No.

Ministry of Fisheries and
Marine Resources Development
Ministry of Public Works and Utilities
The Republic of Kiribati

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
IMPROVEMENT OF FISHERIES TRANSPORTATION
IN SOUTH TARAWA
IN
THE REPUBLIC OF KIRIBATI

JANUARY 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

CONSTRUCTION PROJECT CONSULTANTS, INC.

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PREFACE

In response to a request from the Government of the Republic of Kiribati, the Government of Japan decided to conduct a basic design study on Basic Design Study Report on the Project for Improvement of Fisheries Transportation in South Tarawa and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Kiribati a study team from July 18, to August 23, 2006.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Kiribati for their close cooperation extended to the teams.

January, 2007

Masafumi Kuroki
Vice-President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

January, 2007

We are pleased to submit to you the basic design study report on the Project for Improvement of Fisheries Transportation in South Tarawa in the Republic of Kiribati.

This study was conducted by Construction Project Consultants, Inc., under a contract to JICA, during the period from July, 2006 to January, 2007. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Kiribati and formulated the most appropriate basic design for the project under Japan's Grant Aid scheme.

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

Very truly yours,

Jiro Koyama
Project manager,
Basic Design Study Report on the Project for Improvement of Fisheries Transportation in South Tarawa
Construction Project Consultants, Inc.

SUMMARY

SUMMARY

The Republic of Kiribati (hereinafter referred to as “Kiribati”) belongs to the tropical oceanic climate zone and its capital, Bairiki, is located in South Tarawa (i.e. the southern part of the Tarawa Atoll). As South Tarawa is almost flat with an elevation of 1 – 4 m, rainwater often creates puddles on the roads, etc. The long, narrow topography of the atoll makes it very difficult to construct new roads to be added to the existing roads.

The climate is very temperate with an average temperature of around 28C. While the rainfall fluctuates from one year to another, the annual rainfall is normally around 2,000 mm with no distinctive dry or rainy season.

The land of Kiribati is considerably scattered and the local soil conditions do not offer much potential for either agricultural or forestry development. The Government of Kiribati has, therefore, been attempting the development of the national economy using fisheries, which effectively utilize the vast EEZ, as the principal industry.

According to the 2000 population census, South Tarawa has a population of 36,717 (40,311 as of 2005) with 4,529 households, accounting for more than one-third of the total population of Kiribati of 84,494. A survey by the Ministry of Fisheries and Marine Resources Development (MFARD) has found that some 75% of the households in South Tarawa are involved in fisheries activities in one way or another as of 2005. Apart from being an important source of income, as the principal industry, fisheries are intrinsically linked to the economy and local life as marine products constitute an important supply source of animal protein. On outer islands, fisheries are practiced with a view to shipping products to Tarawa.

In South Tarawa, vehicles constitute the common means of transporting the catch as well as fishermen and the roads on Tarawa play a crucial role in not only the daily life of the islanders and economic activities on the island in general but also in the transportation of marine products and fishermen.

However, the roads on Tarawa are facing multiple problems, including ① the increased traffic volume in recent years due to the population increase, ② the growing size of vehicles, including trailers used to carry containers, due to increased imports, ③ the concentration of traffic on existing roads due to the difficulty of constructing new parallel roads, in turn caused by the long and narrow shape of the island, ④ the severe deterioration of the roads due to aging as many roads were originally constructed in the 1960’s and 1970’s and ⑤ the lack of drainage ditches and such safety facilities as sidewalks and bus lay-bys. These problems are now disrupting safe and smooth transport.

Under these circumstances, the Government of Kiribati decided that the improvement of roads should be an important policy objective, formulated a plan to improve the roads in South Tarawa over a total length of 60 km and made a request to the Government of Japan to provide grant aid assistance in June, 2005 for the improvement of urban roads among the roads identified for improvement in South Tarawa.

The contents of the original request were paving, provision of drainage ditches, sidewalks and bus lay-bys for trunk as well as minor roads in South Tarawa over a total length of 11.4 km and the provision of such road improvement equipment as crushers/screening plant and concrete cutters, etc. and their spare parts.

In response to this request, the Japan International Cooperation Agency (JICA) dispatched the Basic Design Study Team to Kiribati from 18th July to 23rd August, 2006. In addition to discussions on the contents of the request with the relevant officials of the Government of Kiribati, the Study Team conducted a field survey on the project area. Based on the work in Japan conducted after its return to Japan, the Study Team decided to rehabilitate the requested roads listed in the table below, explained the Draft Outline of the Basic Design from 31st October to 11th November, 2006 and obtained the basic agreement of the Government of Kiribati.

District	Section	Length (km)		Width (m)	Paving Type	Average Reinforcing Base Course Thickness (cm)
		Request	Planned			
Betio	South Tarawa Road	7.000	6.491	9.0-10.0	DBST	10.0
	Jetty Road	0.600	0.535	5.0-6.0	DBST	6.0
	Taatirerei Road	0.600	0.436	9.0-10.0	DBST	-
	Police Line Road	0.500	0.398	5.0-6.0	DBST	6.0
Bairiki	South Tarawa Road	1.500	1.460	9.0	DBST	10.0
	Frontage Road		0.124	5.0	BST	6.0
	Tabonikabaurea Road	0.300	0.270	5.5-7.5	BST	-
	TAP Road	0.200	0.155	4.0-6.0	BST	-
	Bairiki Wharf Road	0.400	0.482	4.0-6.0	BST	6.0
Bikenibeu	South Tarawa Road	0.300	0.280	6.5	DBST	6.0
Total		11.400	10.631	-	-	-

Note:DBST: bitumen surface treatment (dual-layer); BST: bitumen surface treatment (single layer)

At existing bus lay-bys, new paving will be provided up to the drainage ditch and carriageway section (bus lay-by) and two new bus lay-bys will be created. Drainage ditches and sidewalks will be installed where permitted by the width of the existing road.

Meanwhile, the originally requested crushers/screening plant have been removed from the scope of assistance as these were purchased by the Kiribati Ministry of Public Works and Utilities with its own budget in March, 2006 after the original request was made. In the case of concrete cutters, given the paving thickness of the existing paved roads of approximately 1 cm, it was judged that a small blade dimension of some 305 mm (maximum cutting depth of 100 mm) rather than the requested blade dimension of 254 – 356 mm (maximum cutting depth of 120 mm) should be sufficient and it was decided to provide two cutters (as requested) with the following specifications.

- Air-cooled petrol engine (3.5 KW or higher)
- Maximum depth: approximately 100 mm)
- Hand-pushed cutting movement
- Spare parts: one set

The Basic Design Study results indicate that the necessary time to implement the Project will be 4.5 months for the detailed design (including tender) and 9.5 months for the construction work if the Project is implemented under the grant aid scheme of the Government of Japan. Meanwhile, the estimated project cost is ¥1,275 million (some ¥1,272 million for the Japanese side and some ¥3 million for the Kiribati side).

Some 40,000 inhabitants of South Tarawa are expected to benefit from the implementation of the Project because of the improved road conditions in Betio, Bairiki and Bikenibeu and the resulting safe and smooth transportation in these districts. The expected effects of the Project are described below.

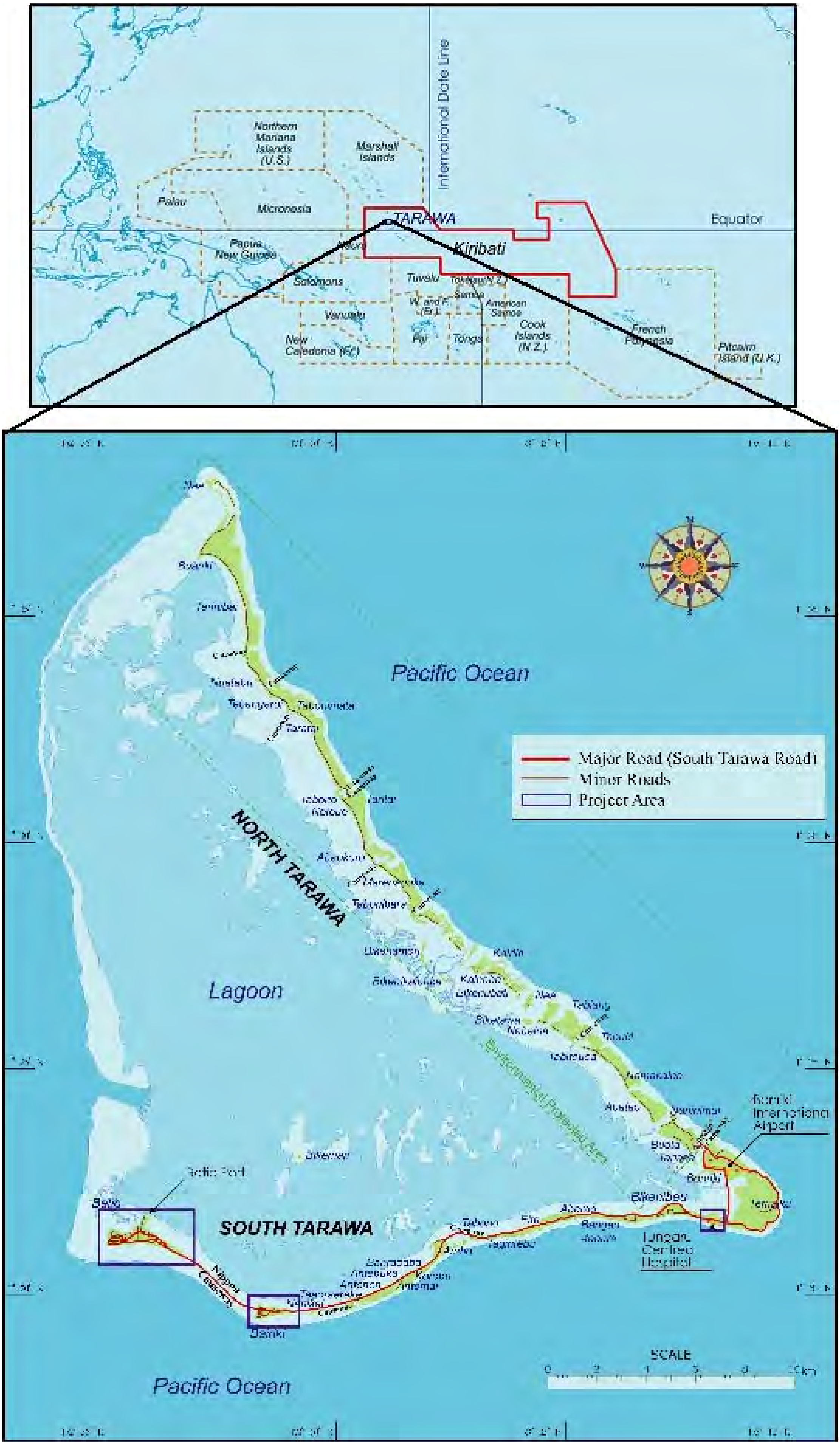
<u>Direct Effects</u>

- The road travelling time which is currently long due to the reduced travelling speed forced by ruts and potholes will be shortened due to the improved travelability.
- The improved road surface conditions will reduce the travelling cost of road users due to the reduction of tyre punctures and abrasion, reduction of suspension damage due to a lower burden and better fuel economy originating from the improved travelability.
- The rehabilitated roads will eliminate traffic on the shoulders, resulting in the avoidance of dangerous contact with fishermen selling their catch on the shoulders. The introduction of sidewalks will eliminate possible contact between vehicles and pedestrians. The improved traffic safety will reduce the number of traffic accidents.
- The elimination of ruts and potholes by the road rehabilitation work will make it easier for fishermen to travel long distances and transport heavy cargoes.
- The provision of concrete cutters will enable the much better repair of roads rather than the current repair work which is of a makeshift nature, resulting in a longer road life. Consequently, the maintenance labour and cost will be reduced and the good road surface conditions will last for a long time.

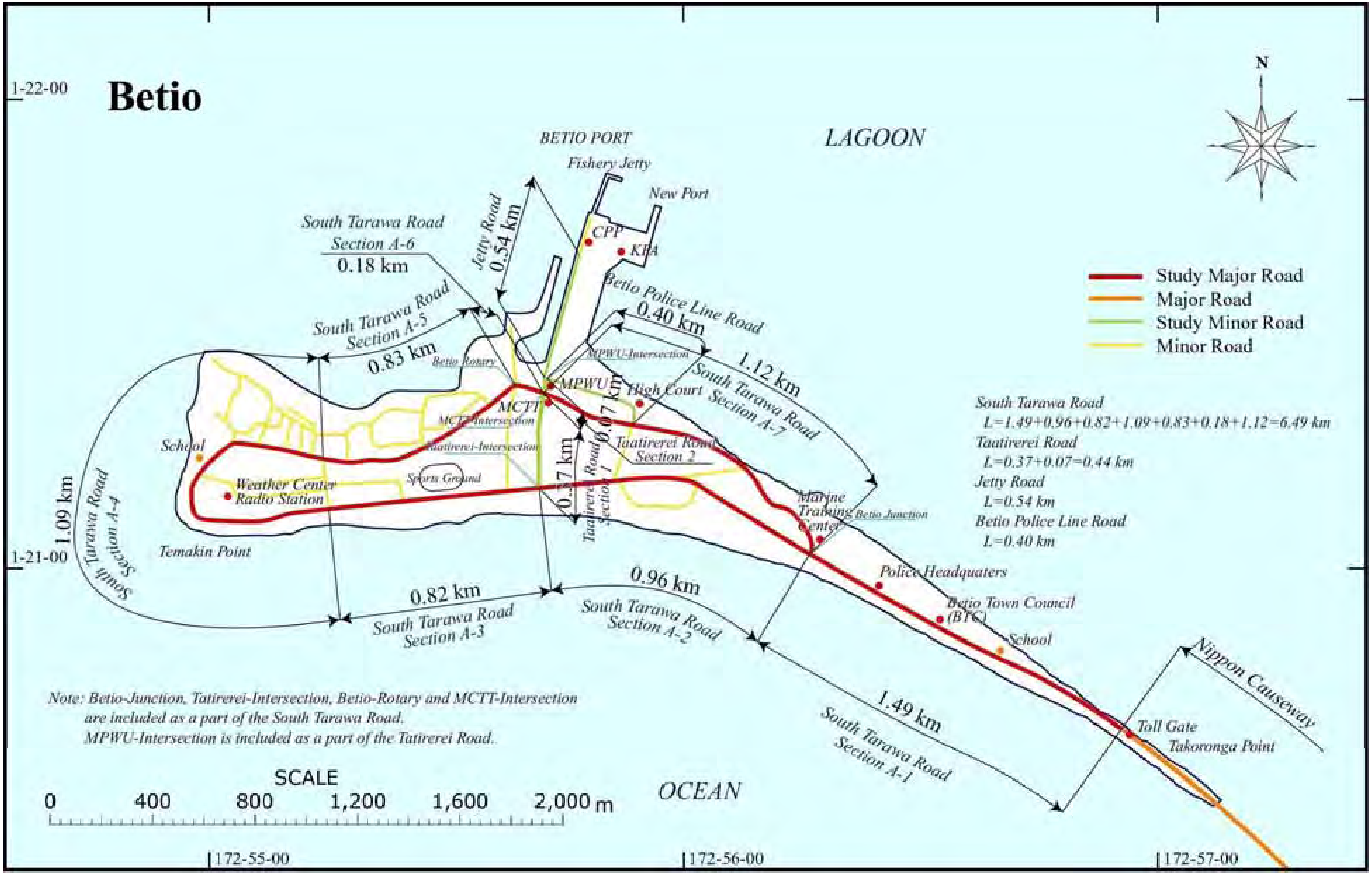
Indirect Effects

- The elimination of traffic on the shoulders due to the rehabilitated roads will prevent the fish sold on the shoulders from being splashed with dirty water and dirt, preventing a decrease of its commercial value.
- The improved travelability on the rehabilitated roads will increase the transportation efficiency of fish, enabling the preservation of fish freshness and the supply of fresh fish to hospitals and schools, etc.
- In the future, the bipolarisation of industries is expected to take place in South Tarawa, i.e. a commercial area centered on Betio and a fisheries area in the east. As a result, the physical distribution of marine products using roads is expected to become much more active. The improved travelability on the rehabilitated roads will increase the future efficiency of fish distribution in South Tarawa.

