or disaster and disaster prevention/reduction. For these reasons, establishment of a new road network with the construction of the Djebale Bridge and access roads, as proposed in the Master Plan, seems the most important approach to improving the traffic situation in Douala city.

As for the effects of the project, including the construction of the Djebale Bridge and access roads, as described in Table 5.12, future traffic demand for the 2nd Bridge will be about 60% compared to if the project were not carried out and the traffic concentration will be substantially reduced. Congestion on the roads and intersections near the 2nd Bridge will also be about 70-80% of the level compared to not performing the project and congestion on the surrounding roads is expected to be reduced. Without the project, the level of congestion of RN3 on the right bank of the Wouri River (Target Road Section 1) and Target Road Section 2 running north from the Deïdo intersection would increase around 1.5fold by 2025 and the traffic volume will reach capacity during many daytime hours. However, if the project is carried out, the level of congestion will be reduced to 1.1-1.2 in 2025 and, despite unavoidable congestion for 1-2 hours during peak periods, long hours of congestion are likely to be eliminated. Implementing the project will also reduce the demand factor for two signalized intersections to less than 0.9 and allow signal processing in terms of traffic capacity.

6.2 Improvement of congested intersections

While construction of the Djebale Bridge and access roads is expected to significantly improve the traffic situation in Douala, the roundabout on the left bank is expected to be highly congested and become a bottleneck. With construction of the Djebale Bridge, the demand factor of the two signalized intersections is expected to be lower than 0.9. However, the actual processing capacity of the intersections will probably be smaller than the calculation due to the shape of the intersections, on-street parking, etc.

The traffic streams of these intersections may improve significantly with measures such as straightening traffic flows by installing dividing lines, guiding traffic flows by installing traffic islands, comparatively small-scale improvements of intersections like adding lanes, installing signals as well as restricting markets and taxi stands, etc. within the intersections. However, in case the traffic demand for the intersections is too large to be addressed with such measures, more drastic measures such as constructing a grade separation will be required.

6.3 Improvement of traffic management

Traffic congestion on existing roads is attributable not only to traffic concentration but also operational issues, such as on-street parking on bridges and intersections and a lack of signals. Violations of traffic rules, such as aggressive merging, cutting in when traffic is heavy or driving in the wrong direction, also exacerbates congestion. It is desirable to optimally exploit the existing stock of roads by strengthening of the traffic management capabilities of the road/traffic administrator and improving traffic regulations and operations as well as implementing the above-described tangible measures. It is also desirable to improve the capabilities to plan and design intersections so that the road/traffic administrator can consider appropriate countermeasure constructions from a traffic engineering perspective for improvements to intersections described in 6.2.

6.4 Improvement of public transportation

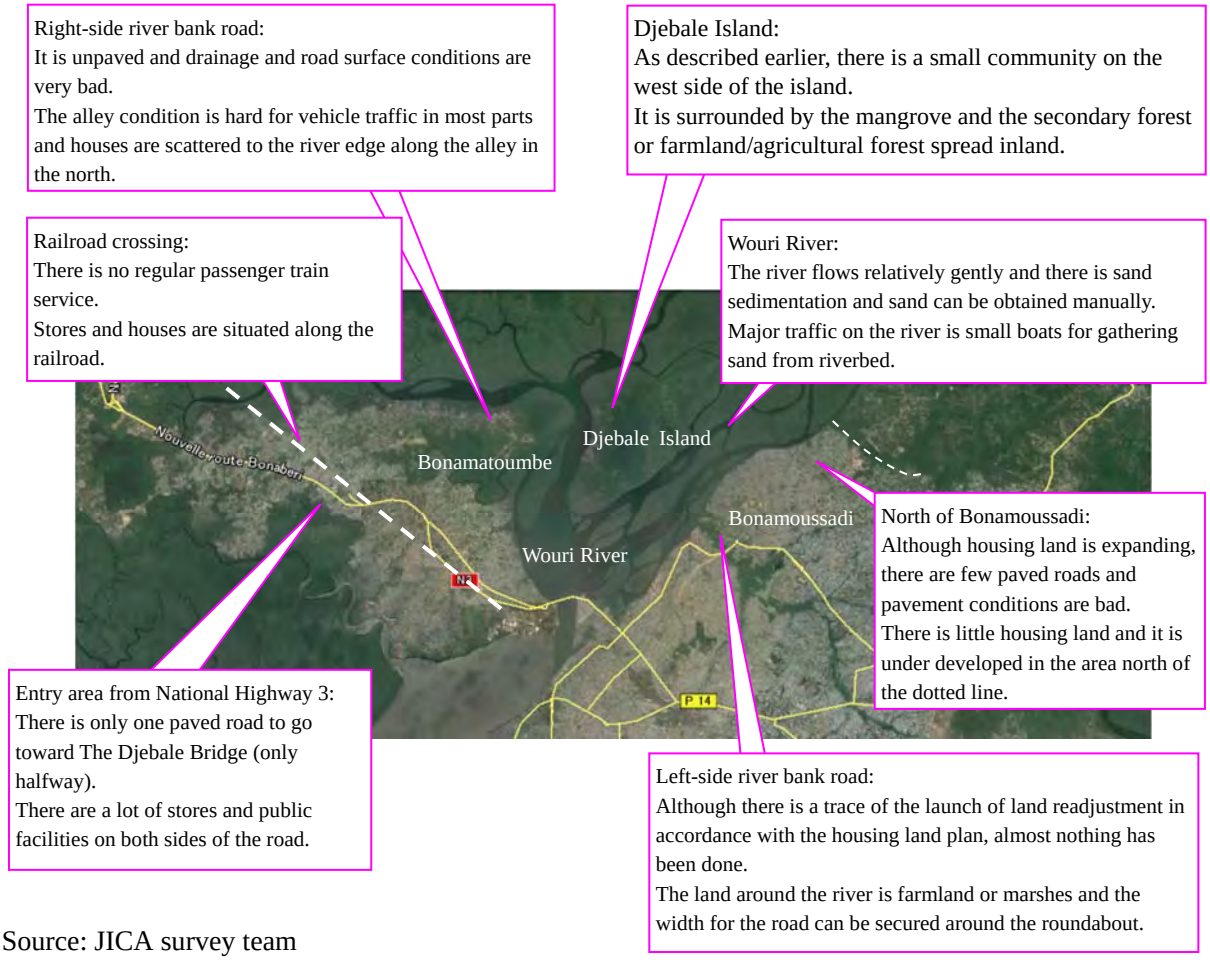
From a long-term perspective, traffic demand itself should be reduced because the development and improvement of road infrastructure and countermeasures related to traffic management alone cannot cope with ever-increasing traffic demand. Accordingly, improving bus services that have been used as an existing means of public transportation and moves to shift from private passenger cars and motorcycles seem priorities to address first of all. To improve the bus services, expansion of the existing bus routes, an increase in service frequency and the introduction of BRT/BHNS, which is currently being planned, are expected. Capacity building of the bus corporation and other business operators will also be essential so that they can operate voluntarily and sustainably.

7. Review of Assumable Infrastructure Development

7.1 Situation around the Djebale Bridge Site

7.1.1 Situation around the bridge

An overview of the area around the Djebale Bridge is provided in Figure 7.1.



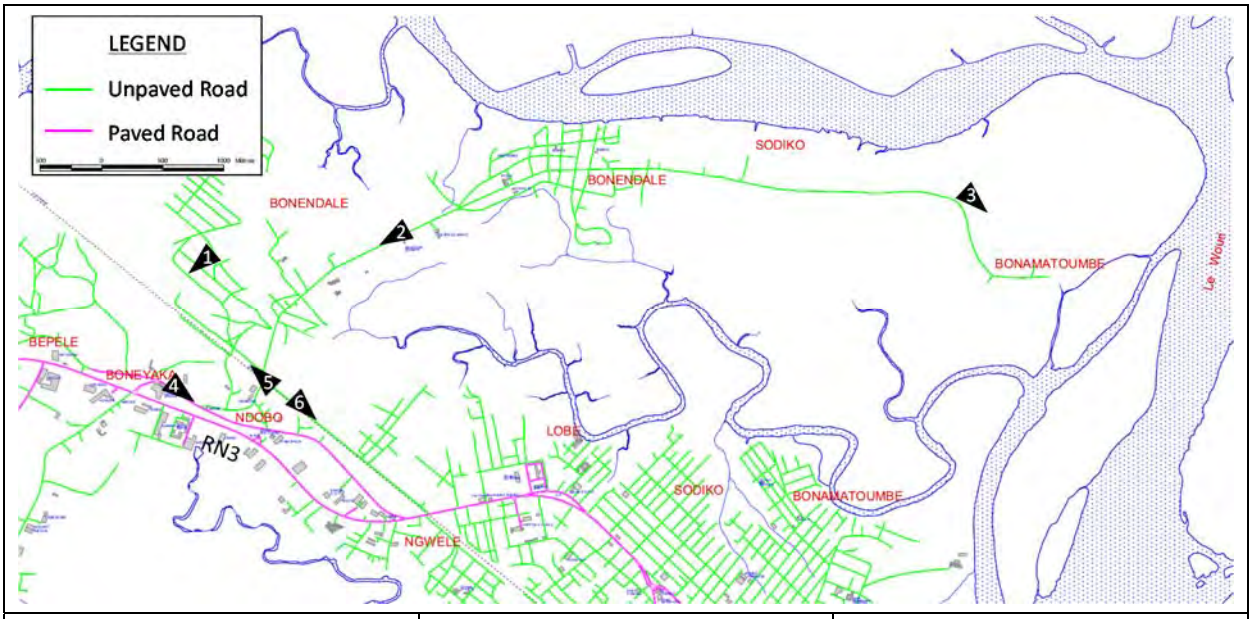
Source: JICA survey team

Figure 7.1 Area around the Djebale Bridge

7.1.2 Access Road

(1) Right bank of Wouri River (Bonamatoumbe)

The access road on Right bank originates at Ngwele or Boneyaka on RN3. After the old road around the railway crossing, an unpaved road continues for approximately 7km toward Bonamatoumbe peninsular area. Width of the unpaved road is approximately 8m and it allows two way traffic. However, every driver must steer erratically due to bumpy and puddled road surface, especially in rainy season. There are a number of stores along the road. Add to this, residences, slaughterhouses and public facilities are found as well. On the west side area of the access road in Bonendale, permanent houses are scattered all over the place.



1. West side of Bonendale

2. Bonendale road (unpaved)

3. Bonamatoumbe area

4. Old road near Boneyaka

5. Railway crossing

6. Rue.4544 along the railway

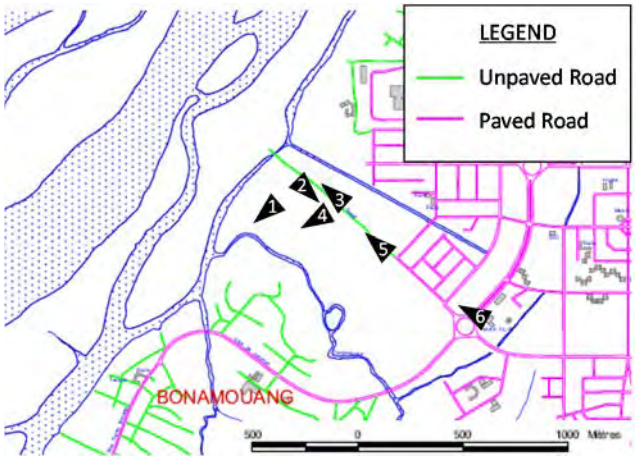
Source: Base map by CUD and photos taken by JICA survey team

Figure 7.2 Surrounding circumstances of the access road in the right bank

(2) Left bank of Wouri River (Bonamoussadi)

Bonamoussadi area is located in the left bank of the river. Road land with 50m wide is secured between the largescale roundabout (Island radius approximately 43m) and Wouri River side. For the first 500m section of South-East, the road surface is paved with asphalt, however be more close to the river, the road condition becomes poor and finally bushes occupy the road land. In the present circumstances, vehicle cannot approach to the riverside.

Along the road land, comparatively largescale residences have been built and further development is processing. According to the cadastral map of Douala, river front area has been subdivided into lots of parcel and the map shows land owner of each parcel. However, the area has been occupied by intact bushes at the moment. The following figures show photo of road land and the cadastral map in Douala which was last updated at July 2016.



1. Developing zone in South-West area

2. Road land with soil

3. Road land with bushes

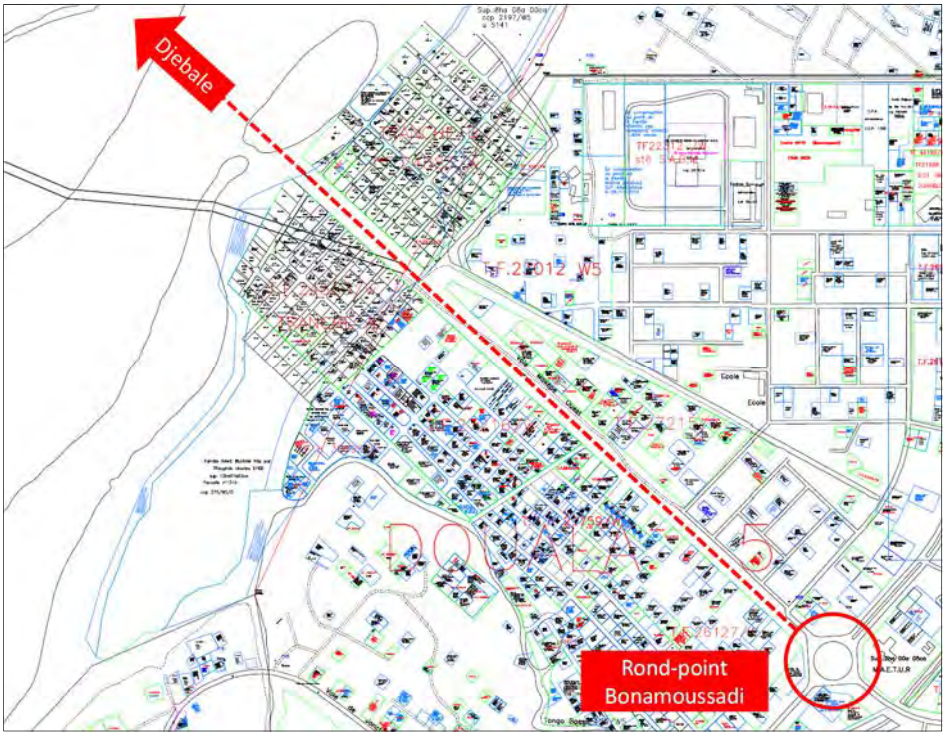
4. Cluster housing along the road land (Under construction)

5. Road land

6. Roundabout in Bonamoussadi

Source: Base map by CUD and photos taken by JICA survey team

Figure 7.3 Surrounding circumstances of the access road in the left bank



Source: MINDCAF (Red objects are added by JICA survey team)

Figure 7.4 Cadastral map of Bonamoussadi

7.1.3 Land development plan in Bonamatoumbe

(1) Outline

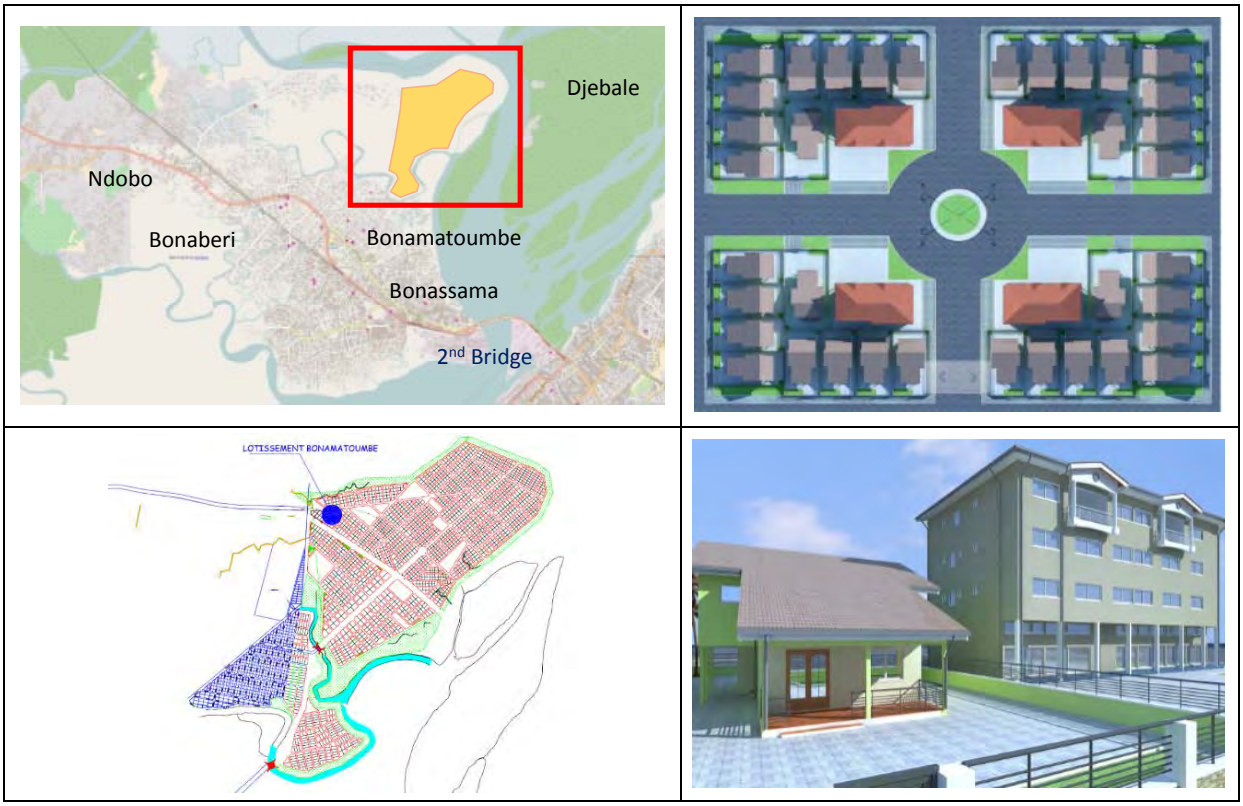
At the peninsular land which is spired form Bonamatoumbe toward the Djebale Island, CUD and a private developer, SAD (La Société d'Aménagement de Douala) are collaboratively processing land development project. The whole development site covers an area of 300 hectare and is divided in approximately 2200 parcels which has 500 to 2000 square meters respectively. Parcels are allocated for use of residences and public facilities. In the site, two major roads are allocated and they cross at the center area. The road from South-West to North-East is Bonamatoumbe Road which is an ongoing road development project being implemented by CUD. The other one connects the existing road (Bonendale Road) and the direction of Djebale Island. It is noted that the latter road alignment follows the route of the Djebale Bridge described in The M/P of Douala.

The land development plan is subject to be implemented conformable to the law for urban planning (N° 2004/03 du 21 Avril 2004 régissant l'Urbanisme), the regulations for residential development (décret n° 79-194 du 19 Mai 1979 portant création de lotissements), the subdivision plan and the specifications which were submitted to CUD.

Objectives of the land develop plan is defined as follows;

- To correspond housing demand due to ever-increasing population
- To hold down the number of illegal residents
- To develop the urban residential area as the prime business city of the country

It is noted that SAD has already commenced to sale some parcels of land.



Source: SAD

Figure 7.5 Land development plan and visual image view of residences

(2) Land use

Land use of the development plan is summarized as the below table.

Table 7.1 Land use of components

Components	Superficies		Part
	m^2	ha	
1. Subdivision	**1,471,132**	**147.11**	
Sector 1	149,531	14.95	
Sector 2	85,170	8.52	
Sector 3	180,514	18.05	**49%**
Sector 4	206,083	20.61	
Sector 5	353,664	35.37	
Sector 6	496,170	49.62	
2. Community facilities	**179,818**	**18.00**	**6%**
3. Road	**770,547**	**77.05**	
Structuring Road			
Primary Road (W=50m)	178,150	17.82	
Secondary Road (W=20m)	21,000	2.10	
Secondary Road (W=15m)	194,340	19.43	**26%**
Tertiary Road (W=10m)	74,430	7.44	
Service Road			
Buffer zone (3)	3,286	0.33	
Tertiary Road (10)	299,341	29.93	
4. Green space	**24,560**	**2.46**	**1%**
5. Forest / Mangrove	**551,080**	**55.11**	**18%**
Total	**2,997,137**	**299.71**	**100%**

Source: CUD

The following table shows the breakdown of land use component. It is noted that estimating a household living in a parcel consists of 5 people on average, the population of the site is estimated as 2,249 x 5 = 11,245 people. Therefore, when all building work completes, the population capacity will be 12,000 inhabitants.

Table 7.2 Residential zone breakdown by sector

Sector	Type of residence	No. of parcel	Area (m^2)
Sector 1, 2	High-priced residence	427	234,701
Sector 3, 4	Mid-priced residence	400	386,597
Sector 5, 6	Public housing	1422	849,834
	Total	**2249**	**1,471,132**

Source: CUD

Table 7.3 Public facilities breakdown

Components	Area (m^2)
Sports field	20,849
Village square	23,744
Health space / Hospital	9,799
Graveyard	20,166
Gendarmerie	7,399
Land of MINEPIA	2,591
Sports and Cultural complex	35,818
Police	3,524
Administration / Market	28,921
School	27,007
Total	**179,818**

Source: CUD

Table 7.4 Green space breakdown by sector

Components	Area (m^2)
Sector1	778
Sector2	0
Sector3	1,748
Sector4	8,213
Sector5	2,896
Sector6	10,925
Total	24,560

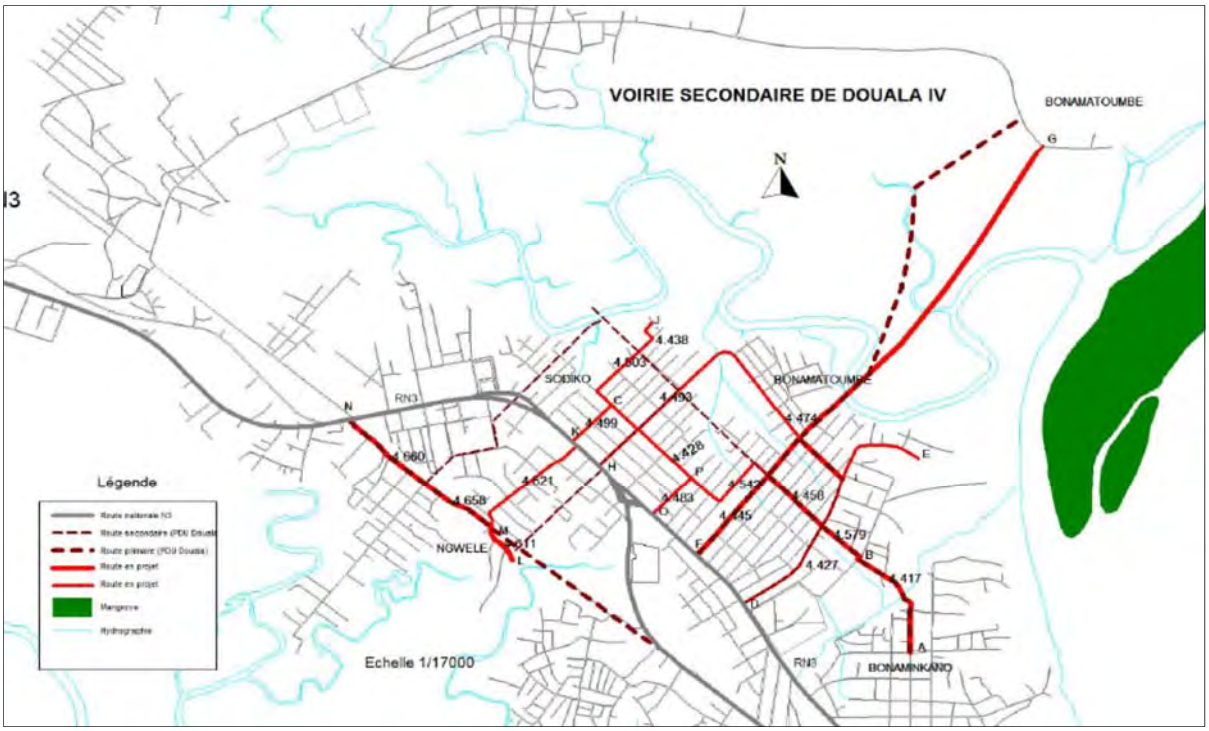
Source: CUD

Source: SAD

Figure 7.6 Zoning plan

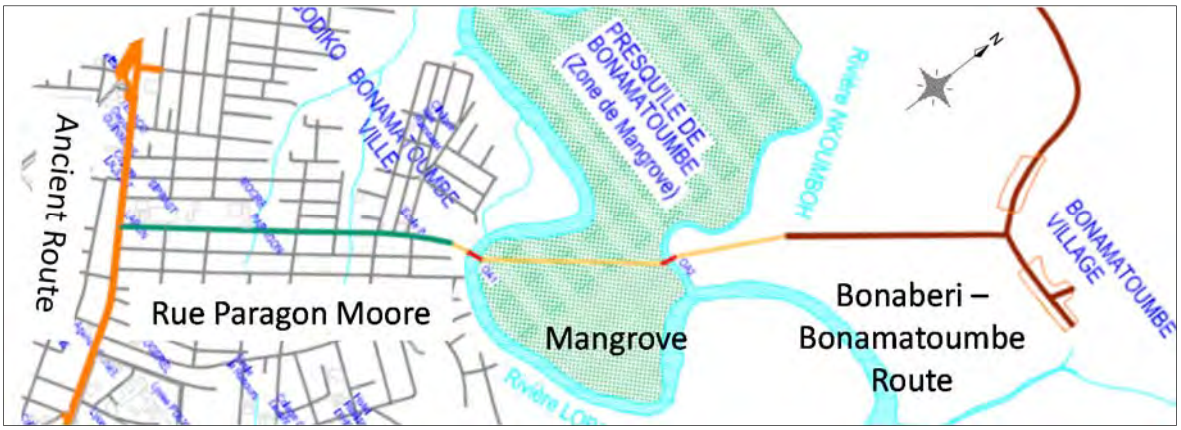
7.1.4 Road improvement plan in Bonamatoumbe

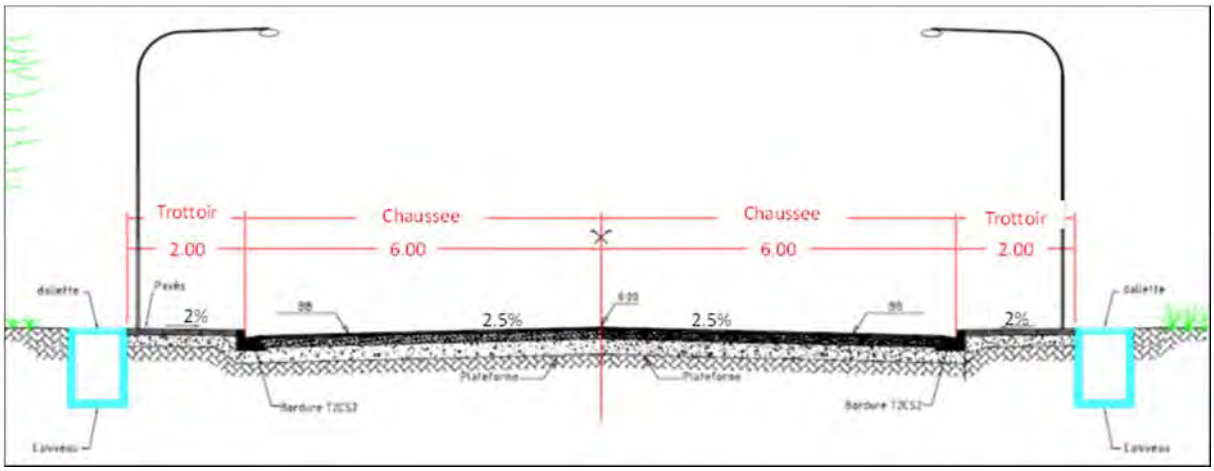
At the vicinity of RN3 in Bonaberi, CUD is processing road improvement projects for the total length of approximately 12.3km. One of the major target road is a section of Paragon Moore Road (Rue.4445) which starts at the ancient road and toward North-East direction. The road project is conveniently called as "Bonamatoumbe Road". It consists of widening and extension of 4lane road for the length of approximately 3.2km. The route origins at urban area near the ancient road and reaches the peninsular of Bonamatoumbe by passing the mangrove bristle area. New construction of two bridges (L=60m and 30m) is planned at the river crossing. It is noted that only few houses have been built around the end point of the route, however the site is expected to be the middle of SAD land development zone in future. The road alignment near the end point looks correspond to the land arrangement in the zoning map of the development plan and the end point will be expected to constitute an intersection. Bonamatoumbe road is defined as a factor of integrated plan of the land development and the M/P established by CUD. Road construction work is scheduled to be completed in 2018.

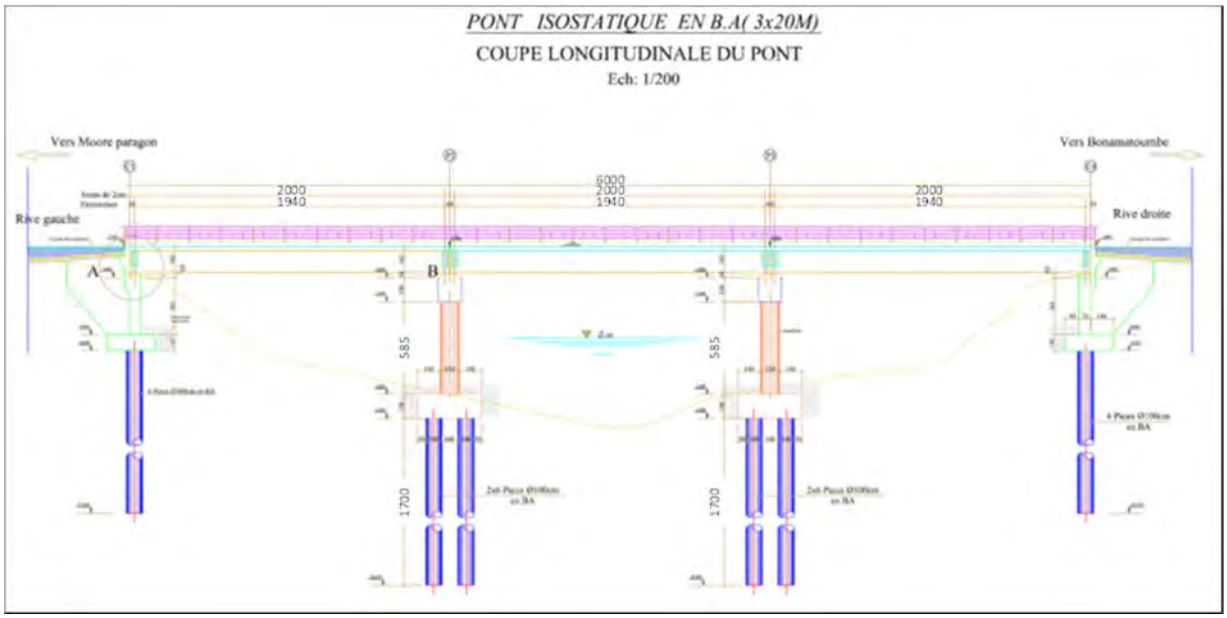


Source: Etudes en vue de la construction de certaines de voiries secondaires de la Ville de Douala (Lot 2). 2015 / CUD

Figure 7.7 Whole location plan of the road improvement project in Bonaberi







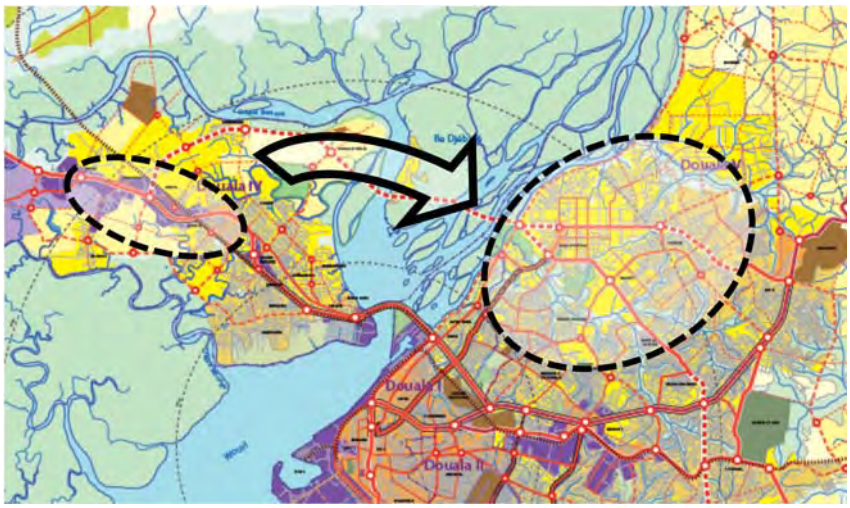
Source: Maitrise d'oeuvre complete portant sur l'etude, le controle technique et la surveillance des travaux de construction de deux ouvrages d'art et les voies d'acces a Bonamatoumbe Village-Douala IV, 2008 / CUD

Figure 7.8 Location plan, Typical cross section and bridge side view (L=60m, LOBE River) of Bonamatoumbe Road

7.2 Basic study condition

7.2.1 Basic condition

In the Douala MP, the project of the Djebale Bridge has been listed as one of measure to ease traffic congestions around the Bonaberi Bridge. The alternative route starts at RN3 in Bonaberi area of the right bank and it goes through Bonamatoumbe and Djebale Island, then it touches the existing road of the left bank. Based on this prerequisite condition, we confirmed validity of the route in MP by comparing with plural alternative routes.



Source: PLAN DIRECTEUR D'URBANISME HORIZON 2025 / CUD, JICA survey team edited

Figure 7.9 Target area of route study for the Djebale Bridge

7.2.2 Planning condition

(1) Standards to refer

In Cameroon, road design work basically refers French design standards, such as ARP (Aménagement des Routes Principales / Service d'Etudes Techniques des Routes et Autoroutes, SETRA) and ICTAVRU(Instruction sur les Conditions Techniques d'Aménagement des Voies Rapides Urbaines / Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques, CERTU), because there is no original standard. ARP is used for principal roads and ICTAVRU is for urban freeways. It is noted that SETRA and CERTU was consolidated from 2014 in a new public administrative establishment, CEREMA (Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement).

For the route study of the Djebale Bridge, we referred mainly ICTAVRU and use Japanese standard as supplements. For the pavement design, Guide pratique de dimensionnement des chaussées pour les pays tropicaux / CEBTP) is referred in the most of tropical country to correspond to its own economic, climatic and geotechnical conditions.

(2) Road classification

The Djebale Bridge route is classified as an urban boulevard and Type "U" in ICTAVRU.

