BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
IMPROVEMENT OF BLANTYRE CITY ROADS
IN
THE REPUBLIC OF MALAWI

JUNE 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

JAPAN ENGINEERING CONSULTANTS CO., LTD.

PREFACE

In response to a request from the Government of the Republic of Malawi, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Blantyre City Roads and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Malawi a study team from November 18, 2006 to December 24, 2006, 37 days.

The team held discussions with the officials concerned of the Government of Malawi , 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 Malawi 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 Malawi for their close cooperation extended to the teams.

June, 2007

Masafumi Kuroki
Vice-President
Japan International Cooperation Agency

June, 2007

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Improvement of Blantyre City Roads in the Republic of Malawi.

This study was conducted by Japan Engineering Consultants Co., Ltd., under a contract to JICA, during the period from November 2006 to May 2007. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Malawi 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,

Hisashi Mutou
Project manager,
Basic design study team on
the Project for Improvement of Blantyre City Roads
Japan Engineering Consultants Co., Ltd.

Summary

(1) Country Profile

Malawi's total land area is 118,000 square kilometers, which is approximately the same area as Hokkaido and Kyushu combined. It is long and narrow landlocked nation stretching north and south and surrounded by Tanzania, Zambia and Mozambique. Most of its territory is situated in the highlands near Lake Malawi, which accounts for more than 15% of its national land area. Although it belongs to subtropical climate, it is relatively cool even in the summer, the highlands exceeding 1,000m. During the four-month rainy season between December and March, it receives 800 to 2,000mm of rainfall.

Despite growth in the national budget from $330 million (2001) to $671 million (2003), including grants by donor nations which accounts for 25% to 35% of the total budget, the GDP fell temporarily due to the effects of drought which occurred in 1992 and 1994. Since then, industries have rebounded resulting in stable growth from 2.9% (2002) to 6.7% (2004). Taking the average population growth of approximately 2% into account, although per capita income appears to be increasing, the per capita GDP in Malawi is still only $149 (2004), which is much lower than the $721 average per capita GDP of surrounding nations.

The Malawian industry is greatly dependent on agriculture, which accounts for 90% of total exports ($430 million in 2004) and 85% of the resident population. However, the exportation of tobacco, the largest source of foreign currency, has fallen dramatically due to a slump in consumption on a global scale. On the other hand, exports of other cash crops such as tea and sugar have also fallen due to Malawi's situation as a landlocked nation.

（2） **Background and Outline of the Requested Project**

Since Malawi is a landlocked country, material and passenger transportation is exclusively dependent on overland transportation. Therefore, infrastructure development of mainly roads is a priority task for economic growth. The total length of roads in Malawi is approximately 16,500km, of which 6,500km (40%) are major trunk roads shouldering the role of international logistics. However, since the majority of existing road surfaces have deteriorated or become damaged due to financial limitations, the pavement rate even for major trunk roads is only 43%. In response to this, the “Road Sector Investment Program (2003 to 2012)” was formulated in 2002 and transport corridors to neighboring African nations to the south and domestic trunk roads have mainly been developed.

The city of Blantyre is located approximately 250km south of Lilongwe, the capital, and is the urban center of commerce and industry. Many of the municipal roads were constructed in the 1950s. The total length of roads in the city is approximately 470km, approximately 113km of which are paved (24% pavement rate) as of 1999. Which means less than half the urban roads nationwide, or 57%, are paved, which is an extremely low level. In addition to the low pavement rate, pavement destruction can often be observed along with the deterioration of road facilities (drainage, pavement and road shoulders) that accompany secular change or the increase in traffic volume. The progress of pavement deterioration is a result of secular change, a chronic shortage of maintenance funding, and an increase in traffic volume associated with an increasing population. Moreover, the rise in traffic congestion and number of accidents due to the increasing volume of traffic is seriously hindering daily life and economic activity. Although the Blantyre City Assembly is formulating a plan on road maintenance and repair, it faces financial difficult in implementing it due to the high cost of repairs.

Faced with this situation, Malawi submitted a request for the Japanese Grant Aid Scheme for improvement and repair of 42 existing routes in Blantyre. In June 2006, the Japan International Cooperation Agency (JICA) conducted a preliminary study. From the study, assuming a basic design study on implementing the Project through the Japanese Grant Aid Scheme, the following matters were confirmed.

① Of the 42 routes subject to the study (4 routes have been repaired by other donors), two routes, Chipembere Highway and Livingstone Avenue, play an important social, industrial and commercial role as trunk transportation routes in Blantyre. However, not only is the pavement deteriorated, but part of the existing roads is only 2-lanes (one-lane each side). Since the daily traffic volume flowing from four major national roads now exceeds 30,000 vehicles, there is a serious traffic congestion problem. Safe, smooth road traffic therefore cannot be guaranteed. Compared with other routes, the urgency for improvement and repair is extremely high.

② Due to insufficient capability of local consultants and contractors in Malawi and an inadequate maintenance system (budget) on the Malawian side, assistance through Grant Aid for Community Empowerment introduced in 2006 appears to have been difficult. In order to accomplish the project goals, the implementation of Grant Aid for General Project is therefore deemed appropriate.

③ In the case of repairing the above-mentioned trunk roads, it may be necessary to relocate or remove some buildings (such as offices) owned by Blantyre City as well as trees. However, according to the explanation provided by the Malawian side, since the lots in question are already owned by Blantyre City, it has been confirmed that large-scale civic relocation or additional securing of private land will not be necessary.

④ From the initial request, since the urgency and necessity of road construction equipment and materials remains low, the original aim can be accomplished even if they are excluded from the Project. The consent of the Malawian side could be obtained.

In due consideration of the above-mentioned results, the Government of Japan decided to conduct a basic design study on improvement and rehabilitation of Chipembere Highway and Livingstone Avenue through Grant Aid for General Project.

(3) Outline of the Study Findings and Project Components

In response to this decision, JICA dispatched a basic study team from November 18 to December 24, 2006. In the field survey, the requested components were confirmed again. At the same time, the natural conditions (geographical features), current pavement conditions and procurement conditions of construction materials and equipment were discussed with concerned parties on the Malawian side. Based on the findings of the said survey, after preparing the specifications to which roads should satisfy, concrete repair and execution methods and estimated project cost in Japan, the basic design study team was dispatched to provide an explanation from April 9 to 21, 2007 and obtained consent on the components of the basic design and undertakings to be taken by both nations through discussions and confirmation.

After the degree of damage to existing roads and cost were considered, renovation of the targeted sections, and renovation mainly through overlaying pavement on existing roads, the appropriate scale (road width, carriageway and pavement structures) and specifications were examined. More specifically, consideration was taken in order to secure safe and smooth road traffic flow by widening bottlenecks on the routes (developing 4-lanes by constructing new 2 lanes), improving intersections and drainage systems and installing safety facilities on roads that exceed 30,000 units per day of traffic volume.

Based on the above-mentioned results, an outline of the final recommendations is described in the following table.

(4) Construction Period of the Project

In regard to the construction period of the project, it is approximately 28.0 months (7.0 months for a detailed design and 21.0 months for construction work) including tendering process appears necessary.