CONTENTS

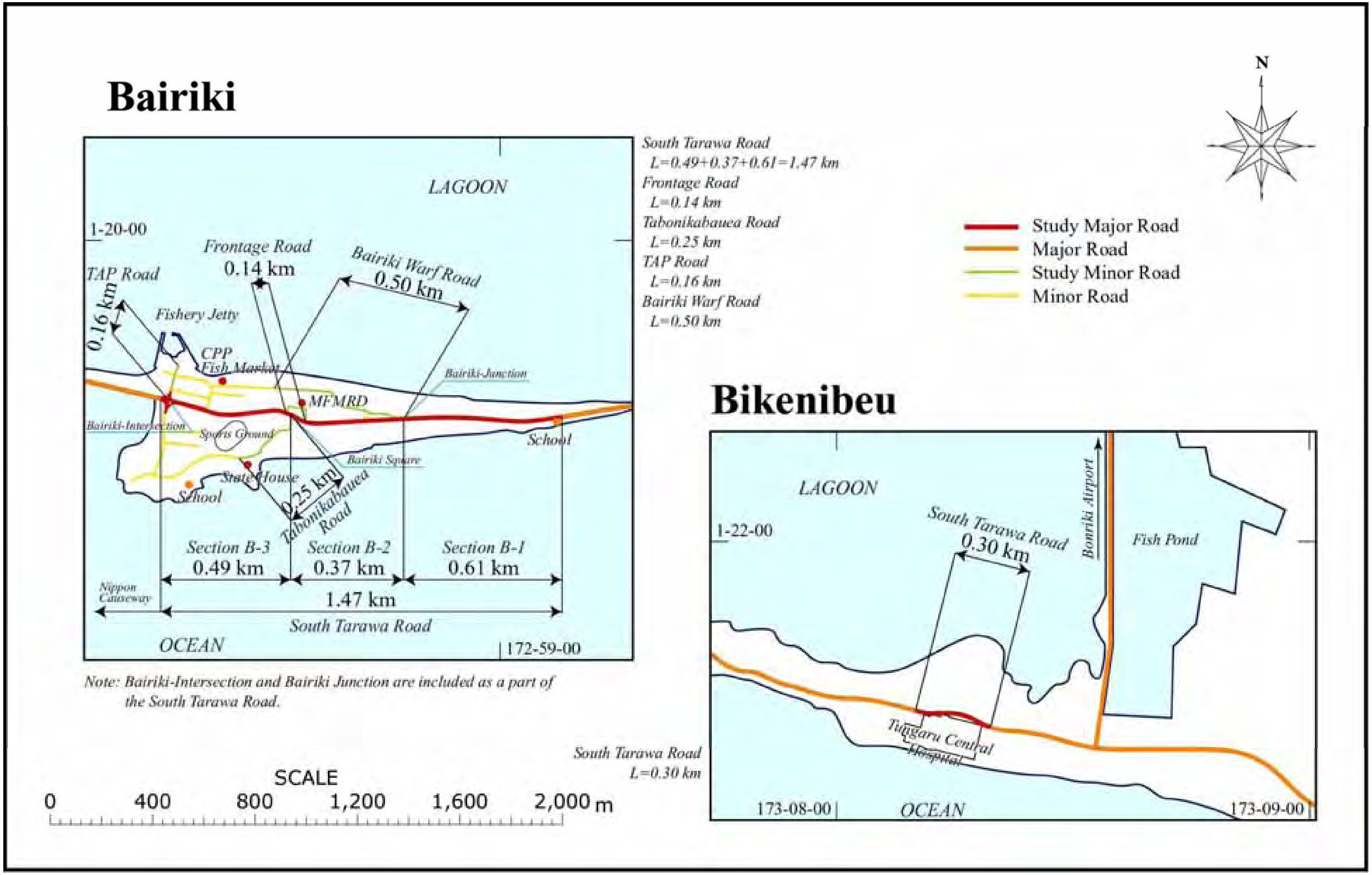


Location Map of the Study Area



Betio
1-22-00
1-21-00
172-55-00
172-56-00
172-57-00
N
LAGOON
OCEAN
BETIO PORT
Fishery Jetty
New Port
CPP
KPA
South Tarawa Road Section A-6 0.18 km
Jetty Road 0.54 km
South Tarawa Road Section A-5 0.83 km
Betio Police Line Road 0.40 km
MPWU-Intersection
Betio Rotary
MPWU
MCTT
MCTT-Intersection
High Court
1.12 km
South Tarawa Road Section A-7
Taatirerei-Intersection
Taatirerei Road Section 2
0.07 km
0.37 km
Taatirerei Road Section 1
School
Weather Center
Radio Station
Sports Ground
Marine Training Center
Betio Junction
1.09 km
South Tarawa Road Section A-4
Temakin Point
Police Headquaters
Betio Town Council (BTC)
School
0.82 km
South Tarawa Road Section A-3
0.96 km
South Tarawa Road Section A-2
1.49 km
South Tarawa Road Section A-1
Nippon Causeway
Toll Gate
Takoronga Point
Study Major Road
Major Road
Study Minor Road
Minor Road
South Tarawa Road
L=1.49+0.96+0.82+1.09+0.83+0.18+1.12=6.49 km
Taatirerei Road
L=0.37+0.07=0.44 km
Jetty Road
L=0.54 km
Betio Police Line Road
L=0.40 km
Note: Betio-Junction, Tatirerei-Intersection, Betio-Rotary and MCTT-Intersection
are included as a part of the South Tarawa Road.
MPWU-Intersection is included as a part of the Tatirerei Road.
SCALE
0
400
800
1,200
1,600
2,000 m

Route Map (1)


Bairiki
South Tarawa Road
L=0.49+0.37+0.61=1.47 km
Frontage Road
L=0.14 km
Tabonikabauea Road
L=0.25 km
TAP Road
L=0.16 km
Bairiki Warf Road
L=0.50 km
N
Study Major Road
Major Road
Study Minor Road
Minor Road
LAGOON
1-20-00
Frontage Road
0.14 km
Bairiki Warf Road
0.50 km
TAP Road
0.16 km
Fishery Jetty
CPP
Fish Market
MFMRD
Bairiki-Junction
Bairiki-Intersection
Sports Ground
Bairiki Square
School
State House
School
0.25 km
Tabonikabauea Road
Section B-3
0.49 km
Section B-2
0.37 km
Section B-1
0.61 km
Nippon Causeway
1.47 km
South Tarawa Road
OCEAN
172-59-00
Note: Bairiki-Intersection and Bairiki Junction are included as a part of the South Tarawa Road.
SCALE
0 400 800 1,200 1,600 2,000 m
Bikenibeu
LAGOON
1-22-00
South Tarawa Road
0.30 km
Bonriki Airport
Fish Pond
Tungaru Central Hospital
South Tarawa Road
L=0.30 km
173-08-00
OCEAN
173-09-00

Route Map (2)

View of the Completed Road

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ABBREVIATIONS

AU$	Australian Dollar
BST	Bituminous Surface Treatment
CES	Civil Engineering Service
CIP	Freight / Carriage & Insurance Paid to named point of destination
CPP	Central Pacific Producers Ltd.
DBST	Double Bituminous Surface Treatment
DCP	Dynamic Cone Penetration
GNI	Gross National Income
GDP	Gross National Product
JICA	Japan International Cooperation Agency
KOIL	Kiribati Oil Company
MCTTD	Ministry of Communication, Transportation and Tourism Development
MELAD	Ministry of Environment, Lands and Agricultural Development
M/D	Minutes of Discussion
MPWU	Ministry of Public Works and Utilities
PVU	Plant Vehicle Unit
TSKL	Telecom Services Kiribati Ltd.

CHAPTER 1　BACKGROUND OF THE PROJECT

CHAPTER 1
BACKGROUND OF THE PROJECT

The Republic of Kiribati (hereinafter referred to as “Kiribati”), has very little possibility of developing agriculture and forestry because its national land is so widely dispersed and soil conditions are poor. Accordingly, since it has to focus on fisheries through effectively utilizing its vast 200 mile exclusive economic zone (EEZ), it is attempting to develop its national economy with the fisheries industry as the main industry. Its 10th National Development Strategies (2004 – 2007) place the primary emphasis on the development, improvement and expansion of social infrastructure to “strengthen the basis for a self-reliant economy and economic development” and to “correct the economic gap between islands”. The following main strategies are called for.

① Public and private cooperation in investment into infrastructure and production facilities;
② Fair distribution of social services and economic benefits;
③ Improvement of public sector services;
④ Realization of social and economic reform on the state, community and individual levels;
⑤ Sustainable use of natural resources and nature; and
⑥ Effective utilization of financial funds for economic development.

As the development, improvement and expansion of the social structure can improve transport and distribution, these efforts are considered to contribute to the development of the fisheries industry. According to the 2000 population census, South Tarawa has a population of 36,717 (40,311 as of 2005) with 4,529 households, accounting for more than one-third of the total population of 84,494. An annual survey by the Ministry of Fisheries and Marine Resources Development (hereinafter simply referred to as “the Ministry of Fisheries”) indicates the close relationship of many of the islanders in South Tarawa with fisheries even though the number of households engaged in fisheries since 2001 varies from one year to another (Table 1-1). As of 2005, 75% of the households in South Tarawa are involved in fisheries activities in one way or another.

Table 1-1 Number of Households Involved in Fisheries Activities

	2001		2002		2003		2004		2005	
Number of Households Involved in Fisheries Activities	2,717	60.0%	3,653	78.0%	2,794	61.7%	2,355	52.0%	3,397	75.0%
Full-Time Commercial Fisheries	168	6.2%	318	9.0%	363	13.0%	377	16.0%	238	7.0%
Part-Time Commercial Fisheries	174	6.4%	141	4.0%	168	6.0%	188	8.0%	204	6.0%
Fisheries for Self-Sufficiency	2,375	87.4%	3,073	87.0%	2,263	81.0%	1,813	77.0%	2,955	87.0%
Number of Households Not Involved in Fisheries Activities	1.812	40.0%	996	22.0%	1,735	38.3%	2,174	48.0%	1,132	25.0%
Total Number of Households	4,529		4,529		4,529		4,529		4,529	

Source: Fisheries Department, Ministry of Fisheries and Marine Resources Development

As each person in Kiribati is said to consume 50 – 78 kg of fish per year, fisheries products are an important source of animal protein supply.

As described above, the fisheries industry in Kiribati is intrinsically linked to the economy and local life. Particularly on outer islands, fisheries is practised with a view to shipping products to Tarawa, where the capital is located. Fish caught near outer islands are frozen and transported by special transport boats to Betio, where they are landed and then transported by truck to the city. On South Tarawa, subsistence fisheries and fisheries combined with other employment are practised. Moreover, from an integrated facility for the handling of marine products which is located next to Port Betio and run by Central Pacific Producers, Ltd. (CPP), fish brought in from outer islands, etc. is delivered every day except Sundays to such large consumption sites as hospitals, schools and hotels in South Tarawa. CPP also irregularly sells skipjack and tuna bought from Korean and Taiwanese fishing boats to fish retailers which travel around South Tarawa to sell them to consumers. Some fishermen use the South Tarawa Road for the transportation of fishing gear and fuel, etc. Some use a mini-bus to reach the harbour where they have moored their fishing boat. As vehicles constitute the common means of transportation of the catch as well as fishermen, roads on Tarawa play a crucial role not only for the daily life of the islanders and economic activities on the island in general but also for the transportation of marine products and fishermen.

However, the roads on Tarawa are facing multiple problems, including ① the increased traffic volume in recent years due to the population increase, ② the growing size of vehicles, including trailers used to carry containers, due to increased imports, ③ the concentration of traffic on existing roads due to the difficulty of constructing new parallel roads, in turn caused by the long and narrow shape of the island, ④ the severe deterioration of the roads due to aging as many roads were originally constructed in the 1960's and 1970's and ⑤ the lack of drainage ditches and such safety facilities as sidewalks and bus lay-bys. These problems are now disrupting safe and smooth transport.

Under these circumstances, the Government of Kiribati decided that the improvement of roads should be an important policy objective, formulated a plan to improve the roads in South Tarawa over a total length of 60 km and made a request to the Government of Japan to provide grant aid assistance in June, 2005 for the improvement of urban roads in South Tarawa.

The contents of the original request were the paving, provision of drainage ditches, sidewalks and bus stopping spaces on trunk as well as minor roads in South Tarawa over a total length of 11.4 km, and the provision of such road improvement equipment as crusher/screening plant and concrete cutters, etc. and their spare parts.

CHAPTER 2　CONTENTS OF THE PROJECT

CHAPTER 2
CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

(1) Superior Objective

In Kiribati, the National Development Strategies are formulated every four years and the current 10th National Development Strategies (2004 – 2007) were formulated in 2003. The strategies in place are ① public and private cooperation for investment in infrastructure and production facilities, ② the fair distribution of social services and economic benefits, ③ improvement of public sector services, ④ realisation of social and economic reform at the state, community and individual levels, ⑤ the sustainable use of natural resources and nature and ⑥ the effective utilisation of financial funds for economic development. As the development, improvement and expansion of the social structure can improve transport and distribution, the implementation of the Project is expected to contribute to the development of the fisheries industry.

(2) Project Targets

To improve road conditions and thereby guarantee safe and smooth traffic in Betio, Bairiki and Bickenibeu districts.

(3) Project Plan

Under the Project, roads listed in (3) below will be repaired and equipment also listed in (3) will be provided as the requested Japanese assistance to achieve the stated targets above.

1) Facilities

Repair of roads in the following districts (total 10.631 km)

- Betio : South Tarawa Road, Jetty Road, Taatirerei Road, Police Line Road
- Bairiki : South Tarawa Road, Frontage Road, Tabonikabauea Road, TAP Road, Bairiki Wharf Road
- Bickenibeu : South Tarawa Road (in front of the Central Hospital)

2) Equipment

Provision of two concrete cutters with replacement parts.

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policies

2.2.1.1 Basic Policies

(1) Policies Regarding the Design Principles

While Kiribati does not have its own road design standards, the Nippon Causeway constructed in 1986 was designed using the Japanese road design standards. Moreover, the asphalt paving standards in Japan were used for the design of the paving. Therefore, the underlying concepts of the Japanese design standards used for the Nippon Causeway will be adopted for the Project to make road maintenance easier and to uniformatise the paving structure standards.

(2) Policies Regarding the Geometric Structural Standards for Roads

All of the target roads of the Study are currently in active service and the basic principle of the improvement plan is to conduct improvement without the relocation of any residents. Accordingly, the scope of the improvement plan will be restricted to the restoration of the function and the reinforcement of the existing deteriorated roads except for such work as the improvement of the drainage function at sections prone to flooding and the introduction of sidewalks to protect pedestrians. As such, no special geometric structural standards are set for the target roads. The existing centre line will be preserved to determine the alignment and no new horizontal alignment will be introduced.

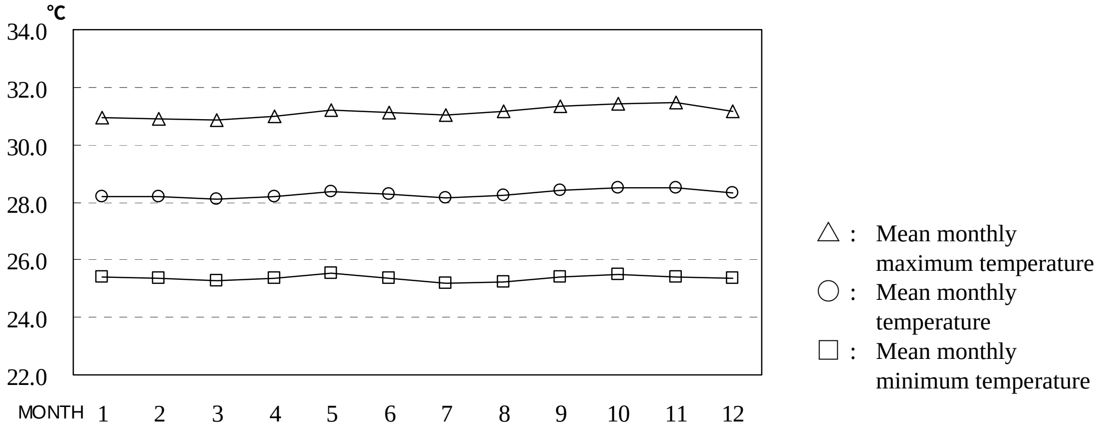
(3) Policies Regarding the Road Width

As the basic purpose of the Project is to repair existing roads to restore their function, the improvement work will be conducted within the existing road width. As a result, the purchase of additional land will be unnecessary.