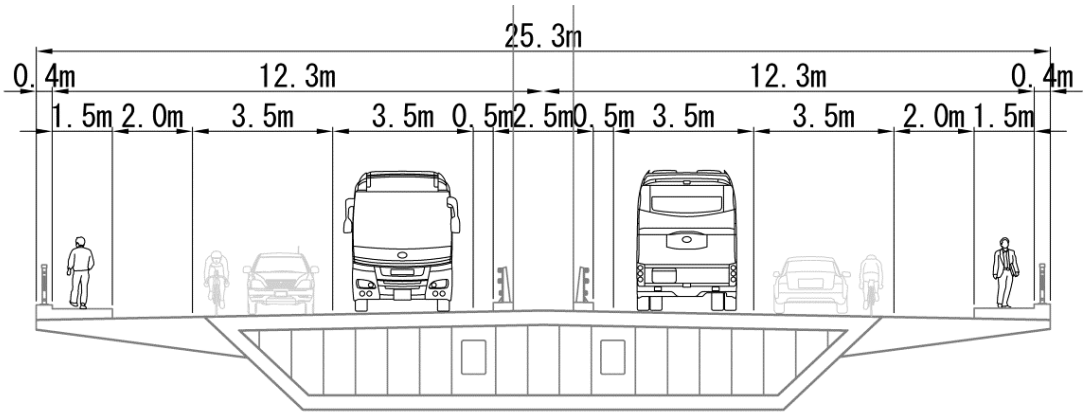
- Road Class : U60,ICTAVRU
- Design Speed : 60km/h
- Minimum R: 200m
- Maximum slope : 6%

It is noted that the related road projects on-going in Douala follow the below standards.

- The 2nd bridge construction project : U60, ICTAVRU
- Study for the 3rd bridge (F/S) : U80 , ICTAVRU
- Bonamatoumbe Road : R60, ARP

(3) Road Width

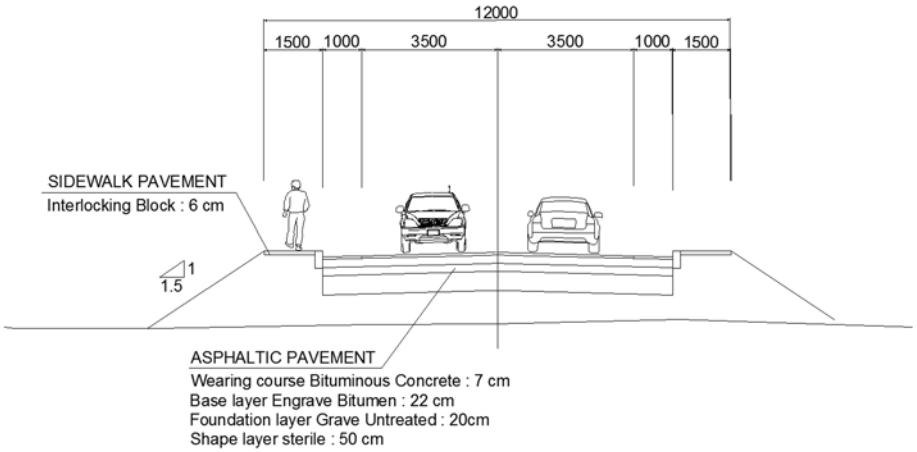
The Douala MP concluded to develop 4 lane road with introducing exclusive bus lanes for the new route. The survey team also found that 2 lane in one way has be provided to satisfy the expected traffic demand in 2025 according to the forecast study, thus, bridge section is defined as 4 lane in both direction. On the access road of the right bank, traffic demand can be divided between Bonendale road and Bonamatoumbe road, thus, 2 lane in both direction is sufficient. Add to this, in point of utilizing these roads during the bridge construction period to allow heavy vehicles pass, early provision of service is desirable. Therefore, basic policy is 2 lane road (W=12.0m) as a first step of development and expand to 4 lane with phased development plan according to further traffic demand forecast. The following figures show reference cross section of bridge, access road (2 lane and 4 lane), respectively.



Median	Carriageway	Shoulder	Sidewalk	Total width
3.5m (incl. main tower and cable width)	3.5m x 4 lane	2.0m	1.5m	25.3m

Source: JICA survey team

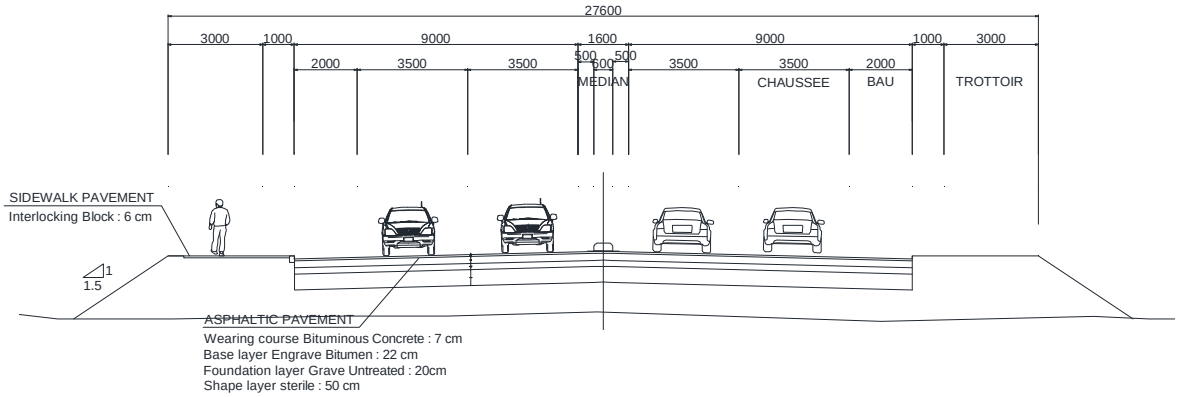
Figure 7.10 Cross section for bridge section (For reference)



Median	Carriageway	Shoulder	Sidewalk	Total width
-	3.5m x 2 lane	1.0m	1.5m	12.0m

Source: JICA survey team

Figure 7.11 Cross section for 2 lane earthwork section (For reference)



Median	Carriageway	Shoulder	Sidewalk	Total width
1.6m	3.5m x 4 lane	2.0m	3.0m	27.6m

Source: JICA survey team

Figure 7.12 Cross section for 4 lane earthwork section (For reference)

7.3 Route study of the Djebale Bridge

7.3.1 Methodology

(1) Methodology

Components of the Djebale Bridge Project are divided by sections of access roads in the right/left bank and river-crossing part. Route study of the bridge route at river-crossing section is shown here. As a procedure of the route study, firstly we establish alternative routes in wide area surrounding/through the Djebale Island, and indicate each route's characteristics which can be compared with the criteria described below.

Origination of the project route is located at the same in any alternative route. It is near west gate of land development zone, SAD, located in Bonamatoumbe peninsular. On the other hand, destination is at river-side area in Douala V on the left bank

(2) Evaluation criteria for the route study

Evaluation criteria are shown here.

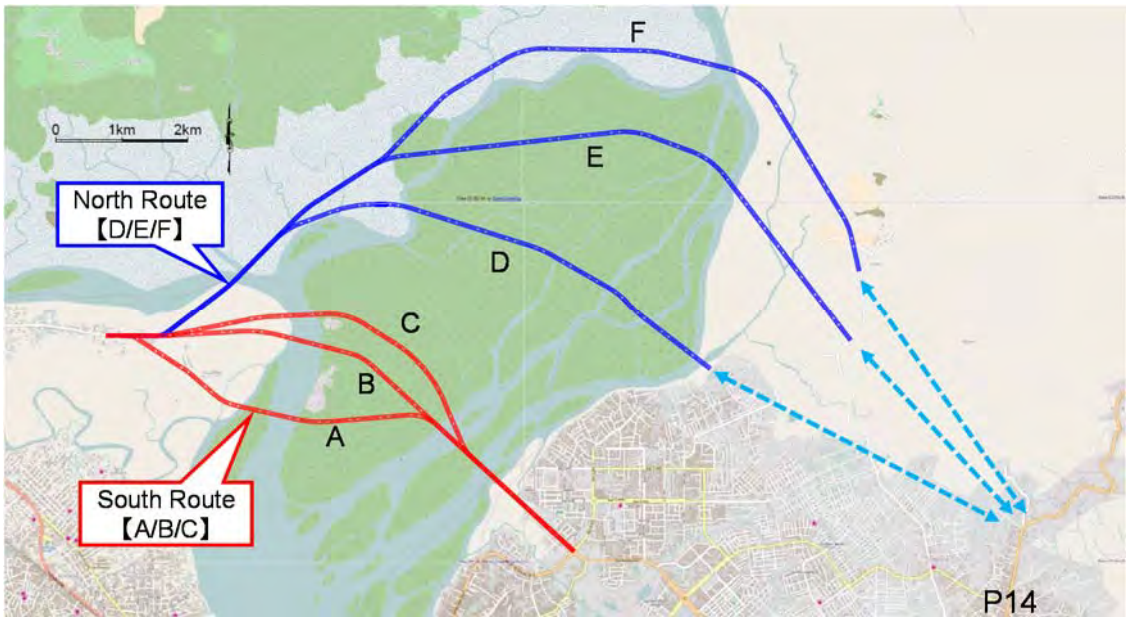
- Land use around the route
- Expected environmental and social impact
- Influence on wide area traffic network
- Connectivity to the related road
- Compatibility with the related project
- Construction cost (roughly estimation)
- Swiftness of positive effects by the project completion

7.3.2 Alternative route study

(1) Proposal of alternative routes

Alternative routes are roughly classified into two groups of “South Route (A,B,C)” which passes around Djebale Island Village and “North Route (D,E,F)” which bypath the village to north side. As a group of “South Route”, A, B and C passes respectively south, middle and north of the village. A route follows the Djebale Bridge alignment in the Douala MP, and passes south side of the village. B route passes between the villages. C route detour the village to the north. Destination of these routes are all the same roundabout in Bonamoussadi. From the river to the roundabout, adequate land has been secured for the approach road.

On the other hand, D,E and F of “North Route” originates at Bonamatoumbe peninsular area and access to the north-east direction to avoid the village in Djebale Island. These alternatives separate off around the north side of Djebale Island and approach to the left bank. F route, the most northern alternative is a detour to avoid direct impact to the island. Destinations in the left bank are set at approximately 5km upstream from the roundabout in Douala V.

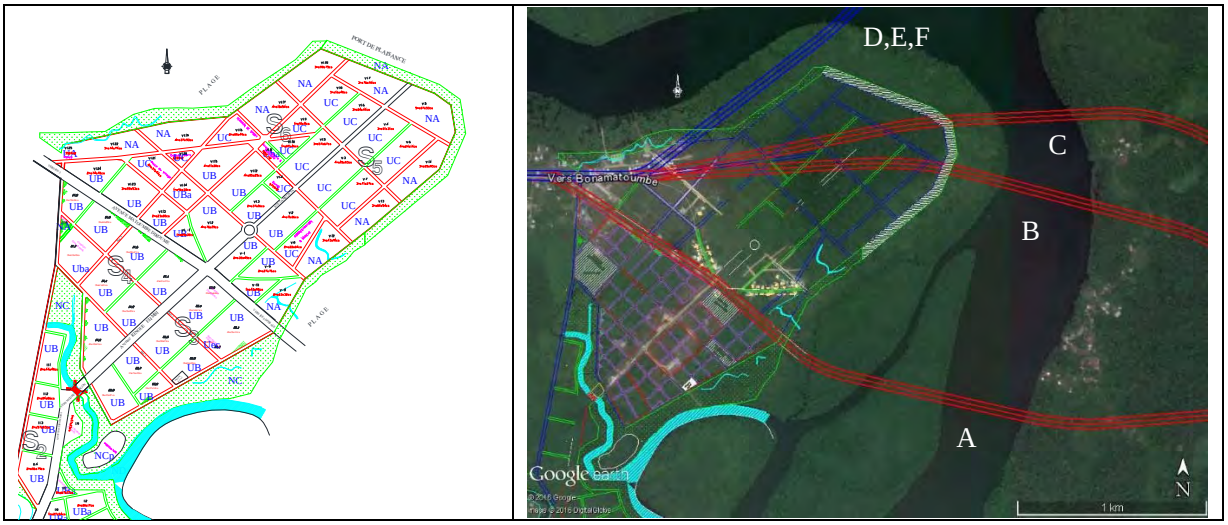


Source: JICA survey team

Figure 7.13 Proposed alternative routes of the Djebale Bridge

(2) Outline of the alternative routes

In South route, basically, there is less difference between the alternatives in evaluation criteria such as road/bridge length. However, in Bonamatoumbe peninsular, A route is accorded with the bypass road described in the plan of SAD land development, B and C route pass other than land scheduled for roads. In view of the situation of going on sale of land, it is expected that a change of arrangement plan causes troublesome procedure and takes a lot of time.



Source: JICA survey team

Figure 7.14 Position relation of SAD land development plan and Route alternatives

Regarding North route, total length is approximately 1.5 times as long as South route. Vicinity of approach road in the left bank is undeveloped and there is a distance of 4 to 5km from the river bank to the main road such as P14. Therefore, additional road improvement works will be needed to build up wide area traffic network. Needless to say, it means taking time to the completion of the project. Add to this, functionality of through traffic is low due to its long distance. Because of these, North route of D,E,F can be evaluated as NOT practical alternatives.

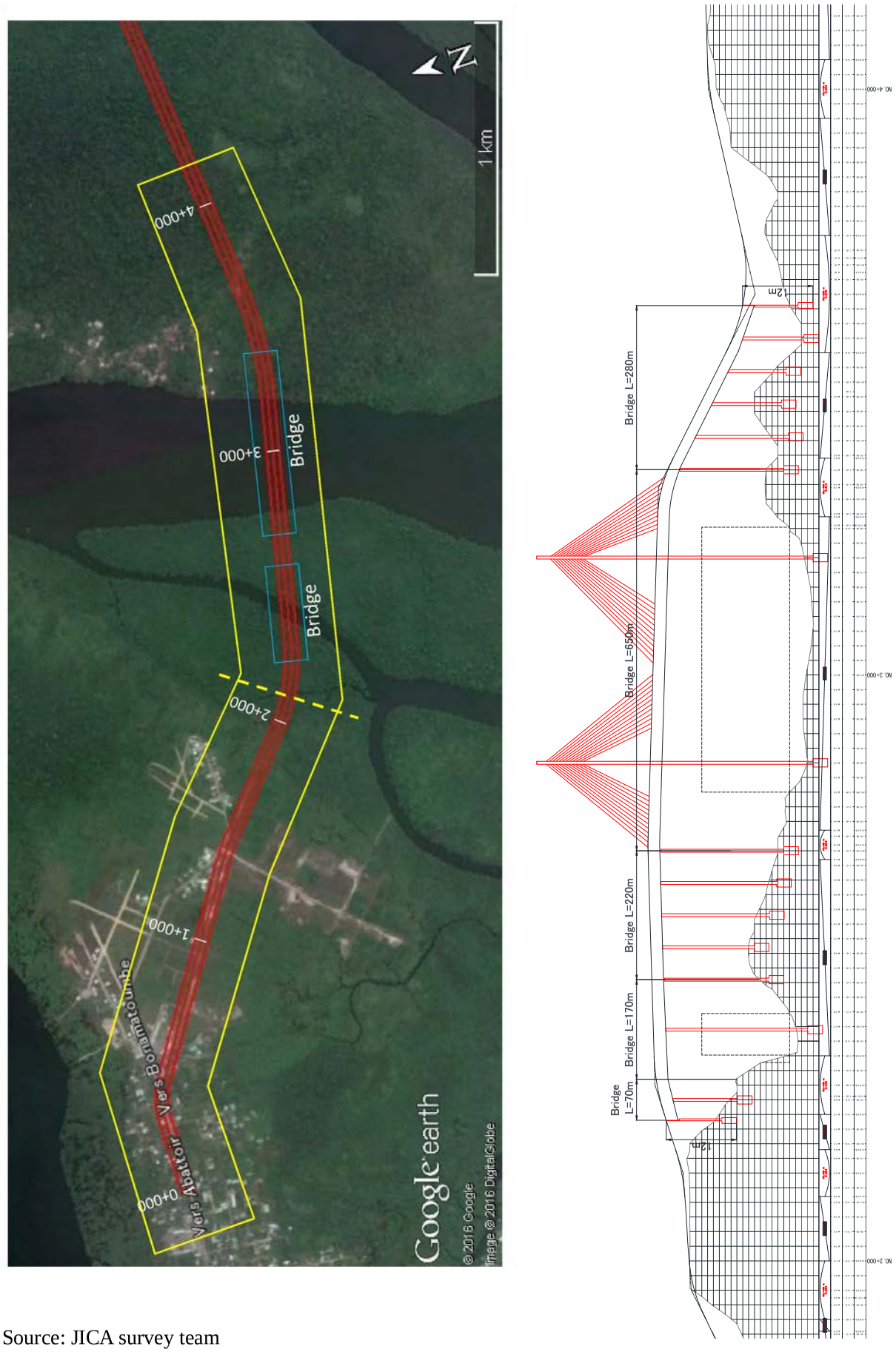
Table 7.5 Summary of alternative routes

	A	B	C	D	E	F
	South Route			North Route		
Total length	8,200m	8,300m	8,700m	10,500m	13,700m	14,800m
Earthwork length	6,600m	6,600m	7,200m	9,000m	12,400m	13,900m
Bridge length	1,700m	1,600m	1,500m	1,500m	1,300m	1,000m
Connectivity to the related road / Compatibility with the related project	Approachable to the existing roundabout in Bonamoussadi with no difficulty. High compatibility with the related road improvement by CUD.			After touch on the left bank, there is still undeveloped area before approach to the arterial road (up to P14), in distance of 4 to 5 km.		
Influence on wide area traffic network	The alternative bridge locates at 4km upstream from the 2nd bridge. This distance is suitable as a detour for through traffic. Enable to access to the Djebale Island village.			Route's workability as a detour is inferior to the other because of the 7 km distance from the existing bridge. Plus, road length is too long to get through easily.		
Swiftness of positive effects by the project completion	The route is practical so it is expected to shorten the project period.			Target length is longer than the other so it is expected that the project will be costly and take longer period to complete. Additional improvement of the left bank area is essential to complete the route.		
Land use / Social and environmental impact						
Right bank	Accord to the plan of SAD land development	Since NOT accord to the plan of SAD land development, a change of plan is needed.		Since NOT accord to the plan of SAD land development, a change of plan is needed.		
Djebale village	South of the village	Between the villages	Near mayor residence	Route is too far from the village to contribute to the local living standard and economic activities.		
Left bank	Land for approach road has been prepared in housing development zone.			Lots of houses are facing along the access road	Houses are facing along the access road	Route pass near major sand pits. Houses sparsely exist.
Impact to ecosystem	Area of cutover is less than North route (D,E,F).			Much mangrove bristle along Wouri river and bridge section. Impact to ecosystem seems not to be small.		

Source: JICA survey team

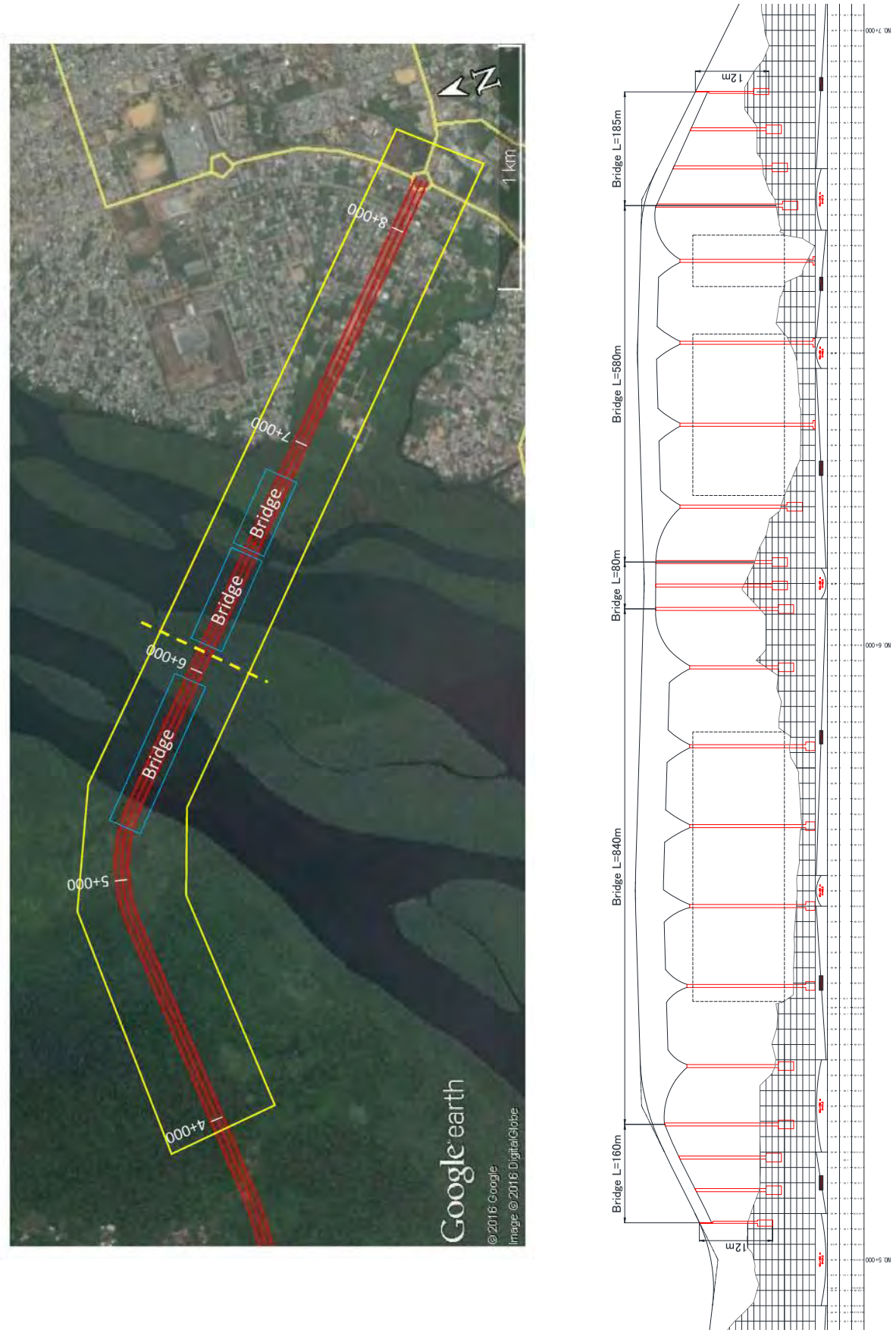
7.3.3 Vertical alignment

Road vertical alignment and profile drawings are established with A Route as a typical example for convenience of structural study described later. Shown ground height is generated from GIS data and values can be used for just reference. In further step, it needs to use precise topographic map to determine vertical alignment, bridge geometric structures and so on. It is noted that the scale ratio of Horizontal/Vertical is 1/10 in the following profile.



Source: JICA survey team

Figure 7.15 Plan and Profile (Bonamatoumbe – Djebale Island)



Source: JICA survey team

Figure 7.16 Plan and Profile (Djebale Island - Bonamoussadi)

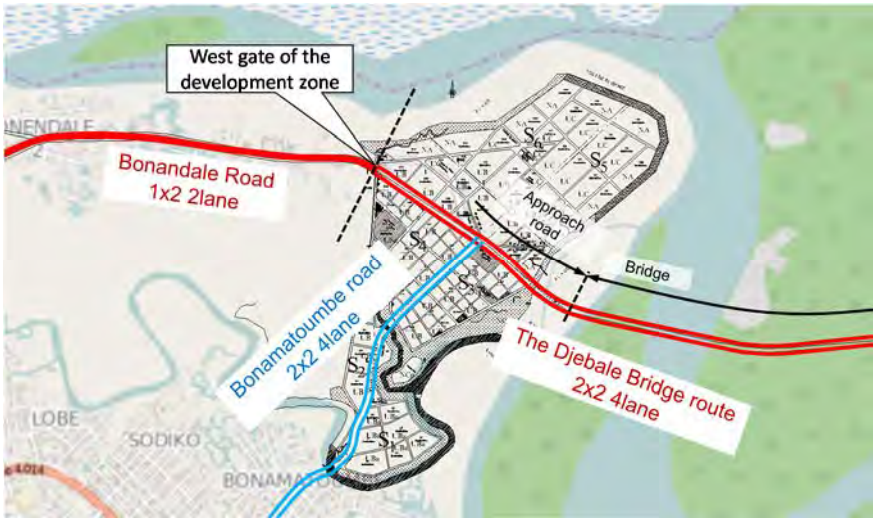
7.4 Access road and intersection study

7.4.1 Access road study

(1) Access road on the right bank

In the right bank, Bonaberi in Douala IV, there are many houses and shops along the existing road. In view of expected social impact, access road improvement should be planned with 2 lane to avoid any resettlement. However, 4 lane expansion can be considered in case the traffic capacity is saturated in future. The influence width should be set for the two-lane road to be constructed. Moreover, attention should be paid to minimize the land acquisition. There is also a need to persuade the owner to refrain from selling land within the right-of-way (ROW) as the road is planned to be widened in the future.

In this study, the main bridge section is planned with 4 lane, and scheduled road in the land development zone has 50m width, adequate for 4 lane road as well. For these reason, 4 lane is applied from the bridge section to the west gate of the development zone. Bonendale Road, the section of west of the gate is planned with 2 lane.



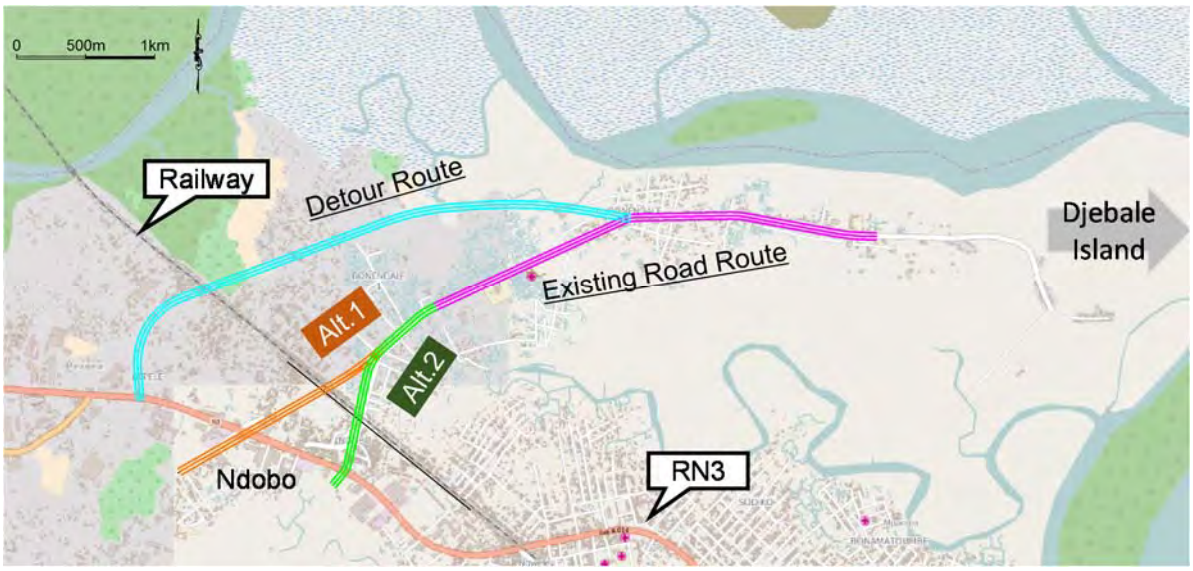
Source: JICA survey team

Figure 7.17 Lane number of the access road on the right bank

The access road in the right bank is planned between the main bridge's west abutment and the approach of RN3 in Ndobo. In the route, there is SAD land development zone and a railway crossing.

In the route study, basically two plans were proposed. The first one is maintain the existing road (Bonendale Road) with road improvement, and the other one is completely new alignment on the west side of the existing road to avoid impact on roadside facilities. These routes are named as "Existing Road Route" and "Detour Route" respectively. As further alternatives of "Existing Road Route" are separated by where to touch RN3. Alt-1 alignment is relatively straight and approach to RN3 in the shortest distance. Alt-2 is utilize the existing road longer and maintain the position of railway crossing. The route of Alt-1 or Alt-2 is defined as a part of "Existing Road Route". Therefore, three alternative routes are proposed in the right bank.

Outlines of each route are summarized in the below figure and table. Rough construction cost are calculated with considering road width, based on references of RN3 east side road widening construction works and the approach road for the 2nd bridge project.



Source: JICA survey team

Figure 7.18 Access road route alternatives in the right bank

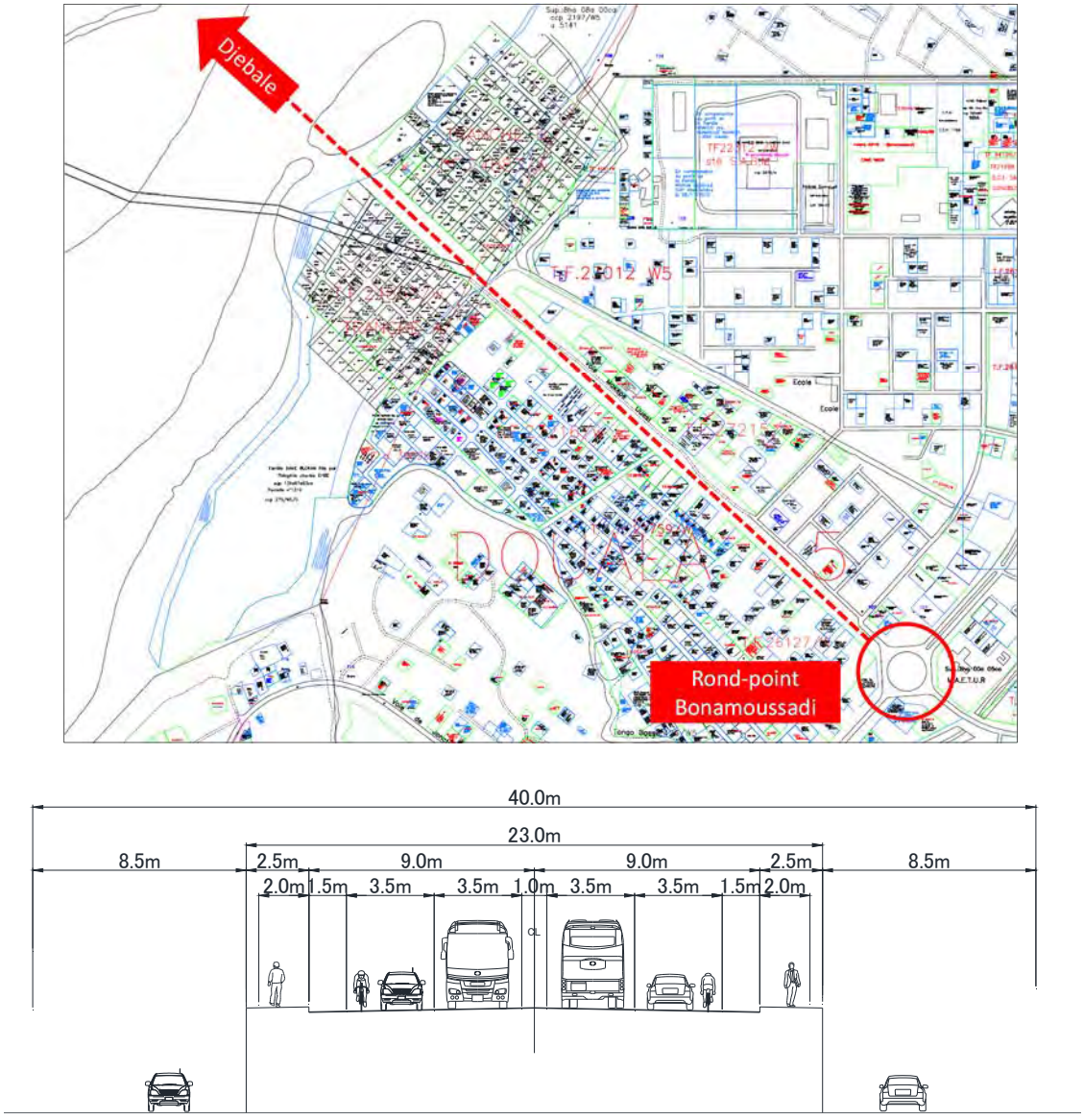
Table 7.6 Summary of alternative routes in the right bank

		1 – Alt.1	1 – Alt.2	2
		Existing Road Route		Detour Route
Total Length		6,600m	6,800m	8,400m
Maintain the existing road		3,800m (58%)	4,700m (69%)	1,200m (14%)
Connection to RN3		- Connecting position to RN3 accords to the end point of RN3 improvement project - Improvement of the existing 4-leg intersection	- Connecting position is relatively closer to the inner city - New construction as a 3-leg intersection	- Connecting position is outer urban - Improvement of the existing 3-leg intersection
Railway crossing		High traveling performance and structural aspects in case of two-level crossing with flyover	Low impact on surrounding environment with an at-grade crossing. Temporarily stop often occurs due to rail crossing.	Same as 1-Alt.1 or 1-Alt.2
Land use / Social and environmental impact				
	Land acquisition	For 1 km, section between RN3 and the existing road connecting point.	Around connecting point to RN3	Large scale land acquisition is expected
	Resettlement	Commercial stores : Approx.20	Residences and shops	Commercial stores : Approx.20
	Control facilities	Private company facilities (2), Petrol station (1), Mosque (1), Islamic school (1), Junior high school (1), Educational facility (under construction,1), Swamp (Mangrove)	Church (1)	Private company facilities (2), Barn (1), Clinic (1), Church (2), Junior high school (1), Primary school (2), Cemetery, Swamp (Mangrove), German-style residence (1), Mobile phone base station
Construction cost (100 mil JPY)		20	15	24

Source: JICA survey team

(2) Access road on the left bank

On the left bank, there is adequate land for use of approach road between Wouri river side and the roundabout of Bonamoussadi. Road height difference between bridge section and the roundabout can be adjusted within the interval of approximately 1.3 km. To secure traffic access from residential area beside the approach road, service roads are to be prepared on the both side of the main road. Construction cost of the access road on the left bank is roughly estimated as approximately 600 million JPY excluding soft soil treatment works.



Source: JICA survey team

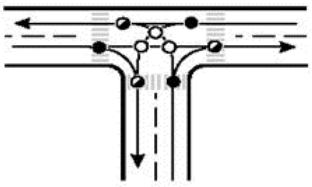
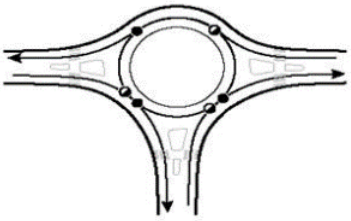
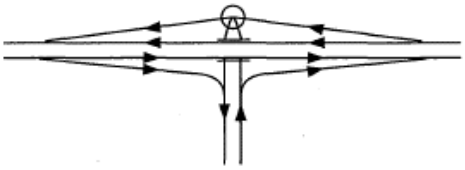
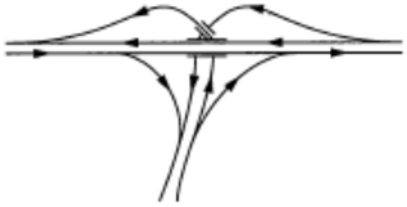
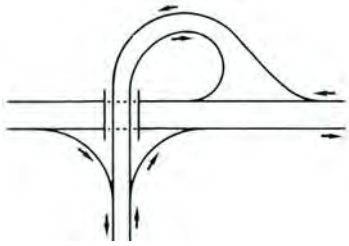
Figure 7.19 Plan and reference section of the access road in the left bank

7.4.2 Study of intersection

(1) Type of intersection

Intersection is the point of crossing of principal and accessory roads. To consider the most suitable type of intersection, clarification of each road class is the first condition. Two-level crossing is applied when the road's physical level or running speed is quite different between the crossing roads. Meanwhile, if the conditions are similar, at-grade intersection is selected. The follows show the description of typical intersections.