Table: Overview of Facilities (Repaired Components)

Section		Repaired Component	Repaired Item
Chipembere Highway 7,010m	Section 1 180m	Pavement Replacement	Existing base course stabilization & wearing course (surface) work 5cm × 2 layers (Semi-flexible pavement)
	Section 2 3,360m	Construction of 2 New Lanes	Construction of 2 lanes toward terminal point. For pavement, base course stabilization work through new materials & wearing course work 5cm
		Repair of Existing Pavement	Overlay work 5cm × 2 layers
		Roundabouts	2 locations. Improvement of Mahatma Gandhi & Johnstone Intersections. Installation of street lights.
		Drainage Facilities	Installation of trapezoid gutters on right & left sides, security of drainage routes until flow end.
		Bus Lay Byes	10 locations in total. Security of retention space for 5 mini buses.
		Kerb Stones	Installation at 4 locations per cross section
		Footpaths	Construction on right & left sides. 2.5m width taking bicycles into account. Concrete plates on wearing course.
	Section 3 2,750m	Repair of Existing Pavement	Overlay 5cm × 2 layers in principle. In the flooded sections, replacement of pavement in order to raise the road. For pavement replacement, existing base course cement stabilization & wearing course work 5cm.
		Bus Lay Byes	Improvement at 8 locations in total including new 2 locations (retention space for 5 mini buses). Installation of street lights.
		Drainage Facilities	By installing trapezoid gutters on right & left sides, security of drainage routes until flow end.
		Kerb Stones	Repair of existing kerb stones & construction of new stones at insufficient locations.

		Footpath	Repair of existing footpath. Concrete plates on wearing course.
	Section 4 720m	Widening of Present Road Width	Widening of present road width by adding right-turn lane at existing 2-lane road.
		Repair of Existing Pavement	Existing base course stabilization & wearing course work 5cm
		Bus Lay Byes	New construction at 1 location (retention space for 5 mini buses). Installation of street lights.
		Drainage Facilities	By installing U-shape gutters with covers on right & left sides, security of drainage routes until flow end.
		Structures	Box culverts (1.5m×1.5m) on 2 locations
		Kerb Stones	Construction of new kerb stones on right & left sides
		Footpath	Construction of new footpath on right & left sides. 2.5m of width. Concrete plates on wearing course.
Livingstone Avenue 890m		Repair of Existing Pavement	Improvement of existing base course cement & wearing course work 5cm
		Drainage Facilities	By installing U-shape gutters on right & left sides, improvement until river of flow end.
		Kerb Stones	Repair of existing kerb stones & construction of new stones on insufficient locations.
		Footpath	Repair of existing footpath. Concrete plates on wearing course.

(5) Operation and Maintenance

The implementing agency of the Project is the Blantyre City Assembly (BCA).

As undertakings to be taken by Malawian under the Project are assumed to be ① relocation and removal of the existing public facilities (such as power distribution lines and telephone lines) and ② removal of the existing structures such as fences and lighting poles (including trees), the necessary expenses will be approximately 8.7% of the total budget of the BCA.

In addition, after renovation of the roads is complete, it is assumed that major maintenance work required every year will include ① cleaning of road surface and drainage facilities and ② replacement of lighting bulbs, etc. As long as maintenance work implemented by the Malawian side can be confirmed, the organization, personnel and owned machinery are considered to be sufficient. In addition, the annual maintenance cost (average) is equivalent to approximately 1.8% of the annual maintenance budget of BCA, so it should be possible to secure the sufficient budget.

On the other hand, with respect to periodical road repairs, since ① pothole repair (every 5 years) and ② overlay of road surfaces (every 10 years) is forecasted, 99.6 million MK (approximately ¥85.7 million) will be necessary to cover this. Although it not always lower than the annual budget of BCA, the study confirmed that the relevant repair cost would be appropriated from revenue (approximately ¥1.45 billion in 2006) generated from a fuel levy imposed by the central government.

(6) Verification of Relevance of the Project

The following direct and indirect effects can be expected through the implementation of the Project. 520,000 citizens of Blantyre are expected to benefit.

1) Direct Effects

① Traffic on trunk roads will flow more smoothly.

By widening the road width and constructing bus lay byes, the average speed of 26km/hour at peak times in the morning and evening (6 to 7 o'clock in the morning, 5 to 6 o'clock in the evening) due to traffic congestion will be improved to around 50km/hour after the renovations.

② Frequency of traffic difficulties due to long-term flooding will be reduced.

Stay of rainwater on road surfaces which occurs 95 days annually (rainy days with over 1mm a day) on lower sections of roads will be significantly reduced.

③ The number of traffic accidents due to traffic congestion will be reduced.

Of the 533 traffic accidents that occurred in 2005, 90% (approximately 480 cases) were caused by traffic congestion. Therefore, by improving traffic flow, installing street lights, and improving roundabouts through the implementation of the Project, the number of accidents caused by traffic congestion will be reduced.

2) Indirect Effects

① By addressing the problem of traffic congestion, the carrying capacity of physical distribution will be improved. In addition, the amount of exhaust gases will be reduced, lessening its impact on the environment.

② By improving the reliability of road traffic, the convenience for local residents who utilize trunk roads will be improved.

③ The maintenance cost for the targeted roads will be reduced from 8.57 million MK/annually to 2.59 million MK/annually.

④ By improving road traffic flow, regional development and the industrial functions of the city will be improved, the economy will be revitalized, and accessibility to social services such as medical and educational institutions will also be improved.

Since the Project is expected to promote recovery of the original functions of inter-urban trunk roads, ensure safe and smooth road traffic, and revitalize the socio-economic activities in the city of Blantyre, the industrial center of Malawi, in turn contributing to the overall development of Malawi, the tremendous significance of implementing the Project through the Japanese Grant Aid Scheme was confirmed.