2.2.1.2 Policies Regarding the Natural and Environmental Conditions

(1) Temperature

Kiribati belongs to the tropical oceanic climate zone. According to data recorded by the Kiribati Meteorological Agency since 1947, the lowest and the highest mean monthly temperatures so far are 23.1°C and 33.1°C respectively. The mean annual temperature is around 28°C, indicating a very warm climate. Fig. 2-1 shows the gross mean monthly temperatures based on the above-mentioned data of the Meteorological Agency, indicating that there is little fluctuation in each type of mean monthly temperature.



Source: Kiribati Meteorological Agency

Fig. 2-1 Mean Monthly Temperatures at South Tarawa

(2) Humidity

Although local records on humidity are unavailable, the interview results at the Meteorological Agency have established that the mean annual humidity is around 75% with minimum and maximum humidity levels around 60% and 100% respectively. These figures suggest a relatively high level of humidity throughout the year without any distinctive dry period.

(3) Rainfall

As mentioned earlier, Kiribati belongs to the tropical oceanic climate zone and there is basically steady rainfall throughout the year. However, the annual rainfall substantially fluctuates as shown in Fig. 2-2. There are years with extremely high or low rainfall. It is well-known that the Pacific Ocean and its coasts in the tropical or sub-tropical zone are liable to the impacts of El Niño and La Niña. These impacts are highly noticeable at Tarawa.

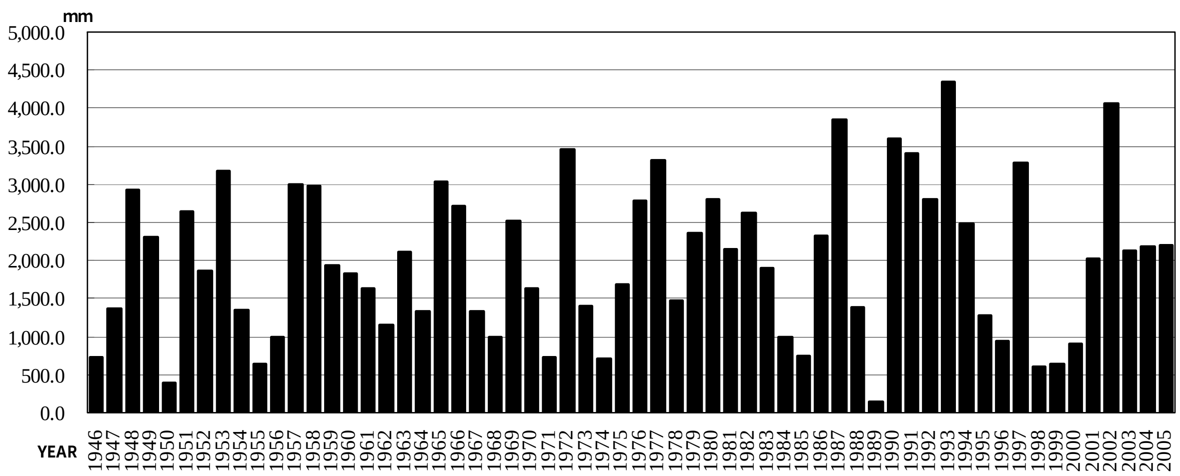


Fig. 2-2 Annual Rainfall (Kiribati Meteorological Agency Data)

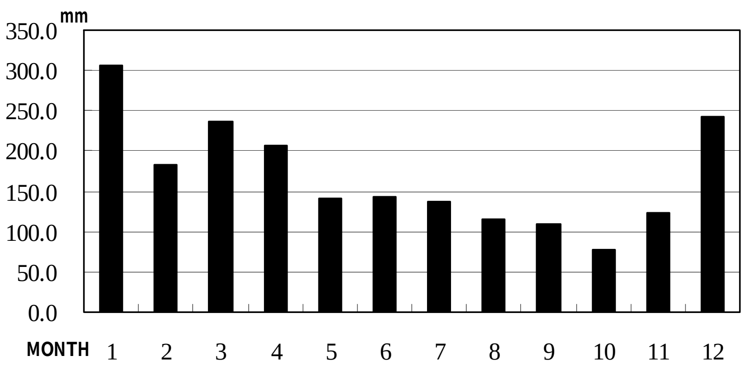
In general, El Niño and La Niña are associated with low rainfall and high rainfall respectively. At Tarawa, however, the reverse phenomenon, i.e. high rainfall in years of El Niño and low rainfall in years of La Niña, occurs.

The analysis results of the data obtained from the Meteorological Agency indicate that the mean annual rainfall is approximately 3,000 mm in years of El Niño and approximately 1,000 mm in years of La Niña. There are more extreme examples. Annual rainfall of more than 4,000 mm has been recorded in a couple of years of El Niño. Conversely, annual rainfall of less than 500 mm has been recorded in a couple of years of La Niña.

For the islanders of Tarawa, annual rainfall of more than 4,000 mm means a difficulty of going out fishing because of bad weather while annual rainfall of less than 500 mm means a difficulty of obtaining drinking water. Both situations have very serious implications for the lives of the islanders.

Rain is the issue of most concern for the road paving work which is the main component of the planned road improvement work. When rain occurs during or immediately after paving work, it directly leads to a qualitative deterioration of the newly paved road surface. It is, therefore, essential to pay careful attention to the phenomena of El Niño and La Niña in connection with the implementation of the Project.

The mean annual rainfall in a normal year without the phenomenon of El Niño or La Niña is approximately 2,000 mm. Fig. 2-3 shows the mean monthly rainfall in a normal year. There is no distinctive dry or rainy season because of the occurrence of rain all year round. The period from December to April, however, experiences a relatively high rainfall level while the period from May to November experiences a relatively low rainfall level.



(Based on Kiribati Meteorological Agency Data)

Fig. 2-3 Mean Monthly Rainfall in a Normal Year

(4) Typhoons

Tarawa is located between 172°50’E and 173°10’E and between 1°20’N and 1°40’N and is almost on the equator. For this reason, it is hardly ever hit by typhoons. It is highly unlikely that a typhoon, cyclone or hurricane born in another area will cross the equator at Tarawa although it cannot be said that this will never happen. The Kiribati Meteorological Agency has no data to suggest that a typhoon has ever approached Tarawa.

(5) Flood Tide and Flood Tide Level

As typhoons do not occur, there is no flood tide caused by a typhoon or similar violent storm. The calm climate is the reason for the islands with an elevation of a mere 4 m or so to be continually inhabited.

Nevertheless, the spring tide can reach approximately 3 m a couple of times a year depending on the relative positions of the earth and the moon. This tide is locally called the king tide. Because of the elevation of some 4 m or less, the island of Tarawa is liable to flooding if the wave height reaches some 50 cm at the time of the king tide. The king tide simply indicates the level of the tide and its timing can be accurately forecast so that the necessary precautions can be taken. The tide forecast is broadcast on the radio weekly by the Weather Centre of the Meteorological Agency and is also published in newspapers.

Tarawa is, in fact, a triangular-shaped atoll but the land above sea level form a wedge shape because the western part has sunk below sea level. When the wind blows from the open west side of the atoll towards the apex of the wedge, it causes high waves. These waves tend to be higher when the water depth of the enclosed area is shallower. The topography of Tarawa is likely to cause high waves under this wind condition as the enclosed area is a lagoon. Along the equator, the wind blows from the east at normal times. As this wind heads towards the closed site of the Tarawa Atoll, it is unlikely to cause the high waves mentioned above. There are times, however, when a seasonal westerly wind or a north-westerly wind caused by a depression blows. At such a time, the land facing the lagoon may be liable to damage by high waves.

(6) Rain Intensity

The rain gauge possessed by the Kiribati Meteorological Agency cannot record hourly rainfall and, therefore, only daily rainfall records are available.

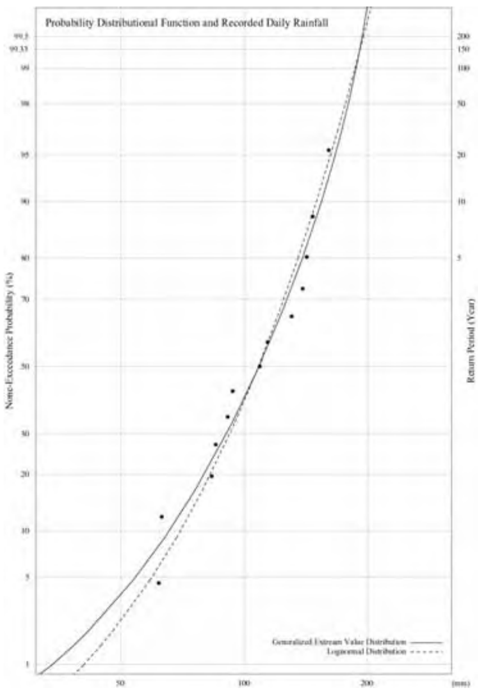
On 26th July, 2006, the Study Team visiting the project site experienced sudden strong rain and recorded an hourly rainfall of some 40 mm from 15:00 to 16:00 using its own cylindrical container.

Fig. 2-4 shows the rainfall intensity probability curve based on the maximum daily rainfall records of the Meteorological Agency for the period from 1993 to 2005. Based on the data for 13 years, the rainfall intensity return period (daily rainfall) can be estimated as shown in Table 2-1.

Table 2-1 Rainfall Intensity Return Period
(Daily Rainfall Estimated Using Data from 1993 to 2005)

Return Period	3 Years	5 Years	10 Years	20 Years	30 Years	50 Years	100 Years
Rainfall Intensity (Daily Rainfall)	124 mm	139 mm	155 mm	167 mm	173 mm	180 mm	188 mm

The standard type of rain in Kiribati is short downpours caused by well-developed cumulonimbus. As it is the standard practice to use the rainfall intensity with a return period of three years for the design of side ditches with an extremely short reaching time, such as roadside drainage ditches, as recommended by the Guidelines for Drainage Works (by the Japan Road Association, June, 1987) or used by actual designs in various countries, this standard practice is adopted for the design of the drainage ditches described later. The lower estimate and the higher estimate for the hourly rainfall intensity with a return period of three years is 62 mm and 124 mm respectively.



Return Period (Year)	Probable Daily Rainfall (mm) GEV	Probable Daily Rainfall (mm) LN3Q
400.0	199.2	203.6
200.0	193.8	195.1
150.0	191.2	191.4
100.0	187.2	186.1
80.0	184.8	183.0
50.0	179.4	176.4
30.0	172.5	168.7
20.0	166.4	162.1
10.0	154.1	149.7
5.0	138.5	135.1
3.0	123.8	121.8
2.0	108.5	108.2
1.5	93.6	95.0

Fig. 2-4 Results of Probable Daily Rainfall Analysis

(7) Wind Velocity

Even though concrete wind velocity data was not obtained, the interview results show that the maximum wind velocity and the mean wind velocity at Tarawa are around 20 m/sec and 5 – 8 m/sec respectively, indicating the relative calmness of the area due to the absence of typhoons, etc.

(8) Coastal Erosion

As Tarawa is an atoll, the shape of the islands is said to be constantly changing due to coastal erosion and sedimentation. According to the interview results, western Betio and southern Bikenibeu are areas with noticeable coastal erosion. In contrast, northern Tarawa is said to be extending northwards due to sedimentation. It can be inferred that the project site for the planned road improvement is unlikely to suffer from coastal erosion in the immediate future.

(9) Lightning

No concrete data on lightning was obtained. As the rain at Tarawa is caused by thick cumulonimbus, it is likely that lightning occurs fairly frequently. However, there is no report of major damage due to lightning.

(10) Waterspouts

A waterspout is caused by an updraft, in turn caused by cumulonimbus. During the field survey, cumulonimbus was observed almost daily around Tarawa. Meanwhile, there have been an increasing number of reports of waterspouts in the tropics. As there is no data to be relied on to estimate the frequency of waterspouts, it is difficult to infer the strength of such waterspouts. Even if a waterspout does occur, the area likely to be affected is quite limited. It is assumed that the likely damage to roads will be light and, therefore, waterspouts are not considered in the road design.

(11) Earthquakes

Tarawa is situated near the centre of the oceanic tectonic plate called the Pacific Plate which is dense and firm. As Tarawa is quite far from the boundaries with the continental plates, it is unlikely to be affected by earthquakes which occur at these boundaries. There is no report of an active deep sea volcano nearby. Accordingly, no special consideration is given to earthquakes in the design for this road improvement project.

(12) Salt Damage

As an atoll island, Tarawa stretches in a long and narrow shape and everywhere on the island is subject to severe salt damage. The groundwater from wells has a high salt content while sand and other materials which may be used as aggregates also has a high salt content. If sand available from the lagoon is to be used for the Project, removal of the salt content will be necessary. However, the only fresh water available at Tarawa comes from rain and there is insufficient water for the washing of sand.

Accordingly, the water used to prepare concrete should basically be tap water. In the case of making reinforced concrete, Quantab strips or similar should be made available so that the salt content of the concrete can be constantly monitored.

2.2.1.3 Policies Regarding the Social Conditions

(1) Function as Urban Road

With the completion of the Nippon Causeway in 1986, South Tarawa Road constitutes the east-west axis connecting the two gateways to Tarawa, i.e. Port Betio at the western end and Bonriki Airport at the eastern end. It also forms a loop for the Betio District. With the creation of this east-west axis, the lifestyle up to that point changed, resulting in increased dependence on imported foreign goods. Moreover, 26 ton trailers and large trucks transporting imported rice and other goods began to frequently use South Tarawa Road some 10 years ago. Mini-buses which are the only public transport for ordinary islanders use South Tarawa Road on the circular route. This road is also used for the delivery of fish from the fisheries facility at Port Betio to such consumption sites as schools and hospitals. Because it is the major road, some 87% of South Tarawa Road is paved.

In contrast, the paving ratio of minor roads which function as bypasses or short cuts of the major road is only 54%. Although simple repair work has been regularly conducted for these roads since their construction, they are suffering from many pot holes, cracks and subsidence, making their fundamental repair essential to ensure smooth and safe passage.

(2) Environmental Considerations

All of the target roads of the Project are urban roads lined with private houses and other buildings on both sides. For this reason, all of the planned repair work will be conducted within the existing road width and no acquisition of land or the relocation of residents will be necessary.

In principle, the repair work will take place for one lane at a time so that vehicles can still alternately use the remaining lane. If the complete closure of a minor road is necessary because of its narrow width, a detour will be provided without exception.

2.2.1.4 Policies Regarding the Local Construction Industry and Procurement Situation

(1) Labour Situation

Major construction work currently taking place in Kiribati is work for the Port Betio Rehabilitation Project (Phase II) with Japanese grant aid. Many skilled workers, including operators, are conducting this work and the technical level of these workers has definitely improved through the two phases of this project. Accordingly, the recruitment of these skilled workers for the road improvement project is judged to be feasible. Meanwhile, Kiribati has several family-run local construction companies involved in small construction work and the employment of workers, carpenters and reinforcing bar workers, etc. from these companies is possible. The National Conditions of Service (Third Edition, 1996 prepared by the Public Service Office) are in place in Kiribati. The NCS governs the employment of workers and stipulates the standard working hours, working conditions, various allowances and other relevant matters.

(2) Procurement Situation of Construction Materials

As Kiribati has few resources with fisheries being practically the sole industry, it relies on imports for not only daily necessities but also for construction materials. The number of local suppliers is quite limited. Consequently, the prices are as high as those in industrialised countries and a monopoly is the norm in most industrial fields.

One locally produced construction material is coral collected from the lagoon. However, this material lacks sufficient strength and cannot be used as a material for the base course or surface or as an aggregate for concrete. At present, it is only used as a material for concrete building blocks and as a material for the repair of pot holes. In view of such situation of local materials, aggregates produced in Fiji which have been used in Kiribati will be imported for use as the base course materials as well as aggregates for the surface and concrete.

The procurement of asphalt and cement from Fiji is planned as Fiji has been the main source of their supply. Meanwhile, the procurement of fuel and lubricating oil from Kiribati Oil (KOIL), a local supplier of these products widely used in Kiribati, is planned. In the case of reinforcing bars and steel for temporary work, procurement from Japan or Fiji is planned in view of the fact that these products have mostly been imported from these countries.