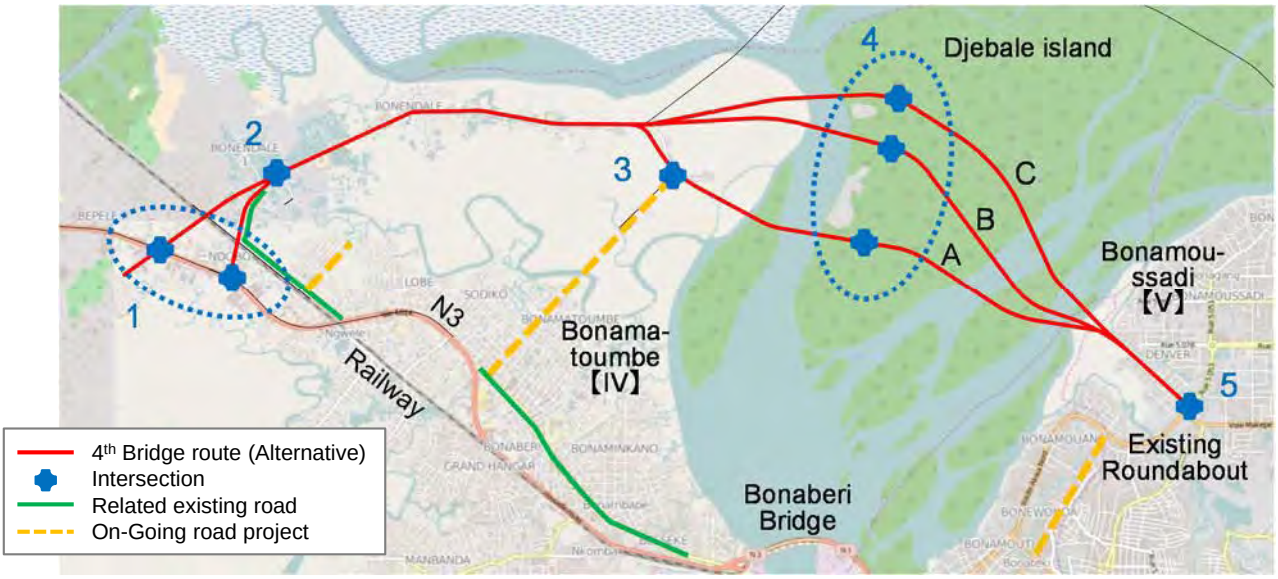
Table 7.7 Typical crossing type (Two-level and At-grade)

Figure	A. 	B. 
Type	Standard grade crossing	Roundabout
Signal control	Signalized	No
Description	- Most typical intersection - Less land acquisition - Less construction cost	- Grade crossing - Large land acquisition - Less construction cost
Figure	C. 	D. 
Type	Diamond	Semi-Directional Y type
Signal control	Signalized (As necessary)	No
Description	- Two-level crossing - Less land acquisition	- Three-level crossing - Suited to crossing of high-standard arterial road and general road - High cost due to multi-level
Figure	E. 	
Type	Trumpet	
Signal control	No	
Description	- Two-level crossing - Most typical type in multi-level intersection	-

Source: JICA survey team

(2) Crossing point of access roads and related roads

Through the route, five crossing points will be found at the locations indicated in the figure. Characteristics and description of the crossing points are shown below.



Source: JICA survey team

Figure 7.20 Location of the crossing points

Table 7.8 Type and description of crossing points

No.	Where connect to	Connection type	Description about Geometry
1	RN3	4-leg or 3-leg at-grade or grade-separated crossing	A detailed study will be required, including a survey of peak traffic volumes in both directions and an examination of the area of influence along the road. All the crossings constructed through the RN3 widening project are roundabouts.
2	Bonendale Road	3-leg at-grade crossing	To be considered only in case of Alt-1. In principle, the road crosses at grade.
3	Bonamatoumbe Road	3-leg at-grade crossing	Connectable only in case of A Route. At-grade intersection is recommended from point of land restriction due to fixed land development project in Bonamatoumbe.
4	Djebale Island village	At the present moment there is no vehicle traffic in the island, therefore, it is not desirable to develop largescale intersection which allow general traffic to come in the island. Because of this, develop as “Way stop” is recommended.	
5	Bonamoussadi crossing point	4-leg at-grade crossing	Connect to the existing roundabout in Bonamoussadi

Source: JICA survey team

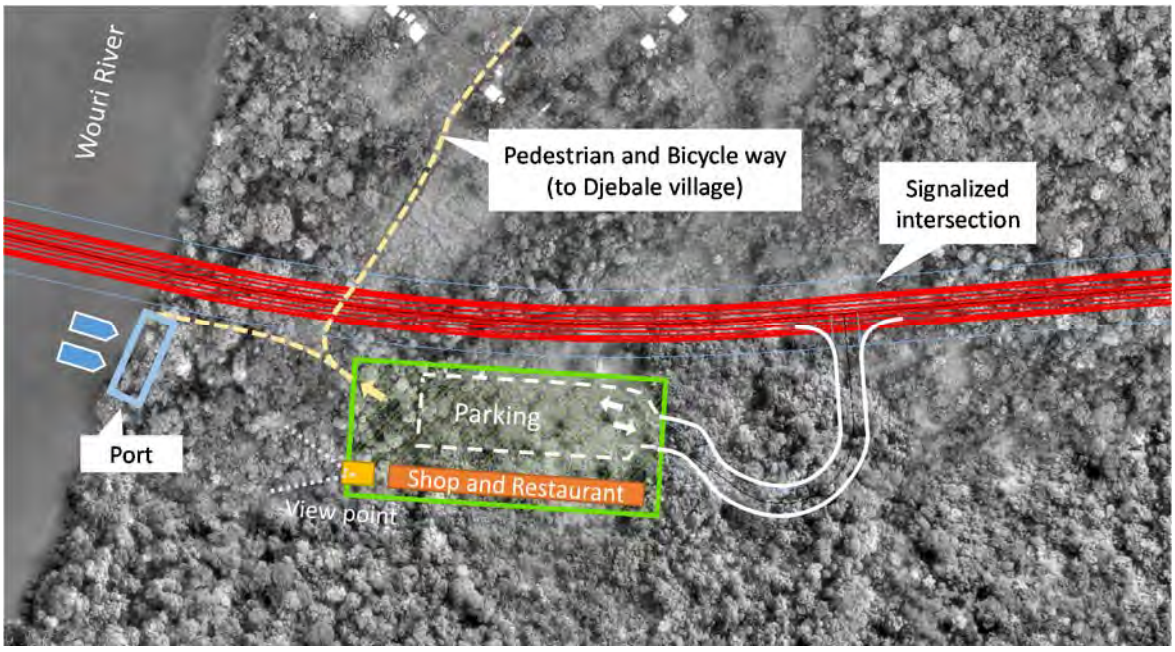
(3) Railway crossing

Any choice of the alternative route cannot avoid the railway crossing to connect to RN3 near Ndobo. At the moment, railway in Bonaberi is operated with single track and the service frequency is quite low.

According to CUD, they have no any upgrade plan such as double track or increasing frequency of operations so far. In general, road-rail crossing type is determined by considering adequacy of crossing type with understanding of railway's operation frequency and road traffic demand. In case of adopt at-grade crossing, the existing road along the railway (Rue.4544) can be utilized as an access to RN3, therefore, a certain traffic capacity can be dealt by connecting Bonendale Road.

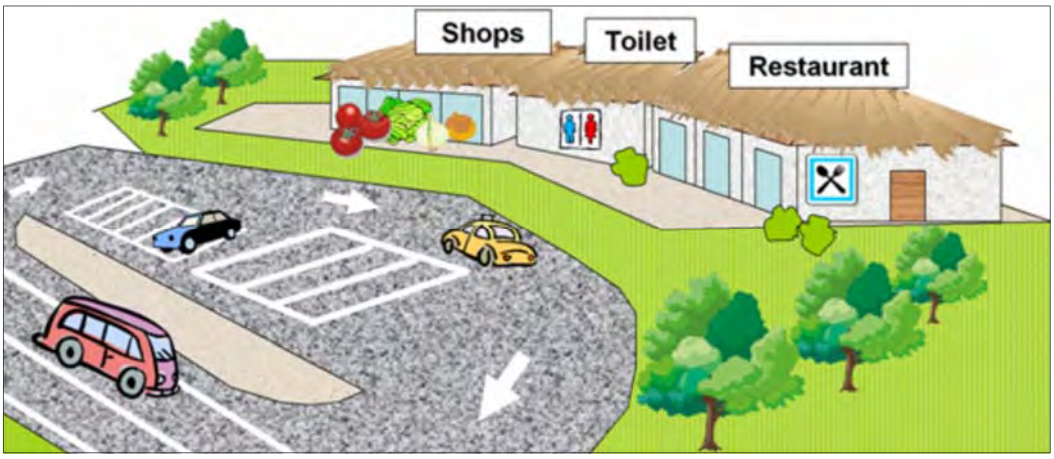
(4) Parking space in Djebale Island

For tourism development of Djebale Island which CUD and local villagers' desire, infrastructure improvement for traffic access to the island is discussed in this section. In the island there is no vehicle traffic and usually villagers move by walk or ship only. As a prerequisite condition to enhance the appeal of eco-tourism, any development activity must not effect a change of villagers' lifestyle, and protection of island's nature should be considered. Therefore, it is desirable that to prepare a parking space near the connection to the main bridge route to switch traffic mode from motorized vehicle to non-motorized. Every vehicle will be restricted to enter and must park at the space to access inside the island. Inevitably, the number of visiting people in the island is controlled by the parking capacity. The parking space can provide commercial facilities such as stores selling local products and restaurants. The facility models after "Michi-no-eki" of Japanese parking place. In addition to this, bicycle rental system is one of solution of tourism in the island, Visitor can switch from bus or vehicle to bicycle to go around a tourist route. Moreover, to develop a port on riverside of Wouri River and connect pedestrian way to the parking, it can be a landing place on the quay for pleasure boat and fishing place. In this matter, the space can be utilized as not only parking but also tourism development.



Source: JICA survey team

Figure 7.21 Proposed arrangement of the parking space in Djebale Island



Source: JICA survey team

Figure 7.22 General image of “Michi-no-eki”

7.5 Soft soil treatment countermeasures

7.5.1 Soil conditions

The survey team has conducted geological survey including borehole survey at 4 locations to figure out the geological conditions and characteristics along the scheduled route. Survey locations and soil conditions are summarized in the following figure.

Item	BH-2	BH-4	BH-3	BH-1
Drilling depth (m)	50.0	50.0	54.0	51.0
Foundation stratum depth (m)	30.0	38.0	21.0	43,5
Soft soil layer (m)	0	8.0	7.0	18.0
Summary	Soft and cohesive clay layer deposit within 5m thickness from the surface of the ground. Although the risk of consolidation settlement occurrence is not high, but some of sliding failure. Thus careful consideration is required for the design.	Sandy clay or silt layer (SPT N=1~7) deposit within 8m thickness from the surface of the ground. Although the risk of occurrence of consolidation settlement is not high, but some of sliding failure. Thus careful consideration is required for the design.	Borehole survey was conducted on the water at a depth of 3.8m. Fine-grained sand and organic soil deposit with 7m thickness from the surface of the ground. The risk of consolidation settlement and sliding failure is high. As the same geological condition can be expected on land near the point, thus careful consideration is required for the design.	Very soft organic clay (SPT N=0) deposit with 18m thickness from the surface of the ground. There is very high risk of consolidation and sliding failure. Thus soft soil treatment is required for construction of the embankment on the ground.

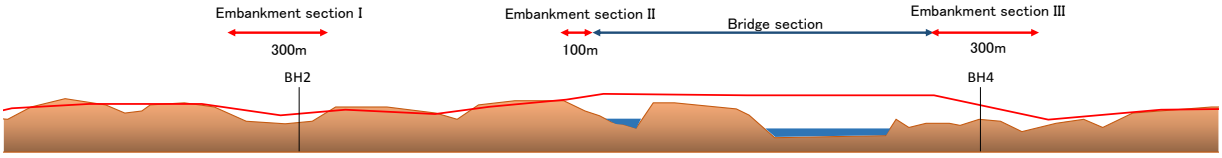
*Clay layer: N≦4, Sand layer: N≦15

Source: JICA survey team, Google Earth

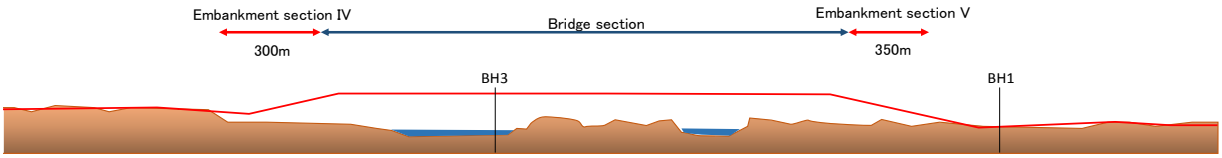
Figure 7.23 Summary of boring survey

7.5.2 Design conditions for countermeasure study

As stated above, it is determined that careful consideration for avoiding consolidation settlement and sliding failure is required according to the survey results. Application of countermeasures need to be considered in the embankment section Road longitudinal plan is shown in the Figure 7.24, and embankment sections are divided into 5 sections. Some of embankment sections needs to have retaining walls due to right of way limit. Maximum height of embankment is assumed 8m to 10m. Condition of each embankment section are summarized in Table 7.9.



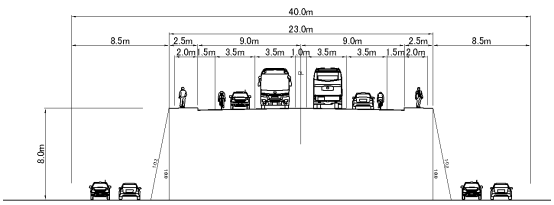
(a) The 1st half (Bonaberi – Djebale)



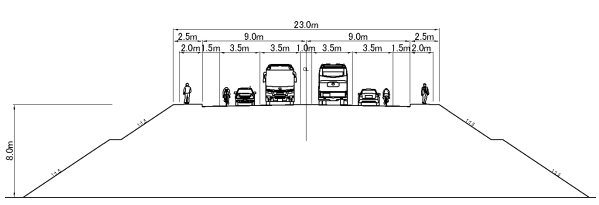
(b) The 2nd half (Djebale – Bonamatoumbe)

Source: JICA survey team, Google Earth

Figure 7.24 Summary of boring survey



(a) Retaining wall section (BH-1)



(b) Earthwork section (BH-2)

Source: JICA survey team

Figure 7.25 Typical cross section embankment section

Table 7.9 Conditions per embankment sections

Embankment section No.	Length (m)	Max. Embankment height (m)	Risk of soft ground		Remarks
			Consolidation settlement	Sliding failure	
I	300	8	Low	Mid	
II	100	10	Low	Mid	
III	300	10	Low	Mid	
IV	300	10	Mid	High	
V	350	10	High	High	Residential zone is close to the road. Thus application of neighboring construction method need to be considered for avoiding the deformation of structures.

Source: JICA survey team

7.5.3 Comparative study of countermeasure against soft ground

Countermeasures are selected with reference to Japanese standard, "Guideline for countermeasure against soft ground (Jun.2012)". As stated above, there are concerns such as settlement and sliding failure according to the survey results. Table 7.10 shows a result of rough comparison of selected countermeasure methods. It is noted that adaptivity of countermeasures should be discussed with more detail analysis based on geological and structural conditions at F/S stage.

Table 7.10 Comparison table of countermeasure method against soft ground

Countermeasure method	(A) Soil replacement method	(B) Geo-Synthetics method	(C) PVD (Prefabricated Vertical Drain)	(D) Deep mixing method	(E) EPS (Expanded Poly-Styrene)
Summary	Remove soft/weak stratum and replace good-quality soil. Long distance transportation is economically inefficient.	As the filling reinforced material formed in the shape of the sheet, geo-grid, geo-textile, synthetic, or steel material or the like is embedded at the bottom or inside of embankment.	Install prefabricated drainage materials into the ground at regular intervals. This method enhances effect to discharge pore water and advance of consolidation settlement.	To add and mix cement material into the ground by the dedicated machine in order to increase bearing capacity. The bearing capacity of created column will be improved as about 0.2 - 1.0 MPa.	Lighter weight materials such as expanded polystyrene is used as the filling material. EPS has effects of less embankment loading, decreasing consolidation settlement and improving structural stability.
Technical characteristics (decreasing effect against -)					
Consolidation settlement	Low	N/A	Mid	High	High
Sliding failure	Mid	Mid	Mid	High	High
Economical evaluation	Mid	Low	Low	High	High
Other evaluations					
Construction period	Mid	Short	Long	Mid	Short
Neighboring construction	Ineffective to decrease impact on surroundings.	Ineffective to decrease impact on surroundings.	Ineffective to decrease impact on surroundings.	Effective by applying low displacement method	Impact on surroundings can be controlled.
Application possibility	Stability for sliding failure is expected to improve. Can be applied at the embankment section I, II, and III.	Stability for sliding failure is expected to improve. Can be applied at the embankment section I, II, and III. By using together with (D) of low improve ratio, the combined method can be applied to the section IV.	Difficult to be applied to this project because the neighboring construction seems impossible and because the PVD construction will take about one year, during which the construction of bridge abutments cannot start.	Applicable to the section V due to structural superiorities of neighboring construction, restraining consolidation settlement and stability against sliding failure.	Applicable to the section V due to structural superiorities of neighboring construction, restraining consolidation settlement and stability against sliding failure.

Source: JICA survey team

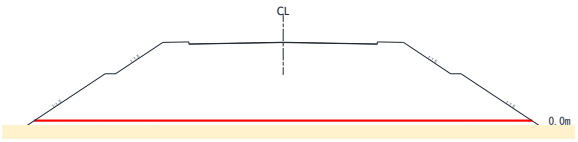
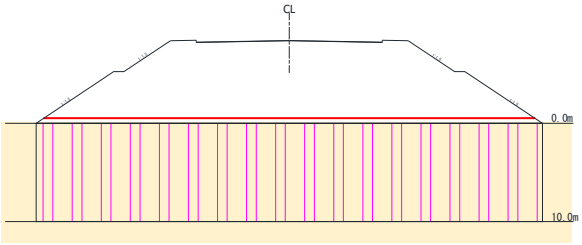
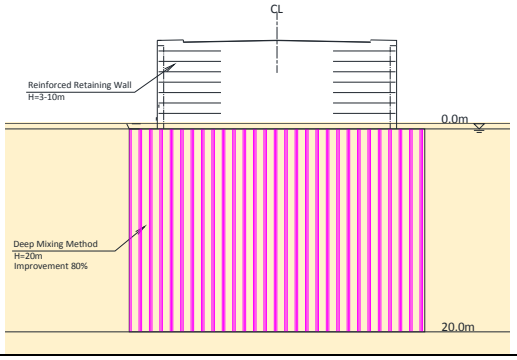
Based on the above study, measures to be proposed to each section are summarized in Table 7.11 and Table 7.12.

Table 7.11 Proposed countermeasure method and rough construction cost

Embankment section	Length (m)	Max. Embankment height (m)	Proposed measure to be applied	Rough construction cost (100 mil. JPY) *countermeasure works only
I	300	8	(B)	0.4
II	100	10	(B)	0.1
III	300	10	(B)	0.4
IV	300	10	(B) + (D)	0.7
V	350	10	(D)	2.5

Source: JICA survey team

Table 7.12 Applications of proposed countermeasure method

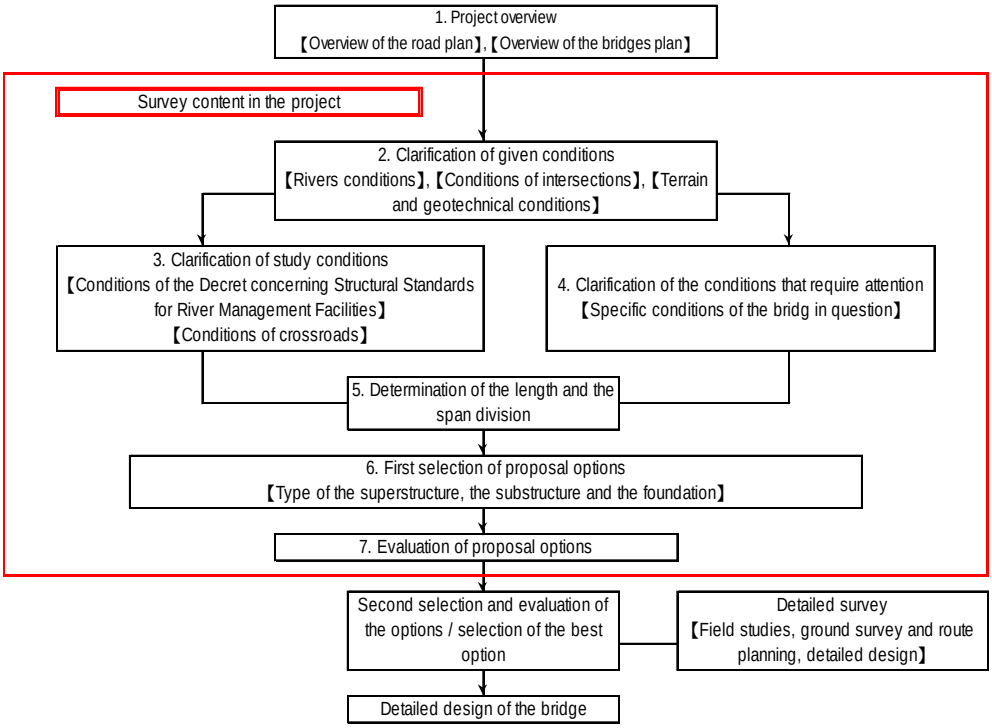
Countermeasure (B) Geo-Synthetics method Applied embankment section: I, II, III Reinforcing material strength: T=600kN/m2	
Countermeasure (B) + (D) Combined of Geo-Synthetics method and Deep mixing method Applied embankment section: IV Reinforcing material strength: T=600kN/m2 Deep mixing method : Improve ratio 20% Height 10m	
Countermeasure (D) Deep mixing method (and reinforced earth) Applied embankment section: V Deep mixing method : Improve ratio 80% Height 20m *To secure adequate width for service roads, reinforced earth retaining wall with vertical surface or slope of 1:0.2 will be applied for the walls.	

Source: JICA survey team

7.6 Study of bridges

7.6.1 Study flow

The study flow is as shown below. In this study, the conditions for bridge planning will be clarified. Based on the bridge types selected according to the conditions, the rough construction cost will be calculated and an evaluation conducted.



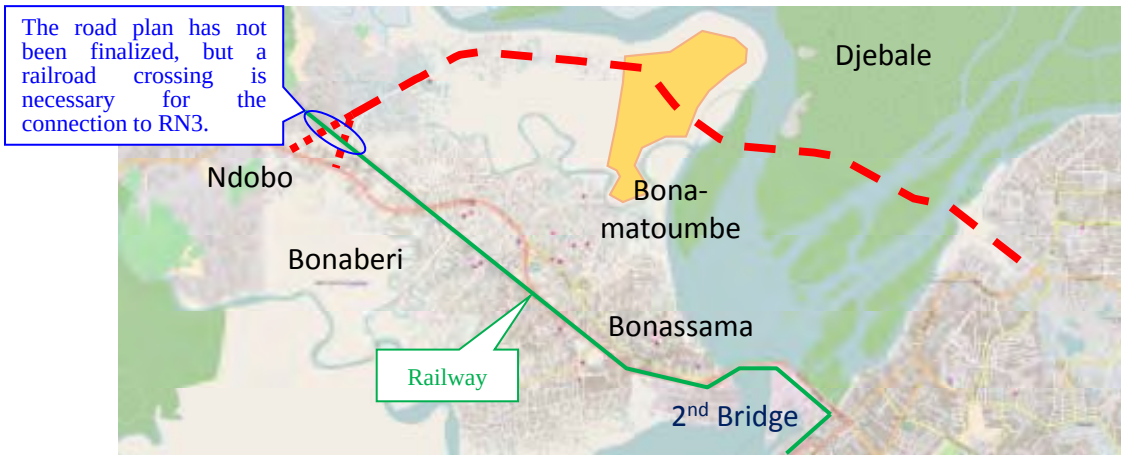
Source: JICA survey team

Figure 7.26 Study Flow

7.6.2 Clarification of given conditions

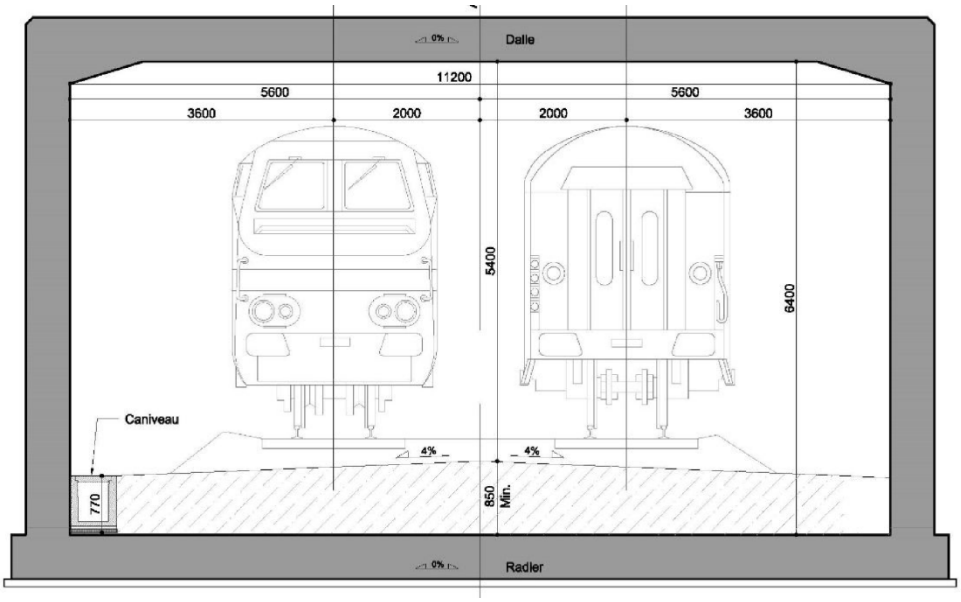
(1) Conditions for crossroads

There are no crossroads in the section crossing the Wouri River. There are no crossroads on either side of the route because land has already been obtained for the route although housing development is planned. With regard to the western section connecting with the NR3, a detailed study will be required, including a survey of peak traffic volumes in the section and an examination of the area of influence along the road, before a decision is made on how to connect these two roads (All the crossings constructed through the NR3 widening project are roundabouts.) The railroad near the connection point needs some measure like a bridge. Below are the conditions for the railroad crossing shown in the plan for the roads related to the 2nd Bridge.



Source: JICA survey team

Figure 7.27 Relationship between the Studied Route and the Railroad



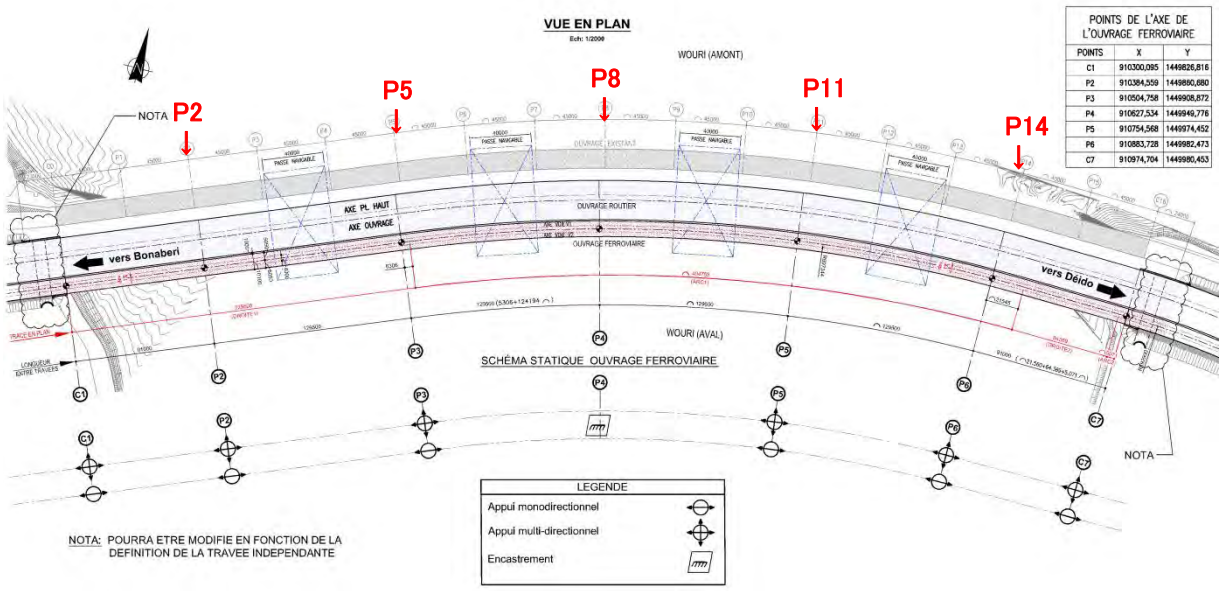
Width of interior: 11.2m, height of interior: 6.4m (5.4m on the railroad CL)

Source: FRANCHISSEMENT DU WOURI-SECOND PONT (2nd Bridge Design Report)

Figure 7.28 Conditions for the Railroad Crossing

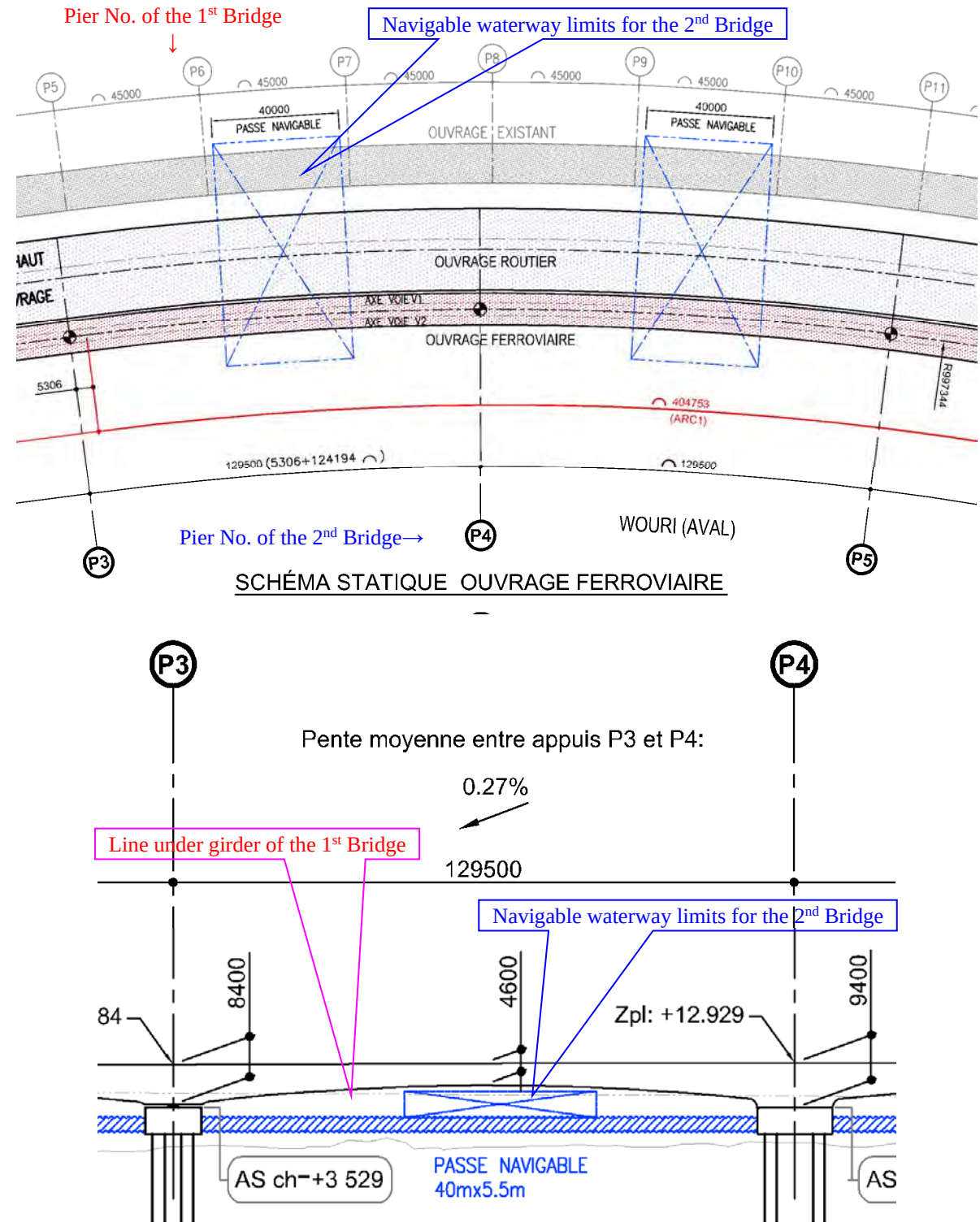
(2) Navigable waterway limits

Only small-size boats use the river, such as small fishing boats, Sand-Gathering Boats of equivalent size and pleasure boats. Navigable waterway limits (40m wide x 5.5m high) have been set for the second bridge, which is being constructed downstream of the planned site and MINTP has been interviewed about the reasons. They said, “Given the nature of the river, the water is shallow and large ships are unlikely to enter in future. Therefore, it was decided that the space to be secured under the girder should be the same size as that for the existing bridge (first bridge)” and provided us with the following drawing. Piers of the second bridge are being constructed on the line-of-sight of P2, P5, P8, P11 and P14 of the first bridge. The width is 40m because the span of the first bridge is 45m and the distance between piers is about 40m. The navigable waterway height limit is about the same as the clear headway under the girder of the existing bridge. An enlarged view of the following figure is shown on the next page. Based on the above, the navigable waterway limits for the fourth bridge should be 40m wide x 5.5m high.