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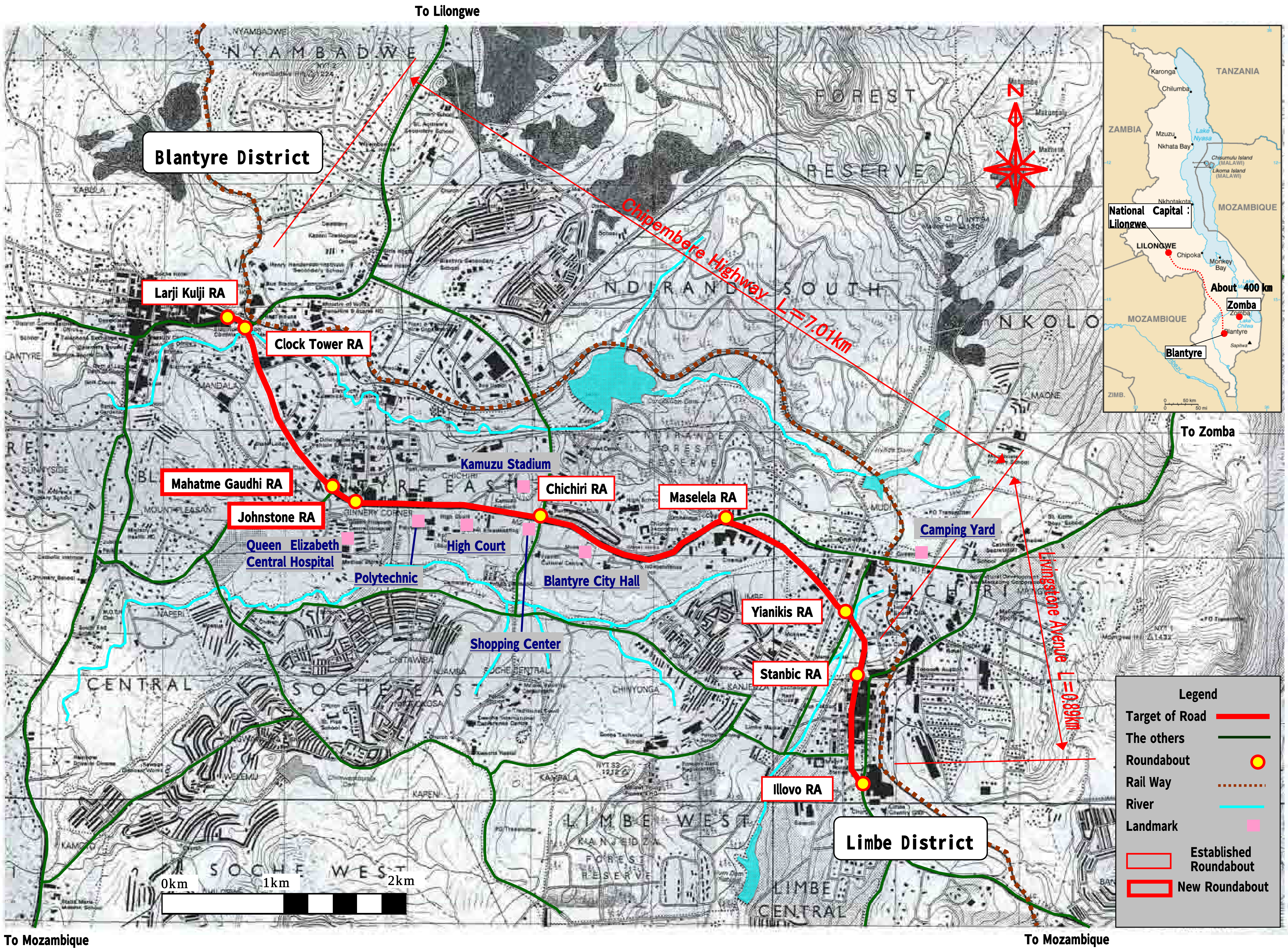
List of contents

The Republic of Malawi

BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF BLANTYRE CITY ROADS

Location Map(1)



To Lilongwe
Blantyre District
Larji Kulji RA
Clock Tower RA
Mahatme Gaudhi RA
Johnstone RA
Kamuzu Stadium
Chichiri RA
Maselela RA
Queen Elizabeth Central Hospital
High Court
Polytechnic
Blantyre City Hall
Shopping Center
Camping Yard
Yianikis RA
Stanbic RA
Illovo RA
Limbe District
Chipembere Highway L=7.01km
Livingstone Avenue L=0.89km
To Zomba
To Mozambique
To Mozambique
0km
1km
2km
N
National Capital : Lilongwe
About 400 km
Zomba
Blantyre
TANZANIA
ZAMBIA
MOZAMBIQUE
MOZAMBIQUE
Legend
Target of Road
The others
Roundabout
Rail Way
River
Landmark
Established Roundabout
New Roundabout

Bird View of Chichiri Roundabout, Chipembere Highway

LIST OF TA BLES

LIST OF FIGURES

ABBREVIATIONS

AASHTO	: American Association of State Highway and Transportation Officials
A/P	: Authorization Pay
AS	: Asphalt Concrete
BCA	: Blantyre City Assembly
CBR	: California Bearing Ratio
DBST	: Double Bituminous Surface Treatment
DCP	: Dynamic Cone Penetrated
B/A	: Bank Arrangement
E/N	: Exchange Note
EIA	: Environment Impact Assessment
EU	: European Union
GPS	: Global Positioning System
IEE	: Initial Environment Examination
JICA	: Japan International Cooperation Agency
LED	: Light Emitting Diode
MK	: Malawian Kwacha
MLGRD	: Ministry of Local Government and Rural Development
NRA	: National Road Authority
PSI	: Present Serviceability Index
PVHO	: Plant and Vehicle Hire Organization
ROADSIP	: Road Sector Investment Programme
RA	: Roundabout
SATCC	: Southern African Transport and Communications Committee
VAT	: Value Added Tax
VCL	: Vertical Curve Length
VCR	: Vertical Curve Radius
USD	: United States Dollar
WB	: World Bank

Chapter 1
Background of the Project

1-1 Background of the Project

The Republic of Malawi (hereinafter referred to as “Malawi”) is a landlocked country surrounded by three other nations whose road system plays a leading role in commodity and passenger transportation, international logistics, and is an important source of economic growth. There are a total 16,500km of roads in Malawi, 6,500km of which are either part of a road network, are major trunk roads or other economic transportation routes. Of those, 43% are paved. However, the surfaces of many of the existing roads have deteriorated or become damaged due to financial constraints. Consequently, road infrastructure development is considered a high priority in the country’s national development plan. In response, the “Road Sector Investment Program (2003 to 2012)” was formulated in 2002and transport corridors to neighboring African nations to the south and domestic trunk roads have mainly been developed.

The project site, Blantyre administrative district, is located approximately 250km south of Lilongwe, the capital and largest city in Malawi and most industrial advanced. Most of municipal roads were constructed in the 1950s. However, not only have road surfaces deteriorated, but traffic volume has also sharply exceeded the designed volume due to the increasing population and industrial development. The resulting traffic congestion and increasing number of traffic accidents has become a serious hindrance to daily life and economic activity.

Faced with these problems, the Government of Malawi has attempted to repair the roads through their own funding. However, due to the vast number, a request was submitted for Japan's Grant Aid Scheme for the improvement of 42 routes.

In response to this request, a preliminary study was conducted in June 2006 for the purpose of confirming the requested components and project sites, positioning the priorities of the requested Japanese assistance, examining the feasibility of the Project through Grant Aid for Community Empowerment and implementing IEE in accordance with the JICA Guidelines for Environmental and Social Considerations, etc. The findings are described as follows.

1) Of the 42 routes subject to the study (four routes have already been repaired through the support of other donors), two routes, Chipembere Highway and Livingstone Avenue connect Blantyre and Limbe districts and are vital to the social, industrial and

commercial infrastructure of Blantyre. However, due to the inflow of traffic from four principal national roads, the volume of daily traffic exceeds 30,000 vehicles, creating chronic traffic congestion. Consequently, ensuring a safe, smooth traffic flow is not possible and so improvement and repair work is urgently needed compared with other routes. However, since many of the other routes are short and are located within industrial and commercial districts and their current traffic volume is not very high compared with the two above-mentioned routes, the expected effects are limited.