(3) Procurement Situation of Construction Machinery

Road construction machinery and equipment are currently owned by the Civil Engineering Section and the Plant Vehicle Unit as listed in Table 2-2 below.

Table 2-2 Machinery Owned by the Public Sector

Owner	Machinery
CES	Motor grader; steel roller; tyre roller; tipper truck; agricultural tractor and trailer; backhoe loader; crushing plant; asphalt distributor; mechanical road sweeper; hand compactor; tyre-type hydraulic shovel
PVU	Backhoe loader; wheel loader; tyre-type hydraulic shovel; tipper truck; motor grader

The machinery owned by the CES is currently used for the infrastructure improvement work (land preparation, road maintenance, sea wall construction and airport maintenance, etc.) of the Section. It is planned to dispatch several machines to outer islands (Marakai Island and Abaiang Island, etc.) for the construction of gravel roads. In view of this situation, the machinery which could be used for the Project was identified during the course of the discussions and the rental prospect of machinery for the Project was clarified. As a result, the Kiribati side has indicated that one motor grader, one steel roller and one tyre roller will be made available with rental condition A (free use at any time during the construction period).

Among the machinery identified, the steel roller is used for the compacting of banked soil and will not be used for the planned construction work under the Project. Two other types of machinery, i.e. the motor grader and tyre roller, show typical signs of the salt corrosion of machinery used in a coastal area of Kiribati. Moreover, as a long time will be required to repair any breakdown or to replace worn parts, the use of these machines as main machines for the planned construction work is judged to be difficult. They should, therefore, be treated as back-up machines.

All of the machines owned by the PVC are 5 – 7 years old. The motor grader is in a state of scrap and the other four machines frequently break down, requiring repair at the workshop once or twice a month. As such, the machines owned by the Plant Vehicle Unit cannot be used for the Project because the planned construction work for which construction machinery plays a major role must progress quickly.

Meanwhile, Kings Holdings, the only private company in Kiribati which leases construction machinery, possesses one backhoe loader and one side lifter-cum-trailer (for container transportation). These machines, however, will not be the main machines for the planned construction work under the Project. Given the local situation described so far, the import of all of the necessary construction machines from Japan will be essential.

(4) Maritime Transportation and Customs Clearance

1) Maritime Transportation

GBH (Pacific Islander) monopolises the regular cargo ship service between Japan and Tarawa (Port Betio) and its bi-monthly service links Port Yokohama to Port Betio in nine days. Meanwhile, CCS (Kiribati Chief) monopolises the regular cargo ship service between Fiji and Tarawa (Port Betio) and its monthly service links Fiji (Port Suva) to Tarawa in five days. The cargo using these services is unloaded offshore because of the shallow water depth at Port Betio and is firstly transferred to a flat bed vessel for final unloading at the quay. Containers should, therefore, be used as much as possible.

2) Customs Clearance

The facility of exempting imported machinery and other goods from tax will be provided in accordance with the certified contracts. For customs clearance, the original document of loading and other related documents will be submitted to the customs office which will then process these documents for tariff calculation and other purposes. Meanwhile, application for tax exemption will be made to the Ministry of Finance and Economic Development and the machinery and goods will be retrieved from the bonded warehouse once a permit for tax exemption has been issued by the said ministry.

2.2.1.5 Policies Regarding the Use of Local Companies

Most public works in Kiribati are funded by overseas aid organizations and most contractors are those of the donor countries. Locally, there is only a small number of family-run construction companies which are capable of conducting small-scale construction work and their participation in the Project is believed to be practically impossible.

2.2.1.6 Policies Regarding Operation and Maintenance

While the Project will be supervised by the Ministry of Fisheries and Marine Resources Development, the actual implementation body of the Project will be the Ministry of Public Works and Utilities. The Civil Engineering Section of the Ministry of Public Works and Utilities has 38 staff members, including the section chief, and its jurisdiction covers not only major national roads but also the sea walls along the Nippon Causeway and airport runways. It is also entrusted with the maintenance of the municipal roads of Betio by the Betio City Council.

At present, repair work is manually conducted using a spade to fill pot holes with fresh paving material and rolling operation cannot be sufficiently carried out. With the provision of concrete cutters under the Project, guidance will be provided to prolong the service life of the repaired sites by means of cutting out the damaged surface in a square shape and rolling of the site with the existing compactor after the filling of pot holes.

2.2.1.7 Policies Regarding the Scale and Other Aspects of the Subject Facilities for Assistance

(1) Policies Regarding Paving Repair

The actual method for repairing the road paving will be selected from among the five types listed in Table 2-3 based on the results of the damage assessment of the road surface conditions which was conducted as part of the field survey and also based on the results of the DCP (dynamic cone penetrometer) test.

In regard to surface treatment, the double bitumen surface treatment (DBST) method which was adopted for the Nippon Causeway and which is the standard method frequently used in Kiribati will be used instead of the hot mixed asphalt method recommended by the Manual for Design and Construction of Asphalt Paving of Japan and others.

Table 2-3 Types of Road Surface Repair/Reinforcement

Type	Level of Repair/Reinforcement	Description of Repair/Reinforcement Work
A	-	No need for repair
B	Partial repair	Patching and sealing, etc.
C	Temporary repair	Overlaying after patching and sealing, etc.
D	Comprehensive repair	Application of the DBST method after removal of the existing surface treatment material and adjustment of the cross-grade with the base course material
E	Comprehensive repair and reinforcement	Application of the DBST method after removal of the existing surface treatment material and the formation of the base course (increased thickness)

(2) Policies Regarding Drainage Facilities

The roads on Tarawa do not have any facilities to drain rainwater. In 2003, the Ministry of Public Works and Utilities installed soak pits in Betio but these pits have not reduced the flooding of roads. Therefore, drainage to these pits is not considered in the present design.

The flooding of roads is particularly noticeable in Betio followed by Bairiki. While the ideal way of rapidly draining rainwater from a road surface is to install U ditches along the entire route, the extremely flat topography in South Tarawa and the absence of small streams to receive the drained rainwater mean that U ditches installed along the entire route will not effectively function.

Accordingly, U ditches will only be installed at those sites where it is believed that they will effectively function (five sites in Betio and one site in Bairiki). These U ditches will be covered by a concrete lid in view of the ease of maintenance.

Meanwhile, at those sites where it is believed that U ditches will be ineffective, L gutters or kerbing blocks to mark the paving limit will be installed to prevent damage to the paving ends by standing water.

(3) Policies Regarding the Introduction of New Sidewalks

New sidewalks will be introduced at some road sections. The basic policy is to secure a sidewalk width of 1.00 – 1.50 m while ensuring that the introduction of these sidewalks does not exceed the existing road width. These sidewalks will not be raised from the road level to avoid any difference in level between them and the land occupied by houses or other buildings. Instead, boundary blocks will be placed to separate the carriageway and the sidewalks. As shown in Fig. 2-5, the design will incorporate grading so that rainwater from the carriageway drains into a ditch at the far end of the sidewalk.

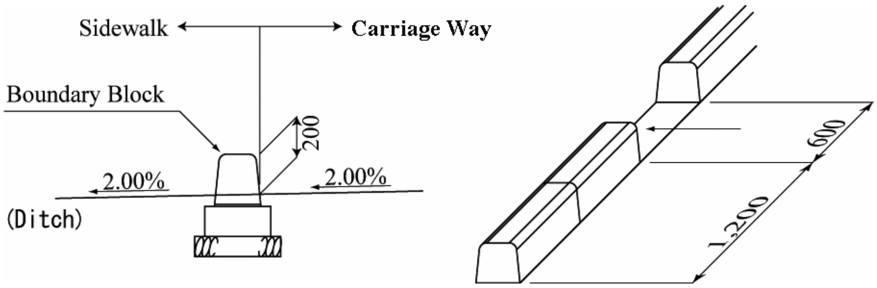


Fig. 2-5 Boundary Blocks for New Sidewalks

(4) Policies Regarding the Repair of Existing Sheltered Bus Lay-Bys and Introduction of New Sheltered Bus Lay-Bys

Since the surface conditions are atrocious and large puddles are apt to occur in front of 11 bus lay-bys in Betio and two bus lay-bys in Bairiki, repair work will be conducted. Moreover, even though there are many service providers in Bairiki, such as the telecommunication service, which are directly linked to the daily lives of the islanders, there is a shortage of bus lay-bys. Therefore, two new bus lay-bys will be constructed.

(5) Policies Regarding the Height Adjustment of Manholes

Manholes for the sewerage system are basically located outside carriageways although some are located on carriageways. As the paving will be repaired while still allowing traffic under the Project, the manhole height adjustment work should be simultaneously conducted with the paving work. Accordingly, to ensure traffic safety during the construction period, the height adjustment of manholes located on carriageways will be treated as part of the road repair work under the Project.

If the relocation, improvement or repair of such underground facilities as power cables, telephone cables and water pipes other than sewer pipes is found to be necessary, the Kiribati side shall undertake the necessary work.

(6) Policies Regarding Hump Repair

The existing roads have humps to reduce the speed of travelling vehicles. For the planned repair of the paving, it will be necessary to remove all of these humps for their reconstruction to match the newly paved surface from the viewpoint of traffic safety. As in the case of the manhole height adjustment work, this hump reconstruction work should be conducted along with the paving work. The hump reconstruction work will, therefore, be conducted as part of the road repair work under the Project.

2.2.1.8 Policies Regarding the Construction Method and Schedule

(1) Policies Regarding the Construction Method

Since most of the construction machinery and materials required for these works will be imported from abroad, it will take a long time for them to arrive in Kiribati and for works to start. Accordingly, mechanised work will be conducted as much as possible to shorten the work period. In the case of work involving roads with two lanes, mainly the major road, the work will be conducted on one lane at a time to avoid the total shutting down of the traffic flow.

(2) Policies Regarding the Work Schedule

The planned road repair under the Project has a high level of urgency and the Project is expected to benefit local fisheries. Even though some time will be required for the procurement of construction machinery and materials as mentioned in (1) above, rapid work progress will be made possible by the adoption of mechanised work. Consequently, the completion of the work in a single year (single phase) is planned, having carefully examined a realistic work schedule for the Project.

2.2.1.9 Policies Regarding the Supply of Equipment

(1) Contents of the Original Request

The items originally requested by the Government of Kiribati in its Request dated April, 2005 are shown in Table 2-4.

Table 2-4 Items Requested in the Request and at the Signing of the M/D

No.	Item	Quantity		Specifications	Purpose of Use Described in the M/D
		Letter of Request	M/D		
1	Crusher and screening plant	1 set	0	Maximum: 30 tons/day when macadam of which the diameter is 40 mm or smaller is produced	(Outside the scope of the Project)
2	Concrete cutter	2	2	Blade: 254 – 356 mm	Road repair work and other
3	Spare parts	1 set	1 set	For the above machines	-

The field survey found that there is no urgency, necessity or relevance for the supply of a crusher and screening plant (hereinafter referred to as a “crushing plant”) because of the reasons given below.

1) Reasons for the Lack of Urgency, Necessity or Relevance for Crushing Plant

- After the initial request was made in 2005, the Ministry of Public Works and Utilities procured a second-hand crushing plant made in Australia in March, 2006 with its own funds.
- This newly procured crushing plant is used to crush coral stones from the lagoon and has a daily crushing capacity of 10 m^3 (7.25 hours).
- At present, this crushing plant is producing coral stones and coral sand for the repair of paved roads. The required total quantity of coral stones and coral sand for the repair of paved roads is an average of 86 m^3/year with a maximum of 460 m^3/year. The existing crushing plant can, therefore, produce the annually required quantity of road repair materials in 9 – 46 days.
- Even if a crushing plant is to be provided under the Project, it will not arrive in Kiribati in time for the planned work for the Project because of the length of time required for tender, contract signing and delivery.

- The Ministry of Public Works and Utilities does not currently have any project which requires a crushing plant other than road repair work.

After explaining these reasons to the Kiribati side, it was decided to withdraw a crushing plant from the requested items. This decision was incorporated in the subsequently agreed and signed M/D.

2) Reasons for the Urgency, Necessity and Relevance of Concrete Cutters

- Roads in South Tarawa cannot withstand an increase of the vehicle weight caused by the change of mode of physical distribution since the time of their original construction. In addition, the lack of rainwater drainage facilities means that rainwater penetrates the base course every time it rains, producing numerous pot holes which are beyond the repair capability. As a result, these roads no longer provide smooth passage while causing damage to travelling vehicles and traffic accidents.
- Although the Ministry of Public Works and Utilities, as a rule, conducts the repair of pot holes caused every time it rains in accordance with the road repair manual, the lack of a concrete cutter means that the repair work cannot be conducted strictly according to the manual.
- For the proper implementation of paved road repair work, the provision of concrete cutters is judged to be urgently required and is also relevant to the spirit of Japan's grant aid scheme.

(2) Basic Principles

The Project for the Improvement of Fisheries Transportation in South Tarawa in the Republic of Kiribati consists of two principal components. One is rehabilitation work for the existing major and minor roads in South Tarawa while the other is regular maintenance work (repair work). The scope of the assistance for machinery/equipment covers the provision of ① concrete cutters to be used for the repair of the existing paved major and minor roads (total length: 41.6 km) in South Tarawa and ② spare parts for the concrete cutters.

The minimum but necessary specifications and quantity of the concrete cutters will be calculated as this machinery is essential for the paved road repair work routinely conducted by the Ministry of Public Works and Utilities.

(3) Maintenance Capability of the Implementation Body

No problems are observed with the current level of the budget, staff strength and technical capability of the Ministry of Public Works and Utilities which is the implementation body for the

Project. As concrete cutters do not have a complicated structure, the current maintenance capability of the Ministry of Public Works and Utilities, especially that of the PVU which will be responsible for equipment repair, should be sufficient to deal with any breakdowns of the concrete cutters.

(4) Procurement Method and Schedule

As the equipment, etc. to be procured for the Project are concrete cutters and their spare parts, the total cost of equipment procurement will be small. The cost will, therefore, be included in the material cost for road improvement and the contractor for the road improvement work will conduct the procurement through the delivery of these items.

The basic policy for the concrete cutter procurement will be the procurement of concrete cutters with standard specifications set by the manufacturer as much as possible for the purpose of shortening the procurement period.

2.2.2 Basic Plan

2.2.2.1 General Plan

(1) Roles of the Target Roads

Road transport infrastructure plays an important role not only for the daily lives of the islanders and general economic activities on the island but also for the physical distribution of marine products and the movement of fishermen. Improvement of the entire roads on the island will contribute to a better life for the islanders and the development of fisheries and will also counteract the recent trends of an increase of the number of traffic accidents and the deterioration of the traffic conditions.

The roles of each road of which improvement has been requested are shown in Table 3-5. These roads are important as the main east-west axis road or minor roads linking main roads. The improvement of the target roads in each district will strengthen the roles of each road.