Source: MINTP

Figure 7.29 Plan View of Navigable Waterway Limits



Source: MINTP

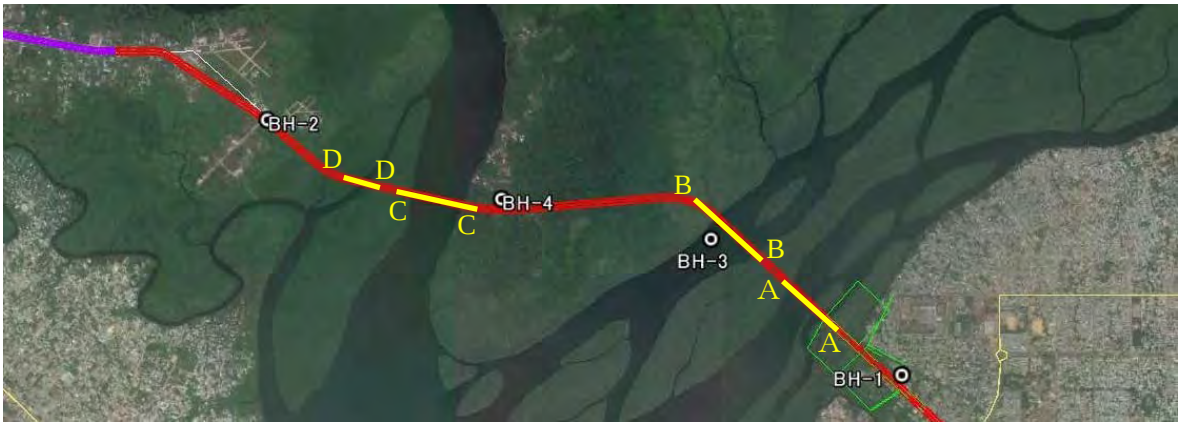
Figure 7.30 Navigable Waterway Limits (Enlarged)

(3) Mangrove habitats

In this survey, the mangrove habitats in each island were identified through field and river surveys. The result is described in the river survey cross-sectional view showing the river conditions. Considering the mangrove habitats as a given condition, the bridge plan will not include a plan to construct a substructure in such areas. The mangroves are 15-20m high. The height of mangroves is 15-20m. The mangrove forests in and around the survey area play an important role in the cultivation and restoration of marine resources as they form habitats for young and small fish as well as feeding and spawning grounds. Not only do the forests form valuable fishing grounds but they also provide firewood to local residents. Moreover, these forests are expected to provide resources for eco-tourism. Thus, the mangrove forests have a potential to contribute to the future development and revitalization of the area.

(4) River conditions

In this study, river cross-sectional drawings of the route were developed through surveying and have been developed for the following locations. The following table shows their characteristics and the drawings. As shown in the “River/ Hydrology” section of this report, the flow section and water level of the river are stable without large fluctuations.



Source: JICA survey team

Figure 7.31 Locations of the River Cross-Section Survey

Table 7.13 Characteristics of the River (1/2)

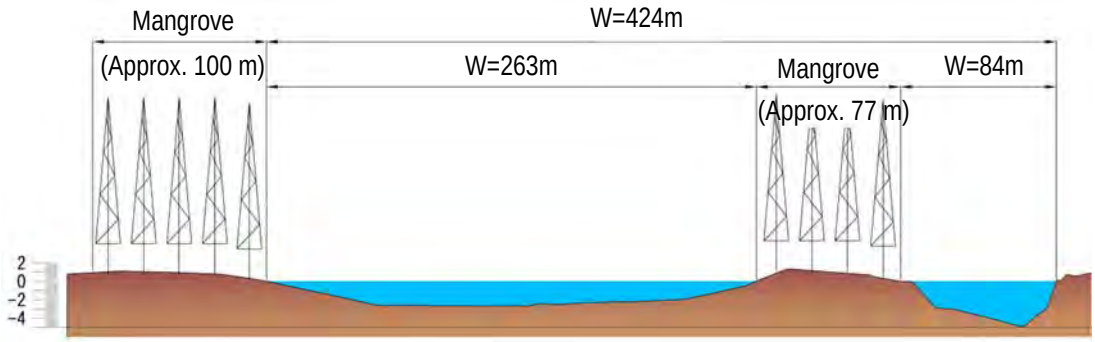
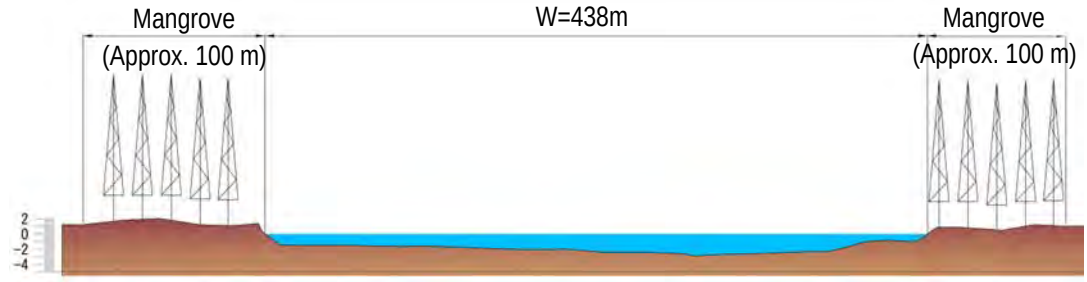
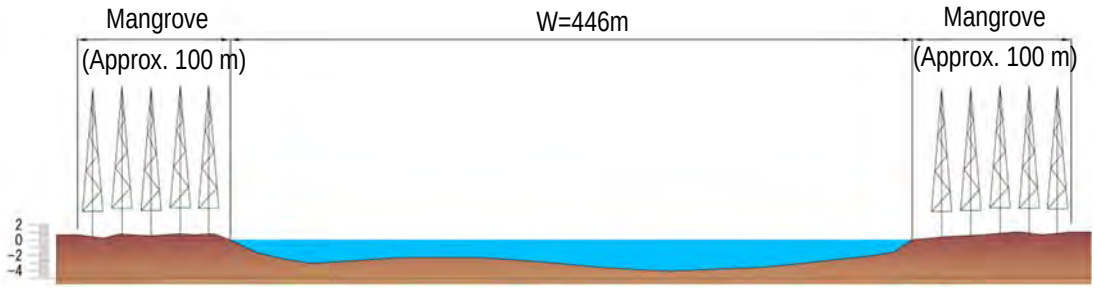
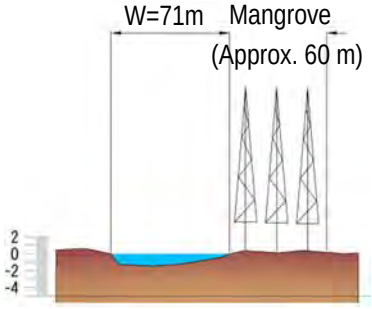
Cross-section No	Characteristics and River Cross-Sections
A-A	• The river widths are 263 and 84m and mangroves grow between them. • The water is 2-5m deep. • Mangroves grow on the west side of the river (left in the drawing). 
B-B	• The river 438m wide. • The water is about 2m deep. • Mangroves grow on both banks of the river. 
C-C	• The river is 446m wide. • The water is about 3m deep. • Mangroves grow on both banks of the river. 

Table 7.14 Characteristics of the River (2/2)

Cross-section No	Characteristics and River Cross-Section
D-D	・ The river is 71m wide. ・ The water is about 1.5m deep. ・ Mangroves grow on the east side of the river (right in the drawing). 

Source: JICA survey team

(5) Terrain and geotechnical conditions

In this study, geological surveys have been conducted on both banks of the Wouri River, Djebale Island and at the river on the east side – four locations in total. The characteristics are as shown below.

Table 7.15 Geotechnical Conditions

Boring No.	Characteristics
BH-1: Left bank	・ There is a clay layer (N = 0) from the ground surface to a depth of 18m. ・ This is followed by an unstable sand layer (N = 8-50) to a depth of 43m. ・ The sand layer starts at a depth of 43m from the ground surface and seems appropriate for a supporting layer.
BH-2: Right bank	・ There is a clay layer (N = 20) from the ground surface to a depth of 28m. (In some portion, N = 56) ・ The gravel layer (N > 30) starts at a depth of 30m from the ground surface and seems appropriate for a supporting layer.
BH-3: In river	・ There is a sand layer (N = almost 0) from the ground surface to a depth of 21m. ・ That gravel layer (N > 45) that starts at a depth of 22m from the ground surface seems appropriate for a supporting layer.
BH-4: Djebale Island	・ There is an unstable sand layer (N = 3-50) from the ground surface to a depth of 38m. ・ The gravel layer (N > 30) that starts at a depth of 38m from the ground surface seems appropriate for a supporting layer.

Source: JICA survey team

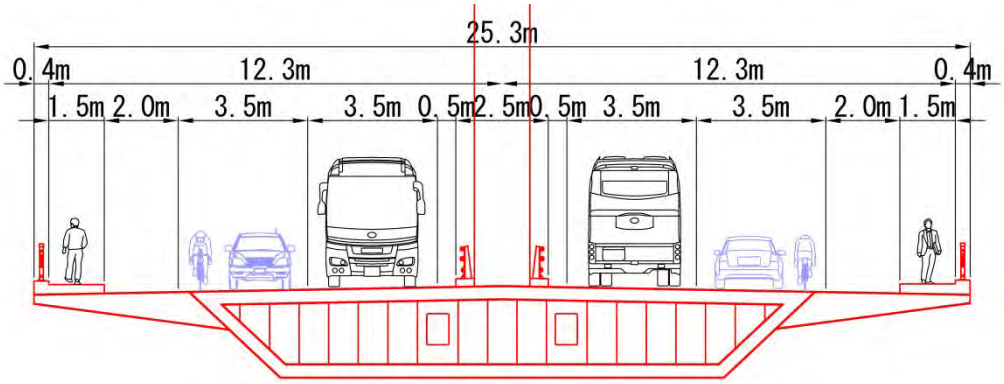
Source: JICA survey team

Figure 7.32 Locations of Geological Surveys

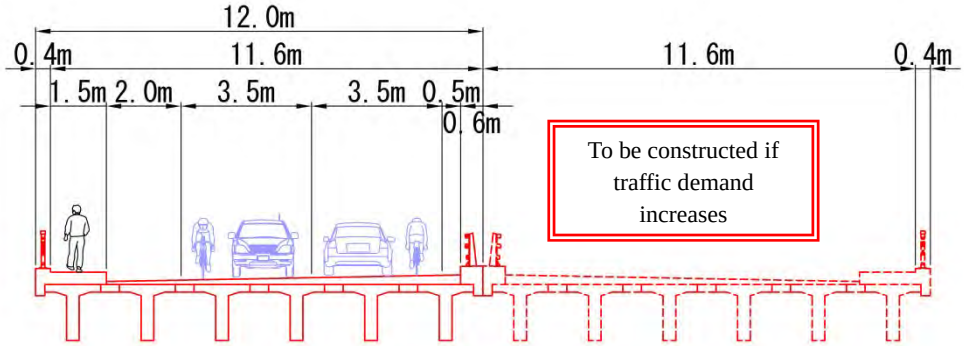
7.6.3 Clarification of study conditions

(1) Width composition

The width composition used for the study is as shown below. The first drawing is for a 4-lane road crossing the Wouri River and the second is for a 2-lane road crossing the railroad. The 2-lane road is tentative and may become a 4-lane road if traffic demand increases in future.



[Section crossing the Wouri River]



[Section crossing the railroad]

Source: JICA survey team

Figure 7.33 Drawing of Width Composition for Study

(2) Cross-sectional area blocking rate

In this study, the number of bridge piers to be installed in a river will be determined with attention to cross-sectional area blocking rates. The latter are calculated from the rate of the sum of the piers blocking the river flow to the river width. According to the "Cabinet Order concerning Structural Standards for River Management Facilities, etc." (River Law amendments in January 1992 and November 1997), the target rate is 5%, or exceptionally, 7% for shinkansen railway bridges and national express highway bridges. Concerning the 7%, 5% is the recommended target in the "Handbook for Planning of Bridges Crossing a River (Draft): July 2009, Japan Institute of Countryology and Engineering". Based on the above, the number of bridge piers will be determined with a target cross-sectional area blocking rate of 5%. As for the 5m pier width, it has been decided that it should be at least 5m to ensure the cross-sectional strength based on the bearing width of 15.2-2m (estimated from the result of the second bridge), the width of the bridge seats for these bearings and the pier height of about 25m.

Table 7.16 Relationship between the Number of Bridge Piers and the Cross-Sectional Area Blocking Rate

section No.	Width of the river (m) ①	Pier width (m)	Number of bridge piers	Total width of the piers (m) ②	Cross-sectional area blocking rate (%) ②/①*100	Assessment in relation to "5%"	Standard span length (m)
A-A	424	5	4	20	4.717	OK	84.8
	424	5	5	25	5.896	OUT	70.7
B-B	438	5	4	20	4.566	OK	87.6
	438	5	5	25	5.708	OUT	73.0
C-C	446	5	4	20	4.484	OK	89.2
	446	5	5	25	5.605	OUT	74.3
D-D	71	3	1	3	4.225	OK	35.5
	71	3	2	6	8.451	OUT	23.7

* The bridge size of section D-D will be smaller than that of the other sections due to its small width of the river, the pier width will therefore be 3 m.

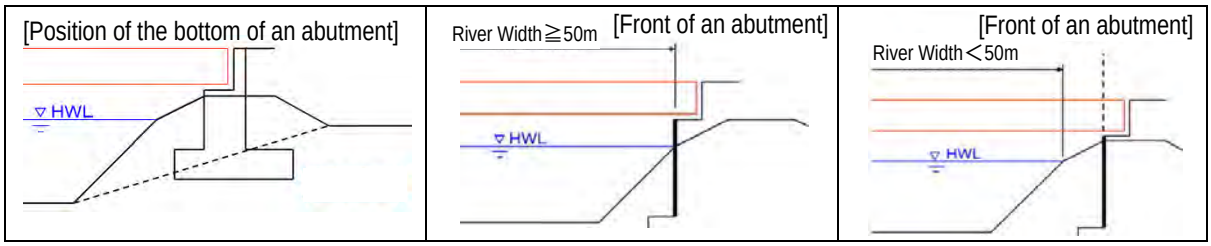
Source: JICA survey team

(3) Position of an abutment

Concerning the bottom of an abutment, Article 61 of the Cabinet Order concerning Structural Standards for River Management Facilities, etc. stipulates that "the bottom of an abutment constructed on an embankment shall be fixed on the embankment ground" and prohibits the construction of pile-bent abutments in an embankment area while posing height restrictions. The following figure illustrates it. As for the position of an abutment, there are standards for rivers both wider and narrower than 50m. The concrete contents were as shown below.

- The bottom of an abutment constructed in a river section with an embankment shall be at the height of the bank ground or lower.
- The "height of the bank ground" is considered a line between the front and rear toes of the bank for an area with an embankment and a line between the front toe and the point that is as wide as the crest.
- In case there is rock ground clearly distinguishable from the embankment ground, it can be lower than the ground (rock, etc.).
- River width 50m or more, back water section, high water section → The frame should not come before the intersection point of the slope face and HWL.
- River width less than 50m → The frame should not come before the embankment slope face.

In this study, the position of an abutment should meet the above conditions and should not interfere with the mangrove habitats.



Source: Handbook for Planning of Bridges Crossing a River (Draft)

Figure 7.34 Position of an Abutment

(4) Position of bridge piers from the riverbank

According to Article 63 Section 3 of the "Cabinet Order concerning Structural Standards for River Management Facilities, etc.", the side span length can be reduced to 25m if the average span length of the bridge is the same or longer than the standard span length (≦#50m). In the case of this bridge, based on the cross-sectional area blocking rates of the River Sections A-A, B-B and C-C, the average span length exceeds 90m. Therefore, the minimum distance between the part in question and the bridge shall be 25m.

(5) Supporting soil

Based on the soil investigation result, the supporting soil starts at a depth of about 40m from the ground surface. Therefore, consideration should be given to pile foundation, etc.

7.6.4 Clarification of the conditions requiring attention

(1) Conditions for calculating construction cost

In this study, the document outlining the cost estimation for the 2nd bridge has been obtained, describing the costs for the superstructure, substructure, foundation structure, tax and design and construction supervision. Concerning the rough construction cost for this study, the unit cost of each work item will be determined by reference to this document and the rough volume will be calculated to ascertain the rough construction cost.

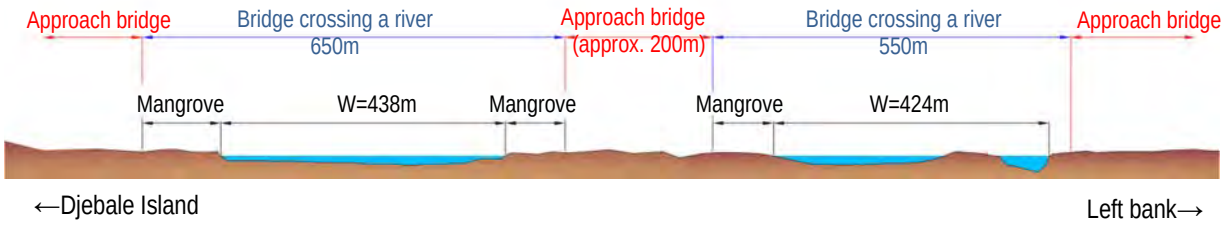
(2) Conditions for transportation

Following the investigation about bridge material suppliers, it has proved difficult to obtain high-quality steel materials for a steel bridge that meet the required performance. Accordingly, if a steel bridge is considered, the material transportation cost should be taken into consideration. In this study, steel material manufacturers have been interviewed about the steel material transportation cost. As for the transportation conditions, transportation by a chartered bulk carrier is assumed, given the lack of regular lines, while the transportation route is assumed to be between Hai Phong Port in Vietnam and Douala Port in Cameroon because Japanese companies have many steel processing plants in Vietnam. Based on these assumptions, the transportation unit cost should be 1400 USD/ton.

7.6.5 Basic bridge plan

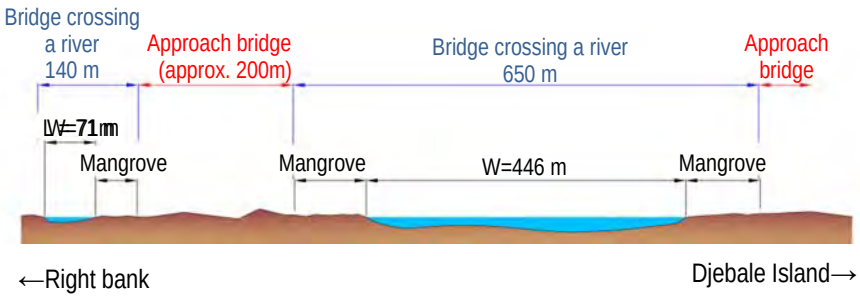
(1) Scope of the bridge plan

This river can be broadly divided into three streams on the left bank and two on the right. Another given condition includes a mangrove habitat, which may constrain the span setting. Accordingly, the study will be conducted separately for bridges traversing mangrove forests and rivers and approach bridges for which no embankment roads can be constructed due to the height of the road section. Based on the design manual of the Ministry of Land, Infrastructure, Transport and Tourism, the maximum structural height of an abutment should be 12m and the structural height of the ground surface should be 8m. The position where the level difference between the longitudinal slope of the road and the ground surface is about 8m is to be the position for the abutment and the starting/ending point of the scope of the bridge. Based on the above, the following drawings show the scopes of plans for the bridges crossing mangrove forests and rivers and the approach bridges for each stream of the river. The bridge lengths shown in the drawings are reference values and may vary depending on the span division.



Source: JICA survey team

Figure 7.35 Scopes of the Planned Bridges on "Cross-Section A-A (Right) and Cross-Section B-B (Left)"



Source: JICA survey team

Figure 7.36 Scopes of the Planned Bridges on "Cross-Section C-C (Right) and Cross-Section D-D (Left)"

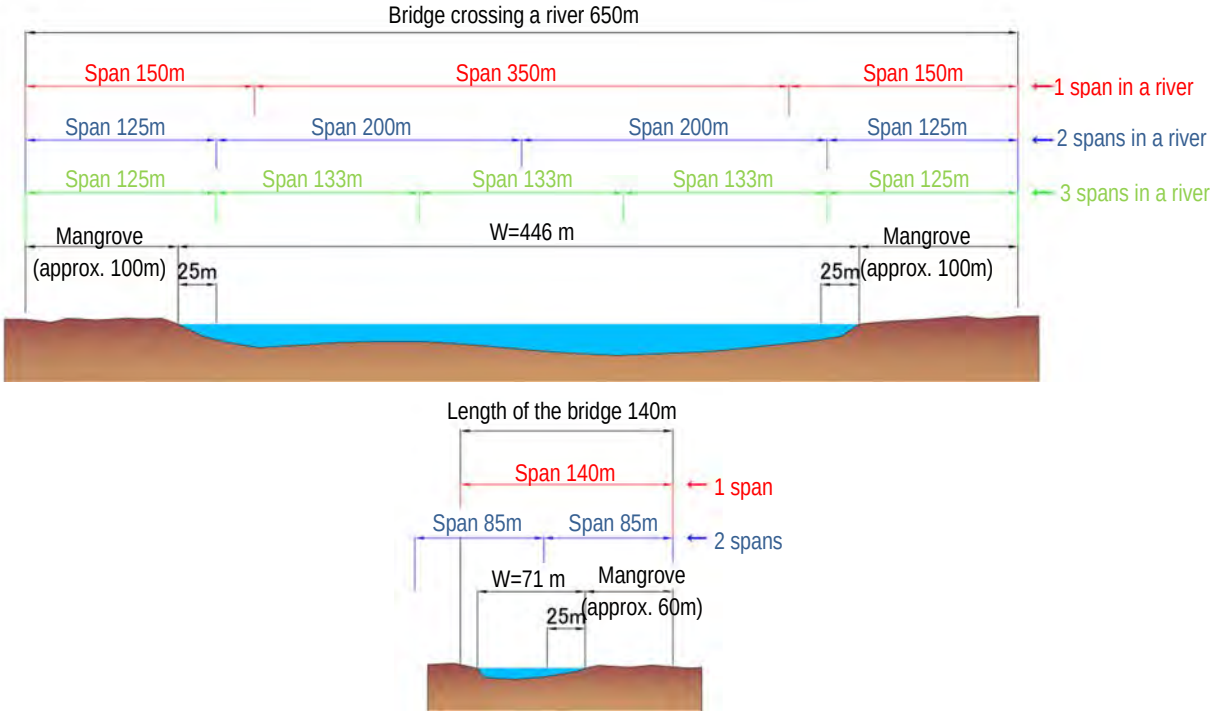
(2) Basic span division plan

With the above-described conditions and the bridge types to be described in mind, basic planning of the span division will be conducted for bridges crossing a mangrove habitat/river. The following matters should be considered for the planning:

[Bridges crossing a river longer than 400m in A-A, B-B or C-C]
- Based on the cross-sectional area blocking rate, the number of piers to be installed in a river should be four or fewer. ➔ The maximum number of bridge spans in a river should should be three.
- The minimum distance between a riverbank and pier should be 25m.
- Abutments or piers should not be constructed in a mangrove habitat.

[Bridges crossing a 71m river in D-D]
- Based on the cross-sectional area blocking rate, the maximum number of piers to be installed in a river should be one. ➔ Bridge with two spans or less
- The minimum distance between a riverbank and pier should be 25m.
- Abutments or piers should not be constructed in a mangrove habitat.

Below is the basic policy for span division using Cross-Section C-C as a representative example and the basic policy for Cross-Section D-D.



Source: JICA survey team

Figure 7.37 Basic Policy for Span Division

7.6.6 Selection of options for study

(1) Superstructure

1) Selection of spans and superstructures of the bridges crossing a river for study

The span length and forms of the bridges crossing a mangrove habitat and river are summarized below. For a steel bridge with a single span (140m) in the section of a 140m bridge, the types of bridges for the 133m span listed in the following table should be selected. PC bridges should not be considered because no types of simple PC bridges usable for a 140m span. According to the "[Reference Material] Standard Types and Spans (Bridges)" to be attached later, the bridge types for a two-span (85m) steel bridge should be the same as those for a 133m-span. Therefore, the bridge types for the latter should be used to study a two-span (85m) steel bridge. For a PC bridge, although a box-girder bridge constructed with the overhanging method

can be selected, it should be excluded from the study because, as described in the note below, the structure requires balancing and would be a three-span bridge requiring two piers, which would be unreasonable.

Table 7.17 List of Bridge Types Selected for the Study

[Steel Bridge]

Span	Span Division	Bridge Length of the Central Part	Bridge Type of the Central Part
133m	(125m)+3@133m+(125m)	400m	3-span continuous steel plate deck box-girder bridge 3-span continuous rationalized truss bridge 3-span Lohse girder bridge
200m	(125m)+2@200m+(125m)	400m	2-span Nielsen girder bridge
350m	150m+350m+150m	650m	3-span cable-stayed bridge

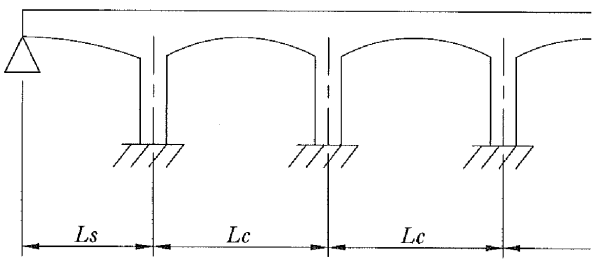
[PC Bridge]

Span	Span Division	Bridge Length of the Central Part	Bridge Type of the Central Part
133m	(90m)+5@133m+(90m)	400m	7-span continuous rigid frame box-girder bridge *Almost the same as the 2nd Bridge
200m	(125m)+100m+200m+100m+(125m)	400m	3-span extradosed bridge

Source: JICA survey team

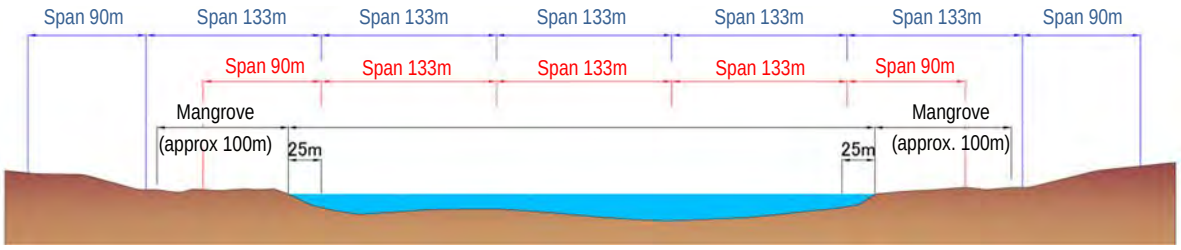
Note: 7-span continuous rigid frame box-girder bridge

This type of bridge has a structure that requires balancing around a bridge pier and Ls/Lc, the ratio of the span on both ends (Ls) and the central span (Lc), should be about 0.7. Under the conditions of this project, if 3 spans were planned for the central part, a pier would be constructed in a mangrove habitat. Therefore, the bridge should be planned as a 5-span bridge to avoid constructing a pier in a mangrove habitat.



Source: JICA survey team

Figure 7.38 Characteristics of a Continuous Rigid Frame Box-Girder Bridge



Source: JICA survey team

Figure 7.39 Measure to Avoid Construction in Mangrove Habitats (3 spans in the center [red measurements] ➔ 5 spans in the center [blue measurements])

2) Selection of spans and superstructure plans for study

Bridge types appropriate for a 20m approach bridge shall be selected. As this is a land bridge and there are no restrictions that impede selection, e.g. hindering the entry of construction vehicles, economic efficiency is important. Looking at past constructions in Japan, the most common land bridge is a continuous non-compositional II-girder bridge for a steel bridge and a post-tensioned cross T-girder bridge for a PC bridge because of their high economic efficiency and workability, with girders that can be fabricated near the site and installed by crane, etc. Under such circumstances, the bridge types for an approach bridge should be selected from among girder bridges. As for PC bridges, bridges with pre-tensioned girders produced in Japan should not be selected because they have no advantage over post-tensioned types in terms of transportation and other costs. The span should be at least 30m, which is a span used for a continuous non-compositional I-girder bridge and a post-tensioned cross T-girder bridge and should not exceed 60m, which makes it difficult to use a girder bridge in general.

Table 7.18 List of Bridge Types Selected for the Study

[Steel Bridge]

Span	Span Division	Bridge Length	Bridge Type of the Central Part
30m	A steel bridge should not be selected because its economic efficiency is obviously lower than that of a PC girder bridge for this span.		
40m	5@40m	200m	5-span continuous noncompositional I-girder bridge
50m	4@50m	200m	4-span continuous noncompositional I-girder bridge

[PC Bridge]

Span	Span Division	Bridge Length	Bridge Type
30m	32m+4@34m+32m	200m	6-span post-tensioned cross T-girder bridge
40m	5@40m	200m	5-span post-tensioned cross T-girder bridge
50m	4@50m	200m	4-span post-tensioned cross U-girder bridge

Source: JICA survey team

[Reference Material] Structures and Spans (Bridge Section)

		Bridge Type	Standard Applicable Span (m)	Girder height-span ratio h/L (f/L)		Judgement reasons other than span
Steel Bridge	Plate Girder	Continuous Noncompositional I-Girder	30 ～ 60	1 / 16 ～ 22	×	
		Continuous Noncompositional Box Girder	40 ～ 80	1 / 20 ～ 30	×	
		Steel Plate Deck I-Girder	30 ～ 60	1 / 22 ～ 28	×	
		Steel Plate Deck Box-Girder	40 ～ 150	1 / 22 ～ 28	○	
		Single Track I-Girder	35 ～ 55		×	
		Single Track Continuous I-Girder	35 ～ 70	1 / 15 ～ 20	×	
		Open Cross-section Box Girder	50 ～ 80		×	
		Narrow Box Girder (Composite - PC Slab)	55 ～ 90		×	
		Rigide Frame (rigidly-connected structure with pier)	50 ～ 130		×	
	Truss	Contiliver Truss	60 ～ 120	1 / 8 ～ 10	×	
		Rationalized Truss	70 ～ 140		○	
	Arch	Langer Girder	60 ～ 120	(1 / 6 ～ 7.0)	×	Unsuitable due to the difficulties of maintenance on Gerber
		Lohse Girder	80 ～ 160	(1 / 6.0 ～ 7.3)	○	
		Langer Truss	120 ～ 150	(1 / 6.8 ～ 6.9)	×	Lohse girder whose applicable span is longer is more desirable
		Trussed Langer Girder	80 ～ 140	(1 / 6.8 ～ 6.9)	×	Lohse girder whose applicable span is longer is more desirable
		Nielsen Girder	100 ～ 200	(1 / 6.5)	○	
		Unstiffened Arch	70 ～ 160	(1 / 5.3 ～ 6.3)	×	Lohse girder whose applicable span is longer is more desirable
		Cablestayed Bridge	130 ～ 400	1 / 4.7	○	
		Suspension Bridge	150 ～ 1900	1 / 8.4	×	Unsuitable because of diseconomy

(Note) commonly applied range　relatively applied range　selected in 1st step comparison　within applicalbe span but unsuitable due to economy and past results

Reference document : "11' Design data book" Japan Bridge Construction Association, "Concrete bridge design handbook" Japan Road Associationm "PC Bridge Planning Manual" Prestressed Concrete Association

			Bridge Type	Standard Applicable Span (m)	Girder height-span ratio h/L (f/L)		Judgement reasons other than span
Concrete Bridge	PC Bridge	Coupling	Pre-tensioning Coupling Slab Girder	5 ～ 24	1 / 14 ～ 24	×	
			Pre-tensioning Coupling T-Girder	18 ～ 24	1 / 18 ～ 20	×	
			Pre-tensioning Coupling U-Combo	15 ～ 20	1 / 14 ～ 16	×	
			Post-tensioning Coupling T-Girder	20 ～ 45	1 / 13 ～ 18	×	
			Post-tensioning Coupling Single Track	25 ～ 45	1 / 14 ～ 19	×	
			Post-tensioning Coupling Combo	25 ～ 45	1 / 13 ～ 17	×	
			Post-tensioning Coupling U-Combo	40 ～ 60	1 / 16 ～ 18	×	
		Continuos	Hollow Slab	20 ～ 30	1 / 22	×	
			Continuous Box Girder (Fixed Scaffolding)	30 ～ 60	1 / 17 ～ 20	×	
			Continuous Box Girder (Movalbe Scaffolding)	30 ～ 45	1 / 17 ～ 20	×	
			Continuous Box Girder (Incremental Launching)	30 ～ 60	1 / 15 ～ 18	×	
			Continuous Box Girder (Cantilever)	50 ～ 110	1 / 15 ～ 35	×	
			Continuous Wavy Web Girder (Fixed Scaffolding)	30 ～ 60	1 / 17 ～ 20	×	
			Continuous Wavy Web Girder (Incremental Launching)	30 ～ 60	1 / 15	×	
			Continuous Wavy Web Girder (Cantilever)	50 ～ 110	1 / 15 ～ 35	×	
		Rigid Frame	T-Rigid Frame Hollow Slab (Fixed Scaffolding)	20 ～ 30	1 / 22	×	
			T-Rigid Frame Box Girder (Fixed Scaffolding)	30 ～ 55	1 / 17 ～ 20	×	
			T-Rigid Frame Box Girder (Cantilever)	40 ～ 80	1 / 10 ～ 30	×	
			Continuous Rigid Frame Box Girder (Fixed Scaffolding)	30 ～ 55	1 / 17 ～ 20	×	
			Continuous Rigie Frame Box Girder (Cantilever)	50 ～ 140	1 / 15 ～ 35	○	
		Arch Bridge		70 ～ 250	(1 / 4 ～ 8)	×	This type of structure is generally applied to bridges over the valley, it is not suitable for those on flat terrain
		Cablestayed Bridge		100 ～ 260	1 / 40 ～ 100	×	If the central spans are 250 m, the piers of the shore spans will be dispatched to the mangrove extent and is not eligible.
		Extradosed Bridge		100 ～ 200	1 / 30 ～ 60	○	

(Note) commonly applied range　relatively applied range　selected in 1st step comparison　within applicalbe span but unsuitable due to economy and past results

Reference document : "11' Design data book" Japan Bridge Construction Association, "Concrete bridge design handbook" Japan Road Associationm "PC Bridge Planning Manual" Prestressed Concrete Association

[Reference Material] Structures and Spans (Approach Bridge)

		Bridge Type	Standard Applicable Span (m)	Girder height-span ratio h/L (f/L)		Judgement reasons other than span
Steel Bridge	Plate Girder	Continuous Noncompositional I-Girder	30 ~ 60	1 / 16 ~ 22	○	This type with the range of 30m is unsuitable because its economic efficiency is lower than that of a post-tensioning I-Girder bridge
		Continuous Noncompositional Box Girder	40 ~ 80	1 / 20 ~ 30	×	This type is unsuitable because its economic efficiency is lower than that of a Steel Plate Deck bridge
		Steel Plate Deck I-Girder	30 ~ 60	1 / 22 ~ 28	×	This type is unsuitable because its economic efficiency is lower than that of a Steel Plate Deck bridge
		Steel Plate Deck Box-Girder	40 ~ 150	1 / 22 ~ 28	×	This type is unsuitable because its economic efficiency is lower than that of a Steel Plate Deck bridge
		Single Track I-Girder	35 ~ 55		×	Single track bridge is unsuitable because of the priority given to continuous girder bridge due to its earthquake resistant structure.
		Single Track Continuous I-Girder	35 ~ 70	1 / 15 ~ 20	×	Unsuitable due to the difficulties of slab repair
		Open Cross-section Box Girder	50 ~ 80		-	
		Narrow Box Girder (Composite - PC Slab)	55 ~ 90		-	

(Note) commonly applied range; relatively applied range
selected in 1st step comparison; within applicalbe span but unsuitable due to economy and past results
Reference document : "11' Design data book" Japan Bridge Construction Association, "Concrete bridge design handbook" Japan Road Associationm "PC Bridge Planning Manual" Prestressed Concrete Association

			Bridge Type	Standard Applicable Span (m)	Girder height-span ratio h/L (f/L)		Judgement reasons other than span
Concrete Bridge	PC Bridge	Coupling	Pre-tensioning Coupling Slab Girder	5 ~ 24	1 / 14 ~ 24	×	
			Pre-tensioning Coupling T-Girder	18 ~ 24	1 / 18 ~ 20	×	
			Pre-tensioning Coupling U-Combo	15 ~ 20	1 / 14 ~ 16	×	
			Post-tensioning Coupling T-Girder	20 ~ 45	1 / 13 ~ 18	○	
			Post-tensioning Coupling Single Track	25 ~ 45	1 / 14 ~ 19	×	Post-tensioning T-Girder bridge (typical girder) is selected as the representative bridge at the first stage of the examination.
			Post-tensioning Coupling Combo	25 ~ 45	1 / 13 ~ 17	×	Post-tensioning T-Girder bridge (typical girder) is selected as the representative bridge at the first stage of the examination.
			Post-tensioning Coupling U-Combo	40 ~ 60	1 / 16 ~ 18	○	
		Continucs	Hollow Slab	20 ~ 30	1 / 22	×	Unsuitable due to maintenance problems (not applicable to a JICA project)
			Continuous Box Girder (Fixed Scaffolding)	30 ~ 60	1 / 17 ~ 20	×	This type is unsuitable because its economic efficiency is lower than that of a post-tensioning T-Girder bridge
			Continuous Box Girder (Movalbe Scaffolding)	30 ~ 45	1 / 17 ~ 20	×	This type is unsuitable because its economic efficiency is lower than that of aT-Girder bridge
			Continuous Box Girder (Incremental Launching)	30 ~ 60	1 / 15 ~ 18	×	This type is unsuitable because its economic efficiency is lower than that of a T-Girder bridge
			Continuous Box Girder (Cantilever)	50 ~ 110	1 / 15 ~ 35	-	
			Continuous Wavy Web Girder (Fixed Scaffolding)	30 ~ 60	1 / 17 ~ 20	×	This type is unsuitable because its economic efficiency is lower than that of a post-tensioning T-Girder bridge
			Continuous Wavy Web Girder (Incremental Launching)	30 ~ 60	1 / 15	×	This type is unsuitable because its economic efficiency is lower than that of a post-tensioning T-Girder bridge
			Continuous Wavy Web Girder (Cantilever)	50 ~ 110	1 / 15 ~ 35	-	

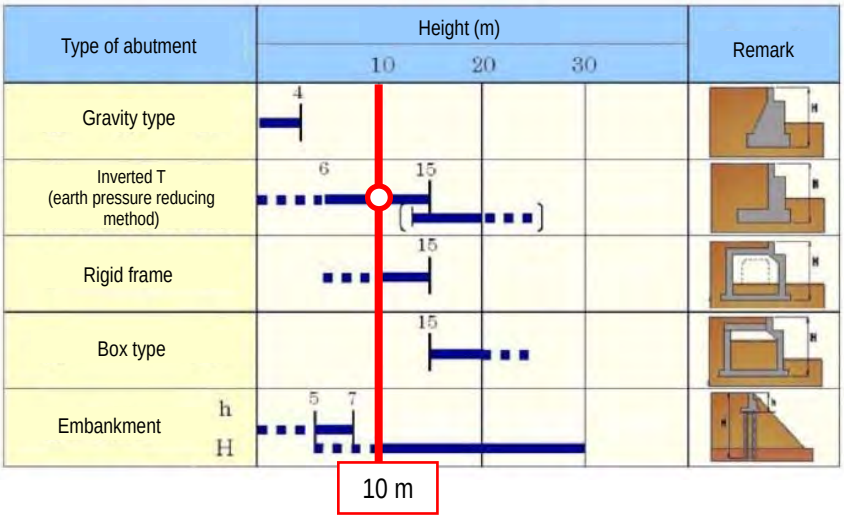
(Note) commonly applied range; relatively applied range
selected in 1st step comparison; within applicalbe span but unsuitable due to economy and past results
Reference document : "11' Design data book" Japan Bridge Construction Association, "Concrete bridge design handbook" Japan Road Associationm "PC Bridge Planning Manual" Prestressed Concrete Association

(2) Comparison of substructure

1) Abutment

The structural height of an abutment is determined by the embankment height of the attachment and the depth of penetration into the ground. In this plan, abutments are planned for roads with 8m embankment that are not too high (1 small level). The height on the ground will be 8m and, considering the thickness of deck slabs and the earth covering, the structural height will be about 10-12m. Based on these conditions and the following table, inverted T abutments, a common type for this size, should be selected.