2) Since many heavy vehicles utilize the trunk roads and it is difficult to apply local specifications, the capacity of local consultants and contractors in Malawi and the maintenance system (budget) on the Malawian side is insufficient. Therefore, assistance through Grant Aid for Community Empowerment is difficult and Grant Aid for General Project has therefore been deemed appropriate.
3) In repairing the above-mentioned trunk roads, it may be necessary to relocate or remove some buildings (such as offices) owned by Blantyre City and trees. However, according to the explanation provided by the Malawian side, since the lots in question are already owned by Blantyre City, it has been confirmed that large-scale civic relocation or additional securing of private land will not be necessary.
4) With regard to the requested components, since the urgency and necessity of road construction equipment and materials remains low, the original aim can be accomplished even if they are excluded from the Project. The Malawian side is also aware of this.

As mentioned above, with respect to the priority repair of 7.90km of the two routes of Chipembere Highway and Livingstone Avenue, the appropriateness of implementing the Project under Japan's Grant Aid Scheme was confirmed.

1-2 Natural Conditions

(1) Geographical Features

Malawi’s total land area is 118,000 square kilometers, which is approximately the same area as Hokkaido and Kyushu combined. It is long and narrow landlocked nation stretching north and south and surrounded by Tanzania, Zambia and Mozambique. Most of its territory is situated in the highlands near Lake Malawi, which accounts for more than 15% of its national land area. Blantyre City, which is the project site, is situated in the Shire valley extending to the south and lies in a hilly zone from 780 to 1,100m above sea level. The city is divided into three areas, a river basin, highlands and hilly zone—the river source where nine catchments (watersheds) have formed by rivers flowing in the city.

(2) Meteorological Conditions

The climate is subtropical continental with the rainy season running from November to March and the dry season from April to October. Hereinafter, meteorological data (1995 to 2006) from the Chichiri Observatory which has jurisdiction over Blantyre City and the vicinity of the project site is listed. A mean value a ten-year period is shown in order to illustrate the overall conditions in recent years. Meteorological data by fiscal year is also attached as reference at the end of this volume.

1) Temperature

With respect to the minimum temperature (mean value) over the past 10 years, the monthly minimum is 10.0℃ for July 2004 and the yearly minimum is 15.5℃ for 1999. With respect to the maximum temperature (mean value), the monthly maximum is 31.4℃ for November 1996 and the yearly maximum is 26.9℃ for 1996. Table-1.1 shows the minimum and maximum monthly temperatures (mean values).

Table 1.1 Minimum and Maximum Monthly Temperatures (1995 to 2006) (℃)

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
Min. Temperature (Mean)	18.7	18.0	17.8	15.8	14.2	12.4	11.7	13.4	15.3	17.2	18.6	18.4	15.9
Max. Temperature (Mean)	26.4	26.1	26.5	25.0	24.2	22.5	21.9	24.6	27.2	28.4	28.7	26.6	25.6

2) Precipitation

The annual rainfall for the past ten years (mean value) was a relatively high 1,175mm. The rainy season lasts from December to March, and accounts for approximately 82% of the total annual rainfall, and the monthly maximum rainfall recorded was approximately 400mm (February 2000).

Table 1.2 Average Monthly Rainfall (1995 to 2006) (mm)

Month	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
Rainfall (Mean)	5	3	7	25	95	244	277	276	170	59	8	6	1,175

※ Mesh parts indicate rainy season.

The maximum daily rainfall recorded over the past 10 years is 123.7mm (February 8, 1997).

Table 1.3 Maximum Daily Rainfall (1995 to 2006) (mm)

	’96	’97	’98	’99	’00	’01	’02	’03	’04	’05
Maximum Daily Rainfall	59.2	65.7	123.7	72.1	126.0	86.0	95.0	112.0	56.0	83.0

3) Number of Rainy Days

The number of days with more than 0.3mm of rain over the past 10 years is 95 days annually, 70% of which are concentrated in the rainy season between December and March.

Table 1.4 Average Number of Rainy Days by Month (1995 to 2006)

Month	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Average
No. of Rainy Days	3	2	1	2	8	16	20	15	15	8	3	2	95

4) Wind Velocity

The average wind velocity over the past 10 years is 1.7m/s and the maximum by month is a relatively low 3.6m/s (January 1996), and is judged to have little or no adverse effect on the Project.

(3) Hydrology

Three river systems are located near the routes that fall within in the project site, the Mudi River, Naperi River and Limbe River. The drain ends for the routes at the project site will be these rivers. The rivers eventually flow into the Zambezi River, and their headwaters are Zambia and Angola Rivers. Figure-1.1 illustrates the Blantyre City river system.

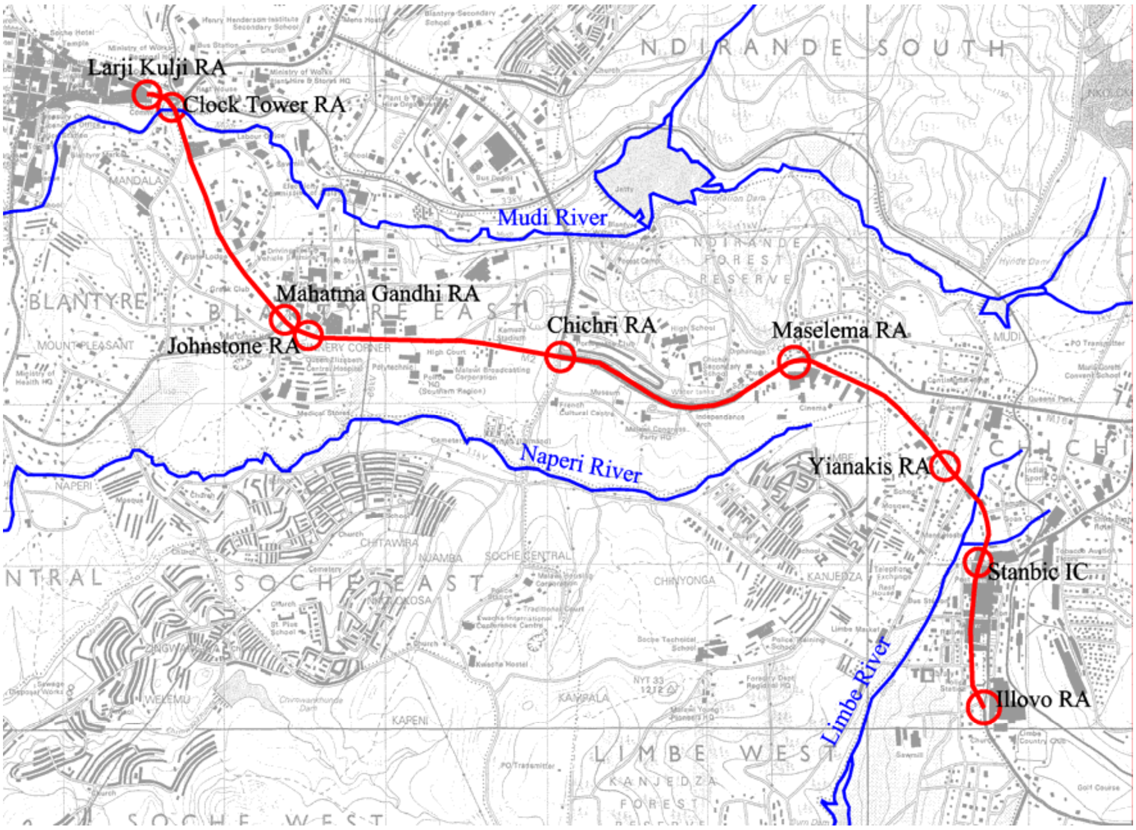


Figure 1.1 Blantyre City River System

(4) Geology and Soil Quality

Most of Malawi belongs to the Mozambique Belt of the Precambrian era to the early Paleozoic era where metamorphic rocks primarily containing gneiss and new metamorphic rocks such as granite and gabbro which have permeated into the same era are distributed. Of these, laterite which is weathered clay and bedrock from diluvia formations of the Pleistocene Epoch of the Quaternary Period, is widely distributed and is accumulated at the project site.