Table 2-5 Roles of Roads in Each District

Road Section		Road Type	Roles
Road Name	District		
South Tarawa Road	Betio Bairiki Bikenibeu	Main Road	• This is the most important road in South Tarawa, constituting the east-west axis connecting Port Betio and Bonriki Airport. • The road is used for not only the transportation of marine products and fishing gear but also for the traveling of fishermen to the mooring sites of their fishing boats. • Processed marine products are regularly delivered on this road from the CPP Headquarters at Betio to large consumption sites, such as schools, hospitals and hostels, as well as the CPP's sales outlets. • The mini-buses used by the family members of fishermen to attend school or for shopping use the circular route provided by South Tarawa Road. • Many direct fish sale stalls run by fishermen and commonly used by the citizens are located along South Tarawa Road. These stalls operate at some 10 m intervals in such districts as Betio and Bairiki with a concentrated population. • Tungal Hospital in the Bikenibeu District is along this road and the processed marine products delivered by the CPP for hospital meals are brought to the hospital compound from this road.
Jetty Road	Betio	Minor Road	• Jetty Road provides access to entire South Tarawa from the CPP Headquarters • This road is used as an access road to the fisheries jetty located at the northern end of Port Betio. • Port Betio (New), an international port, is the only port for the landing of imported goods for daily life and the imported goods are distributed to entire South Tarawa from here.
Taatirere Road	Betio	Minor Road	• This road provides the north-south connection between the loop sections of South Tarawa Road in the Betio District, creating a short cut. • The delivery of fish from the CPP's Headquarters to large consumption sites in Bairiki and Bikenibeau mainly uses this road.
Police Line Road	Betio	Minor Road	• When traveling eastwards (in the direction of the Nippon Causeway) from Port Betio, this road functions as a partial detour for the northern loop section of South Tarawa Road which runs through an urban area. • For the reasons described above, this road provides a route for the transportation of processed marine products for schools meals from the CPP's Headquarters to the Tarawa Technical Institute (some 100 students) and the Kiribiti Maritime Training Centre (some 150 students), both of which are located in the eastern part of the Betio District.
Frontage Road	Bairiki	Minor Road	• This road runs in front of the head office building of the Ministry of Fisheries (MFMRD) and is always used for movement from the Ministry of the CPP's Headquarters or the Fisheries Division of the Ministry located at the eastern end of South Tarawa and also for surveys on fishing grounds. • This road is adjacent to Bairiki Square at the heart of Bairiki and some 15 fish stalls constantly operate nearby.
Tabonikabauea Road	Bairiki	Minor Road	• Some 20 fishing families live on the west coast of Bairiki in a relatively scattered manner and transport the catch to South Tarawa Road, especially near Bairiki Square, via Tabonikabauea Road for direct sale. • Some 30 fishing families live on the south coast of Bairiki (west side at the back of the President's official residence) and transport the catch to South Tarawa Road, especially near Bairiki Square, for direct sale. The target section of 250 m is most frequently used because of its proximity to the village made up of these 30 families. • This road is the only access road to such important places as the official residence of the President, the Ministry of Foreign Affairs and the main stand of the national stadium, etc. • The road is also used as an access road to the market for daily goods located to the southwest of Bairiki Square.
TAP Road	Bairiki	Minor Road	• Some 5,200 fishermen in North Tarawa use Bairiki Fishing Port when they want to sell the catch or buy daily goods in South Tarawa. TAP Road is used as the shortest access route from Bairiki Fishing Port to South Tarawa Road. • In general, national events are held at the national stadium. During these events, South Tarawa Road is closed and TAP Road and Bairiki Wharf Road function as bypasses.
Bairiki Wharf Road	Bairiki	Minor Road	• A fishing village of some 40 families exists along the coast to the north of the target section of 500 m. The fishermen in this village transport the catch on Bairiki Wharf Road and sell it along South Tarawa Road. Meanwhile, fishermen living on the coast to the north of Bairiki Square transport the catch on Bairiki Wharf Road and a minor road, traveling to the south to sell the catch near Bairiki Square. • The Bairiki Branch of the CPP is located to the west of the target section of Bairiki Wharf Road. Apart from delivery to and processing at the CPP's Headquarters, the fish is sold to general consumers at the branch office in addition to delivery to such large consumption sites as hospitals and schools. This branch office is popularly used when the coastal catch is small due to weather. Customers from East Bairiki use Bairiki Wharf Road for this purpose. • When people move from Bairiki Fishing Port to East Bairiki, Vikenibeu to the east of South Tarawa or Bonriki where the airport is located, they use Bairiki Wharf Road as a short cut to South Tarawa Road. • Bairiki Wharf Road is used as a bypass for South Tarawa Road when a national event is held at the national stadium.

Based on the assessment results shown in Table 2-5, the requested improvement of the roads will strengthen their functions and contribute to the improved living of people as well as the development of fisheries in South Tarawa. Accordingly, the requested Japanese assistance is judged to be relevant for the purpose of the grant aid scheme of the Government of Japan.

(2) Length of Road Sections for Improvement

The road sections for improvement under the Project and their individual length are shown in Table 2-6. The distances indicated here were obtained as a result of local surveying.

Table 2-6 Length of the Road Sections for Improvement

District	Section	Length (m)
Betio	South Tarawa Road (entire section in Betio)	6,491
	Jetty Road	535
	Taatirerei Road	436
	Police Line Road	398
	Sub-Total	7,860
Bairiki	South Tarawa Road (entire section in Bairiki)	1,460
	Frontage Road	124
	Tabonikabauea Road (Bairiki Square – Residence of the President)	270
	TAP Road	155
	Bairiki Wharf Road	482
	Sub-Total	2,491
Bikenibeu	South Tarawa Road (in front of Tungal Hospital only)	280
	Sub-Total	280
Total		10.631

South Tarawa Road is the major road running through South Tarawa which narrowly stretches from east to west. Other roads, i.e. Jetty Road, Taatirerei Road, Police Line Road, Frontage Road, Tabonikabauea Road, TAP Road and Bairiki Wharf Road, are minor roads which branch off from South Tarawa Road.

(3) Horizontal Alignment

The horizontal alignment will inherit the centre line of the existing road at all sections.

(4) Vertical Alignment

The vertical alignment will inherit the height of the existing road except at those sites where the base course thickness will be increased to reinforce the roadbed.

(5) Standard Cross-Section

As the planned improvement work under the Project aims at restoring the function of the existing roads, the standard width of the sections for improvement will follow the existing cross-section of the road in question without any change of the road width. The standard cross-section for each section is shown in Fig. 2-6 through Fig. 2-20.

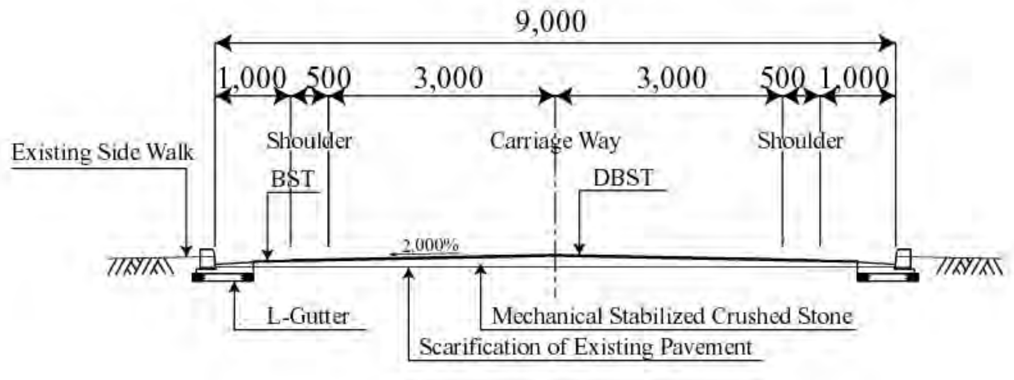


Fig. 2-6 Standard Cross-Section: South Tarawa Road in Betio (1)

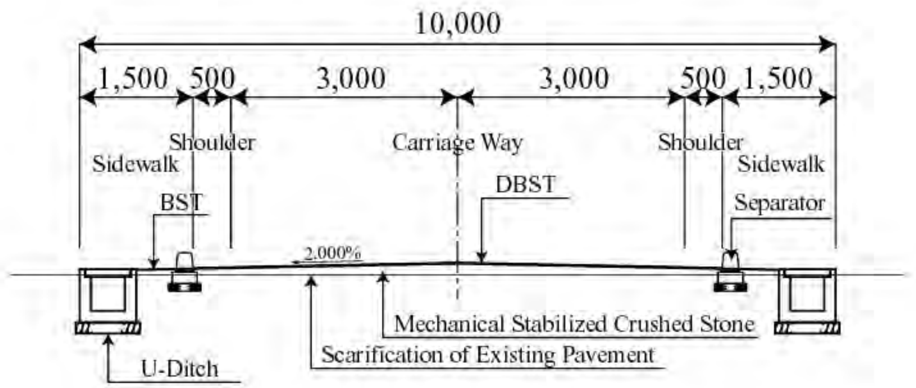


Fig. 2-7 Standard Cross-Section: South Tarawa Road in Betio (2)

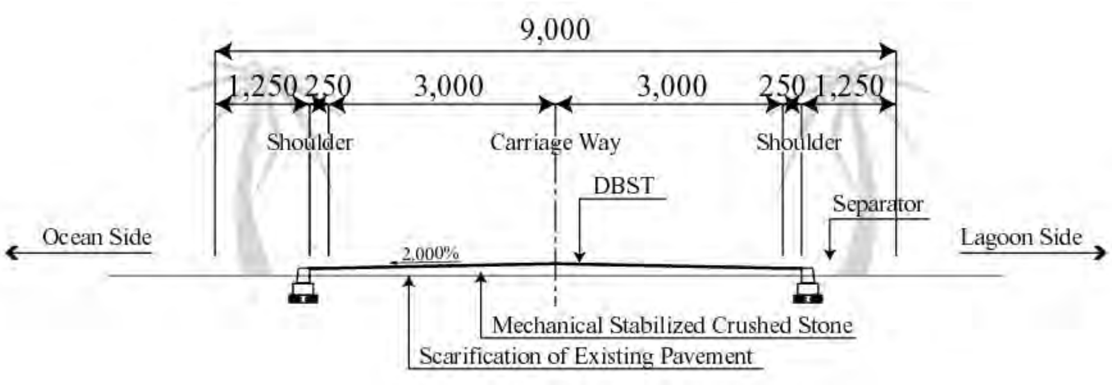


Fig. 2-8 Standard Cross-Section: South Tarawa Road in Bairiki (1)

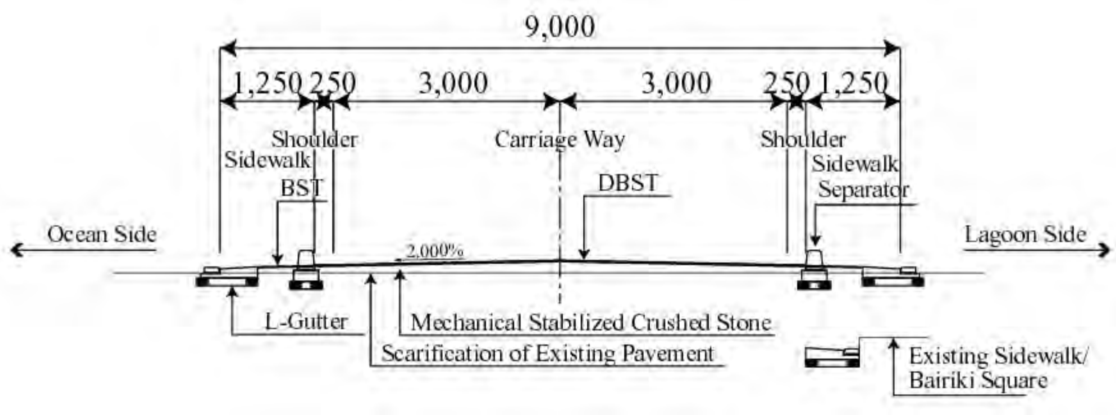


Fig. 2-9 Standard Cross-Section: South Tarawa Road in Bairiki (2)

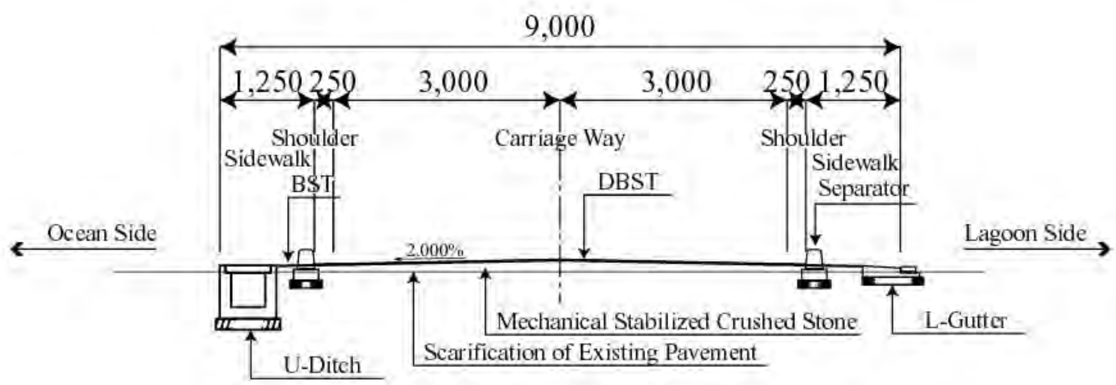


Fig. 2-10 Standard Cross-Section: South Tarawa Road in Bairiki (3)

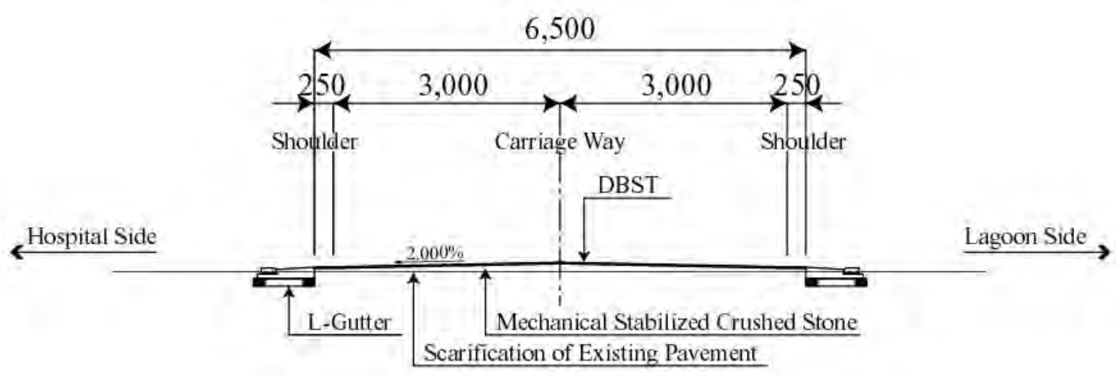


Fig. 2-11 Standard Cross-Section: South Tarawa Road in Bikenibeu

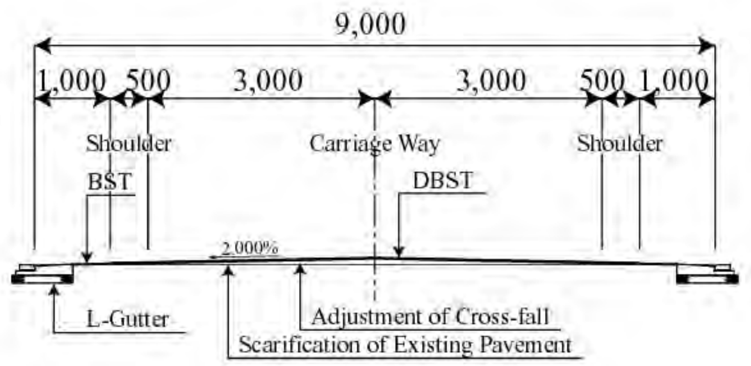


Fig. 2-12 Standard Cross-Section: Taatirerei Road in Betio (1)

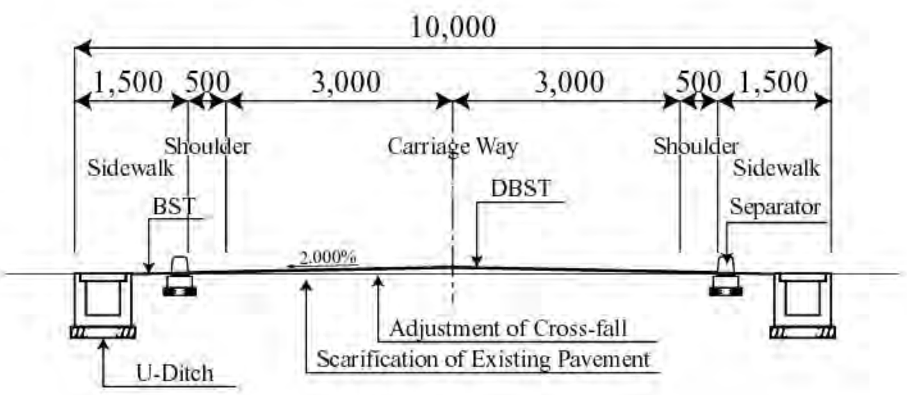


Fig. 2-13 Standard Cross-Section: Taatirerei Road in Betio (2)