Table 7.19 Rough Standards for the Selection of Abutments

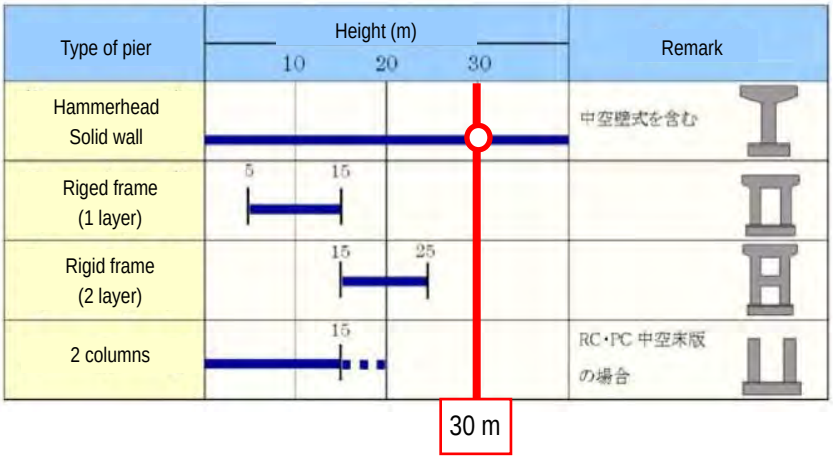


Source: Guideline for Civil Engineering Work Design, by the Ministry of Land, Infrastructure, Transport and Tourism

2) Bridge piers

The structural height of a bridge pier is determined by the height of the longitudinal section of the road and the depth of penetration into the ground. As it is an area with mangroves, the height on the ground surface will be 23m or more. Considering the depth of penetration into the bottom of the river (water about 3-5m deep and earth covering about 2m), posts should be about 30m high. Based on these conditions and the following table, overhang piers should be selected.

Table 7.20 Rough Standards for the Selection of the Bridge Pier Type



Source: Guideline for Civil Engineering Work Design, by the Ministry of Land, Infrastructure, Transport and Tourism

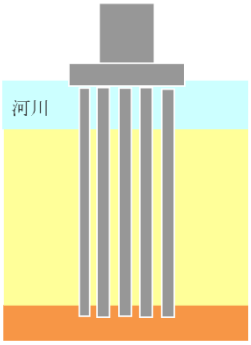
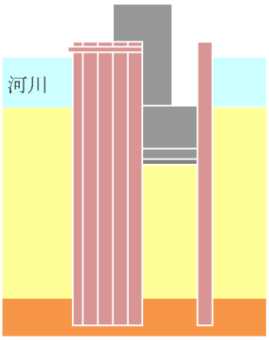
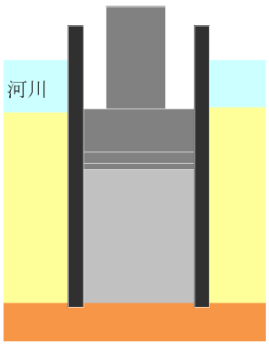
(3) Comparison of foundation structures

Geological surveys for this bridge were conducted in 4 locations (2 locations in the river, 2 locations on land). The result of the surveys indicates that attention should be paid to the following matters for the study of foundation structures.

- The water is about 3-5m deep.
- The structure should be able to withstand large vertical load (reaction force of superstructure). *Experience with large bridges
- The supporting layer lies comparatively deep. (40m or more from the ground surface)
- Construction will be carried out on water.

The table for selecting the foundation structure (on the following page) included in the highway bridge specifications and the actual results of the large river bridge foundation construction suggest that four types of bridge foundation – PHC piles with small bearing force, concrete cast-in-place piles except SC piles, steel pipe piles, steel pipe sheet pile sunk well foundation, and caisson – usable. When steel pipe piles and steel pipe sheet pile sunk well structure are compared, the latter is economically advantageous because the former requires a temporary cofferdam. Based on the above, candidate types are narrowed down to three types - concrete cast-in-place piles, steel pipe piles and caisson. The structural characteristics of these three types are as shown below. Following this comparison, cast-in-place piles are recommended and the study will be continued accordingly.

Table 7.21 Comparison of Foundation Structures

	Cast-in-place pile	Steel pipe sheet pile sunk well structure	Caisson
Foundation Type			
Structural Characteristics *Measures against scoring *Collision of ships	○ - Scoring does not easily occur in this river. - As it is assumed that only small ships will sail, there will be no problem if attention is paid at the design stage.	○ Strong	○ Strong
Ease of Construction	○ - This type has been used for the 2nd Bridge. - It requires the construction of a temporary bridge and a cofferdam.	○ - Many have been constructed on water due to the ease of construction. - It requires a temporary bridge.	○ - Many have been constructed on water due to the ease of construction. - It requires a temporary bridge.
Ease of Maintenance	○	△ - Attention should be paid to corrosion because steel materials are used.	○
Environmental Friendliness	△ - Attention should be paid to water quality when concrete is cast. - This type has been used for the 2nd Bridge.	△ - If piles are driven, attention should be paid to noise and vibration.	△ - A large machine may be required to sink the caissons fabricated on land and significant impacts may be exerted on the surrounding environment.
Construction Cost (Ratio from past cases)	○ (1: 00)	○ (1: 09)	△ (1: 22)
Evaluation	◎ (○-4, △-1)	○ (○-3, △-2)	△ (○-3, △-2) Economically disadvantageous

Sour: JICA survey team

Table 7.22 Relationship between the Ground Condition and Foundation Type

Adaptability				Pile foundation													
				Driving pile			Pile installation by inner excavation						Steel with soil pile	Concrete pile in site			
				PHC・SC	Steel-Pile		PHC-pile・SC-pile			Steel-Pile							
				PHC・SC	Driving	Vibratory hammer	Last blow	Spout stirring	Concrete-cast	Last blow	Spout stirring	Concrete-cast	Steel with soil pile	All-casing	Reverse	Drill	Cast in place
Soil condition	From ground to support layer	There is an extremely soft layer in the near ground or middle layer.		○	○	○	○	○	○	○	○	○	○	×	○	○	×
		There is an extremely hard layer in the middle layer.		△	△	△	○	○	○	○	○	○	○	△	○	×	○
		Gravel in the middle layer	Size 50mm less than	△	○	○	○	○	○	○	○	○	○	○	○	○	○
			Size 50～100mm	△	△	△	△	△	△	△	△	△	○	△	×	○	○
			Size 100～500mm	×	×	×	×	×	×	×	×	×	×	△	×	×	○
	Support layer	depth	5m less than	×	×	×	×	×	×	×	×	×	×	×	×	×	○
			5～15m	○	○	○	○	○	○	○	○	○	○	○	△	○	○
			15～25m	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			25～40m	○	○	○	○	○	○	○	○	○	○	○	○	△	△
			40～60m	△	○	○	△	△	△	○	○	○	○	△	×	○	×
			60m more than	×	△	△	×	×	×	×	×	×	△	×	△	×	×
		soil type	Sand,Gravel (30≦N)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			Cohesive soil (20≦N)	○	○	○	○	△	×	○	△	×	△	○	○	○	○
			Rock	×	○	△	○	△	×	○	△	×	△	○	○	○	△
			Hard rock	×	×	×	×	×	×	×	×	×	×	△	△	△	○
		The slope of support layer is steep.		△	△	△	△	△	△	△	△	△	△	○	○	○	○
	ground water	The water level is near ground.		○	○	○	○	○	○	○	○	○	○	△	△	△	△
		The amount of water is much.		○	○	○	○	○	○	○	○	○	△	△	△	△	×
		The height of water is more than 2m from the ground.		○	○	○	×	×	×	×	×	×	×	×	×	×	×
		The velocity of water is more than 3m/min.		○	○	○	○	×	×	○	×	×	×	×	×	×	×
Support type		Support pile		○	○	○	○	○	○	○	○	○	○	○	○	○	○
		Friction pile		○	○	○	×	×	×	×	×	×	○	○	○	○	
Site condition	water	The depth of water is less than 5m.		○	○	○	△	△	△	△	△	△	×	×	×	×	
		The depth of water is more than 5m.		△	○	○	△	△	△	△	△	△	×	×	×	×	
	The construction yard is narrow.			△	△	△	△	△	△	△	△	△	△	△	△	△	○
	Batter pile			○	○	○	×	×	×	×	×	×	×	×	×	×	×
	Poisonous gas			○	○	○	○	○	○	○	○	○	○	○	○	○	×
	area	Vibration and Noise		×	×	△	△	○	○	△	○	○	○	○	○	○	○
		The influence of the near structure		×	△	△	△	○	○	△	○	○	○	○	○	○	△

Adaptability → ○ : Good △ : not bad × : Bad

* PHC piles and PC piles are existing products with a small diameter, which have low bearing force and
Are likely to be used for large bridges, hence, they should be excluded from the study.

* When steel pipe piles, rotational piles and steel pipe sheet pile sunk well structure are compared, the former two are economically disadvantageous because they require a temporary cofferdam.
Although deemed inapplicable for construction in water, cast-in-place piles (all-casing) should still be selected because such construction is possible if a full arc rotating machine is used on a temporary bridge.

* As a pneumatic caisson is moderately applicable at a depth of 40-60m, an open caisson should be selected here.

Source: Pile Foundation Design Handbook

7.6.7 Evaluation of possible options

(1) Evaluation items and criteria

Plans for study will be selected using the evaluation items shown in the following table. The evaluation criteria should basically be the same as those for the basic structure and additional criteria about aesthetic and social characteristics will be included in response to the recipient country's wishes. In this study, rather than selecting the most appropriate plan, only the evaluation result will be presented.

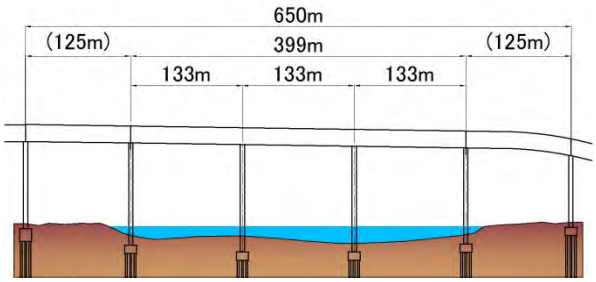
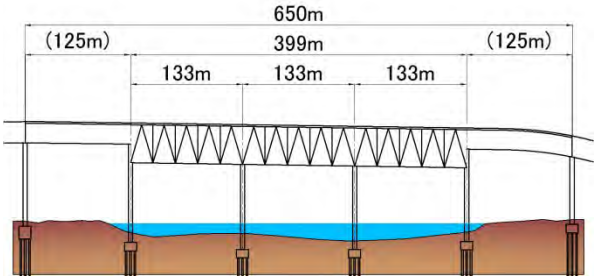
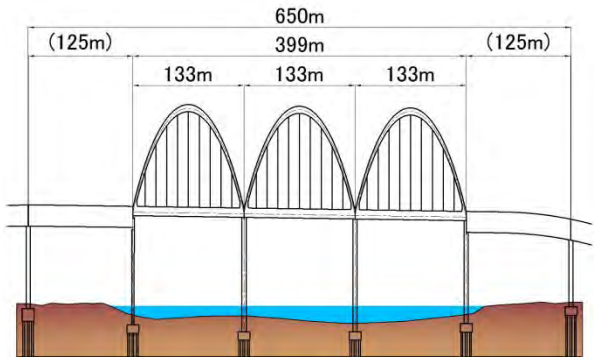
Table 7.23 Evaluation Items

Item	Contents of Evaluation		Evaluation
Structural characteristics	Earthquake resistance	Light load on substructure	◎
		Moderate burden on substructure	○
		Heavy load on substructure	△
	Quality	Mostly fabricated in plant ➔ Quality can be stable.	◎
		Fabricated in plant and on the spot	○
		Mostly fabricated on the spot ➔ Quality control is important.	△
Ease of construction	Ease (influence of weather)	Mostly fabricated in plant ➔ Not easily affected by weather	◎
		Fabricated in plant and on the spot	○
		Mostly fabricated in plant ➔ Easily affected by weather	△
	Construction period	Mostly fabricated in plant ➔ Quick	◎
		Fabricated in plant and on the spot	○
		Mostly fabricated in plant ➔ Slow	△
Ease of maintenance	Ease	Few components have to be managed.	◎
		Many components have to be managed.	○
	Difficulty	Low cost and frequency	◎
		High cost and frequency	○
Aesthetic characteristics	Tourism resource	Can be a tourism resource.	◎
		Ordinary bridge	○
Social characteristics	Contribution to the recipient country	Resources and plants of the recipient country usable.	◎
		Resources and plants of the recipient country will not be significantly used.	○
	C/P's wishes	This is the bridge type targeted by the C/P wishes.	◎
		This type has been used before and the C/P considers it a regular bridge.	○
Economic efficiency	Economic efficiency indicated in the ratio with a rough estimation or the lowest construction cost expressed as 1		

Source: JICA survey team

(2) Comparison table

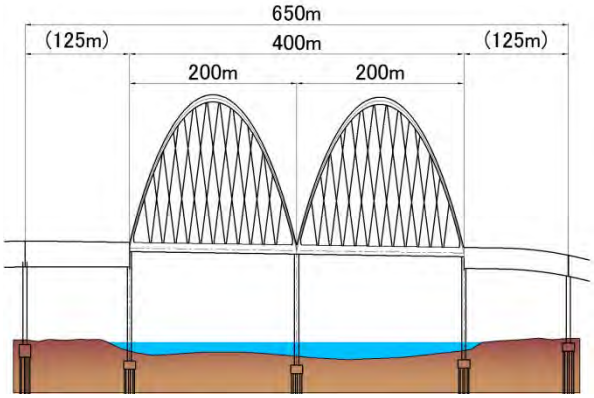
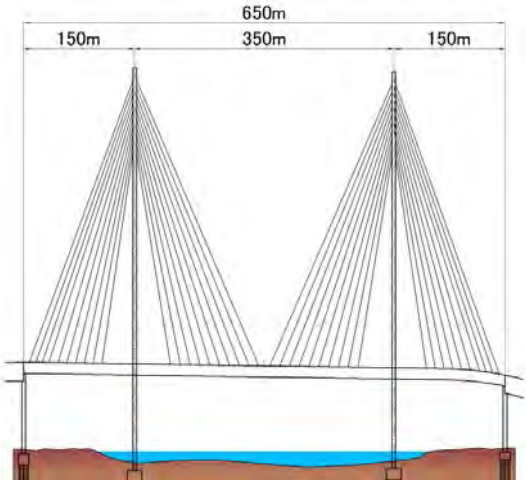
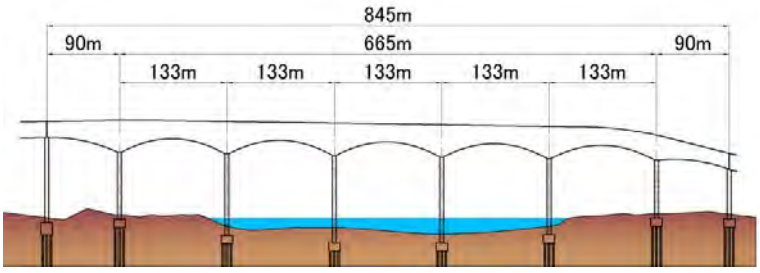
Table 7.24 Bridge Type Comparison Table – Section Crossing the River (1/3)

3-span continuous steel plate deck box-girder steel bridge			
	Structural Characteristics	Earthquake resistance	◎
		Quality	◎
	Ease of construction	Ease	◎
		Construction period	◎
	Ease of maintenance	Ease	◎
		Difficulty	○
	Aesthetic characteristics	Tourism resource	○
	Social characteristics	Contribution	○
		C/P's request	○
	Economic efficiency	1.544	
3-span rationalized truss steel bridge			
	Structural Characteristics	Earthquake resistance	△
		Quality	△
	Ease of construction	Ease	△
		Construction period	○
	Ease of maintenance	Ease	○
		Difficulty	○
	Aesthetic characteristics	Tourism resource	◎
	Social characteristics	Contribution	○
		C/P's request	○
	Economic efficiency	2.217	
3-span Lohse girder steel bridge			
	Structural Characteristics	Earthquake resistance	△
		Quality	○
	Ease of construction	Ease	○
		Construction period	○
	Ease of maintenance	Ease	○
		Difficulty	○
	Aesthetic characteristics	Tourism resource	◎
	Social characteristics	Contribution	○
		C/P's request	○
	Economic efficiency	2.007	

- The steel weight is 400kg/m^3 – 600kg/m^2 for a steel plate deck box-girder bridge and 600kg/m^3 – 800kg/m^2 for an arch or truss bridge.
- The fewer the components, the better the quality and ease of construction. In general, "box-girder < arch < truss".
- Cameroon has both arch and truss bridges.

Source: JICA survey team

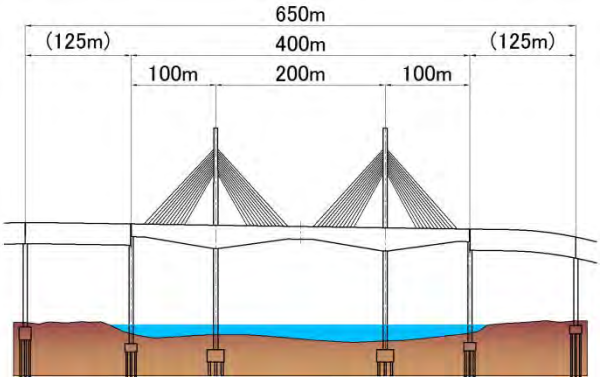
Table 7.25 Bridge Type Comparison Table – Section Crossing the River (2/3)

2-span Nielsen girder steel bridge			
	Structural Characteristics	Earthquake resistance	△
		Quality	○
	Ease of construction	Ease	○
		Construction period	○
	Ease of maintenance	Ease	○
		Difficulty	○
	Aesthetic characteristics	Tourism resource	◎
	Social characteristics	Contribution	○
		C/P's request	◎
	Economic efficiency	2.280	
3-span cable-stayed steel bridge			
	Structural Characteristics	Earthquake resistance	◎
		Quality	◎
	Ease of construction	Ease	○
		Construction period	○
	Ease of maintenance	Ease	○
		Difficulty	○
	Aesthetic characteristics	Tourism resource	◎
	Social characteristics	Contribution	○
		C/P's request	◎
	Economic efficiency	1.692	
7-span continuous rigid frame box-girder PC bridge			
	Structural Characteristics	Earthquake resistance	△
		Quality	△
	Ease of construction	Ease	△
		Construction period	△
	Ease of maintenance	Ease	◎
		Difficulty	◎
	Aesthetic characteristics	Tourism resource	○
	Social characteristics	Contribution	◎
		C/P's request	○
	Economic efficiency	1.000	

- A Nielsen bridge, which uses PC cables for suspension, is light and aesthetic and seems to meet the C/P's wishes.
- The steel weight of a cable-stayed steel bridge is 400kg/m^3 – 600kg/m^2.

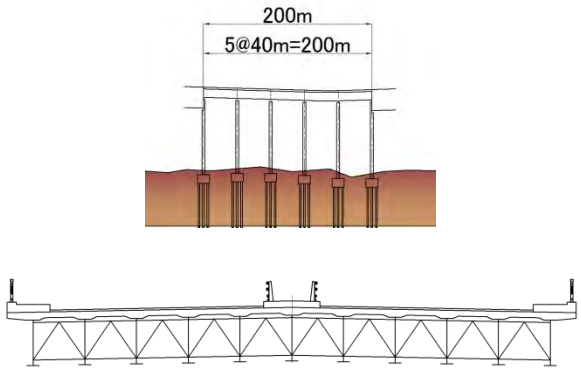
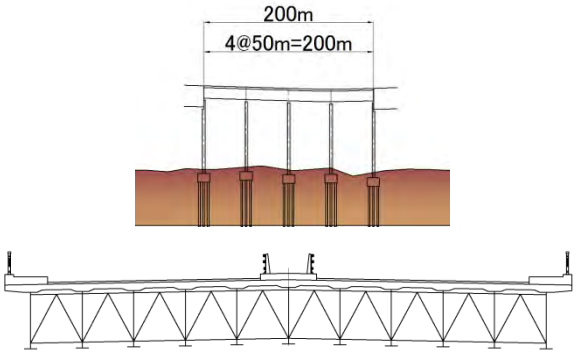
Source: JICA survey team

Table 7.26 Bridge Type Comparison Table – Section Crossing the River (3/3)

3-span extradosed PC bridge			
	Structural Characteristics	Earthquake resistance	△
		Quality	△
	Ease of construction	Ease	△
		Construction period	△
	Ease of maintenance	Ease	◎
		Difficulty	◎
	Aesthetic characteristics	Tourism resource	◎
	Social characteristics	Contribution	◎
		C/P's request	◎
	Economic efficiency	1.313	

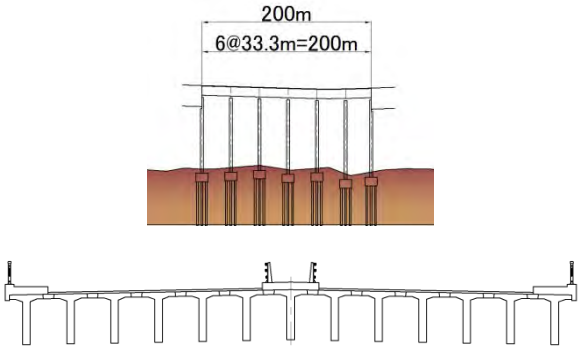
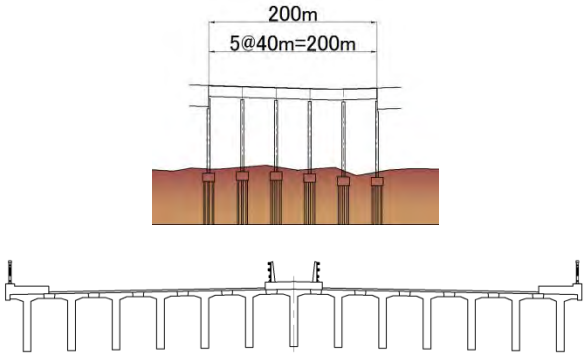
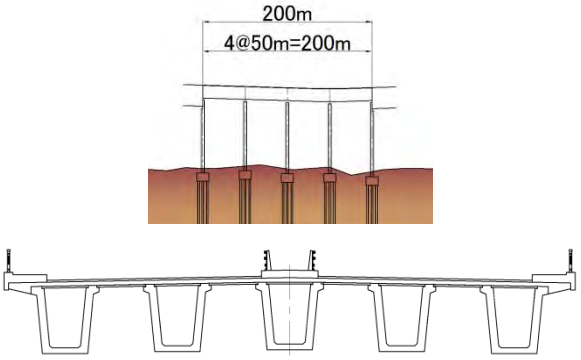
Source: JICA survey team

Table 7.27 Bridge Type Comparison Table – Approach Section (1/2)

5-span continuous non-compositional I-girder steel bridge			
	Structural Characteristics	Earthquake resistance	◎
		Quality	◎
	Ease of construction	Ease	◎
		Construction period	◎
	Ease of maintenance	Ease	◎
		Difficulty	○
	Aesthetic characteristics	Tourism resource	○
	Social characteristics	Contribution	○
		C/P's request	○
	Economic efficiency	1.321	
4-span continuous non-compositional I-girder steel bridge			
	Structural Characteristics	Earthquake resistance	◎
		Quality	◎
	Ease of construction	Ease	◎
		Construction period	◎
	Ease of maintenance	Ease	◎
		Difficulty	○
	Aesthetic characteristics	Tourism resource	○
	Social characteristics	Contribution	○
		C/P's request	○
	Economic efficiency	1.138	

Source: JICA survey team

Table 7.28 Bridge Type Comparison Table – Approach Section (2/2)

6-span post-tensioned cross T-girder PC bridge			
	Structural Characteristics	Earthquake resistance	○
		Quality	○
	Ease of construction	Ease	○
		Construction period	○
	Ease of maintenance	Ease	◎
		Difficulty	◎
	Aesthetic characteristics	Tourism resource	○
	Social characteristics	Contribution	◎
		C/P's request	○
	Economic efficiency	1.444	
5-span post-tensioned cross T-girder PC bridge			
	Structural Characteristics	Earthquake resistance	○
		Quality	○
	Ease of construction	Ease	○
		Construction period	○
	Ease of maintenance	Ease	◎
		Difficulty	◎
	Aesthetic characteristics	Tourism resource	○
	Social characteristics	Contribution	◎
		C/P's request	○
	Economic efficiency	1.238	
4-span post-tensioned cross U-girder PC bridge			
	Structural Characteristics	Earthquake resistance	○
		Quality	○
	Ease of construction	Ease	○
		Construction period	○
	Ease of maintenance	Ease	◎
		Difficulty	◎
	Aesthetic characteristics	Tourism resource	○
	Social characteristics	Contribution	◎
		C/P's request	○
	Economic efficiency	1.000	

- To construct a post-tensioned bridge, a fabrication yard for girders should be established near the site. With the yard roofed, high-quality girders can be made while unaffected by the weather.

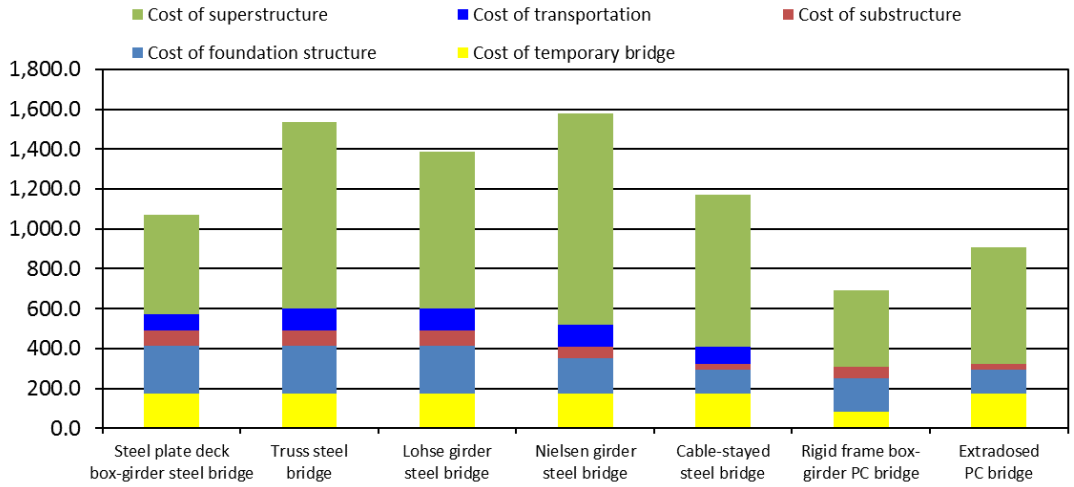
Source: JICA survey team

(3) Breakdown of the construction cost

Proportions of the construction cost of the superstructure, transportation (steel materials for a steel bridge), substructure, foundation structure and temporary bridge (for construction) will be clarified for each bridge type to be studied. The following chart shows the cost per m^2 of the bridge area.

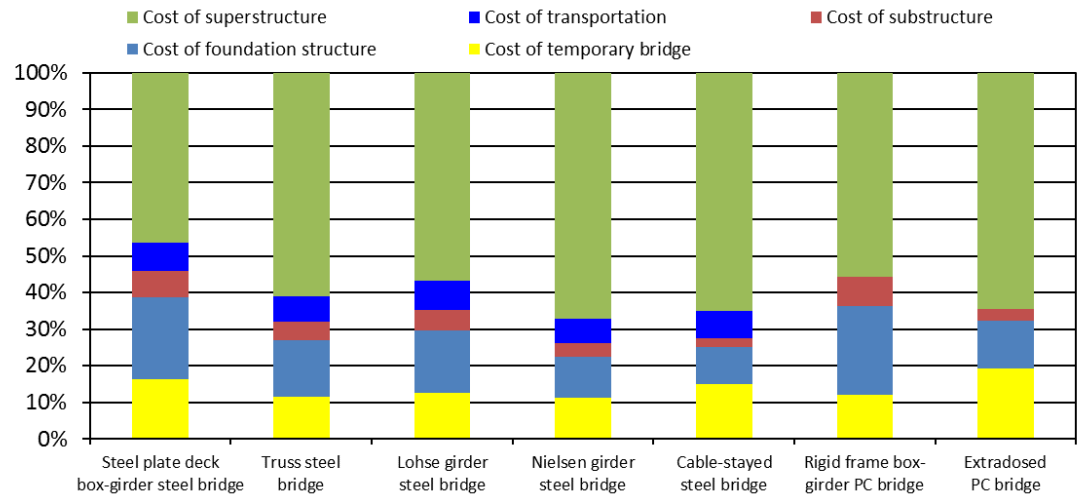
1) Section crossing a river

The construction cost for a Nielsen steel bridge is the highest, 1600K yen/m². The least expensive type is a rigid frame box-girder PC bridge, which is almost the same as the second bridge, at a construction cost of 700K yen/m². A cable-stayed steel bridge comes fourth in terms of economic efficiency because, compared with a truss or arch bridge, this type has fewer substructure units and requires less steel, making the substructure and transportation more economical. As for the construction cost proportions, the superstructure generally accounts for 50-70%, which is quite common. A PC bridge does not require material transportation cost and has larger proportions of the substructure and foundation structure.