Since roadsides of soft and hard rock were not observed during a site reconnaissance of the routes subject to improvement, the surface soil is assumed to be mainly composed of thickly accumulated laterite. Therefore, if this and the findings of a geotechnical soil test are taken into consideration, it could be said that essentially no so-called fragile soil or unsuitable soil necessary for soil improvement was discovered. In addition, surplus soil that will accompany the construction work can be reused at the construction site.

1-3 Environmental and Social Considerations

As the Project was classified to be Category B in the preliminary study, a survey on the necessity of an environmental impact assessment (EIA) by the concerned authorities in Malawi and stakeholders' meetings were held. As the result, the necessity for implementation of an EIA was recognized by the Department of Environmental Affairs in Malawi, and Blantyre City submitted an EIA report accordingly. As the result of the EIA report by the Department of Environmental Affairs, the implementation of the Project was approved. The related documents are attached to the Minutes of Discussions (M/D) at the end of this volume.

The stakeholders' meetings were organized as shown in Table-1.5 in order to make the Project known to the concerned parties.

Table 1.5 Organization of Stakeholders' Meetings

Date	Instruction
22nd January, 2007 2:30 am - 4:30 pm	Media House • Radio • Television • Print Media
23rd January 2007 10:00 am - 12:00 noon	Public Institutions • Hospitals • Churches • Educational Institutions
2:30 pm - 4:30 pm	People Living Along the Main Road • Businesses • Residents
24th January 200710:00 am - 12:00 noon	Opinion Leaders • Members of Parliament • Chiefs • Community Development Committees
2:30 pm - 4:30 pm	Public Utility Services • Electricity • Water • Communications • Sewers
25th January, 2007 10:00 am - 12:00 noon	Road Users • Minibus Association of Malawi • Truck Companies • Road Traffic Department • Road Safely Council • Traffic Police • Ministry of Works and Public Affairs • Consumer Association of Malawi

The primary purpose of the Project is to expand Chipembere Highway to four lanes and add a median strip between both sides so there will be restrictions; however, as in the past right turns will still be possible from the roadsides. Consequently, Blantyre City explained the Project to roadside residents within the section between the Clock Tower Roundabout and Chichiri Roundabout who will be particularly affected and obtained their consent. The related documents are included in the reference materials attached to the end of this volume.

Chapter 2
Contents of the Project

2-1 Basic Concept of the Project

(1) Overall Plan and objective of the Project

Since most of the roads in Blantyre were constructed in the 1950’s, the growth of traffic volume, due to increasing levels in population concentration, further industry development and pavement damage from severe use throughout the years, has resulted in daily traffic congestion and a higher number of accidents. From this situation, different obstacles can be noticed in relation to citizens’ ordinarily life and economic activity in general. Therefore, it is expected that, by strengthening road conveyance capacity levels through the improvement of Blantyre city roads, the social economy of Blantyre, and that of Malawi for that matter, shall be activated.

(2) Outline of the Project

The Project will involve the implementation of the Japanese Grant Aid Scheme in order to accomplish the overall goal including construction to improve roads in Blantyre City. Through this, the development and repair of existing roads in Blantyre City is expected. The requested Japanese assistance will include the repair of major trunk roads Chipembere Highway (7.01km) and Livingstone Avenue (0.89km) in order to ensure safe and smooth traffic flow in Blantyre City.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

(1) Widening of 4-lane Road on Chipembere Highway

According to the traffic volume survey, the volume of traffic is approximately 12,500 to 18,500 vehicles daily on Chipembere highway and approximately 3,800 to 8,000 vehicles daily on Livingstone Avenue, and is particularly severe on Chipembere Highway. And since this is equivalent to the volume for a major trunk road by Japanese standards, the current traffic volume cannot be sufficiently

Photo 2.1 Congestion conditions on Chipembere Highway (Section 4). It is the existing 2-lane road and retention of vehicles turning right on main lane invites traffic jam.

handled with only two lanes. Consequently, widening the 2-lane section of Chimpembere Highway to 4 lanes is judged to be essential.

Along the sections of Chipembere Highway, a width of 24m for lots and 4m for lanes has been secured at Yianakis Roundabout and Stanbic Intersection (Section 4). However, due to fences and buildings installed alongside the road an additional lane will be necessary to accommodate vehicles tuning right; so it appears 4-lane development will be difficult. Moreover, even if the findings of the traffic volume survey or utilization of the periphery roads are taken into account, the probable cause of traffic congestion is not an insufficient number of lanes, but rather vehicles that are held up in the main lane waiting to turn right onto access roads. In this section, two lanes will be developed in principle, and it appears fitting to develop three lanes by adding an extra lane to accommodate vehicles turning right.

As Churchill Road runs parallel with Livingstone Avenue, these two routes both play an important traffic function, and is therefore largely similar to the securing of four lanes. In addition, there are many shops lining Livingstone Avenue so there is no room for any new widening of the road. Accordingly, instead of developing four lanes through the widening of Livingstone Avenue, the existing width of two lanes will be repaired. Figure 2.1 illustrated this.