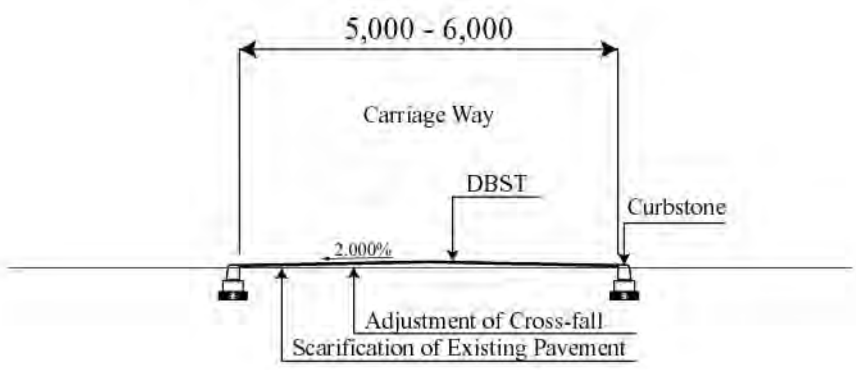


Fig. 2-14 Standard Cross-Section: Jetty Road in Betio

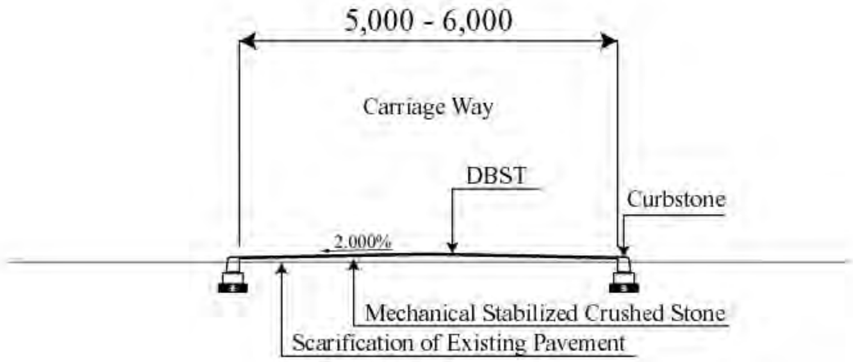


Fig. 2-15 Standard Cross-Section: Police Line Road in Betio

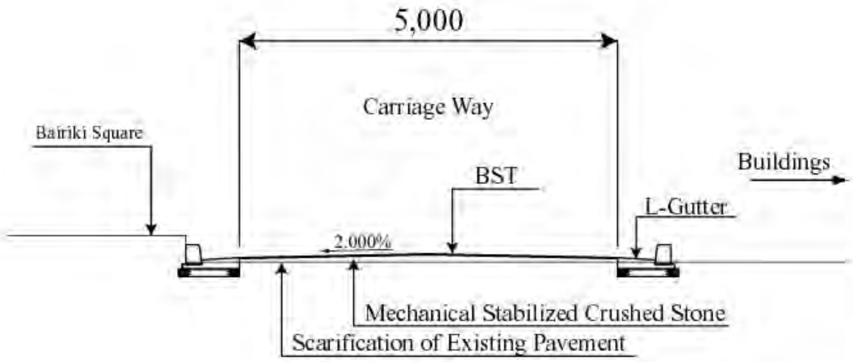


Fig. 2-16 Standard Cross-Section: Frontage Road in Bairiki

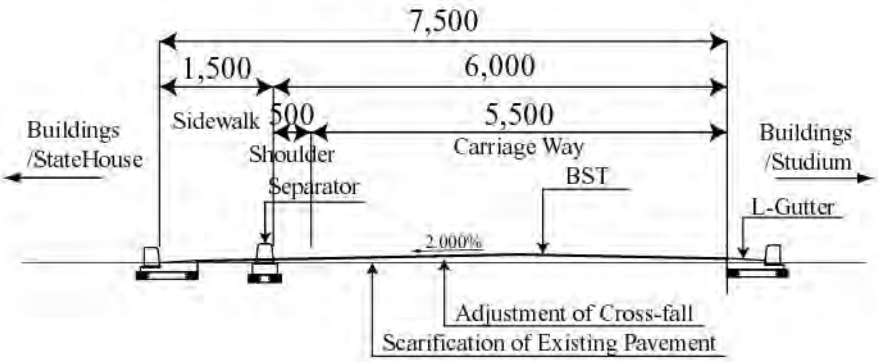


Fig. 2-17 Standard Cross-Section: Tabonikabauea Road in Bairiki (1, with sidewalks)

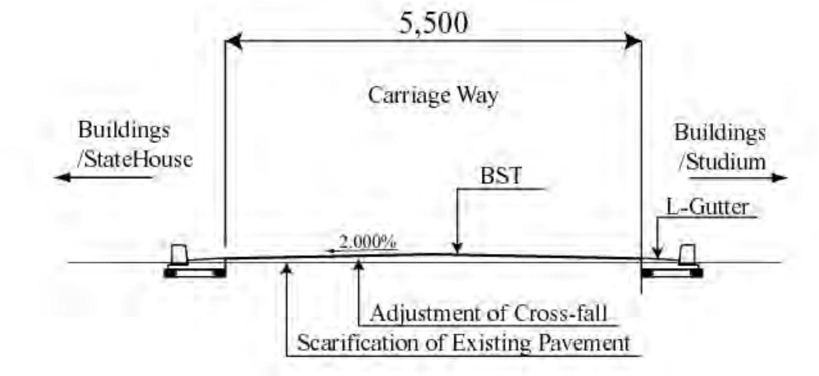


Fig. 2-18 Standard Cross-Section: Tabonikabauea Road in Bairiki (2, without sidewalks)

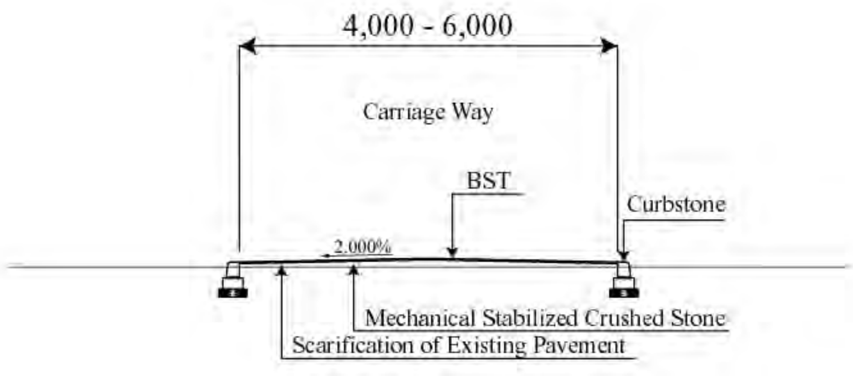


Fig. 2-19 Standard Cross-Section: Bairiki Wharf Road in Bairiki

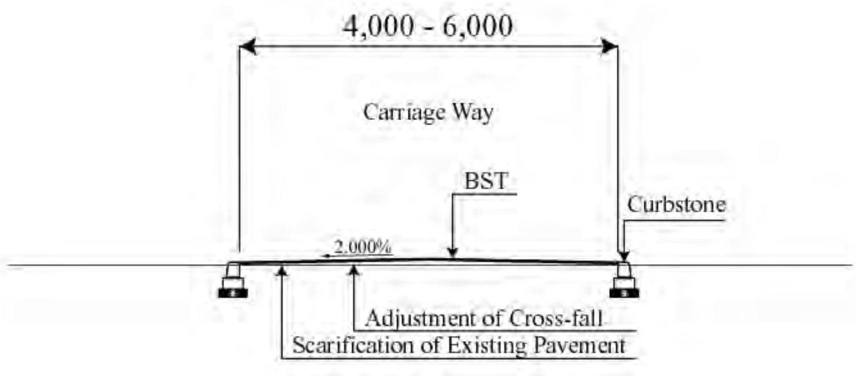


Fig. 2-20 Standard Cross-Section: TAP Road in Bairiki

2.2.2.2 Facilities Plan

(1) Paving Improvement Plan for Each Section

1) Base Course Survey (DCP)

Based on the results of the DCP test, the target roads can be classified into “roads of which the strength of the base course is judged to be noticeably weak” and “roads of which the strength of the base course is judged to be sufficient” as shown in Table 2-7.

Table 2-7 Roads with High/Low Base Course Strength Based on the DCP Test Results

Target Roads with Low Base Course Strength	South Tarawa Road (in Betio, Bairiki and Bikenibeu Police Line Road Bairiki Wharf Road Frontage Road
Target Roads with High Base Course Strength	Taatirerei Road Jetty Road Tabonikabauea Road TAP Road

2) Road Surface Survey

The visual observation of cracks, pot holes, ruts and ravelling on the road surface was conducted during the field survey period.

3) Types of Repair Methods

Five types of repair/reinforcement work are feasible and the appropriate type will be decided for each target road based on the results of the road surface survey mentioned in 2) above in correspondence with the degree of paving damage. However, as described in 1) – Base Course Survey, some roads have sufficient base course strength. In the case of these roads, it will be unnecessary to conduct base course improvement work. Accordingly, suitable work is planned for each road category as shown in Table 2-8.

Table 2-8 Types of Repair/Reinforcement by Cement Base Course Strength

Sub-Grade Condition	Sufficiently Strong	Weak
Subject Road	Taatirerei Road Jetty Road Tabonikabauea Road TAP Road	South Tarawa Road (Betio, Bairiki and Bikenibau) Police Line Road Bairiki Wharf Road Frontage Road
Scope of Application	One of Type A through Type D will be employed based on the road surface survey results.	One of Type A through Type E will be employed based on the road surface survey results.

Type	Description of Repair/Reinforcement Work
A	No need for repair
B	Patching and sealing, etc.
C	Overlaying after patching and sealing, etc.
D	Application of the DBST method after removal of the existing surface treatment material and adjustment of the cross-grade with the sub-grade material
E	Application of the DBST method after removal of the existing surface treatment material and the formation of the upper sub-grade (increased thickness)

4) Assessment of the Degree of Road Surface Damage

To determine the suitable repair method (type of repair) based on the road surface observation results, assessment of the degree of road surface damage is necessary. Table 2-9 shows the relation between the current road surface damage and its cause and the type of repair work required.

Table 2-9 Road Surface Damage, Cause and Type of Repair Work Required

No.	Road Surface Condition	Cause of Road Surface Deterioration	Type of Repair Work	Sample Photograph
a	Crisscrossing crack	Insufficient base course strength Deterioration of the paving Poor groundwater drainage	D or E	
b	Linear crack	Deterioration of the asphalt paving Poor work	B, C or D	
c	Pot hole	Localised insufficient base course strength Deterioration of the asphalt paving Poor work	B, C or D	
d	Rutting	Insufficient base course strength Inappropriate mixture design Poor quality of the aggregates used	D or E	
e	Ravelling	Inappropriate mixture design Poor quality of the aggregates used Poor work	C or D	

The road surface survey method and the damage assessment method used are explained next for each type of road surface condition.

i) Area of Cracks

During the road surface survey, imaginatory meshes of 1 m by 1 m each were projected onto the road surface and the area of visible cracks was recorded. In this estimation of cracked areas, areas of pot holes and patching were not included as these were assessed separately.

ii) Ratio of Cracks

The ratio of cracks was calculated for each road section by dividing the area of cracks by the area of the road section in question (paving width x length). In general, when the necessity for road repair is judged solely on the basis of the ratio of cracks, the total area of pot holes is included for calculation of the ratio of cracks. However, in the case of roads in South Tarawa, uneven road surface as well as rutted surface are generally observed in addition to more prominent cracks and pot holes. Given this situation, it was decided to firstly assess each type of road surface damage before comprehensive assessment of the road surface damage. Accordingly, the ratio of cracks here does not include areas of pot holes and patching, etc.

iii) Pot Holes/Patching

The number of visible pot holes and repaired pot holes was recorded using a counter. A pot hole or repaired pot hole with a size of some 30 cm by 30 cm was counted as one (1). When the size was some 60 cm by 60 cm, such pot hole or repaired pot hole was counted as two (2).

iv) Rutting

The surface of most roads is dented due to either deterioration of the base course or insufficient base course strength to start with. The observed ruts were recorded in terms of their general running direction, i.e. either along the transverse direction or along both the transverse and longitudinal directions.

v) Ravelling

The occurrence of ravelling due to the poor quality of the aggregates and other materials used is observed at most road sections. However, as the Ministry of Public Works and Utilities has sprayed asphalt emulsion over the road surface (although this is not an appropriate repair method) on its own initiative, it is difficult to verify the ravelling at many places. Consequently, those places where conspicuous ravelling is observed are given a high damage rank while partial occurrence formed the baseline for assessment.

Based on the above approach to road surface damage, Table 2-10 shows the method used to score the degree of damage by each type of damage.

Table 2-10 Scoring Method for Each Type of Damage

Ratio of Cracks	Pot Holes/ Patching	Rutting	Ravelling	Overall Assessment	Assessment Score
≧ 20%	≧ 200	Severely uneven along both the transverse and longitudinal directions	Entire road surface	Average score of 4 – 5	5
≧ 15% but < 20%	≧ 150 but < 200	Waving along both the transverse and longitudinal directions	Approximately half of the road surface	Average score of 3 – 4	4
≧ 10% but < 15%	≧ 100 but < 150	Waving along the transverse direction	Partial ravelling	Average score of 2 – 3	3
≧ 5% but < 10%	≧ 50 but < 100	Partial occurrence	Limited occurrence	Average score of 1 – 2	2
> 5%	> 50	Slightly visible	Slightly visible	Average score of 0 – 1	1
0%	0	None	None	Average score of 0	0

5) Application of Specific Type of Repair by Each Road Section

Based on the damage assessment score described in Table 2-10, the specific type of repair to be applied has been decided for each 100 m section of each target road. Table 2-11 shows the correspondence between the damage assessment score and the applicable type of repair for “target roads with sufficient base course strength” and “target roads with weak base course strength”.

However, if the type of repair shown in Table 2-11 is rigorously applied, there may be some problems. For example, if one section marked for repair Type D is located between sections marked for repair Type E, the new road surface of the former will be lower than that of the latter, causing a problem of inadequate drainage. In such a case, even if the section in question is marked for repair Type D, it should be subject to repair Type E.

Table 2-11 Correspondence of Damage Assessment Score and Type of Repair

Case	Sufficiently Strong Base Course Strength		Weak Base Course Strength	
Target Road	Taatirerei Road Jetty Road Tabonikabauea Road TAP Road		South Tarawa Road (Betio, Bairiki and Bikenibeu) Police Line Road Bairiki Wharf Road Frontage Road	
Degree of Damage and Type of Repair	Degree of Damage (Overall Score)	Type of Repair	Degree of Damage (Overall Score)	Type of Repair
	3 or higher	D	4 or higher	E
			3	D
	2	C	2	C
	1	B	1	B
	0	A	0	A

The applicable type of repair for each 100 m section of the target roads is shown in Table 2-12 through Table 2-21 based on the judgement criteria shown in Table 2-11. The total length by type of repair is listed below. (Further checking is necessary based on the final findings.)