Source: JICA survey team

Figure 7.40 Unit Cost per m^2 for Each Type of Bridge Crossing a River



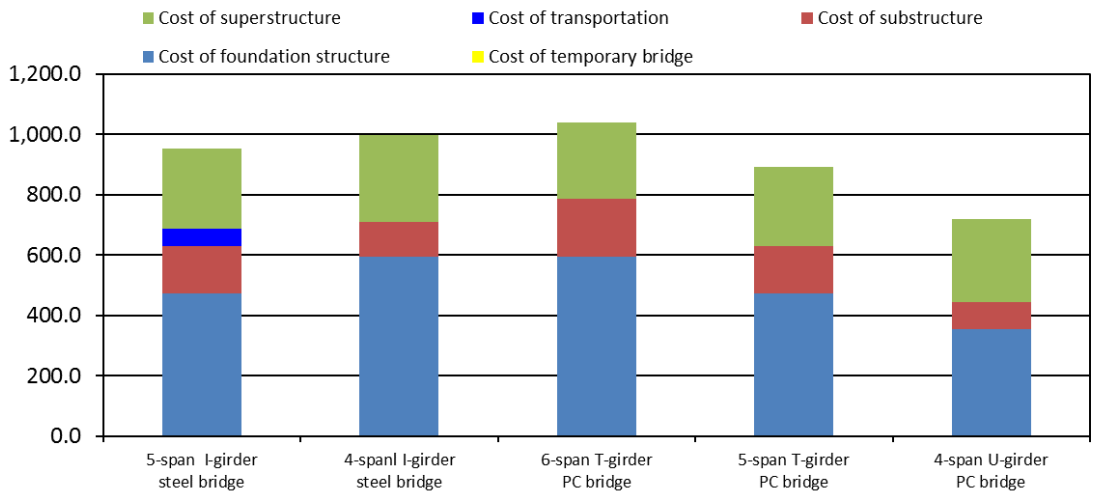
Source: JICA survey team

Figure 7.41 Construction Cost Proportions for Each Type of Bridge Crossing a River

2) Approach

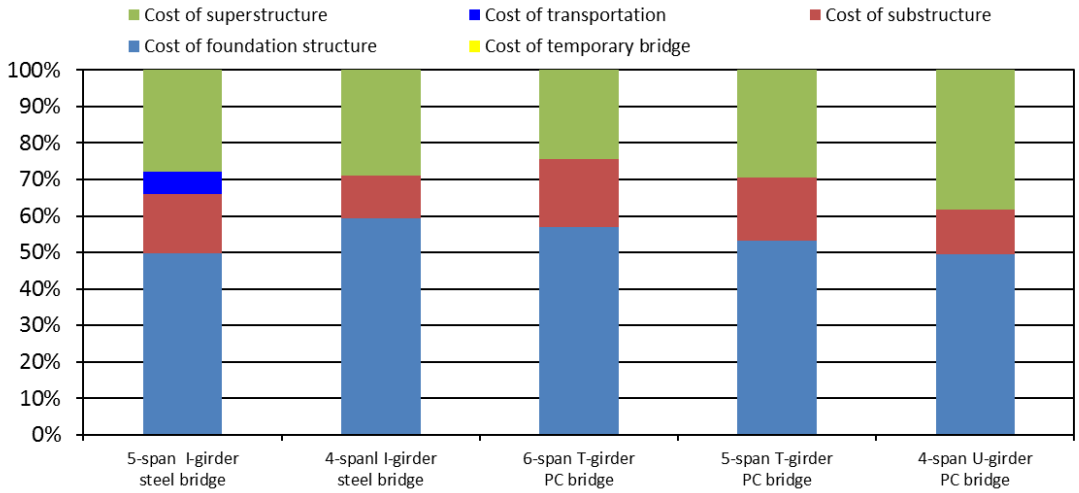
A six-span T-girder PC bridge is the costliest to construct at 1050K yen/m², while the least expensive type is a four-span U-girder PC bridge, costing 700K yen/m². A steel approach bridge tends to be more expensive, with few piers, while a PC bridge with numerous piers tends to be more expensive. A steel bridge is less advantageous than a PC bridge as the cost of transporting the superstructure is incurred.

In the case of elevated bridges in Japan, a PC bridge is less expensive than a steel bridge unless there are serious issues with construction conditions or the conditions for crossing a river. For post-tensioned girders (cast-in-place), a larger span is more advantageous.



Source: JICA survey team

Figure 7.42 Unit Cost per m^2 for Each Approach Bridge Type



Source: JICA survey team

Figure 7.43 Construction Cost Proportions for Each Approach Bridge Type

7.7 Total construction cost of each proposed plan

7.7.1 Bonamatoumbe (right bank) – Djebale – Bonamoussadi (left bank)

(1) Road/bridge plan with a focus on economic efficiency

For this plan, economically advantageous bridge types have been selected. As a PC bridge is selected in many cases, Japan's technologies will not be used much.

Table 7.29 Construction Cost Calculation Table 1

Location	Length	Structure	Construction cost (K yen)	Note
Bonamatoumbe – right bank	2300m	Embankment road	746,000	2-4 lanes
	70m	Bridge (approach)	1,276,000	PC T-girder
River on the right bank	170m	Bridge (river)	4,599,000	Steel box-girder
Island (on the right bank)	120m	Bridge (approach)	2,187,000	PC T-girder
Central river on the right bank	845m	Bridge (river)	14,802,000	PC rigid frame box-girder
Djebale Island	180m	Bridge (approach)	3,280,000	PC T-girder
Djebale Island	1430m	Embankment road	568,000	4 lanes
Djebale Island	160m	Bridge (approach)	2,803,000	PC T-girder
Central river on the left bank	840m	Bridge (river)	14,714,000	PC rigid frame box-girder
Island (on the left bank)	80m	Bridge (approach)	1,458,000	PC T-girder
River on the left bank	580m	Bridge (river)	10,160,000	PC rigid frame box-girder
Left bank – Bonamoussadi	185m	Bridge (approach)	3,371,000	PC T-girder
	1330m	Embankment road	824,000	4 lanes + reinforced earth wall
		Total	60,788,000	
		Japan's technologies – roads, included in the total	154,000	
		Japan's technologies – bridges, included in the total	2,493,000	
		Percentage of Japan's technologies as a proportion of total cost	4.35	

Source: JICA survey team

(2) Road/bridge plan with a focus on tourism development in Djebale Island

Unlike the plan described above, this plan features a cable-stayed steel bridge used to connect the right bank and Djebale Island. The cable-stayed bridge will symbolize tourism development in Djebale Island as a new type of bridge with new technologies sought after by Cameroon.

Table 7.30 Construction Cost Calculation Table 2

Location	Length	Structure	Construction cost (K yen)	Note
Bonamatoumbe – right bank	2300m	Embankment road	746,000	2-4 lanes
	70m	Bridge (approach)	1,276,000	PC T-girder
River on the right bank	170m	Bridge (river)	4,599,000	Steel box-girder
Island (on the right bank)	220m	Bridge (approach)	4,009,000	PC T-girder
Central river on the right bank	650m	Bridge (river)	19,264,000	Cable-stayed steel bridge
Djebale Island	280m	Bridge (approach)	5,103,000	PC T-girder
Djebale Island	1430m	Embankment road	568,000	4 lanes
Djebale Island	160m	Bridge (approach)	2,803,000	PC T-girder
Central river on the left bank	840m	Bridge (river)	14,714,000	PC rigid frame box-girder
Island (on the left bank)	80m	Bridge (approach)	1,458,000	PC T-girder
River on the left bank	580m	Bridge (river)	10,160,000	PC rigid frame box-girder
Left bank – Bonamoussadi	185m	Bridge (approach)	3,371,000	PC T-girder
	1330m	Embankment road	824,000	4 lanes + reinforced earth wall
Total			68,895,000	
Japan's technologies – roads, included in the total			154,000	
Japan's technologies – bridges, included in the total			16,437,000	
Percentage of Japan's technologies as a proportion of total cost			24.08	

Source: JICA survey team

(3) Road/bridge plan with construction between Bonamatoumbe and Djebale carried out by Japan

In this plan, the development of an access road to Djebale Island, where infrastructure needs to be improved, is prioritized. This plan is based on the assumption that the Japanese side will construct roads and bridges from the right bank to Djebale Island and that other donors will construct other roads and bridges.

Table 7.31 Construction Cost Calculation Table 3

Location	Length	Structure	Construction cost (K yen)	Note
Bonamatoumbe – right bank	2300m	Embankment road	746,000	2-4 lanes
	70m	Bridge (approach)	1,276,000	PC T-girder
River on the right bank	170m	Bridge (river)	4,599,000	Steel box-girder
Island (on the right bank)	220m	Bridge (approach)	4,009,000	PC T-girder
Central river on the right bank	650m	Bridge (river)	19,264,000	Cable-stayed steel bridge
Djebale Island	280m	Bridge (approach)	5,103,000	PC T-girder
Djebale Island	100m	Embankment road	79,000	4 lanes
Djebale Island				
Central river on the left bank				
Island (on the left bank)				
River on the left bank				
Left bank – Bonamoussadi				
Total			35,067,000	
Japan's technologies – roads, included in the total			0	
Japan's technologies – bridges, included in the total			16,437,000	Cable-stayed steel bridge
Percentage of Japan's technologies as a proportion of total cost			46.86	

Source: JICA survey team

7.7.2 NH3 – Bonamatoumbe (right bank)

For this road, an access road will be developed on the right bank and surrounding intersections will be improved to generate a development effect on Djebale Bridge. The following table shows the roads and bridges to be developed and the rough cost of such construction. The rough construction cost has been calculated by referencing the project cost document for improvement works in two sections on the east and west sides of NH3 collected during this study. The cost for the road has been calculated from the cost per unit paved area (cost of a similar road project divided by paved area), while the cost for the overpass has been calculated from the average cost of the flyovers in three locations constructed in similar projects.

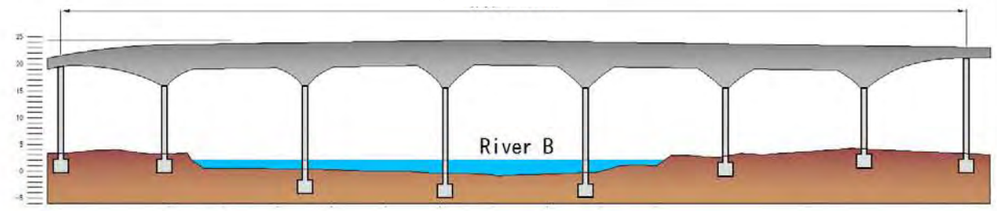
Table 7.32 Construction Cost Calculation Table 4

Location	Length	Structure	Construction cost (K yen)	Note
Intersection on RN3	-	Roundabout	22,000	At-grade intersection
Intersection on RN3 – Railway	700m	Widened road	156,000	2 lanes
Overpass	30m	Bridge	568,000	PC T-girder
Overpass – Bonamatoumbe	5,900m	Widened road	1,316,000	2 lanes
		Total	2,062,000	

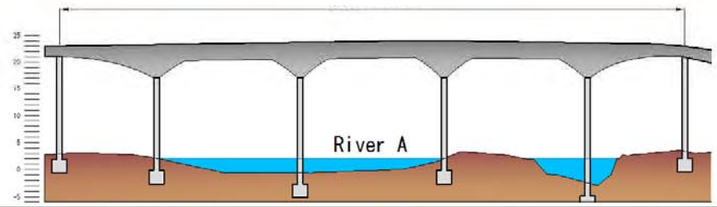
Source: JICA survey team

Plan A1:S=1:250 A3:S=1:500

Bridge length 840 m



Bridge length 580 m



Common bridge type
Economic efficiency
Tourism development

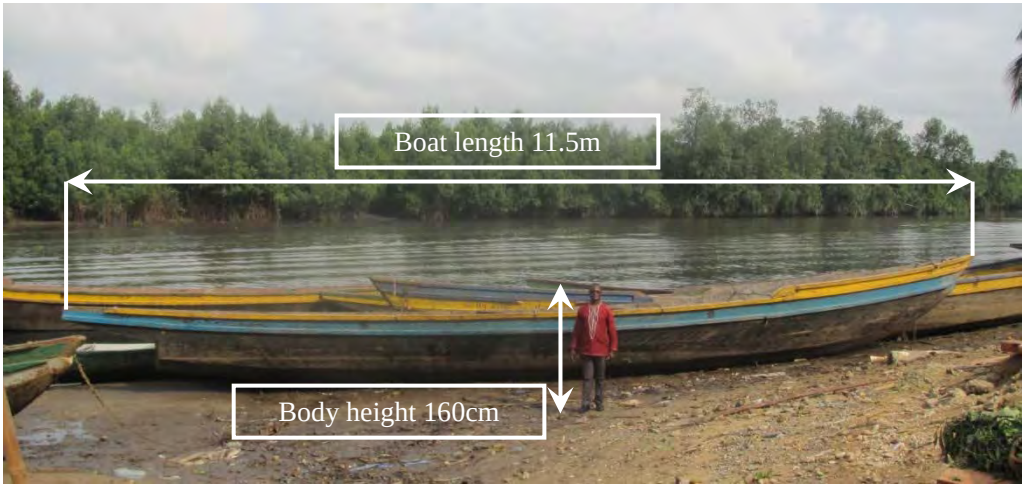
Bridge length 170m

Republic of Cameroon MINTP and CUD JAPAN INTERNATIONAL COOPERATION AGENCY	CONSULTANTS: INGEROSEC CORPORATION Metropolitan Expressway Co., Ltd. Nippon Koei Co., Ltd.	PROJECT NAME: Data Collection Survey on the Transport Network Development in Douala, Republic of Cameroon	DRAWING TITLE: PLAN	DATE: PREPARED BY: CHECKED BY:	DRAWING No. :

7.8 Other matters to consider for the study of bridges

7.8.1 Matters to consider concerning navigable waterway limits of the Djebale Bridge that will be desirable in future

During the visit to Japan organized by our research institution, visitors took a sightseeing boat connecting Asakusa and Odaiba to observe new and old bridges over the Sumida River. Having an interest in sightseeing boats, Mr. Gilbert, Deputy Mayor of Duala city and Mr. Yango of CUD seemed to think that operating sightseeing boats around Djebale Island would benefit future tourism development. If ships other than small boats such as sightseeing boats meander along the Wouri River, attention should be paid to the water depth. According to the result of the survey conducted in this study, the water depth in some spots is about three meters, meaning the draft depth should probably be 2m or less. As for the width of the navigable waterway, attention should be paid to ship length and, according to the "Technical Standards of Port Facilities and Explanations (supervised by the Ports and Harbor Authority, the Ministry of Transport), the width should be 1.5-2.0 times longer than the ship length if ships often pass each other. Currently, Sand-Gathering Boats often travel and the width of the navigable waterway should be at least 23m – twice as long as the boat length. Moreover, in case the type of sightseeing boats described below are operated in future, the width of the navigable waterway should be at least 45m – 1.5 times longer than the boat length. Below are the conditions for the boats on the Sumida River, which were observed during the visit to Japan and the specifications of sightseeing boats:



Source: JICA survey team

Figure 7.44 Size of a Sand Gathering Boat

Conditions for Boats on the Sumida River	Specifications of Sightseeing Boat "Himiko"
Total length 30m, draft up to 2m 	Total length 30m, width 8.5m 

Source: Bureau of Construction, Tokyo Metropolitan Government, and Tokyo Cruise Ship

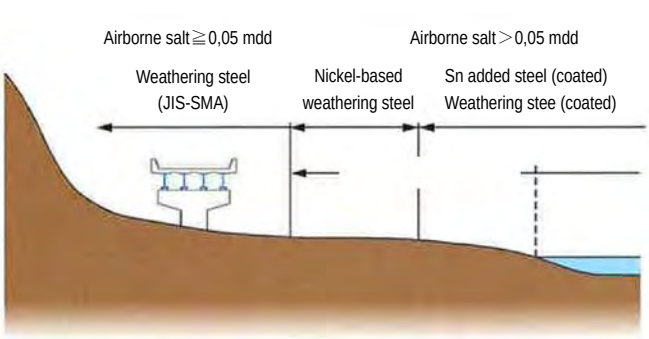
Figure 7.45 Conditions for Boats on the Sumida River and Specifications of the "Himiko" Sightseeing Boat

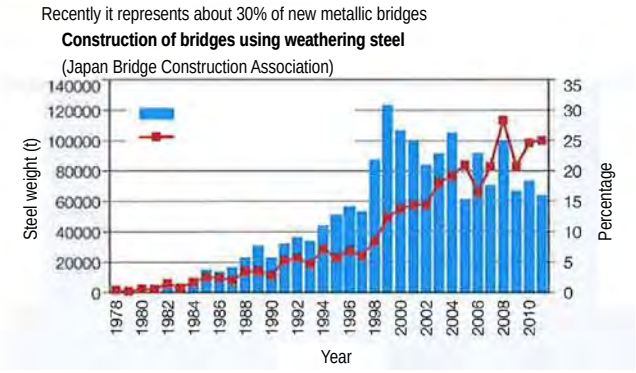
7.8.2 Test concerning steel material corrosion

(1) Overview of the test

A sheet of 2 types of weathering steel that can minimize anticorrosion LCC was placed in 2 locations at the 1st Bridge and 2 houses in Djebale Island (4 locations in total) for a test to check applicability of weathering steel to be used for a steel bridge. The test is called "sticker-type exposure test for weathering steel". Pieces of weathering steel are attached and left over a year to check how corrosion progresses. The characteristics of the 2 types of weathering steel are as described below.

[Weathering steel] Alloy (Cu, Cr and Ni) is added to form protective rust on the surface and reduced the pace of corrosion speed..
[Nickel-based weathering steel] Ni is added so that weathering steel can be used, in an environment with a high level of airborne salt.





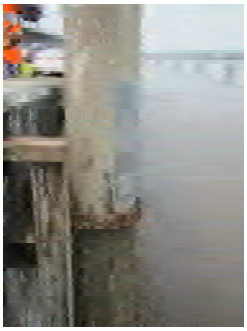
Source: Catalog of a steel manufacturer

Figure 7.46 Characteristics of Weathering Steel

(2) Details of the placement

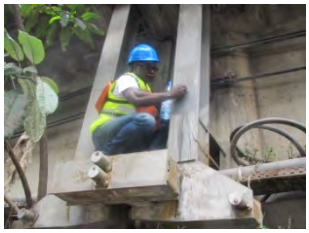
The following table describes the details of the installation such as locations, date and surrounding environment.

Table 7.33 Details of the Placement (1/3)

<table>
<tr><td colspan="3">Details of the Placement of “Steel Material No.: JIS-SMA(M2741), 1% Ni(LN079)”</td></tr>
<tr><td colspan="3">[Date of the Placement] Thursday November 17, 2016, 11:00
[Weather] Fine
[Persons in Charge] INGEROSEC: Shinichi Nii
[Accompanying person] MINTP: Simon (Director in charge of the Littoral Region), CUD: Prisca (officer of the DEPID)
[Location and Method of the Placement]
・ Placed on an iron pole on P12 Bridge (4th pier from the east side) of the 1st Bridge (existing bridge)
・ Steel materials facing upstream.
・ Placed from a sidewalk.</td></tr>
<tr><td>“Photo of the pole from the west”</td><td>“Photo of the pole from the east”</td><td>“State of the placement”</td></tr>
<tr><td>  </td><td>  </td><td> 
Top: JIS-SMA(M2741)
Bottom: 1%Ni(LN079)</td></tr>
</table>

Source: JICA survey team

Table 7.34 Details of the Placement (2/3)

Details of the Placement of "Steel Material No.: No: JIS-SMA(M2742), 1% Ni(LN080)"		
[Date of the Placement] Thursday November 17, 2016, 12:30 [Weather] Fine [Persons in Charge] INGEROSEC: Junji Ogata, Shinichi Nii, [Accompanying person] MINTP: Simon (Director in charge of the Littoral Region) [Location and Method of the Placement] ・ Placed on a beam (side of the seat) of P12 Bridge (4th pier from the east side) of the 1st Bridge (existing bridge) ・ Steel materials face the downstream direction. ・ Landed on a deck slab by boat and climbed onto a beam to place the steel materials.		
"Boat and placement work"	"Photo taken from downstream"	"State of the placement"
 	 Placed at ○	 Left: JIS-SMA(M2742) Right: 1%Ni(LN080)
Details of the Placement of "Steel Material No.: No: JIS-SMA(M2743), 1% Ni(LN081)"		
[Date of the Placement] Thursday November 24, 2016, 11:45 [Weather] Fine [Persons in Charge] INGEROSEC: Junji Ogata, Shinichi Nii, [Accompanying person] CUD: Prisca (officer of the DEPID) [Location and Method of the Placement] ・ Placed in an attic of a bulletin board near a port on the south of Djebale Island. ・ Steel materials face downstream. ・ Installed with a ladder.		
"Boat and placement work"	"Photo taken from downstream"	"State of the placement"
 	 Placed at ○	 Left: JIS-SMA(M2743) Right: 1%Ni(LN081)

Source: JICA survey team

Table 7.35 Details of the Placement (3/3)

Details of the Placement of "Steel Material No.: No: JIS-SMA(M2744), 1% Ni(LN082)"		
[Date of Installation] Thursday November 24, 2016, 11:45 [Weather] Fine [Persons in Charge] INGEROSEC: Junji Ogata, Shinichi Nii [Accompanying person] CUD: Oscar, Prisca (officer of the DEPID) [Location and Method of the Placement] ・ Placed on an unused well 30m east of the village mayor's house on the north side of Djebale Island ・ The steel materials face west (river side).		
"Photo taken from west (river side)"	"Photo taken from east"	"State of the placement"
 Placed at ○		 Left: JIS-SMA(M2744) Right: 1%Ni(LN082)

Source: JICA survey team

7.8.3 Study of aesthetic characteristics of a cable-stayed bridge

(1) Overview of the study

A study will be conducted to determine the aesthetic characteristics of candidate bridges that are large and can be tourism resources, such as cable-stayed and extradosed bridges. As discussed above, there are 3 locations where the river width is sufficient to accommodate such bridge. In this study, a 3D-CAD system will be used to check the view from the "center of the 2nd Bridge", the view from the "left bank of the 2nd Bridge" and from the "right bank of the 2nd Bridge" respectively.

(2) Distance to and view of each bridge

The views of each bridge from the vicinity of the 2nd Bridge are as described below. The distance to each bridge is relatively similar, at around 4km. As for the views, the bridges would look as if they were the same size and it is difficult to decide which is better than the others.

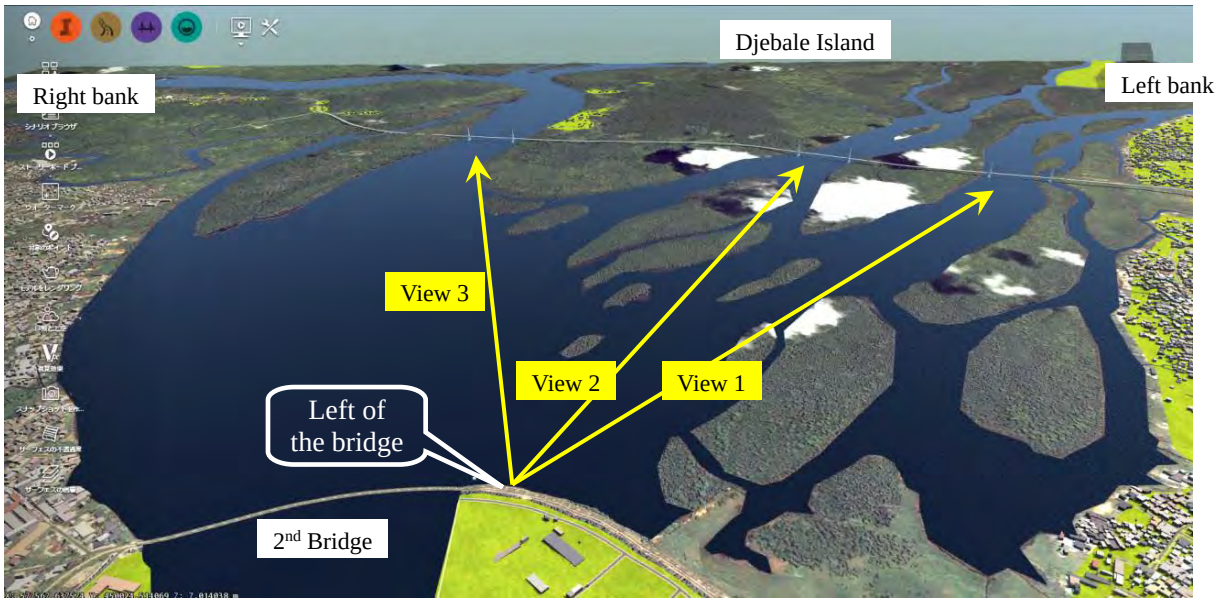
Table 7.36 Contents of the Study

View from	Distance	How it looks
Center of the 2nd Bridge	Bridge on the left bank: 4.2km Bridge in the center: 4.2km Bridge on the right bank: 3.6km	From any of the 3 locations, the three bridges look to be of equivalent size and quite attractive.
Left bank of the 2nd Bridge	Bridge on the left bank: 3.9km Bridge in the center: 3.9km Bridge on the right bank: 3.5km	
Right bank of the 2nd Bridge	Bridge on the left bank: 4.5km Bridge in the center: 4.5km Bridge on the right bank: 3.6km	
Port on the right bank	Bridge on the left bank: 4.6km Bridge in the center: 4.5km Bridge on the right bank: 3.2km	

Source: JICA survey team

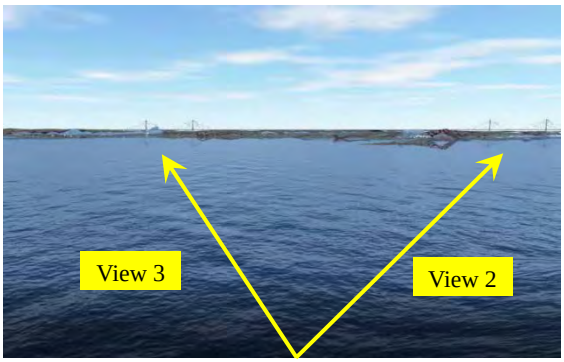
Source: JICA survey team

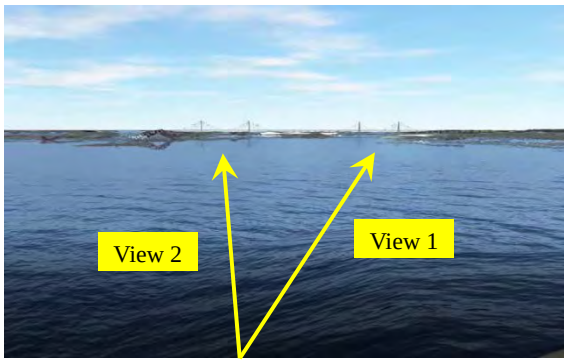
Figure 7.47 Views of the Candidate Bridges from the 2nd Bridge



Source: JICA survey team

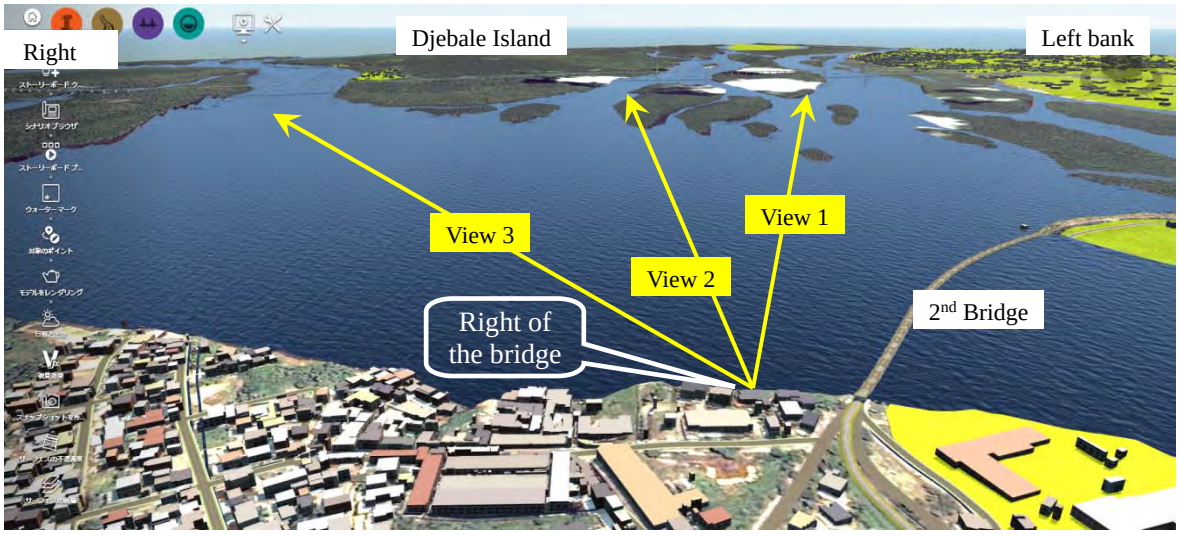
Figure 7.48 Views of the Left Bank from the 2nd Bridge (1/2)

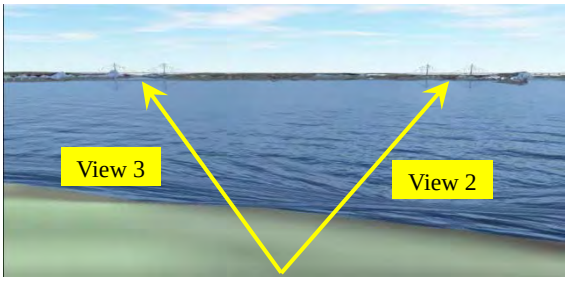


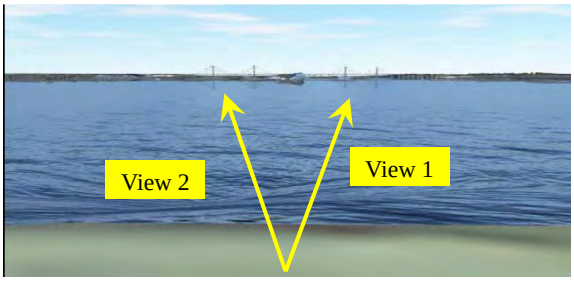


Source: JICA survey team

Figure 7.49 Views of the Left Bank from the 2nd Bridge (2/2)

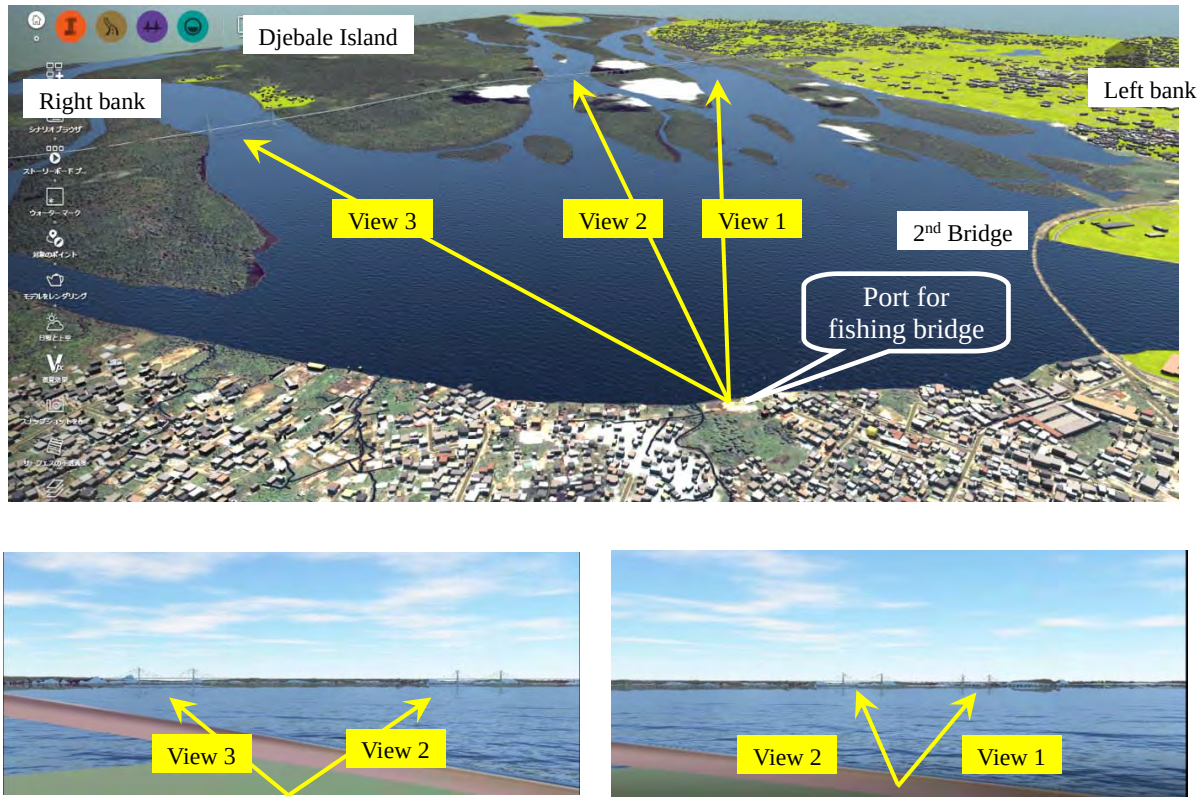






Source: JICA survey team

Figure 7.50 Views of the Right Bank from the 2nd Bridge



Source: JICA survey team

Figure 7.51 Views of the Right Bank from the 2nd Bridge

Finally, Figure 7.52 shows the views of the bridge on the right bank from the west side of Djebale Island, which has villages. The cable-stayed bridge stands out against the blue sky, giving a symbolic impression. Considering tourism development of Djebale Island, it will be effective.

Source: JICA survey team

Figure 7.52 Views of the Bridge on the Right Bank from Djebale Island

8. Environmental and Social Considerations

8.1 Overview of the project components that have an impact on the environment and society

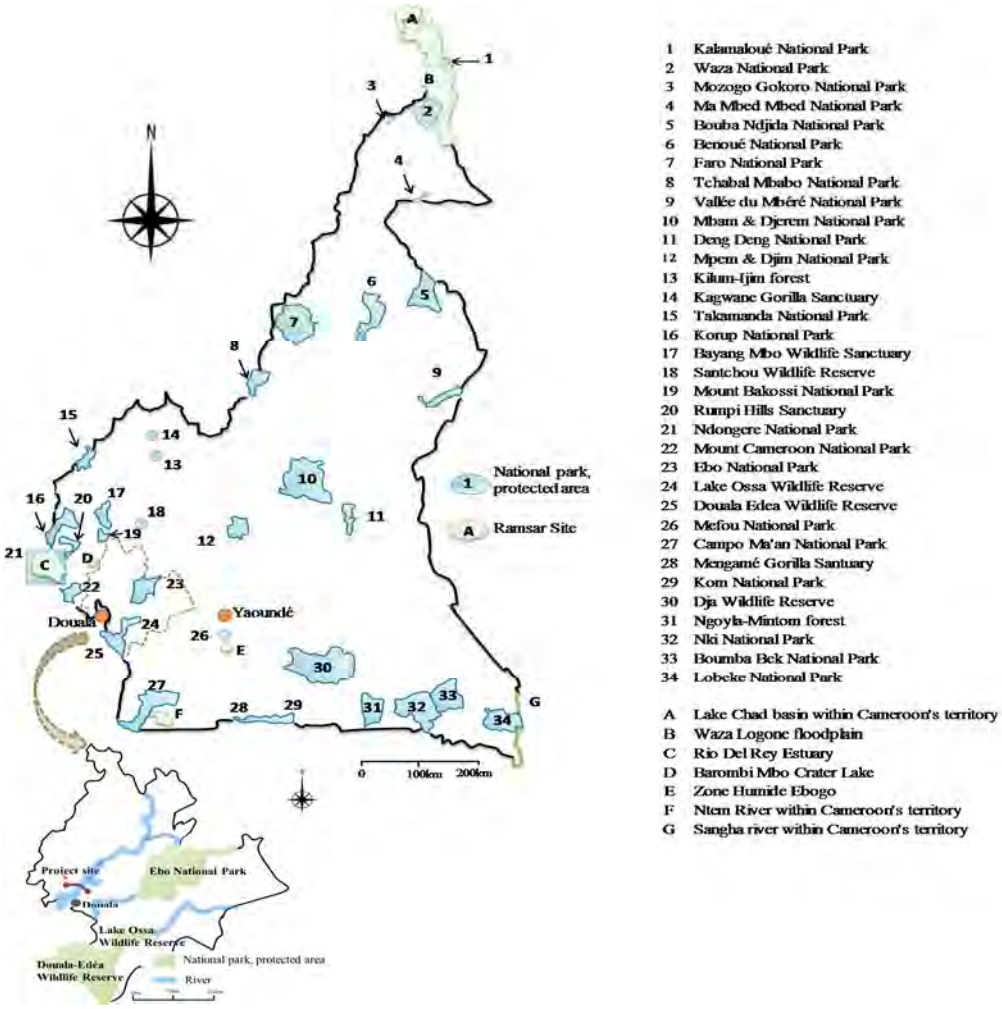
The project has two project components that have an impact on environment and society; bridge construction and road improvement. However, the negative impact on the natural and social environment will be limited because the planned bridge construction will not require residents to relocate and will avoid deforestation whenever possible. Moreover, the planned road improvement will not result in any major changes to the alignment and width of existing roads.