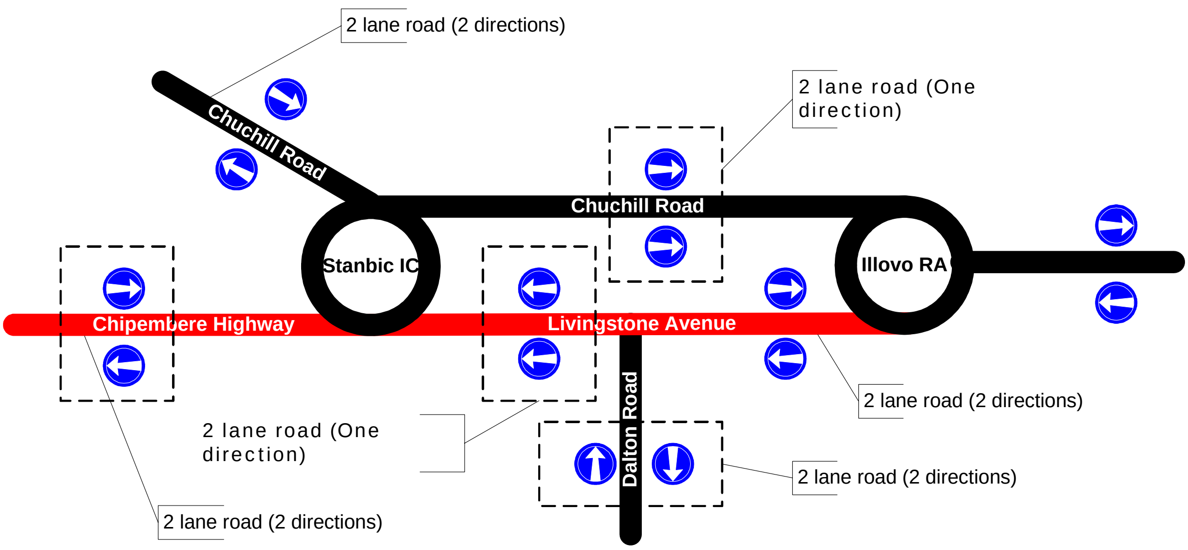


Figure 2.1 Traffic conditions in Limbe District

As described above, the number of lanes for the targeted route is as follows. Figure 2.2 illustrates this.

Chipembere Highway (Section 1)	Rehabilitation of existing 4-lane road	L=180m
Chipembere Highway (Section 2)	Rehabilitation of existing 2-lane road ＋ construction of new 2-lane road	L=3,360m
Chipembere Highway (Section 3)	Rehabilitation of existing 4-lane road	L=2,750m
Chipembere Highway (Section 4)	Widening of existing 2-lane road to 3-lane road	L=720m
Livingstone Avenue	Rehabilitation of existing 2-lane road	L=890m

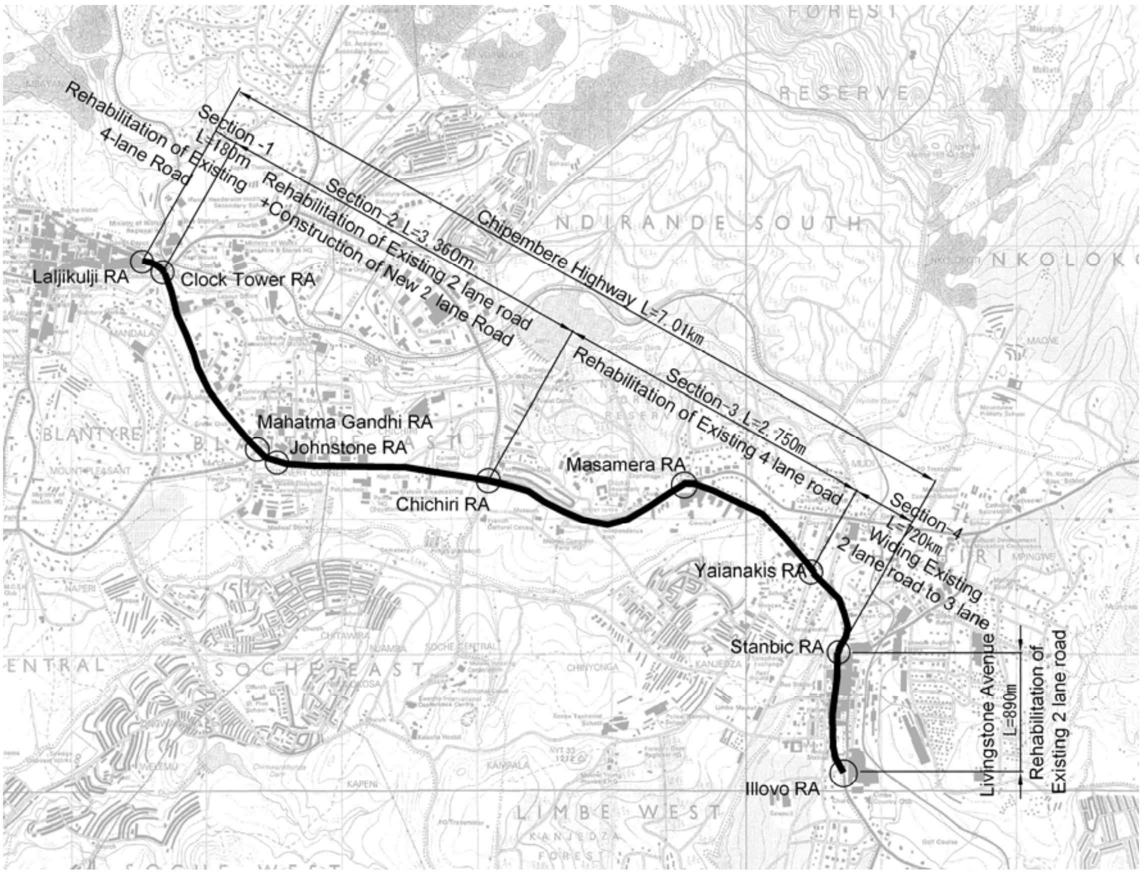


Figure 2.2 Development Plan for Targeted Routes

(2) Pavement Structure of Present Roads and Frontage (Service) Roads

The pavement structure would be determined properly by considering the results obtained from soil survey and traffic volume survey. Overlay or rehabilitation (exchange materials from the base or subbase) method would be selected for each section generally by evaluating the PSI value, the crack ratio and the pothole ratio. Pavement flow failure resulting from high torque could be often observed at some locations such as roundabouts or climbing lanes where the speed of large-scale trucks drops. Therefore, semi-flexible pavement -pouring liquid cement on asphalt surface- would be applied. Service roads that would be destroyed during the construction work would be repaired since they will be used for transporting construction materials to, and from the construction site.

【Semi-flexible Pavement】

By poring liquid cement (cement milk) into the asphalt mixture, semi-flexible pavement has both the flexibility of asphalt pavement and rigidity of concrete and is superior in fluidity and oil resistance. This can be accomplished by using general machinery utilized for ordinary asphalt pavement, so no special machinery is required. Compared with the 10-year life of ordinary asphalt pavement, the life of semi-flexible pavement is regarded to be greater than 20 years. And since it is essentially maintenance-free, operating cost can be kept to a minimum.

(3) Change from Signal Intersections to Roundabouts (2 Locations)

Although Mahatma Gandhi Intersection and Johnstone Intersection are signalized at the present time and the signals are in good operation, they have become a cause for traffic congestion due to inadequate dispersal rate of traffic volume. For a traffic plan utilizing signals to be appropriate, the current traffic volume should be understood and the cycling time (timing of green and red) for the signal should be adjusted according to the time period and season. In addition, the cycling time should also be adjusted periodically by renewing traffic volume data, which is a significant maintenance burden.

Consequently, the request to change these into roundabouts is judged to be appropriate. In the planning for roundabouts, there will be three conditions under which roundabouts are scheduled within road lots. Traffic capacity should be secured for proper dispersal of traffic volume and to meet the future requirements of the planned Mahatma Gandhi Road.