Type A:	No need for repair	:	0 m	0.0%
Type B:	Patching and sealing, etc.	:	0 m	0.0%
Type C:	Overlaying after patching and sealing, etc.	:	0 m	0.0%
Type D:	Application of the DBST method after removal of the existing surface treatment material and adjustment of the cross-grade with the base course material	:	2,936 m	27.62%
Type E:	Application of the DBST method after removal of the existing surface treatment material and the formation of the upper base course (increased thickness)	:	7,695m	72.38%

Table 2-12 Assessment of Damage and Type of Repair by Section (South Tarawa Road/Betio)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravel-ling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	71.4	5	29	0.29	3	■	3	■	3	4	E	=	E
2	100 - 200	42.9	5	18	0.18	2	■	3	■	3	4	E	=	E
3	200 - 300	92.9	5	50	0.50	4	■	3	■	3	4	E	=	E
4	300 - 400	100.0	5	372	3.72	5	■	3	■	3	4	E	=	E
5	400 - 500	85.7	5	119	1.19	5	■	3	■	3	4	E	=	E
6	500 - 600	57.1	5	55	0.55	4	■	3	■	3	4	E	=	E
7	600 - 700	50.0	5	44	0.44	3	■	3	■	3	4	E	=	E
8	700 - 800	42.9	5	105	1.05	5	■	3	■	3	4	E	=	E
9	800 - 900	28.6	5	46	0.46	3	●	5	■	3	4	E	=	E
10	900 - 1,000	71.4	5	210	2.10	5	●	5	■	3	5	E	=	E
11	1,000 - 1,100	Few	1	41	0.41	3	○	4	■	3	3	D	>	E
12	1,100 - 1,200	Few	1	56	0.56	4	○	4	■	3	3	D	>	E
13	1,200 - 1,300	Few	1	100	1.00	5	○	4	■	3	4	E	=	E
14	1,300 - 1,400	Few	1	145	1.45	5	●	5	■	3	4	E	=	E
15	1,400 - 1,500	14.3	4	241	2.41	5	●	5	■	3	5	E	=	E
16	1,500 - 1,600	42.9	5	301	3.01	5	●	5	■	3	5	E	=	E
17	1,600 - 1,700	42.9	5	266	2.66	5	■	3	■	3	4	E	=	E
18	1,700 - 1,800	14.3	4	87	0.87	4	■	3	■	3	4	E	=	E
19	1,800 - 1,900	14.3	4	120	1.20	5	●	5	■	3	5	E	=	E
20	1,900 - 2,000	21.4	5	329	3.29	5	●	5	■	3	5	E	=	E
21	2,000 - 2,100	7.1	3	156	1.56	5	●	5	■	3	4	E	=	E
22	2,100 - 2,200	7.1	3	285	2.85	5	■	3	■	3	4	E	=	E
23	2,200 - 2,300	Few	1	217	2.17	5	○	4	■	3	4	E	=	E
24	2,300 - 2,400	Few	1	107	1.07	5	■	3	■	3	3	D	>	E
25	2,400 - 2,500	Few	1	82	0.82	4	●	5	■	3	4	E	=	E
26	2,500 - 2,600	Few	1	62	0.62	4	■	3	■	3	3	D	=	D
27	2,600 - 2,700	Few	1	53	0.53	4	■	3	■	3	3	D	=	D
28	2,700 - 2,800	Few	1	42	0.42	3	■	3	■	3	3	D	=	D
29	2,800 - 2,900	Few	1	30	0.30	3	○	4	■	3	3	D	=	D
30	2,900 - 3,000	Few	1	62	0.62	4	■	3	■	3	3	D	=	D
31	3,000 - 3,100	Few	1	53	0.53	4	■	3	■	3	3	D	=	D
32	3,100 - 3,200	Few	1	26	0.26	3	■	3	■	3	3	D	=	D
33	3,200 - 3,300	Few	1	17	0.17	2	■	3	■	3	3	D	=	D
34	3,300 - 3,400	Few	1	31	0.31	3	■	3	■	3	3	D	=	D
35	3,400 - 3,500	Few	1	57	0.57	4	■	3	■	3	3	D	=	D
36	3,500 - 3,600	Few	1	22	0.22	2	■	3	■	3	3	D	=	D
37	3,600 - 3,700	Few	1	38	0.38	3	○	4	■	3	3	D	=	D
38	3,700 - 3,800	Few	1	87	0.87	4	○	4	■	3	3	D	=	D
39	3,800 - 3,900	Few	1	119	1.19	5	●	5	■	3	4	E	=	E
40	3,900 - 4,000	14.3	4	182	1.82	5	●	5	■	3	5	E	=	E
41	4,000 - 4,100	Few	1	295	2.95	5	○	4	■	3	4	E	=	E
42	4,100 - 4,200	Few	1	261	2.61	5	●	5	■	3	4	E	=	E
43	4,200 - 4,300	Few	1	105	1.05	5	■	3	■	3	3	D	>	E
44	4,300 - 4,400	Few	1	61	0.61	4	■	3	■	3	3	D	>	E
45	4,400 - 4,500	Few	1	107	1.07	5	○	4	■	3	4	E	=	E
46	4,500 - 4,600	Few	1	66	0.66	4	■	3	■	3	3	D	>	E
47	4,600 - 4,700	Few	1	118	1.18	5	○	4	■	3	4	E	=	E
48	4,700 - 4,800	Few	1	113	1.13	5	○	4	■	3	4	E	=	E
49	4,800 - 4,900	Few	1	62	0.62	4	●	5	■	3	4	E	=	E
50	4,900 - 5,000	7.1	3	37	0.37	3	■	3	■	3	3	D	>	E
51	5,000 - 5,100	Few	1	24	0.24	2	■	3	■	3	3	D	>	E
52	5,100 - 5,200	Few	1	55	0.55	4	■	3	■	3	3	D	>	E
53	5,200 - 5,300	Few	1	148	1.48	5	●	5	■	3	4	E	=	E
54	5,300 - 5,400	Few	1	247	2.47	5	●	5	■	3	4	E	=	E
55	5,400 - 5,500	Few	1	281	2.81	5	●	5	■	3	4	E	=	E
56	5,500 - 5,600	Few	1	158	1.58	5	●	5	■	3	4	E	=	E
57	5,600 - 5,700	Few	1	207	2.07	5	●	5	■	3	4	E	=	E
58	5,700 - 5,800	Few	1	339	3.39	5	●	5	■	3	4	E	=	E
59	5,800 - 5,900	Few	1	96	0.96	4	●	5	■	3	4	E	=	E
60	5,900 - 6,000	Few	1	101	1.01	5	●	5	■	3	4	E	=	E
61	6,000 - 6,100	Few	1	136	1.36	5	●	5	■	3	4	E	=	E
62	6,100 - 6,200	Few	1	209	2.09	5	●	5	■	3	4	E	=	E
63	6,200 - 6,300	Few	1	49	0.49	3	●	5	■	3	3	D	>	E
64	6,300 - 6,400	Few	1	71	0.71	4	●	5	■	3	4	E	=	E
65	6,400 - 6,490	Few	1	152	1.69	5	●	5	■	3	4	E	=	E

Table 2-13 Assessment of Damage and Type of Repair by Section (South Tarawa Road/Bairiki)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravelling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	30.8	5	117	1.17	5	■	3	■	3	4	E	=	E
2	100 - 200	15.4	5	122	1.22	5	■	3	■	3	4	E	=	E
3	200 - 300	15.4	5	319	3.19	5	■	3	■	3	4	E	=	E
4	300 - 400	46.2	5	244	2.44	5	■	3	■	3	4	E	=	E
5	400 - 500	7.7	3	225	2.25	5	■	3	■	3	4	E	=	E
6	500 - 600	7.7	3	125	1.25	5	■	3	■	3	4	E	=	E
7	600 - 700	7.7	3	70	0.70	4	■	3	■	3	4	E	=	E
8	700 - 800	38.5	5	83	0.83	4	■	3	■	3	4	E	=	E
9	800 - 900	7.7	3	230	2.30	5	○	4	■	3	4	E	=	E
10	900 - 1,000	7.7	3	251	2.51	5	●	5	■	3	4	E	=	E
11	1,000 - 1,100	7.7	3	334	3.34	5	●	5	■	3	4	E	=	E
12	1,100 - 1,200	23.1	5	181	1.81	5	○	4	■	3	5	E	=	E
13	1,200 - 1,300	46.2	5	169	1.69	5	■	3	●	5	5	E	=	E
14	1,300 - 1,400	None	0	16	0.16	2	○	4	■	3	3	D	=	D
15	1,400 - 1,470	None	0	29	0.41	3	●	5	■	3	3	D	=	D

Table 2-14 Assessment of Damage and Type of Repair by Section (South Tarawa Road/Bikenibeu)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravelling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	Few	1	155	1.55	5	●	5	■	3	4	E	=	E
2	100 - 200	Few	1	341	3.41	5	●	5	■	3	4	E	=	E
3	200 - 300	Few	1	114	1.14	5	■	3	■	3	4	D	=	D

Table 2-15 Assessment of Damage and Type of Repair by Section (Taatirerei Road/Betio)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravelling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	7.1	3	198	1.98	5	●	5	■	3	4	D	=	D
2	100 - 200	7.1	3	72	0.72	4	●	5	■	3	4	D	=	D
3	200 - 300	7.1	3	111	1.11	5	●	5	■	3	4	D	=	D
4	300 - 400	7.1	3	78	0.78	4	●	5	■	3	4	D	=	D
5	400 - 440	7.1	3	155	3.88	5	●	5	■	3	4	D	=	D

Table 2-16 Assessment of Damage and Type of Repair by Section (Jetty Road/Betio)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravelling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D
2	100 - 200	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D
3	200 - 300	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D
4	300 - 400	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D
5	400 - 500	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D
6	500 - 540	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D

Table 2-17 Assessment of Damage and Type of Repair by Section (Police Line Road/Betio)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravel-ling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	unpaved	5	unpaved	−	5	●	5	unpaved	5	5	E	=	E
2	100 - 200	unpaved	5	unpaved	−	5	●	5	unpaved	5	5	E	=	E
3	200 - 300	unpaved	5	unpaved	−	5	●	5	unpaved	5	5	E	=	E
4	300 - 400	unpaved	5	unpaved	−	5	●	5	unpaved	5	5	E	=	E

Table 2-18 Assessment of Damage and Type of Repair by Section (Frontage Road/Bairiki)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravel-ling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
2	100 - 140	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E

Table 2-19 Assessment of Damage and Type of Repair by Section (Tabonikabauea Road/Bairiki)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravel-ling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	7.1	3	112	1.12	5	□	2	■	3	4	D	=	D
2	100 - 200	7.1	3	78	0.78	4	□	2	■	3	3	D	=	D
3	200 - 300	21.4	5	17	0.34	3	△	0	■	3	3	D	=	D

Table 2-20 Assessment of Damage and Type of Repair by Section (Bairiki Wharf Road/Bairiki)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravel-ling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
2	100 - 200	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
3	200 - 300	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
4	300 - 400	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
5	400 - 500	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
6	500 - 600	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
7	600 - 700	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
8	700 - 800	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E
9	800 - 840	100.0	5	∞	∞	5	●	5	●	5	5	E	=	E

Table 2-21 Assessment of Damage and Type of Repair by Section (TAP Road/Bairiki)

No.	Section	Cracks (%)	Score	Pot Holes/ Patching (No. of Places)	Per Unit (No. of Places)	Score	Rutting	Score	Ravel-ling	Score	Over-all Score	Type of Repair/Reinforcement		
												Based on Overall Score		Based on Required Drainage Grade
1	0 - 100	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D
2	100 - 140	100.0	5	∞	∞	5	●	5	●	5	5	D	=	D

6) Estimate of Traffic Volume of Heavy Vehicles

The results of the traffic survey conducted by the Study Team for South Tarawa Road indicate a massive increase of the traffic volume of heavy vehicles compared to the results of a similar survey conducted by the Ministry of Public Works and Utilities in 1999.

Table 2-22 Changes of the 12 Hour Traffic Volume (Both Directions) of Heavy Vehicles (South Tarawa Road)

District	1999 (Traffic Survey by the Ministry of Public Works and Utilities)	2006 (Traffic Survey by the Study Team)	Rate of Increase (from 1999 to 2006)	Average Annual Rate of Increase
	No. (vehicles/12H)	No. (vehicles/12H)	%	%
Betio	63	137	217.5	11.7
Bairiki	26	66	253.4	14.2
Bikenibeu	34	67	197.1	10.2

The figures calculated from the tollgate payment data for the Nippon Causeway shown in Table 2-23 are used for the day-time to night-time traffic ratio of the above traffic volume.

Table 2-23 Day-time to Night-Time Traffic Ratio (Based on Tollgate Payment Data for the Nippon Causeway)

Type of Vehicle	29th July, 2006 07:00 – 19:00	29th July, 2006 19:00 – 07:00	Total	Day-Time to Night-Time Ratio
	No. of Vehicles (vehicles/12H)	No. of Vehicles (vehicles/12H)	No. of Vehicles (vehicles/24H)	
Motorcycle	130	56	186	1.43
Passenger Car	603	135	738	1.22
Mini-Bus	63	22	85	1.35
Medium to Large Vehicle	779	187	966	1.24

Note: Because some vehicles are exempt from the toll or pay monthly, the number of vehicles is not identical to that of the traffic survey.

The traffic volume of heavy vehicles with some allowance in 10 years time is estimated below, taking the rate of traffic increase based on the traffic survey by the Study Team and the day-time to night-time ratio shown in Table2-23 into consideration.

Here, two cases of the traffic increase rate are considered. One is the ratio determined by the traffic survey while the other is half the ratio. Each ratio is then combined with either the day-time to night-time ratio for medium to large vehicles in Table 2-23 or the day-time to night-time ratio of 1 (no heavy vehicle traffic during the night-time) to allow a flexible estimate of the future traffic volume of heavy vehicles. The estimation results are shown in Tables 2-24 and 2-25.

Table 2-24 Estimated Future Traffic Volume of Heavy Vehicles (10 Years Time)

District	2006 (Single Direction, 24 Hours)	Future Traffic Volume of Heavy Vehicles in 10 Years Time (Single Direction, 24 Hours)			Future Traffic Volume of Heavy Vehicles in 10 Years Time (Single Direction, 24 Hours)	
	[1)] No. of Vehicles (vehicles/ 12H)	[2)] Average Annual Rate of Increase	[3)] 10 Years Time	[4)] No. of Vehicles (vehicles/12 H)	[5)] Day-Time to Night-Time Ratio	[6)] No. of Vehicles (vehicles/24H)
Betio	68	1.117	3.02	205	1.24	254
					1.00	205
		1.059	1.77	120	1.24	149
					1.00	120
Bairiki	33	1.142	3.77	124	1.24	154
					1.00	124
		1.071	1.99	66	1.24	82
					1.00	66
Bikenibeu	33	1.102	2.64	87	1.24	108
					1.00	87
		1.051	1.64	54	1.24	67
					1.00	54

Notes:

1) Since the number of vehicles for 2006 shown in Table 2-22 shows traffic in both directions day and night, these figures show half the total going in one direction during daytime only.
2) The upper row figures show the mean annual rates of increase (%) shown in Table 2-22 multiplied by 1/100 with 1 added, while the lower row figures show the mean annual rates of increase (%) shown in Table 2-22 divided by 2 and then multiplied by 1/100 with 1 added (based on the assumption that the mean annual rates of increase are only half of those shown in Table 2-22).
3) The values shown in the above (2) raised to the 10^{th} power in order to obtain the increase rate in 10 years time.
4) Forecast traffic volume in 10 years time obtained by multiplying (1) by (3).
5) The '1.24' in the top row is the daytime ratio of medium and large vehicles at the Nippon Causeway toll booth as obtained in Table 2-23, while the '1.0' in the bottom row is the daytime ratio assuming the case where traffic only occurs during daytime.
6) Forecast traffic volume in 10 years time obtained by multiplying (4) by (5).

Table 2-25 Estimated Future Traffic Volume of Large Heavy (10 Years Time)

District	Estimated Future Traffic Volume of Heavy Vehicles in 10 Years Time (Single Direction, 24 Hours)
Betio	120 – 254 vehicles
Bairiki	66 – 154 vehicles
Bikenibeu	54 – 108 vehicles

7) Paving Design for Target Roads/Sections

As a basic design rule, no paving design will be conducted and a cross-sectional configuration taking the present paving conditions into consideration will be adopted for those sections where the Type A through Type D repair method (restoration of the road function) will be applied based on the road surface damage assessment results. For those sections where the Type E repair method is applied, the design will be based on the following process to determine the thickness of the base course.

As in the case of the paving design for the Nippon Causeway, the Ta method referred to in the "Manual for Design and Construction of Asphalt Paving" and the "Manual for Low Cost Paving" of the Japan Road Association will be applied as the design base (local standard specifications will be followed, however, for the paving specifications). The Ta method is a convenient way of determining the configuration of various paving layers to meet the required paving thickness (target value) which is decided based on either the traffic volume of heavy vehicles or the wheel load of travelling vehicles and the roadbed strength (design CBR). As it is theoretically compatible with the AASHTO (US standards) and others, it is considered to be an appropriate method.

In addition to the Ta method, there are many methods to design the paving configuration, including analysis of the stress and distortion of paving. However, the use of these methods in Kiribati is difficult as the Ministry of Public Works and Utilities does not have the required data for analysis. Table 2-26 shows the classification of the traffic volume listed in the Manual for Design and Construction of Asphalt Paving.