8.2 Baseline of the environmental and social condition

8.2.1 Natural environment

(1) National parks and protected zones

In Cameroon, there are seven Ramsar sites and 34 national parks or protected zones among those, Dja Wildlife Reserve and Lobeke National Park are registered as World Heritage sites. There are three protected areas in the Littoral Region where the target area of the survey is located such as the Douala-Edéa wildlife reserve, the lake Ossa wildlife reserve and Ebo national park.



Source: MINEPDED

Figure 8.1 National parks and protected zones in Cameroon

Primates, including chimpanzees, colobus and rare species such as forest elephants, sitatungas, blue tigers, African manatees and sea turtles inhabit the Douala-Edéa Wildlife Reserve. The presence of African manatees in the Lake Ossa Wildlife Reserve and Western lowland gorillas, chimpanzees, drills, and Preuss's monkeys, etc. in Ebo forest has also been confirmed. None of these habitats will be affected because they are well away from the target area.

(2) Ecosystem

Mangrove grows on both sides of the Wouri River and along Djebale Island. The survey team confirmed that it is not rare species or subject to protection with the Ministry of Forest and Fauna (Ministère des Forêts et de la Faune, hereinafter referred to as "MINFOF") and instructor of Faculty of Coastal Ecosystem, University of Douala.

Table 8.1 Mangroves on the Project Sites

IUCN Category	Academic Name of Mangrove
LC (Least Concern)	Avicennia germinans
LC (Least Concern)	Phizophora mangle
-	Phizophora harrizonii
-	Clusia mangle/ Clusia venosa/ Clusia minor

Source: Faculty of Coastal Ecosystem, University of Douala

The following tables show the major tree species found in Douala City. There are many cycads on Djebale Island, where tree felling is expected. Following confirmation with MINFOF and literature research, inhabitation of endangered species on the island was unconfirmed. In the preliminary survey, however, tree species must be investigated through interview, etc. with academic institutions and residents.

Table 8.2 Tree Species in Douala City

IUCN Category	**Nomenclature of trees**
EN (Endangered IB)	Mansonia altissima
VU (Vulnerable)	Lophira alata, Afzelia africana, Baillonella toxisperma, Afzelia pachyloba, Entandrophragma cylindricum, Entandrophragma utile sprague
NT (Near Threatened)	Latinized Ancient Greek*
LC (Least Concern)	Triplochiton scleroxylon*
No information	Piptadenia strum, Pycnanthus angolensis, Entandrophragma candollei, Sterculia rhinopetala, Celtis africana, Staudtia gabonensis, Cylicodiscus gabunensis, Erthrophleum africanum, Pericopsis elata, Terminalia superba, Cocos nucifera*, Nauclea diderrichii merrill*, Guibourtia tessmannii*, Milicia excelsa*, Cycadales*, Meliaceae*

* Tree species inhabiting Djebale Island

Source: Wouri River 3rd Bridge Initial Environmental Assessment

According to an interview with the Ministry of Environment, Nature Protection and Sustainable Development (hereinafter referred to as "MINEPDED"), Eichhornia crassipes proliferate in the Wouri River and an environmental NGO collects them to clean the river as a means of recycling.

According to the result of interviews with fishermen and hunters on Djebale Island, fish species living around the island include tilapia, threadfin, sea catfish, carp, bonga, threeline grunt and striped mullet, while animal species include monitor lizards, crocodiles and guenon monkeys. The MINFOF, the MINEPDED and the Ministry of Livestock, Fisheries and Animal Industries (Ministère de l'Elevage, des Pêches et des Industries Animales, hereinafter referred to as "MINEPIA") have confirmed that no endangered fish or animal species inhabit the island.

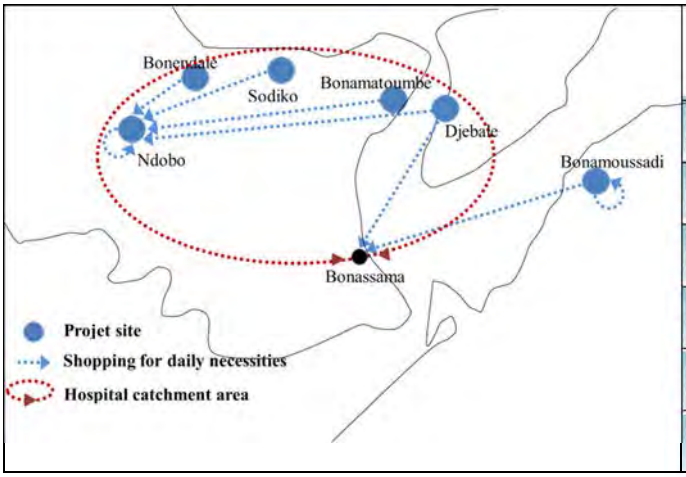
8.2.2 Social environment

(1) Residents

Located on the left bank of the Wouri River, Bonamoussadi is a residential area close to Douala downtown. It has the smallest proportion of poor people among all the target areas of the survey and many householders are company employees and merchants. Residents use medical facilities and schools in the village and take boats to beat the traffic to visit a market in Bonassama on the opposite side of the river for shopping.

Djebale Island is isolated and only accessible by boat. 80% of the residents are unemployed, retired, or small-scale farmers/fishermen and many are poor. The island lacks stores and people go to markets in Bonassama and Ndobo for daily necessities and medical facilities in Bonassama.

On the right bank of the Wouri River, Bonamatoumbe, Sodico, Bonendale and Ndobo are situated next to each other. Many householders are owners of general stores, motorcycle taxi drivers and self-employed stonemasons, etc. Underdevelopment of roads is the biggest concern for the residents and they sometimes walk back and forth between Bonamatoumbe or Sodico to Ndobo, where markets are situated, along a 7km unpaved road, to buy daily necessities. For hospital care, they either use a simple clinic in their village or go to medical facilities in Bonassama.



	Percentage of households existing on an income of 50,000 FCFA or less/month
Bonamoussadi	39.2%
Djebale	88.9%
Bonamatoumbe	61.5%
Sodico	48.9%
Bonendale	66.0%
Ndobo	53.7%

Source: Developed by the JICA survey team based on interview results

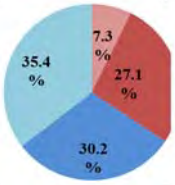
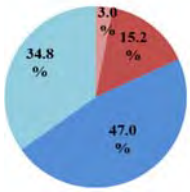
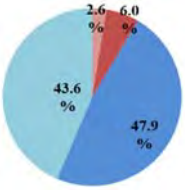
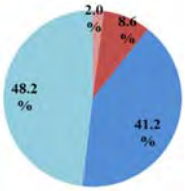
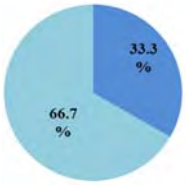
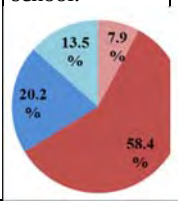
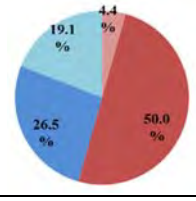
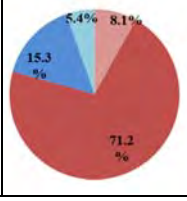
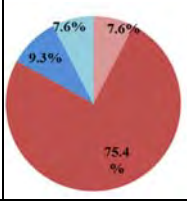
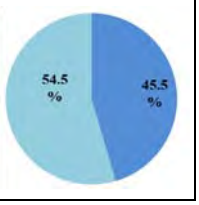
Figure 8.2 Locations of Markets and Hospitals and Rates of the Poor in Each Village

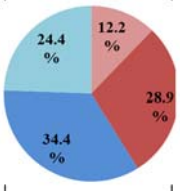
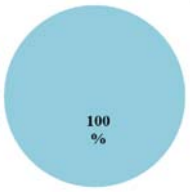
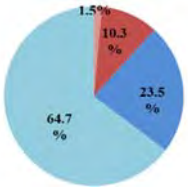
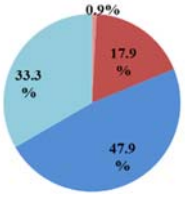
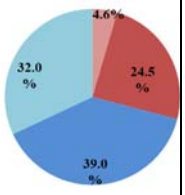
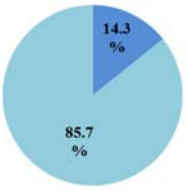
It was confirmed through consultations with each village committee that some residents regard the Wouri River as sacred. In the preliminary survey, close consultations with residents should be held concerning the social impact and mitigation measures of the project to obtain their understanding for construction works at the Wouri River.

(2) Social infrastructure

The following table shows the infrastructure conditions in each village and the residents' level of satisfaction.

Table 8.3 Infrastructure Conditions in Each Village

	Bonamoussadi	Bonamatoumbe	Sodico	Bonendale	Ndobo	Djebale Island
Road conditions	While it is close to an arterial road and has easy access to the urban area, roads in the village are undeveloped.	The road connecting to national road supports people's travel and activities. However, it is an unpaved road on sandy/muddy soil, which becomes muddy and has deep paddies when it rains. In Bonamatoumbe, Sodico and Bonendale, people highlighted issues such as the lack of taxis due to poor road conditions and extortionate taxi fares. In Ndobo, people highlighted the problematic congestion of arterial roads and poor road conditions.				The Island has no road or bridge connecting the island and the urban area. The only access is by boat.
Residents' level of satisfaction						
School	The village has ten private primary schools, four private secondary schools and a public secondary school.	The village does not have kindergartens or primary schools and children go to school in Ndobo or Bonendale.	The village has all levels of schools from kindergarten to secondary school.	The village has public and private kindergartens and primary schools.	The village has six each of public kindergartens, middle schools and secondary schools and 12 public primary schools as well as private schools.	Schools in the village have been abolished. Children move to a town with school.
Residents' level of satisfaction						

Trash collection	The city collects trash every week. Trash may not be collected for several weeks due to road congestion. When trash is not collected, residents dump trash in rivers.	Due to extremely poor road conditions, trash trucks cannot come in. Trash is dumped in mangrove forests and rivers.	Due to poor road conditions, trash is collected about once a month. Residents dump trash in mangrove and other forests.	Due to poor road conditions, trash is collected about once a month. Residents dump trash in mangrove and other forests.	The city collects trash daily. Trash may not be collected for several days due to road congestion.	There is no trash collection. Garbage is used as field fertilizer and plastic trash is incinerated.
Residents' level of satisfaction						
Electricity	About 70% of households are connected to an electric power grid. However, voltage is low and there are frequent power outages.	Electric power is supplied, but many households cannot pay the electricity bill.	About 90% of households are connected to the electric power grid of a power company. However, the voltage is low and power outages occur frequently.			Electricity is not supplied. Many families use kerosene lamps.
Water service	About 70% of households use tap water. The water supply is stable. Families without running water use well water.	People use well water.	About 20% of households use tap water, but the water often stops. Well water is used in areas without running water or during water outages.	About 50% of households use tap water, but the water often stops. Well water is used in areas without running water or during water outages.	About 30% of households use tap water, but the water often stops. Well water is used in areas without running water or during water outages.	Well water is used.

Legend: Very satisfied; Somewhat satisfied; Somewhat dissatisfied; Very dissatisfied

Source: Developed by the JICA survey team based on interview results

8.3 Systems and organizations related to environmental and social considerations in the recipient country

8.3.1 Basic environmental law

The most basic environmental law in Cameroon is the Environmental Protection Law (*Law No. 96/12 of 5 August, 1996 establishing a framework for management of the environment*), established in 1996, which lays out basic principles concerning health control, environmental impact assessment, environmental protection (air, inner water, external water, soil and living environment), waste, hazardous chemical substances, noise, preservation of animals and plants, penalties for violators, etc. Concerning the information disclosure system, the law states that "all residents shall have the right to demand the disclosure of information about the environment, including information about toxic substances and harmful activities". The law also stipulates for public hearings that, "for cases with a large impact on the environment, arrangements shall be made by discussing with related traders, organizations and residents", which is comparable to JICA Guidelines for Environmental and Social Considerations (hereinafter referred to as

"JICA Guidelines"). The following table lists other laws concerning environmental and social considerations in Cameroon.

Table 8.4 Laws concerning Environmental and Social Considerations

Name	Enacted in
General environmental law	
Loi portant loi-cadre relative à la gestion de l'environnement	August, 1996
Laws concerning environmental impact assessment	
Décret fixant les modalités de réalisation des études d'impact environnemental	February, 2005
Décret fixant les modalités de réalisation des études d'impact environnemental et social	February, 2013
Arrêté fixant les différentes catégories d'opérations dont la réalisation est soumise à une étude d'impact environnemental	March, 2005
Arrêté définissant le contenu général des termes de référence des études d'impact environnemental	February, 2007
Arrêté fixant les conditions d'agrément des bureaux d'études à la réalisation des études d'impacts et audits environnementaux	July, 2007
Laws concerning forests	
Loi portant régime des forêts, de la faune et de la pêche	January, 1994
Lettre circulaire relative aux procédures de délivrance et de suivi d'exécution des petits titres d'exploitation forestière	June, 2007
Laws concerning waste disposal	
Décret fixant les conditions de tri, de collecte, de stockage, de transport, de récupération, de recyclage, de traitement et d'élimination finale des déchets	September, 2012

Source: JICA survey team

Cameroon has joined the following conventions and agreements with neighboring countries.

- United Nations Convention to Combat Desertification
- Convention on Biological Diversity
- United Nations Framework Convention on Climate Change
- Ramsar Convention
- Washington Convention
- Bamako Convention
- Abidjan Convention concerning Cooperation in the Protection, Management and Development of the Marine and Coastal Environment, African Convention on the Conservation of Nature and Natural Resources

8.3.2 Environmental and emissions standards

The Environmental Protection Law stipulates the basic policy of environmental and emissions standards, the specifics of which are provided in the Environmental Standards and Guidelines for the Inspection of Industrial and Commercial Establishment in Cameroon and not inferior to the standards of international organizations, including the International Finance Corporation.

8.3.3 Environmental impact assessment and its procedures

The Government of Cameroon has required all projects that affect the environment to undergo an environmental impact assessment (hereinafter referred to as "EIA") since February 2005. This is carried out in accordance with the current procedures provided in a government decree (*Decree No. 2013/0171/PM of 14 February, 2013 establishing the methods performing environmental and social impact assessments*). It stipulates a review of alternative plans, information disclosure and public hearings, far from being inferior to the JICA Guidelines for Environmental and Social Considerations (hereinafter referred to as "JICA Guidelines"). It also includes the following features:

- Projects are subject to a simple or detailed survey in accordance with the degree of their assumed environmental impact. Projects that are assumed to have significant impacts are subject to detailed surveys. As the project involves road and bridge construction that covers an extensive area and logging and resettlement of residents, it is subject to a detailed survey.
- The EIA can be performed only by environmental consultants certified by the environmental authorities. Certified consultants must satisfy the criteria to be certified to conduct the EIA (*Bylaw No. 00004/MINEP of 03 July, 2007*).
- Public hearings are held and an assessment committee is set up to carry out the EIA. The project operator bears the cost.

1) Screening of Terms of Reference (hereinafter referred to as "TOR"): 2 million FCFA
2) Screening of EIA report: 5 million FCFA (in the detailed survey)
3) Commission to environmental consultant: 30 million FCFA as a rough guide

The EIA procedures and the time required for the same in the case of detailed survey are summarized in Table 8.5.

Table 8.5 Summarized EIA Procedures and Required Time (Detailed Survey)

Period	EIA Procedures
30 days	1) Project operator chooses an environmental consulting firm and requests it to prepare TOR. 2) The environmental consulting firm prepares TOR based on information it obtained through interview, etc. 3) The project operator submits TOR and the following documents to environmental authorities and discloses information. - EIA request - Project summary - Screening fees (2,000,000 FCFA)
10 days	4) Environmental authorities submit EIA requests to the Minister of Environment, Nature Protection and Sustainable Development.
20 days	5) Environmental authorities review the need for EIA, TOR and category of EIA (detailed or simple survey). 6) Environmental authorities notify the project operator of the comment on TOR.
30 days	7) When the EIA request is approved by environmental authorities, the project operator prepares EIA instructions and sends them to environmental consulting firms certified by the authorities. 8) Environmental consulting firms that are interested in the project prepare an EIA plan and quote and submit them to the project operator. 9) The project operator then selects one consulting firm from among those having submitted the plan.
50 days	10) The environmental consulting firm performs the EIA in accordance with TOP and produces an EIA report. 11) Project operator submits the EIA report and screening fees (5,000,000FCFA) to environmental authorities.
40 days	12) Environmental authorities form a survey committee comprising relevant ministries, conduct a site survey, confirm the contents of the EIA report and produce a screening report.
20 days	13) The survey committee submits the screening report to environmental authorities. 14) Environmental authorities form an assessment committee comprising relevant ministries and check the survey results and EIA report.

30 days	15) When the EIA report is approved, the project operator holds a public hearing. 16) Project operator submits the minutes of the public hearing to environmental authorities.
10 days	17) Environmental authorities submit the following documents to the assessment committee comprising relevant ministries. - Approved EIA report - Assessment report - Minutes of public hearing
20 days	18) The assessment committee reviews the contents of the documents and evaluates the EIA. 19) When the EIA is approved, the environment ministry issues an environmental certificate. - When it is approved conditionally, measures to be taken by the project operator to obtain the environmental certificate are instructed. - When it is not approved, the project cannot be implemented.

Source: Government decree on EIA survey

EIA procedures require around 9 months according to the above table. In the following tables, EIA procedures and "environmental and social considerations required for intended projects" between JICA Guidelines and Cameroon Laws are compared.

Table 8.6 Comparison of EIA Procedures between JICA Guidelines and Cameroon Laws

No.	JICA Guidelines	Cameroonian Laws	Gap between JICA Guidelines and Cameroon Laws	Project Policies
1	Cameroon has EIA procedures which need to be completed officially and approved by the country when the project is subject to them.	EIA procedures are put into a statutory form and approved by an assessment committee comprising environmental authorities and relevant ministries.	In conformity with JICA Guidelines	In compliance with JICA Guidelines
2	EIA report needs to be written in the official language or widely used languages in the country where the project is implemented. It also needs to be written in a language and form that can be understood by the local people.	The EIA report is written in the official language of Cameroon. (Chapter 2.20, Decree establishing the methods for conducting social and environmental impact assessments)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
3	EIA report must be disclosed in the country where the project is implemented, including to local residents and it can be copied so local residents and other stakeholders can view it.	Disclosure of report and minutes of meeting to stakeholders is put in a statutory form. (Chapter 2.10, Decree establishing the methods for conducting social and environmental impact assessments)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
4	The EIA report must be prepared based on sufficient information disclosure and talks with local residents and other stakeholders in advance and the discussions need to be recorded.	Discussions with stakeholders and preparation of their minutes are put into a statutory form. (Chapter 2.20, Decree establishing the methods for conducting social and environmental impact assessments)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
5	Although discussions with local residents and other stakeholders should be conducted as needed while the project is prepared and implemented, they should preferably be conducted when the EIA items are selected and a draft is prepared in particular.	It is written that discussions with stakeholders are conducted as needed through the implementation period. (Chapter 3.20, Decree establishing the methods for conducting social and environmental impact assessments)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
6	The scope and details of EIA report are decided in accordance with the degree	The EIA report includes the following items:-Overview	In conformity with JICA	In compliance with JICA

No.	JICA Guidelines	Cameroonian Laws	Gap between JICA Guidelines and Cameroon Laws	Project Policies
	of impact of the project. The EIA report should include the following items: - Overview - Project description - Basic information (local features) - Environmental impacts - Analysis of alternative plans - Environmental management plan - Discussions	- Project description - Basic information (local features) - Environmental impacts - Analysis of alternative plans - Environmental management plan - Discussions (Chapter 2.10, Decree establishing the methods for conducting social and environmental impact assessments)	Guidelines	Guidelines J

Source: JICA Survey team

Table 8.7 Comparison of "Environmental and Social Considerations Required for Intended Projects" between JICA Guidelines and Cameroonian Laws

JICA Guidelines	Cameroonian Laws	Project Policies
Underlying Principles		
Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan.	EIA must be conducted before implementing the project to examine alternatives or mitigation measures (Chapter 3.2.19, the Framework Law on the Environmental Management)	In compliance with JICA Guidelines. Alternatives and mitigation measures are examined during the preliminary survey in line with JICA Guidelines.
Such examinations must be endeavored to include an analysis of environmental and social costs and benefits in the most quantitative terms possible, as well as a qualitative analysis; these must be conducted in close harmony with the economic, financial, institutional, social, and technical analyses of projects.	Alternatives and mitigation measures are examined from technical, economic, environmental and social aspects (Chapters 1.3 and 3,2,19, the Framework Law on the Environmental Management).	In compliance with JICA Guidelines
The findings of the examination of environmental and social considerations must include alternatives and mitigation measures, and must be recorded as separate documents or as a part of other documents. EIA reports must be produced for projects in which there is a reasonable expectation of particularly large adverse environmental impacts.	EIA and examination of alternatives and mitigation measures are mandated if a project has any adverse impact on the environment and society (Chapter 3.2.19, the Framework Law on the Environmental Management).	In compliance with JICA Guidelines
For projects that have a particularly high potential for adverse impacts or that are highly contentious, a committee of experts may be formed so that JICA may seek their opinions, in order to increase accountability.	An evaluation committee comprising relevant organizations evaluates the EIA report (Paragraph 24 of Chapter 3, Decree establishing the methods for conducting social and environmental impact assessments)	In compliance with JICA Guidelines
Examination of Measures		
Multiple alternatives must be examined in order to avoid or minimize adverse impacts and to choose better project options in terms of environmental and social considerations. In the	Alternatives and mitigation measures are examined from economic, environmental and social aspects (Para. 19, Art. 2 of Chap. 3 of the	In compliance with JICA Guidelines

JICA Guidelines	Cameroonian Laws	Project Policies
examination of measures, priority is to be given to avoidance of environmental impacts; when this is not possible, minimization and reduction of impacts must be considered next. Compensation measures must be examined only when impacts cannot be avoided by any of the aforementioned measures.	Framework Law on the Environmental Management).	
Appropriate follow-up plans and systems, such as monitoring plans and environmental management plans, must be prepared; the costs of implementing such plans and systems, and the financial methods to fund such costs, must be determined. Plans for projects with particularly large potential adverse impacts must be accompanied by detailed environmental management plans.	Environmental management plans and monitoring plans and system must be prepared (Chapter 2.10, Decree establishing the methods for conducting social and environmental impact assessments).	As costs and procurement methods are not stipulated, they are confirmed in the preliminary survey.
Scope of Impacts to Be Assessed		
The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including transboundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety.	While there are descriptions related to air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, pollution, human health and safety and social infrastructure (Chapter 1.1, the Framework Law on the Environmental Management), not all items mentioned in the left column are covered.	Screening is carried out in line with JICA Guidelines. Mitigation measures are examined when any impact is predicted.
In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project	Not provided for under Cameroonian laws.	Screening is carried out in line with JICA Guidelines. Mitigation measures are examined when any impact is predicted.
Compliance with Laws, Standards, and Plans		
Projects must comply with the laws, ordinances, and standards related to environmental and social considerations established by the governments that have jurisdiction over project sites (including both national and local governments). They must also conform to the environmental and social consideration policies and plans of the governments that have such jurisdiction.	Laws related to environmental and social considerations must be complied with (Chapter 1.3, the Framework Law on the Environmental Management)	In compliance with JICA Guidelines
Projects must, in principle, be undertaken outside	Projects must be implemented outside	In compliance

JICA Guidelines	Cameroonian Laws	Project Policies
of protected areas that are specifically designated by laws or ordinances for the conservation of nature or cultural heritage (excluding projects whose primary objectives are to promote the protection or restoration of such areas). Projects are also not to impose significant adverse impacts on designated conservation areas.	those areas designated for the conservation of nature or cultural heritage (Chapter 5, the Framework Law on the Environmental Management)	with JICA Guidelines
Social Acceptability		
Projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which they are planned. For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans.	Consultations with stakeholders are conducted via disclosure of information to them at an earlier stage of a project. the outcome of such consultations is incorporated into the project (Chapters 3.11 to 3.12; Decree establishing means of conducting social and environmental impact assessments).	In compliance with JICA Guidelines
Appropriate consideration must be given to vulnerable social groups, such as women, children, the elderly, the poor, and ethnic minorities, all members of which are susceptible to environmental and social impacts and may have little access to decision-making processes within society.	Not provided for under Cameroonian laws.	Screening is carried out following JICA Guidelines. Mitigation measures are examined when any impact is predicted.
Ecosystem and Biota		
Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests.	Forests and natural habitats are protected by the national government and no development is allowed without permission (Chapter 2.11 to 2.12, Law on Forestry, Wildlife and Fisheries).	In compliance with JICA Guidelines
Illegal logging of forests must be avoided. Project proponents etc. are encouraged to obtain certification by forest certification systems as a way to ensure the prevention of illegal logging.	To ensure illegal logging can be prevented, certification of development is needed for logging (Circular concerning procedures for issuing and monitoring the logging of forests).	In compliance with JICA Guidelines
Involuntary Resettlement		
Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected.	Where resettlement is unavoidable due to public works, relocation is carried out in line with laws (Law No. 85-09 of July 4, 1985 and Decree No. 87-1872 of December 16, 1987). The laws stipulate details of compensation, preparation of a relocation plan and its implementation, establishment of a mechanism to handle grievances and responsible organizations, consultations with residents and others.	In compliance with JICA Guidelines
People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported by project proponents etc. in a	Compensation for illegal residents is not provided for. Although compensation must be provided for prior to relocation (Chapter 1.4, Law No. 85-09 of July 4,	Compensation policy in compliance with JICA Guidelines

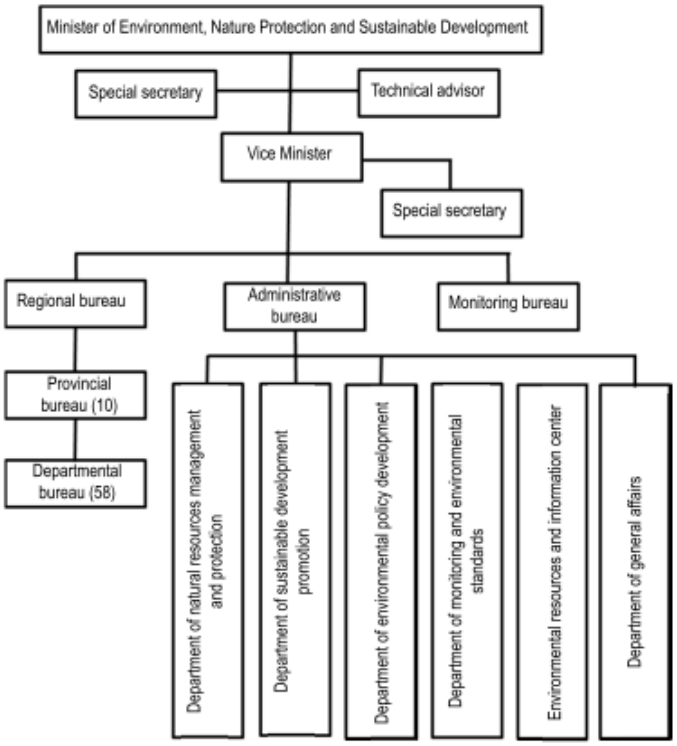
JICA Guidelines	Cameroonian Laws	Project Policies
timely manner. Prior compensation, at full replacement cost, must be provided as much as possible. Host countries must make efforts to enable people affected by projects and to improve their standard of living, income opportunities, and production levels, or at least to restore these to pre-project levels. Measures to achieve this may include: providing land and monetary compensation for losses (to cover land and property losses), supporting means for an alternative sustainable livelihood, and providing the expenses necessary for the relocation and re-establishment of communities at resettlement sites.	1985), compensation may be provided after relocation in emergency cases.	is established before the relocation plan is prepared.
Appropriate participation by affected people and their communities must be promoted in the planning, implementation, and monitoring of resettlement action plans and measures to prevent the loss of their means of livelihood. In addition, appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	An explanation to the community is made in advance (Chapter 1, Decree No. 87-1872 of December 16, 1987) and a grievance mechanism is established (Chapter 3, Law No. 85-09 of July 4,t 1985).	In compliance with JICA Guidelines
For projects that will result in large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.	A relocation plan is prepared for a target community of any size and explained to the affected residents and community in advance (Chapter 1, Decree No. 87-1872 of December 16, 1987).	In compliance with JICA Guidelines
Monitoring		
After projects begin, project proponents etc. monitor whether any unforeseeable situations occur and whether the performance and effectiveness of mitigation measures are consistent with the assessment's prediction. They then take appropriate measures based on the results of such monitoring	Necessary measures should be taken immediately when any unforeseeable situations occur during a project (Chapter 3.2.20, the Framework Law on the Environmental Management).	In compliance with JICA Guidelines
In cases where sufficient monitoring is deemed essential for appropriate environmental and social considerations, such as projects for which mitigation measures should be implemented while monitoring their effectiveness, project proponents etc. must ensure that project plans include feasible monitoring plans.	Monitoring plans should be prepared for all projects with EIA, to be implemented by relevant organizations (Chapter 4.27, Decree establishing the methods for conducting social and environmental impact assessments).	In compliance with JICA Guidelines
Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders.	All residents have the right to claim disclosure of all information related to the environment (Chapters 1 and 3.9, the Framework Law on the Environmental Management).	Disclosure of monitoring plans is confirmed.
When third parties point out, in concrete terms, that environmental and social considerations are	Consultation with stakeholders is provided as needed during a project	In compliance with JICA

JICA Guidelines	Cameroonian Laws	Project Policies
not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems.	(Chapter 3.20, Decree establishing the methods for conducting social and environmental impact assessments). In Cameroon, such consultations must be provided conventionally during the initial and evaluation stages of EIA.	Guidelines

Source: JICA Survey team

8.3.4 Overview of the organization concerned

The MINEPDED is in charge of environmental issues in general and its sustainable development promotion bureau is in charge of the EIA.



Source: MINEPDED

Figure 8.3 MINEPDED Organization

8.3.5 Procedures of forest and mangrove logging

The law on forest, fauna and fisheries (Loi no 94 /01 du 20 janvier 1994 portant régime des forêts, de la faune et de la pêche) stipulates rules on mangrove and other forest management. It stipulates that the Government of Cameroon should have the authority to protect and manage all forests in the country and prohibit logging or burning forests or disposing of waste that may affect flora and fauna into forests, rivers, ocean and lakes without government permission. However, the purpose of the law is to control unregulated forest logging, land burning, or illegal disposal of toxic waste by residents and private companies and it must not interfere with development plans. As the target area is not a protected zone, mangrove and forest logging can be conducted. Logging requires an application for the development permit (permis d'exploitation) to the MINFOF to obtain it.

Table 8.8 Procedures to Obtain a Development Permit for Forest Logging

Procedures to obtain a development permit for forest logging
1) The project operator prepares the following documents and submits them to MINFOF. - Plan overview - Plan implementation permit signed by the supervising minister - Specifications prepared by the responsible organization - Plan map - EIA results
2) MINFOF issues development permit after receiving the above documents.
3) MINFOF makes the permit known to the public and selects the logging company in a bid. One logging company authorized by MINFOF is selected in the bid.
4) The bid winner pays the logging charge to MINFOF and conducts logging.

Source: Notice on forest development procedures (MINFOF)

8.4 Scoping

The impacts of the project on the natural and social environment have been forecast and evaluated through a field survey, examination of noise, and collected documents, interviews, etc. The following table shows the scoping result and reasons for evaluation.

Table 8.9 Scoping Result

No	Impact	During construction	After completion	Reason
Pollution control measure				
1	Air pollution	B^-	$B^{+/-}$	During construction: Construction vehicles may generate dust. After completion: As traffic congestion eases, exhaust gas may also decline. Increased traffic may increase exhaust gas.
2	Water pollution	B^-	D	During construction: Foundation and bank protection works may pollute water. After completion: No water pollution is expected.
3	Waste	B^-	$B^{+/-}$	During construction: Waste construction soil and materials will be generated. After completion: No waste will make an impact.
4	Soil pollution	B^-	D	During construction: Fuel may leak from construction vehicles. After completion: Trash disposal may increase, associated with an increase in passing vehicles while road improvement will allow garbage trucks to access to boost the frequency of garbage collection.
5	Noise and vibration	B^-	B^-	During construction: Using machinery and construction vehicles may generate noise. After completion: Increased traffic may generate noise and vibration.
6	Ground settlement	B^-	C	During construction: Due to soft ground, land subsidence may occur. After completion: No works will result in subsidence on the soft ground.
7	Odor	D	D	During construction: There will be no work causing odor. After completion: There will be no problematic odor source.
8	Bottom material	B^-	D	During construction: Drilling work of rivers may cause soil runoff. After completion: Piers and other structures will not impact bottom materials.
Natural environment				
9	Protected zone	D	D	There are no protected zones nearby.
10	Ecosystem	B^-	B^+	During construction: Cutting mangroves and other deforestation may impact the ecosystem, particularly aquatic lives. After completion: When roads are developed and trash trucks can enter, trash collection will be more frequent and less waste will be dumped in mangrove and other forests.