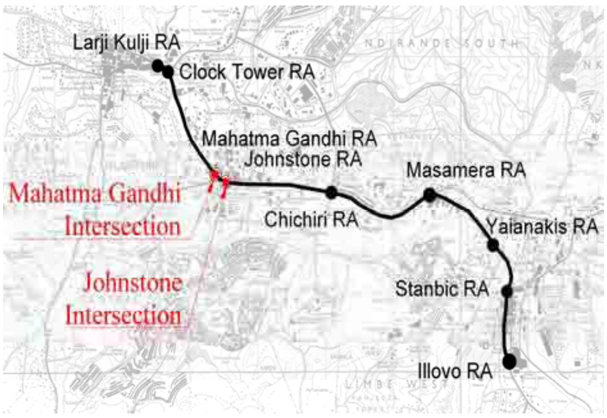


Figure 2.3 Positions of Signalized Intersections

Photo 2.2 Traffic congestion due to the signal at Mahatma Gandhi Intersection

(4) Rehabilitation of Existing Roundabouts (6 Locations)

Although most of the improvements will initial begin at Clock Tower Roundabout, in due consideration of the integrity of the road, the section until Larji Kuiji Roundabout will also be included through discussions with the recipient government. Since pavement flow as a result of torque from large vehicle is the biggest issue at the existing roundabouts, semi-flexible pavement which is superior in fluidity resistance will be applied here. Roundabouts at the following 6 locations will be subject to rehabilitation.

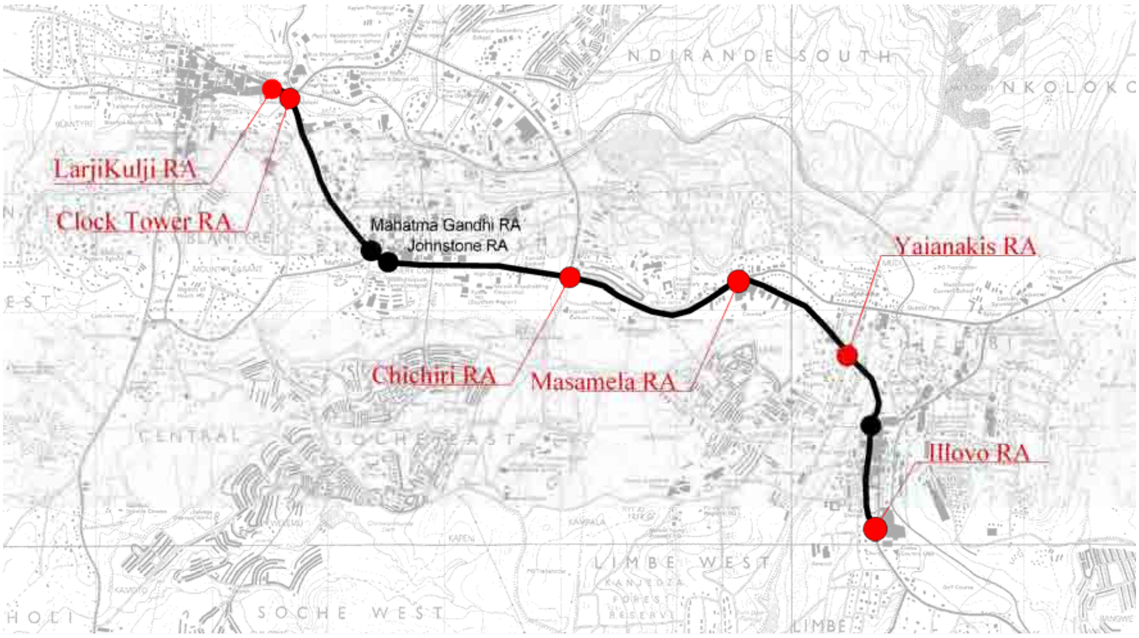


Figure 2.4 Existing Roundabouts to be Rehabilitated

(5) Rehabilitation of Drainage System

Drainage must be improved so that roads can be permanently utilized after improvements are made, and its planning and design will be taken based on the following principles.

Photo 2.3 Mudi River condition around flow end of traffic origin

a) To secure drainage routes to flow end

Water on the road should be transferred into a river or lake by channeling it down gutters along the road side. If only the roadside gutters are improved, water cannot be promptly transferred from the road and becomes stagnant halfway causing water to backup, causing damage to pavement. Therefore, drainage routes should be secured until flow end.

b） Manpower

To reduce the burden of maintenance, assuming that cleaning will be done by manpower, the facility structure or layout will be examined. To be more specific, since 600mm will be applied as the width to enable workers to easily clean gutters, the design of various facilities such as drainage pits or crossing pipes will conform to this. A width of 600mm is assumed to be the minimum required for a man to enter but necessary width for cleaning. In addition, to reduce the burden of maintenance and reduce the amount of deposited soil, concrete linings will generally be adopted.

（6） Repair and New Construction of Bus Lay Byes

Since there is space for only two mini buses at the existing bus lay byes, vehicles that cannot be parked block the traffic lane and creating traffic congestion, so sufficient space should be secured. Based on the findings of the site reconnaissance, space for at least five vehicles is judged to be necessary. In addition, due to a request for the construction of new bus lay byes at the following locations, some passengers were actually observed getting on and off when onsite confirmation was being conducted. This is a primary commercial district, or a place where churches or meeting places are located where public gatherings are held. Therefore, the need is judged to be high. As a consequence, bus lay byes at ten locations (× both sides) will be improved under the Project. Figure-2.5 is a list of the locations.

Table 2.1 New Bus Lay Byes and Reason for Improvement

(Tentative) Name of New Bs Lay Bye	Reason for Improvement
Hellenic Community	There are churches and meeting places for public gatherings. There is no existing bus lay bye in the vicinity.
Kriss and Co.	Although there are companies or factories located here and to which many people commute, there is no existing bus lay bye in the vicinity.
Lotus Motors	Although it is a commercial district and there are many shoppers, there is no existing bus lay bye in the vicinity.