Table 2-26 Classification of Design Traffic Volume

Category of Design Traffic Volume	Range of Traffic Volume of Heavy Vehicles (No/Day/Direction)
L	Traffic Volume < 100
A	100 ≦ Traffic Volume < 250
B	250 ≦ Traffic Volume < 1,000
C	1,000 ≦ Traffic Volume < 3,000
D	3,000 ≦ Traffic Volume

Source: Japan Road Association, Manual for Design and Construction of Asphalt Paving

Based on the estimation results of the future traffic volume of heavy vehicles mentioned earlier, the category of the design traffic volume for each target road is shown in Table 2-27. In the case of South Tarawa Road, the Category A traffic volume is applied to the sections in Betio and Bairiki as 100 or more heavy vehicles are expected to travel through these sections. Category L is applied for the Bikenibeu section of South Tarawa Road. Category L, which is the lowest traffic volume category for large vehicles, is also applied for all minor roads.

As far as the paving specifications are concerned, the basic principle is the application of double bituminous surface treatment (DBST) which is the standard practice in Kiribati. However, bituminous surface treatment (BST) which is similar to the existing specifications will be applied for Frontage Road, Tabonikabauea Road, TAP Road and Bairiki Wharf Road where the actual traffic volume of heavy vehicles is small.

Table 2-27 Category of Design Traffic Volume and Paving Specifications by Target Road

District	Section	Design Traffic Volume Category	Paving Specifications
Betio	South Tarawa Road	A	DBST
	Jetty Road	L	DBST
	Taatirerei Road	L	DBST
	Police Line Road	L	DBST
Bairiki	South Tarawa Road	A	DBST
	Frontage Road	L	BST
	Tabonikabauea Road	L	BST
	TAP Road	L	BST
	Bairiki Wharf Road	L	BST
Bikenibeu	South Tarawa Road	L	DBST

Table 2-28 shows the paving design results for the target roads for which Type E repair is judged to be necessary.

Table 2-28 List of Paving Design Results (Type E Repair)

South Tarawa Road (Betio)		Traffic Volume Category A, Roadbed CBR = 25 (Ta = 13 cm)					
New	Surface Layer	DBST	2.0	×	0.55	=	1.1
	Base Course	Mechanically stabilised crushed stones (CBR ≧ 80)	7.0	×	0.35	=	2.5
		Sub-Total	9.0				3.6
Assessment of Present CBR	Sub-Grade	CBR ≧ 30	40.0	×	0.25	=	10.0
		Sub-Total	40.0				10.0
		Total	49.0				13.6

OK

South Tarawa Road (Bairiki)		Traffic Volume Category A, Roadbed CBR = 19 (Ta = 13 cm)					
New	Surface Layer	DBST	2.0	×	0.55	=	1.1
	Base Course	Mechanically stabilised crushed stones (CBR ≧ 80)	7.0	×	0.35	=	2.5
		Sub-Total	9.0				3.6
Assessment of Present CBR	Sub-Grade	CBR ≧ 30	40.0	×	0.25	=	10.0
		Sub-Total	40.0				10.0
		Total	49.0				13.6

OK

South Tarawa Road (Bikenibeu)		Traffic Volume Category L, Roadbed CBR = 13 (Ta = 11 cm)					
New	Survey Layer	DBST	2.0	×	0.55	=	1.1
	Base Course	Mechanically stabilised crushed stones (CBR ≧ 80)	3.0	×	0.35	=	1.1
		Sub-Total	5.0				2.2
Assessment of Present CBR	Sub-Grade	CBR ≧ 30	40.0	×	0.25	=	10.0
		Sub-Total	40.0				10.0
		Total	45.0				12.2

OK

Police Line Road		Traffic Volume Category L, Roadbed CBR = 20 (Ta = 11 cm)					
New	Surface Layer	DBST	2.0	×	0.55	=	1.1
	Base Course	Mechanically stabilised crushed stones (CBR ≧ 80)	3.0	×	0.35	=	1.1
		Sub-Total	5.0				2.2
Assessment of Present CBR	Sub-Grade	CBR ≧ 30	40.0	×	0.25	=	10.0
		Sub-Total	40.0				10.0
		Total	45.0				12.2

OK

Bairiki Wharf Road		Traffic Volume Category L, Roadbed CBR = 15 (Ta = 11 cm)					
New	Surface Layer	BST	1.3	×	0.55	=	0.7
	Base Course	Mechanically stabilised crushed stones (CBR ≧ 80)	3.0	×	0.35	=	1.1
		Sub-Total	4.3				1.8
Assessment of Present CBR	Sub-Grade	CBR ≧ 30	40.0	×	0.25	=	10.0
		Sub-Total	40.0				10.0
		Total	44.3				11.8

OK

Frontage Road		Traffic Volume Category L, Roadbed CBR = 10 (Ta = 11 cm)					
New	Surface Layer	BST	1.3	×	0.55	=	0.7
	Base Course	Mechanically stabilised crushed stones (CBR ≧ 80)	3.0	×	0.35	=	1.1
		Sub-Total	4.3				1.8
Assessment of Present CBR	Sub-Grade	CBR ≧ 30	40.0	×	0.25	=	10.0
		Sub-Total	40.0				10.0
		Total	44.3				11.8

OK

(2) Drainage Facilities Plan

As the topography of South Tarawa is extremely flat with a maximum elevation of some 4 m, the roads have hardly any longitudinal slope. For this reason, rainwater tends to remain on the road at present and the state of flooding continues until such rainwater evaporates. To improve the situation, the introduction of drainage facilities is planned under the Project.

The lack of a longitudinal slope of these roads, however, means that if the standard road drainage design method in Japan or another industrialised country is applied, the end result will be the failure of these facilities to properly channel rainwater unless the new ditches are given a steep longitudinal slope to facilitate the flow of collected rainwater. Given the fact that the topography of South Tarawa is extremely flat with a very low elevation from sea level, the adoption of a design which demands a perfect drainage performance in accordance with the general design guidelines for roadside ditches is practically impossible. Accordingly, the drainage plan here is based on the following considerations with a view to improving the present state of flooding as much as possible.

1) Target Rainwater Runoff

The survey on the meteorological conditions conducted during the visit to South Tarawa estimates that the rainfall intensity with a return period of three years is 124 mm in terms of the daily rainfall. As local rain is often in the form of squalls with strong intensity and lasting for a short period of time (1 – 2 hours), the hourly rainfall intensity with a return period of three years can be estimated to be 62 mm/hr – 124 mm/hr. The following examination assumes the hourly rainfall intensity with a return period of three years of 90 mm/hr, roughly the halfway figure of the above range.

The hourly runoff of rainwater per unit metre falling on a 9 m wide road is calculated by the following expression. Here, a runoff coefficient of 0.75 is employed.

$$q\_C = 0.75 \times 90/1,000 \times 9 = 0.608 \ m^3/hr$$

Assuming that drainage ditches are installed on both sides of a road, the hourly rainwater runoff to be dealt with by one ditch is estimated as follows.

$$q\_C = 1/2 \times 0.608 = 0.304 \ m^3/hr$$

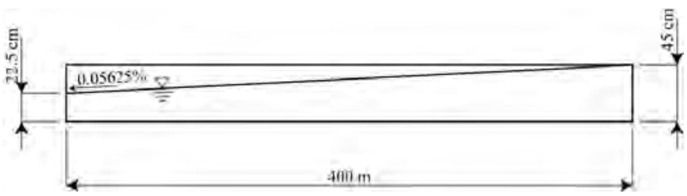
2) Required Capacity of Drainage Ditches

The discharge capability of ditches is extremely low because of the fact that there is hardly any longitudinal slope. Accordingly, any design guidelines which presuppose the smooth flow of water in ditches cannot be adopted. The capacity of the planned ditches must be evaluated assuming a situation where rainwater entering the ditches remains there for gradual discharge.

In the case of a U ditch with internal dimensions of 450 mm x 450 mm, the water holding capacity can be calculated as follows.

$$q_U = 0.45 \times 0.45 = 0.2025 \text{ m}^3/\text{m}$$

Here, a 400 m long U ditch (450 mm x 450 mm) which is installed horizontally is assumed to ultimately have the flow shown in the illustration below.



Using Manning's formula, a ditch with a width of 45 cm, a height of 22.5 cm, a hydraulic grade of 0.05625% and a roughness coefficient of 0.15 has the following runoff.

$$q_M = 0.0373 \text{ m}^3/\text{sec} = 134.28 \text{ m}^3/\text{hr}$$

Assuming that the above state is reached one hour after the commencement of rain, the amount of rainwater to be discharged hourly is calculated below.

$$q_O = \int 134.28\, t\, dt = 67.14 \text{ m}^3/\text{hr}$$

When the capacity of this 400 m long U ditch is considered to include the amount of water held in the ditch, such capacity can be calculated as follows.

$$\Sigma Q = 0.2025 \times 400 - 1/2 \times 0.225 \times 0.45 \times 400 + 67.14 = 127.89 \text{ m}^3/\text{hr}$$

The capacity per unit metre is calculated as follows.

$$q = 127.89/400 = 0.3197 \text{ m}^3/\text{hr}$$

As this value exceeds the calculated runoff, i.e. q_C = 0.304 m^3/hr, it can be judged that the introduction of ditches on both sides of a road will somewhat prevent the flooding of the road.

3) Cross-Section of U Ditches

Based on the above examination, the introduction of U ditches of 450 mm x 450 mm at those places where such U ditches can be installed on both sides of the road is proposed. At those sections after the confluence of U ditches and those sections where a U ditch can only be introduced on one side of the road to carry rainwater falling on the entire road width, the installation of a double capacity U ditch (650 mm x 650 mm) is proposed. At sections where a U ditch cannot be introduced, discharge to the neighbouring land will simply be hoped for as is the case so far.

(3) Repair of Sheltered Bus Lay-Bys and Introduction of New Sheltered Bus Lay-Bys

The scope of the work to repair or construct sheltered bus lay-bys will be up to the drainage ditch (or gutter) in front of a bus lay-by and the paving of the carriageway where buses stop as shown in Fig. 2-21. The locations of the subject existing bus lay-bys and two new bus lay-bys are indicated on the relevant basic design drawings.

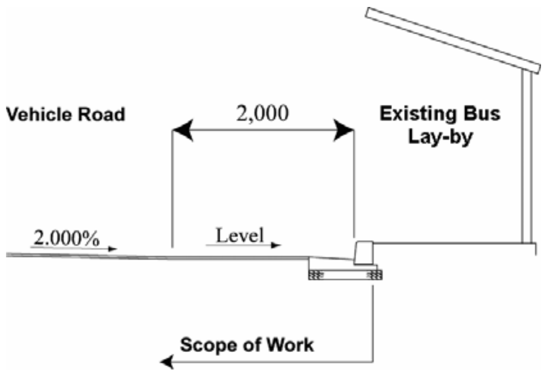


Fig. 2-21 Scope of the Improvement Work for Sheltered Bus Lay-Bys

(4) Access to South Tarawa Road

At those sections of South Tarawa Road where a L gutter is introduced, the concrete paving shown in Fig. 2-22 will be introduced to prevent any difference in the level between South Tarawa Road and the feeder road or adjoining private land.

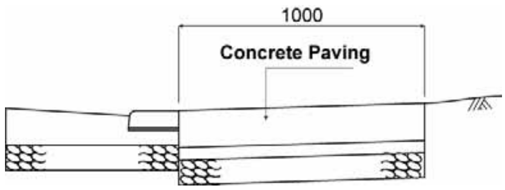


Fig. 2-22 Concrete Paving at Access Points

2.2.2.3 Equipment Plan

(1) Overall Road Repair Plan

The use of the requested road repair equipment (concrete cutters and their spare parts) for the paving repair work for the major and minor roads in South Tarawa is planned. The total length of paved roads in South Tarawa is 41.6 km. As these paved roads suffer from many pot holes due to the deterioration of their paving, the Ministry of Public Works and Utilities constantly conducts pot hole repair work.

The quantity and specifications of the concrete cutters must be carefully selected and calculated to contribute to the improved maintenance of paved roads while checking the relevance of the request for the formulation of a suitable equipment plan.

(2) Paved Road Repair Standards

The basic concept of the paved road repair adopted by the Ministry of Public Works and Utilities is the repair of such roads at minimum cost to make them safely usable throughout the year. The thickness of the existing paving is approximately 1 cm and the road width is generally 6 m with sections of either 4.5 m or 7 m in width.

The pot hole repair work for paved roads is currently conducted partly in accordance with the urgent repair method suggested by the road repair manual which was prepared in 1998 with Australian assistance. This method suggests the following repair process.

① Use of a cutter to cut out the edges of the pot hole in a rectangular shape
② Cleaning and then wetting of the inside of the pot hole
③ Application of diluted emulsion on the sides and bottom of the pot hole
④ Filling in of the pot hole with a mixture of asphalt emulsion and aggregates and then rolling the surface of the pot hole

(3) Contents of Paved Road Repair Work

Every time it rains in South Tarawa, pot holes are produced or enlarged. At present, the average diameter of these pot holes is 20 cm with an average depth of 15 cm. Larger pot holes have a diameter of some 40 cm and a depth of some 20 cm. An average of some 10 pot holes are observed on every 1 km of road and the Ministry of Public Works and Utilities plans to repair the entire paved road length of some 41.6 km every week, i.e. four times a month.

The pot hole repair method (urgent repair method) used so far involves cleaning of the inside of the pot hole, pouring of asphalt emulsion, filling of the pot hole with 19 mm coral stones up to two-thirds of the hole depth, pouring of 9 mm coral stones up to just above the road surface and laying of coral sand on top of the coral stones. After this work, rolling (compacting) is expected to be conducted by travelling vehicles.

The actual practice described above differs from the manual in two aspects relating to ① and ④ above. Because the Ministry of Public Works and Utilities does not possess a concrete cutter, it is quite difficult to cut pot holes in straight lines (①). As any attempt to do so without a concrete cutter is time-consuming, this work is not currently conducted. In regard to ④ rolling, the Ministry of Public Works and Utilities does possess two hand compactors and plans to conduct rolling work using these compactors in accordance with the manual once it acquires a concrete cutter.

(4) Existing Equipment for Paved Road Repair Work

The Ministry of Public Works and Utilities currently has two paved road repair teams. Each team has one agricultural tractor and one trailer, both funded by Australia, and is staffed by one tractor operator and three workers. The trailer carries 9 mm and 19 mm coral stones, coral sand and asphalt emulsion in drums as well as such tools as pick axes, spades and buckets to pour the asphalt emulsion.

(5) Specifications and Required Quantity of Concrete Cutters

1) Specifications

As the paving thickness of the existing paved roads is approximately 10 mm, a concrete cutter with a blade dimension of 305 mm (maximum cutting depth of 100 mm) should be sufficient instead of the requested larger concrete cutter with a blade dimension of 254 mm – 356 mm (maximum cutting depth of 120 mm). The specifications of this smaller concrete cutter will be the standard specifications of the manufacturer as described below.

- Air-cooled petrol engine (approximately 3.5 kW)
- Maximum cutting depth: approximately 100 mm

- Hand-pushed movement
- Spare parts: one set

2) Required Quantity

The required quantity of concrete cutters has been examined in the following manner.

At present, new pot holes on the existing paved roads occur every time it rains which is at least once a week even during the dry period. According to an explanation given by the Ministry of Public Works and Utilities, the average diameter of these pot holes is approximately 20 cm with an average density of 10 per kilometre.

A concrete cutter takes more than 10 minutes to cut a length of 1 m for a normal paving thickness of 5 cm. Because of the fact that the paving thickness in South Tarawa is as thin as 1 cm and also because of the fact that coral stones, which are the standard aggregates used for the base course, are weak, the cutting of 1 m of the road surface in 5 minutes should be possible.

At present, pot hole repair work for the total paved road length of 41.6 km is conducted by two teams in five days and the length covered by one team a day is 4.16 km with 10 pot holes of 20 cm in diameter on average being found per kilometre.

Assuming that the cutting length per side of a pot hole is 25 cm, the total cutting length per pot hole is 1 m, making the required cutting length per 1 km of paved road to be 10 m. Based on such calculation results, the required cutting length per day is 41.6 m to cover the road length subject to daily repair work of 4.16 km. Assuming that the cutting time per 1 m is 5 minutes, 208 minutes (approximately three and a half hours) are required to cut 41.6 m. Given the daily working hours of 7.25 hours, the provision of one cutter for each team should be sufficient.

Based on the above examination, the provision of two concrete cutters, i.e. one concrete cutter for each pot hole repair team, is planned.

2.2.3 Basic Design Drawings

The basic design drawings for the Project are given in following pages.