No	Impact	During construction	After completion	Reason
11	Hydrometeor	B^-	B^-	During construction: Works in a river may cause changes to the riverbeds. After completion: The flow condition around bridge piers may change.
12	Topography and geography	B^-	B^-	During construction: Drilling to construct abutments and piers may temporarily change the current landform. After completion: The current landform may change in the embankment sections of access roads.
Social environment				
13	Relocation of residents	B^-	C	During construction: Residents and merchants will have to relocate.
14	The poor	B^-	B^+	During construction: Residents and merchants will have to relocate. After completion: Access to/from the city will be possible and local revitalization can be expected. It will be easier to use taxis and an improved quality of life can be expected.
15	Ethnic minorities and indigenous peoples	C	D	During construction: The Douala has a traditional religious festival of Ngondo at the mouth of the Wouri River at the beginning of December every year. However, the impact will be limited because it is far from the project sites.
16	Local economy including employment and livelihoods	C	B^+	During construction: Fishing and sand gathering operations are carried out near Djebale Island and there may be some impact during the construction. However, fishing takes place throughout the entire Wouri River area and the impact of local construction will be limited. Sand gathering is normally carried out at the junction with a tributary about 4km upstream of the project site, except that it is carried out around Djebale Island when the water amount increases after rain, etc. Therefore, the impact will be limited. After completion: Access to/from the city will be possible and local revitalization can be expected.
17	Use of land and local resources	C	D	Nearly half the households in Bonamoussadi, Djebale Island and Bonamatoumbe use mangroves as firewood. However, it is small-scale personal use and the impact will be limited.
18	Water use	B^-	D	During construction: Water from the target rivers is used by some residents in Bonamoussadi and Djebale Island as living water for cleaning, laundry, etc. and there may be some impact during construction. However, as the water is not used as drinking water, the impact will be limited. After completion: No impact on water use is expected.
19	Existing social infrastructure and social services	B^-	B^+	During construction: Road closures and traffic restrictions are expected to cause traffic congestion. The operation of boats connecting the left and right banks of the Wouri River and Djebale Island may be affected. After completion: Improved access to schools, hospitals and markets and frequency of trash collection is expected.
20	Social capitals and social organizations such as local decision-making bodies	D	D	There will be no impact on social capital and social organizations, such as local decision-making bodies.
21	Uneven distribution of damage and benefit	D	D	There will be no unfair damage or benefit to the local economy.
22	Conflict of interest in the region	D	D	There will be no conflict of interest in the target area.
23	Cultural assets	D	D	There are no cultural assets in the area that should be protected.
24	Scenery	D	D	There is no scenery nearby that should be protected.

No	Impact	During construction	After completion	Reason
25	Gender	D	B^+	During construction: There are no plans that will have a negative impact on gender issues. After completion: The development of roads will make it easier to use taxis, etc. and access to markets will be improved.
26	Children's rights	D	B^+	During construction: There are no plans that have a negative impact on children's rights. After completion: The development of a road will improve access to the school.
27	HIV/AIDS and other infectious diseases	B^-	D	During construction: The inflow of construction workers may spread infectious diseases.
28	Working environment	D	B^+	During construction: There will be no negative impact on workers. After completion: Access to/from the city will be possible and local revitalization and creation of employment can be expected.
Others				
29	Accident	B^-	B^-	During construction: Caution should be used to prevent accidents during construction. After completion: The development of roads may increase the volume and speed of traffic, causing more accidents.
30	Transboundary impacts and climate changes	D	D	There will be no transboundary impacts or impacts on climate changes.

Source: JICA survey team

8.5 Mitigation measures

Through discussion with the local organizations concerned and analysis of documents, measures to mitigate possible impacts have been studied as below.

Table 8.10 Proposed Mitigation Measures

No	Impact	Reason
1	Air pollution	During construction: Mandate periodic water sprinkling, management of heavy equipment and construction vehicles and no idling. After completion: Conduct monitoring and take appropriate actions when necessary such as water sprinkling.
2	Water pollution	During construction: Use caution to prevent waste water from spreading using oil fences or pollution prevention nets, etc. Inspect construction vehicles appropriately.
3	Waste	During construction: Before construction, a waste management plan (clarifying the waste disposal method for each type of waste in compliance with the law) will be developed by the executing organization and approved by MINEPDED. The contractor will dispose of waste according to the plan. After completion: Garbage collection and monitoring periodically.
4	Soil pollution	During construction: The contractor will conduct appropriate inspections to prevent liquid spilling from construction vehicles and other abnormal incidents. The contractor will use appropriate construction vehicles.
5	Noise and vibration	During construction: Prohibit carrying in/out or construction at night. After completion: Install traffic signs and conduct traffic control.
6	Subsidence	During construction: Select a construction method for those sections with soft ground assumed, referring to Guidelines for Road Earthwork and Countermeasures against Soft Ground. After completion: Monitor periodically.
7	Bottom materials	During construction: Examine a construction method which will reduce the impact on bottom materials, such as soil runoff.
8	Ecosystem	During construction: Minimize cutting of trees, particularly mangroves and take tree cutting procedures according to the domestic law.

No	Impact	Reason
9	Hydrometeor	During construction: Consider minimizing changes of riverbeds when determining the locations of bridge piers, designing foundations, etc. After completion: Monitor periodically.
10	Topography and geography	During construction: Consider minimizing changes to geographical features of the river when determining the locations of bridge piers, designing foundations, etc. After completion: Monitor periodically.
11	Relocation of residents	During construction: Pay appropriate compensation according to the JICA Guidelines. After completion: Monitor appropriately according to the JICA Guidelines.
12	The poor	
13	Ethnic minorities and indigenous peoples	During construction: Consider taking some measures on the day and during the preparation of the Ngondo festival so that construction work will not affect the festival.
14	Local economy including employment and livelihoods	During construction: Inform fishermen and sand collectors of the construction period and sites in advance. When the project results in any change in employment and livelihoods, compensation for such change is provided in compliance with JICA Guidelines.
15	Use of land and local resources	During construction: Inform the households that may be affected of the construction period and sites in advance.
16	Water use	During construction: Inform the households that may be affected of the construction period and sites in advance.
17	Existing social infrastructure and social services	During construction Inform road uses and the parties in charge of river crossing boats of the construction period and sites in advance. Secure a route and place personnel for traffic control.
18	HIV/AIDS and other infectious diseases	During construction: Carry out health checkups and educational activities for construction workers.
19	Accident	During construction: Install construction signs and night lighting. Deploy personnel for traffic control when using construction vehicles. After completion: Install traffic signs and street lamps. Conduct traffic control.

Source: JICA survey team

8.6 Legal framework and implementation system concerning land acquisition and relocation

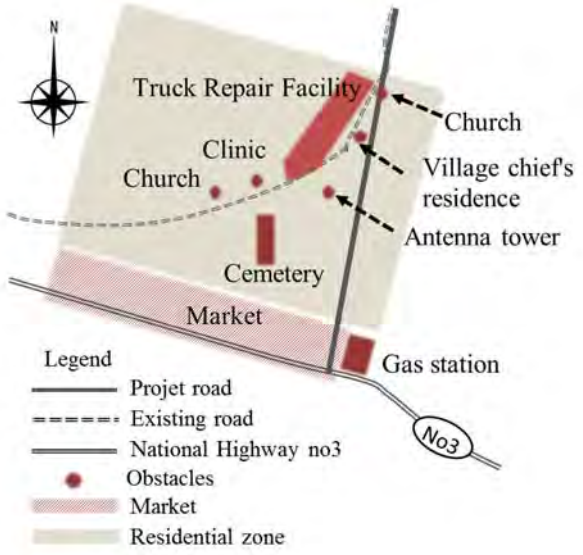
8.6.1 Scale of land acquisition and relocation

In the project, improvement to the access road on the right bank (Bonamatoumbe – Sodico – Bonendale – Ndobo) is planned without making major changes in road alignment and width to minimize relocation. Therefore, new land acquisition for roads is not expected. However, for the connection point between the access road and NR3 in Ndobo, land must be obtained to construct the road and the need for residents and merchants to relocate is confirmed. Along the NR3 in Ndobo, there are many commercial facilities, including restaurants and butcher shops as well as houses behind the road. These buildings are mostly simple block or barrack structures.

Conversely, for the Djebale Bridge (Bonamoussadi – Djebale Island – Bonamatoumbe), land need not be obtained for bridge construction on either bank because Cameroon has a housing development plan that includes the development of access roads and the route will avoid houses on Djebale Island.

The following table shows the scale of relocation at the connection point with the national road and interfering properties around the planned road.

Table 8.11 Scale of Relocation and Interfering Properties in Ndobo

Scale of Relocation	Locations of Interfering Properties
[Interfering property] Church: 1	
[Relocation of residents] Shops: Approx. 10 Houses: Approx. 50 Estimated No. of residents: Approx. 187 (The No. of residents is based on the average number of family members (3.73/family) in the target area determined through the Douala City population census.)	

Source: JICA survey team

8.6.2 Legal framework for land acquisition and resettlement and its implementation structure

The law on compensation for public works projects (Law No. 85-09 of 4 July, 1985 on expropriation in the public interest and the means of compensation) stipulates procedures of resettlement of residents due to such projects and compensation for the same. It applies when the project is implemented and includes information disclosure, compensation for losses and development of a system to handle grievances.

However, the law is not applied to illegal residents and not observed in some cases. Since compensation has been limited to monetary compensation due to the lack of any available vacant lot in Douala City recently, no compensation can be paid before resettlement in emergency projects. Because they differ from procedures of JICA Guidelines, discussions are needed with Cameroon when the project is implemented. When a project involves resettlement of residents, a verification and evaluation committee (Commission de Constat et d'Evaluation, hereinafter referred to as "CCE") comprising relevant ministries is set up by the Ministry of Public Domain, Cadaster and Land Affairs (Ministère des Domaines, du Cadastre et des Affaires Foncières, hereinafter referred to as "MINDGAF"). The CCE is responsible for formulating a resettlement plan and chaired by the governor. It is set up when project implementation is decided and an ordinance is issued.

Table 8.12 Resettlement Procedures and Necessary Time Period

Period	Resident Resettlement procedures
1.0 month	1) After the decision to implement the project, the CCE, comprising relevant ministries and director of the Wouri branch is set, with the Wouri governor as the chair. 2) CCE decides the border of project site.
3.0 months	3) CCE conducts a population census and understands the number of residents subject to resettlement. 4) The cutoff date is decided after census completion.
-	5) CCE organizes a public hearing for residents subject to resettlement and explains the project overview and its needs. The public hearing is repeated until residents agree on the project implementation. (Time required for 5 differs by project.)
1.5 months	6) CCE conducts a census of residents subject to resettlement, conducts their property and land survey, calculates the amount of compensation and prepares a survey report.
10 days	7) CCE reviews the survey report to examine whether its contents (calculation of amount of compensation, resettlement plan and census survey results) are in line with the provisions. 8) When the report is determined as problematic as a result of the review, the survey is repeated and the report is revised. 9) When it is decided that there is no problem, the report is submitted to the Ministry of Finance.
10 days	10) The Ministry of Finance checks the contents of the survey report.
-	11) The Ministry of Finance prepares an ordinance based on the survey report. It specifies the decision of project site and compensation. 12) The ordinance is confirmed and signed by the President or Prime Minister. (Time required for 11 and 12 differs by project.)
-	【Procedures of grievance handling system】 13) Accept petitions and complaints from residents subject to resettlement. 14) Petitions and complaints are submitted to CCE and the contents are reviewed for handling. 15) A lawsuit is filed when residents do not agree to 14 above. 16) Compensation is paid after handling of all complaints is confirmed. 17) Resettlements begin. (Time required for 13 to 15 differs by project.)

Source: Cameroon Law on Compensation for Public Works Projects

Comparison of JICA Guidelines and Cameroon Laws on Land acquisition

Table 8.13 Comparison of JICA Guidelines and Cameroonian Laws on Resettlement Procedures

No	JICA Guidelines	Cameroonian Laws	Gap between JICA Guidelines and Cameroonian Laws	Project's Resettlement Policies
1	Involuntary resettlement and loss of means of livelihood are to be avoided where feasible by exploring all viable alternatives.	Where resettlement is unavoidable due to public works, relocation is carried out in line with laws (Law No. 85-09 of July 4, 1985 and Decree No. 87-1872 of December 16, 1987). The laws stipulate details of compensation, preparation of a relocation plan and its implementation, establishment of a mechanism to handle grievances and responsible organizations, consultations with residents and others.	In conformity with JICA Guidelines	In compliance with JICA Guidelines
2	When resettlement is unavoidable, effective measures to minimize the impact and to compensate for losses must be taken.			
3	Residents subject to resettlement are compensated and supported sufficiently so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.			
4	Compensation must be based on the full replacement cost as much as possible.	Compensation necessary for recovering losses of assets is provided. (Chapter 2.8-9, Law No. 85-09 of 4 July 1985)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
5	Compensation and other kinds of assistance must be provided prior to physical resettlement.	Compensation is provided before resettlement. (Chapter 1.4 *Law No. 85-09 of 4 July 1985)* However, compensation money may be paid after resettlement in emergency cases.	Compensation money has to be paid prior to resettlement under JICA Guidelines.	Decided after establishment of CCE
6	For projects that involve large-scale involuntary resettlement, resettlement plans must be prepared and made available to the public.	Resettlement plans are formulated by CCF. (Chapter 1.2, Decree No. 87-1872 of 16 December, 1987)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
7	In preparing a resettlement plan, discussions must be held with the affected people and their communities based on sufficient prior discussions.、	Explanations are given to affected residents and communities in advance. (Chapter 1.9-11, Decree No. 87-1872 of 16 December, 1987)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
8	When discussions are held, explanations must be given in a language and form that are understandable to the affected people.			
9	Appropriate participation of affected people must be promoted in planning, implementation and monitoring of resettlement plans and measures against loss of means of living.	CCE conducts interview survey with residents and produces minutes.(Chapter 1.10-12, Decree No. 87-1872 of 16 December, 1987,)	Residents meetings are customarily held to comply with JICA Guidelines.	Organize a participatory consultation with residents before the relocation plan is prepared and obtain their

No	JICA Guidelines	Cameroonian Laws	Gap between JICA Guidelines and Cameroonian Laws	Project's Resettlement Policies
				agreement with a policy for compensation and support
10	Grievance mechanisms must be established for the affected people and their communities	CCE establishes grievance mechanisms. (Chapter 3, Law No. 85-09 of 4 July, 1985)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
11	Affected people are to be identified and recorded through an initial baseline survey (including population census, asset inventory and socioeconomic survey) to establish their eligibility to receive compensation and support, preferably at the earliest project stage, to prevent a subsequent influx of encroachers of others who seek to receive such benefits.	Verification and assessment committee members conduct population census. (Chapter 1.9-12, Decree No. 87-1872 of 16 December, 1987)	In conformity with JICA Guidelines	In compliance with JICA Guidelines
12	Those who are eligible to receive compensation and support are those who have legal rights to land, those who do not have legal rights to land but such rights are recognized if they claim them based on the laws of the target country, and those who have no recognizable legal right to the land they are occupying or the claim to it.	No compensation for illegal residents is stipulated.	JICA Guidelines require compensation for illegal residents.	To be confirmed after CCE is set up.
13	Preference should be given to land-based resettlement strategies for those whose livelihoods are land-based.	Land with elements equivalent to those of acquired land is provided. (Chapter 2.8, Law No. 85-09 of 4 July, 1985) Compensation is only monetary as there is no vacant lot in Douala.	JICA Guidelines require consideration of provision of alternative land when their livelihoods are land-based.	To be confirmed after CCE is set up.
14	Provide support for the transition period.	It is not put into statutory form.	JICA Guidelines require support particularly for the vulnerable.	To be confirmed after CCE is set up.
15	Special considerations are given to vulnerable social groups, particularly the poor, non land-owners, the elderly, women, children, indigenous people and ethnic minorities.			
16	A resettlement plan is formulated for projects that involve resettlement of fewer than 200 residents or land acquisition.	A resettlement plan is formulated regardless of the scale of residents subject to resettlement. (Chapter 1.2. Decree No. 87-1872 of 16 December, 1987).	In conformity with JICA Guidelines	In compliance with JICA Guidelines

Source: JICA survey team (based on Guidelines)

9. Clarification of Japan's Course of Assistance

The following are our proposals for each soft component, such as bridges, access roads on the right bank and technical assistance.

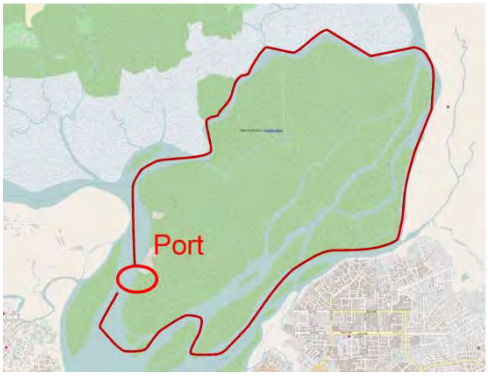
9.1 The Djebale Bridge Construction Project

1) Background and proposal of a scheme

Currently, a road connecting the east and west sides of the Wouri River via Djebale Island is planned in CUD's masterplan, etc. to relieve traffic congestion on the roads in the city. Although three bridges, around 600m long, are planned, Cameroon cannot plan or construct such bridges with its own technologies and it will not be easy to secure huge funds needed for their construction. Therefore, the government of Cameroon may request that in future, Japan provide a yen loan to construct such long bridges. One of the purposes of constructing this road and these bridges is to improve the living environment in Djebale Island, where infrastructure for water, gas and electricity remains underdeveloped. Moreover, constructing a symbolic bridge would boost tourism of Djebale Island and the Wouri River as the CUD considers, while ripple effects on the economic growth of Douala city could also be expected. Rades-La Goulette Bridge, a long oblique structure constructed in Tunis, Tunisia, exemplifies these benefits and has been featured on the design of a national bank note. Constructing such bridges will impact on the people in Cameroon and strongly impress Japan's assistance on them as well. Looking at the current budgeted expenditure of Cameroon, debt repayment takes up a large proportion. Accordingly, unlike the development of ports, etc. carried out by China and Korea, such bridge construction will not generate profit and implementation with a yen loan will probably be questioned. Conversely, Cameroon has a high level of confidence in Japanese technologies. It is believed that implementing the Project using the advanced technology and rich experiences of Japan within the Special Terms for Economic Partnership (STEP), which is a system created to promote the international aid emphasizing Japan's presence through the transfer of technology to developing countries, with a proper understanding of the financial situation of the country, will be effective in promoting good relations with the country and introduction of Japanese technologies, and that there will be benefits in terms of life cycle and economy. Assistance for tourism development as an additional part of the Project is also believed to be effective and "equipment provision and operation management of sightseeing boats around Djebale Island" and "construction and operation management of a roadside station in Djebale Island" through PPP could also be proposed.

Source: JICA survey team

Photo 9.1 Rades-La Goulette Bridge in Tunisia (Below: Bank note with the bridge)



Source: JICA survey team

Figure 9.1 Other Supplementary Projects (Proposal):
Left-Sightseeing Boat Route, Right-Roadside Station

2) Project purpose

Smooth and stable transportation in Douala city is ensured by establishing a road connecting east and west sides of the Wouri River.

3) Project outputs

The Project will constitute eliminating traffic congestion in Douala city, improving the living environment in Djebale Island and developing the tourism of the city.

4) Target area

Bonamoussadi (left bank) – Djebale Island – Bonamatoumbe (right bank)

5) Local organization concerned

MINTP

6) Rough project cost

For all sections: Approx. 69 billion yen

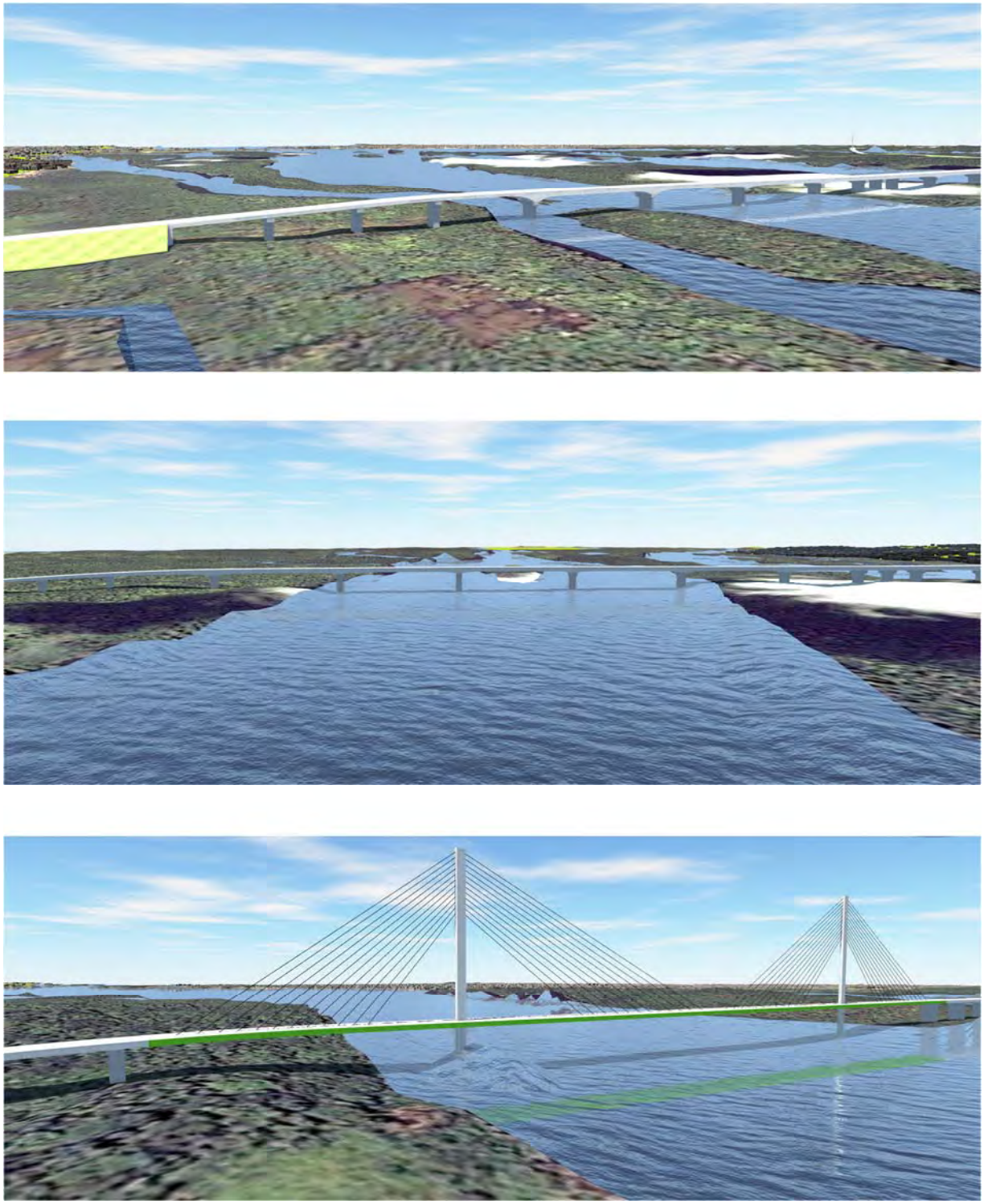
* For Bonamoussadi (left bank) – Djebale Island": Approx. 36 billion yen

7) Points to consider for project implementation

Not all the three long bridges need be symbolic or very costly to construct. If the need to "improve the living environment in Djebale Island" and "develop tourism in Douala city", cited as project outputs, are prioritized, constructing roads and bridges that only connect the right bank to Djebale Island would contribute to these outputs. If such a symbolic bridge is to be constructed in Cameroon as a first, the soft components to be described (technical assistance projects) should be added, which is also what engineers in Cameroon want.

Source: JICA survey team

Figure 9.2 Conceptual Drawing (1/2) (Proposal: a steel cable stayed bridge on the right (③) and 2 PC box-girder bridges on the left bank (① and ②))



Source: JICA survey team

Figure 9.3 Conceptual Drawing (2/2)

(Upper image: View of the PC box-girder bridge from the left bank (①); Middle image: View of the PC box-girder bridge from the Wouri River (②); Lower image: View of the steel cable stayed bridge from Djebale Island (③))

9.2 Development of access roads and improvement of intersections

To generate the effect of the development of the Djebale Bridge, the development of access roads on the right bank and improvement of surrounding intersections seems necessary. Table 9.1 shows the proposed approaches.

Table 9.1 Proposed Assistance Approaches

No	Project Title (Proposal)	Assistance Scheme	Challenges/Issues to be Reviewed
2-1	Project to improve access roads for the Djebale Bridge on the right bank	Grant aid	・ Decision on the Djebale Bridge route ・ Relocation of local residents ・ Future railroad planning (In this study, securing two tracks was requested.) ・ Degree of interest of contractors in Japan (Grant aid is necessary, to facilitate inclusion of qualified companies in Japan to ensure construction quality in case Japanese technologies are required)
2-2	Same as above	Yen loan (including joint financing)	・ Decision on the Djebale Bridge route ・ Relocation of local residents
2-3	Same as above	To be borne by the recipient country	・ Technical capabilities (construction of overpasses and improvement of intersections) ・ Implementation capabilities (including funding and administrative supervision) ・ Delay in road sharing due to delay in construction
2-4	Project to improve congested intersections on the left bank	Grant aid	・ Selection of intersections to be improved ・ Construction plan (traffic control, etc.) ・ Degree of interest of contractors in Japan (Grant aid is necessary, to facilitate inclusion of qualified companies in Japan to ensure construction quality in case Japanese technologies are required)

Source: JICA survey team

9.3 Soft components

(1) List of proposals

Table 9.2 shows assistance approaches taken to improve bridge maintenance and traffic control capacity.

Table 9.2 Proposals of Assistance Approaches (Introduction of Soft Components)

No	Project Title (Proposal)	Assistance Scheme	Assistance
3-1	Bridge Maintenance Capacity-Building Project	Technical assistance	・ Enhanced maintenance capacity for the types of bridges to be introduced to Cameroon as firsts (cable-stayed, extradosed bridges, etc.) ・ Introduction and guidance of BMS
3-2	Traffic Control Capacity-Building Project	Technical assistance	・ Assistance to improve capacity for intersection process planning and intersection designing ・ Social experiment on the introduction of a signal system and improvement of traffic operation ・ Assistance in education concerning traffic safety and traffic rules ・ Assistance to improve the license system

3-3	Public Bus Corporation Operation Capacity-Building Project	Technical assistance	・Provision of bus operation recorders and other equipment ・Assistance for comprehensive traffic policies, including BRT plan ・Assistance in transferring operational techniques

Source: JICA survey team

(2) Overview of the "Bridge Maintenance Capacity-Building Project"

1) Background to the project

For the Djebale Bridge, a new bridge type was selected for the first time in Cameroon and technical assistance concerning maintenance methods is required because MINTP and CUD, who will be in charge of maintaining the bridge, lack experience in maintaining this particular type of structure. Manuals for inspection, diagnosis, repair, reinforcement, etc. also remain incomplete for general types of bridges.

Accordingly, technical assistance will be provided for the maintenance plan for Djabale Bridge and other general bridges.

2) Project sites

The Djebale Bridge and other bridges, including existing structures managed by MINTP (Yaoundé-Douala)

3) Beneficiaries

MINTP personnel (head office and local offices), CUTD, employees of private companies (construction companies and consultants), university officials, etc.

4) Period of assistance

Three years after completion of the Djebale Bridge

5) Rough project cost (to be borne by the Japanese side)

About 300 million yen

6) Local counterparts

MINTP and CUD

7) Overall goal

By properly maintaining bridges in the Douala Metropolitan Area, including the Djebale Bridge, this project aims to contribute to the development of urban transport networks in Douala City, an economic capital of Cameroon, and the smooth transportation of people and goods.

8) Project purpose

By providing practical training to Cameroonian researchers and engineers engaged in the maintenance of bridges in the Douala Metropolitan Area, including the Djebale Bridge, through on-the-job training in the relevant technical cooperation project, this project aims to enhance bridge maintenance capacity and ensure proper maintenance.

9) Outputs

Output 1:	To build maintenance capacity, all employees in MINTP and CUD maintenance departments receive training and their capacity is improved.
Output 2:	To build maintenance capacity, a bridge maintenance system is established.
Output 3:	To build maintenance capacity, the necessary equipment and testing devices are prepared and operated appropriately.

10) Activities

[Activity 1]

To improve maintenance capacity, engineers engaged in maintenance will receive OJT training concerning damage diagnosis with bridge inspection and material testing using XX bridge (to be determined through discussion with C/P), which is significantly damaged.

[Activity 2]

To improve maintenance capacity, a bridge ledger and bridge maintenance manual will be developed.

[Activity 3]

To improve maintenance capacity, guidance will be given to officials of the head office and local offices and on-site engineers about bridge inspections, inspection result report, maintenance methods and how to use the bridge ledger and the bridge maintenance manual.

[Activity 4]

To improve maintenance capacity, a bridge maintenance system appropriate for the current state of Cameroon will be established.

[Activity 5]

To learn the latest bridge construction technologies, training will be conducted overseas (in Japan).

11) Inputs

The following inputs are expected:

(a) Japan

- Dispatch of experts
- Training in Japan
- Provision of equipment
- Local activity cost

(b) Cameroon

- Appointment of counterparts (MINTP and CUD)
- Project office
- Provision of facilities and equipment necessary to implement the Project
- Operation cost and current expenditure

(3) Overview of the "Traffic Control Capacity-Building Project"

1) Background to the project

In Duala city, soaring traffic in connection with industrial clusters and population is causing large-scale congestion. The causes include violation of driving and parking rules, a lack of regulation and control over such violations as well as a lack of capacity at intersections and underdevelopment of traffic control facilities (such as signals and signs).

This project is intended to ease traffic congestion and reduce accidents in Duala city by improving the implementation capacity of the traffic controllers for intersection planning, traffic control and driver education.

2) Project site

Duala city

3) Beneficiaries

CUD, police and drivers

4) Period of assistance

3 years from 201X

5) Rough project cost (to be borne by the Japanese side)

Approx. 300 million yen

6) Local counterpart

CUD

7) Overall goal

In Duala, traffic congestion and accidents are reduced and road traffic conditions are improved.

8) Project purpose

Control the traffic capacity of CUD and enhance the police.

9) Outputs

Output 1: CUD's traffic design and improvement planning capacity is enhanced.
Output 2: Traffic regulation and control capacity of the police and CUD is improved.
Output 3: CUD's capacity for traffic safety education and awareness activities is improved.

10) Activities

[Activity 1]

1-1: Selection of target intersections and execution of traffic census

1-2: Consideration and design of improvement measures

1-3: Execution of social experiments concerning improvement of intersections

[Activity 2]

2-1: Analysis of current state and identification of issues concerning traffic regulations

2-2: Consideration of traffic regulations and manner in which manuals are operated and developed

2-3: Execution of social experiments concerning traffic regulations and operation

[Activity 3]

3-1: Current analysis and identification of issues concerning traffic safety guidance and license system

3-2: Development of a driver education program

3-3: Execution of a traffic safety campaigns for road users

11) Inputs

The following inputs are expected:

(a) Japan

- Dispatch of experts
- Training in Japan
- Provision of equipment
- Local activity cost

(b) Cameroon

- Appointment of counterparts (CUD and police)
- Project office
- Provision of facilities and equipment required to implement the project
- Operation cost and current expenditure

(4) Overview of the "Public Bus Corporation Operation Capacity-Building Project"

1) Background of the project

In Duala city, soaring traffic in connection with industrial clusters and population is causing large-scale congestion. Although public buses are operated by SOCATUR, owned by CUT, the services are insufficient in terms of frequency and scope and many people opt for taxis instead. Vehicles have also been provided by other countries. To ensure the sound development of urban transportation in Douala, it is essential to establish a system where SOCATUR maintains its equipment sustainably and can provide better urban public bus services.

This project is to improve the level of public bus services by clarifying people's requests concerning bus services in general and implementing preferential bus transportation policies through technical assistance from Japan.

2) Project site
   Douala city
3) Beneficiaries
   SOCATUR, bus users, etc.
4) Period of assistance
   Three years from 201X
5) Rough project cost (to be borne by the Japanese side)
   About 300 million yen
6) Local counterpart
   SOCATUR
7) Overall goal
   Improve public bus services in Douala.
8) Project purpose
   SOCATUR's operating capacity of SOCATUR is improved.
9) Outputs

Output 1: Management of the bus corporation is improved. Output 2: Public bus service improvement measures reflecting people's requests are implemented. Output 3: Appropriate public transportation policies and plans concerning public bus transportation are established.

10) Activities
   [Activity 1]
   1-1: Measures to improve the operation status (such as establishing a mid-term management plan and improving a fare recording system) will be implemented.
   1-2: Training will be provided to improve the capacities of the counterparts for accounting, operation, vehicle maintenance and guidance.
   1-3: Equipment and facilities will be installed/improved for vehicle operation and management.
   1-4: Social experiments for public bus transportation will be conducted.
   [Activity 2]
   2-1: A transportation committee will be established to ensure the effective use of buses.
   2-2: Opinions and requests concerning bus services will be collected.
   2-3: Bus service evaluation criteria and service standards will be established.
   2-4: Bus routes and locations of bus stops will be planned and reviewed as requested by the community.
   2-5: Bus service improvement measures will be carried out.

[Activity 3]

3-1: The bus fare structure will be reviewed and an appropriate fare system established.

3-2: Consideration will be given to a policy to subsidize public bus transportation.

3-3: A mid-term public bus transportation plan will be established.

3.4: A preferential bus transportation policy (strengthening crackdowns on illegal parking, etc.) will be promoted.

3-5: Public transportation policies and plans will be updated (BRT, taxi, etc.).

11) Inputs

The following inputs are expected:

(a) Japan

- Dispatch of experts
- Training in Japan
- Provision of equipment (bus operation recording machines, computers, traffic analysis software, etc.)
- Local activity cost

(b) Cameroon

- Appointment of counterparts
- Project office
- Provision of facilities and equipment required to implement the project
- Operation cost and current expenditure

9.4 Proposal

As traffic congestion has become a serious issue affecting the economic activities of Cameroon and Douala city, the development of transportation infrastructure is crucial. The need to expand the road network is particularly urgent and it seems the "Djebale Bridge Construction Project" and the "Project to Improve Access Roads on the Right Bank of the Djebale Bridge" will be highly effective. Concerning the construction of the Djebale Bridge, the access roads on the right bank that are currently undeveloped and unpaved should be first developed as construction roads to ensure access to the site and transport materials and equipment. To generate a development effect after the bridge construction, the construction of the bridge and development of the access roads go hand in hand.

To optimally exploit existing roads and bridges, technical assistance projects such as the "Douala City Traffic Control Capacity-Building Project" and the "Bridge Maintenance Capacity-Building Project" should be carried out from a mid-term perspective and synergy with the construction of the Djebale Bridge and its access roads discussed above can be expected. Moreover, collaborative assistance will also be possible; for example, small-scale improvements to existing congested intersections, installation of traffic lights, etc. can be carried out as social experiments in the "Douala City Traffic Control Capacity-Building Project" and grade separation can be constructed for intersections where small-scale improvements are insufficient in the "Project to Improve Congested Intersections in Douala".

Based on the above-mentioned, we classify 6 project proposals in 3 categories according to their respective implementation period (short, medium and long term), as shown in Table 9.3.

We hope that the projects proposed in this study will be carried out at appropriate timing and in a planned manner so that they will boost the economic growth of Cameroon and Duala and improve people's living standards.

Table 9.3 List of Proposed Projects

No.	Project Title	Assistance Scheme	Priority determined by the Survey Team
Short-term (to be initiated in about five years from now)			
1	The Djebale Bridge Construction Project	Yen loan	High
2	Project to Improve Access Roads on the Right Bank of Djebale Bridge	Grant aid Yen loan (including joint financing)	High
Mid-term (to be initiated in about 5-10 years from now)			
3	Douala City Traffic Control Capacity-Building Project	Technical assistance	High
4	Project to Improve Congested Intersections in Douala	Grant aid	Moderate
Long-term (to be initiated in about 10 years from now)			
5	Bridge Maintenance Capacity-Building Project	Technical assistance	High
6	Public Bus Corporation Operation Capacity-Building Project	Technical assistance	Moderate

Source: JICA survey team