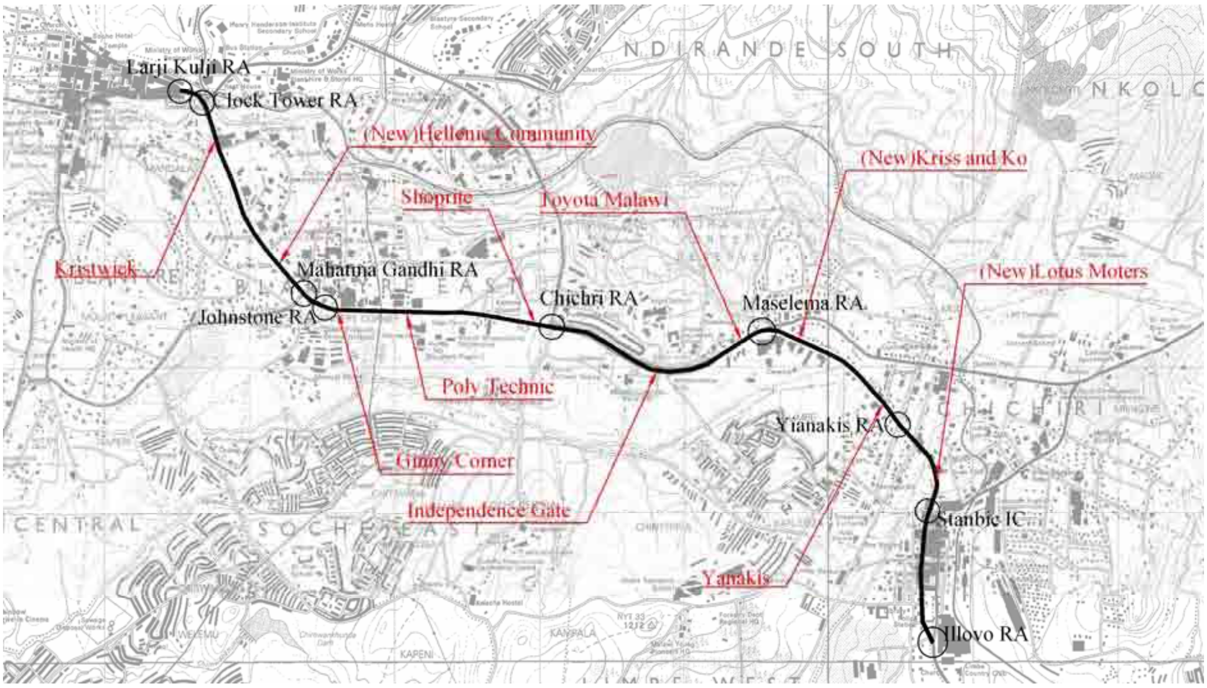


Figure 2.5　Improvement Locations for Bus Lay Byes (including New Construction)

(7)　Footpath Improvement

Chipembere Highway is a trunk road connecting Blantyre District and Limbe District where governmental buildings such as the university, courthouse, police headquarters and medical center or large shops, companies and residences, etc. are located. Approximately 600 persons pass through this area everyday. And since this is only pedestrian data, if the number of bicycles is included the traffic volume is forecasted to be more. Consequently, the necessity for improving footpaths along the trunk road is judged to be high.

However, along the sections where service roads have been installed people can walk on the service roads, so footpaths do not need to be improved, thus limiting the improvement of new sections. In addition, considering that both pedestrians and bicycles pass through this area, a width of 2.5m (2 pedestrians and 1 unit of a bicycle) is necessary for footpaths.

(8)　Installation of Kerb Stones

Kerb stones will be installed at the edge of pavement to prevent breakdown as a result of pavement erosion. Sections where kerb stones have already been installed will be repaired and re-used. New kerb stones will be constructed in sections where they have not yet been installed.

(9)　Road Signs and Pavement Markings

Too many types of safety installations such as road signs and markings can be confusing to drivers. It is therefore better to stick with the types already installed.

Accordingly, safety installations will be installed in accordance with Malawian standards. However, the Japanese standard of 4m instead of the Malawian standard of 2m will be used for the width of markings at pedestrian crossings in order to enhance driver perception (visibility).

(10) Repair and Construction of New Streetlights

Although installation of streetlights along the entire line was included in the initial request, lighting will be installed based on location and necessity from the viewpoint of traffic safety. In addition, the replacement of bulbs, wiring or re-use of existing streetlights that must be relocated or removed during road improvement will be examined. For example, streetlights will be installed at the following locations.

- Bus lay bys
- Roundabouts (intersections)
- Pedestrian crossings

Photo 2.4 Crossing based on Malawian standards. The narrow width of 2m creates low visibility for drivers.

(11) Pedestrians Signals

At the present time, pedestrian signals are installed at two locations, in front of the Polytechnic University and at an independent gate. Since a new pedestrian bridge was installed near the signal in front of the independent gate, markings for the pedestrian crossing will be applied with no improvement to the signal.

On the other hand, since the Polytechnic University is located on both sides of Chipembere Highway, many university students currently use the pedestrian signal. Therefore, the installation (reconstruction) of a pedestrian signal at this location will be examined. The signal will be a power-saving LED type design with lower maintenance specifications.

Photo 2.5 Pedestrian signal in front of the Polytechnic University. Students wait for a chance to cross.

2-2-1-2 Natural Conditions

The mean annual precipitation in Blantyre District in Malawi is 1,175mm, 75% of which is rain tat falls during the rainy season between December and March. The mean minimum and maximum temperatures are 15.5℃ and 26.9℃ respectively, which shows a relatively mild climate. A soft foundation (weak ground) or inferior soil necessary for the improvement has not been observed. Work supervision should be planned taking these factors into consideration. In particular, the relatively long rainy season of four months should also be taken into account.

2-2-1-3 Socio-economic Conditions

Christianity is the primary religion in Malawi and the same applies to Blantyre City. There are eleven holidays annually, and when implementing construction work the Malawian Labor Code should be strictly observed. At the same time, planning should be formulated in due consideration of religious customs.

2-2-1-4 Construction Conditions

Under the Project, by fully understanding environmental-related legislation in Malawi, smoke and pollution discharged through the installation and operation of asphalt plants and through the manufacturing of concrete should be disposed of. In addition, a work schedule should be formulated in due consideration of local customs such as Christmas holidays, etc.

2-2-1-5 Effective Use of Local Companies

Although there are several main contractors in Blantyre City that receive contracts for maintenance work, it is clear that they do not have adequate experience in road construction for the Project and lack the required equipment. However, they do have experience with small-scale road construction projects or incidental road facilities such as box culverts commissioned by the Government of Malawi, so they are judged to have sufficient skills and experience in construction work, even though they do not meet Japanese standards.

Accordingly, in the site execution of the Project local contractors will be utilized effectively for partial subcontracting of relatively simple construction under the supervision and guidance of Japanese engineers. In addition, it appears implementation of the Project through this method will contribute to upgrading the construction operational capacity and technical ability of local contractors through.

2-2-1-6 Operation and Maintenance

As roads in Blantyre City are maintained by the city on a daily basis, simple pothole repair, plant care or replacement of bulbs on lighting poles, etc. are implemented systematically despite severe budget conditions. Periodical management required for larger rehabilitation is implemented by the National Roads Authority by commissioning to the city.

Accordingly, sustainable maintenance is expected after the completion of the Project.

2-2-1-7 Grade Setting for Facilities and Equipment

The aim of the Project is to contribute to the revitalization of society and economy not only in Blantyre City but also in all of Malawi through improved road transportation capacity in order to ensure safe and smooth road traffic by renovating Chipembere Highway and Livingstone Avenue. To accomplish this goal, in accordance with the above-mentioned principles, Chipembere Highway and Livingstone Avenue will be repaired.

- Development of four lanes along Chipembere Highway and renovation of Livingstone Avenue
- Converting two signal intersections to roundabout intersections
- Asphalt pavement on main routes (semi-flexible payment will be partially applied to surfaces)
- Development of drainage facilities until flow end
- Improvement of bus lay byes to ensure retention space
- Installation of lightings at bus lay byes, roundabouts and pedestrian crossings
- Installation of signals at pedestrian crossings

2-2-1-8 Construction and Procurement Methods, Construction Period

As the majority of construction-related materials in Malawi are imported from South Africa, despite their relatively high cost due to transportation, they are available within Malawi. Construction machinery is also available within Malawi through rental companies. Construction materials and machinery will be therefore procured within Malawi; except traffic signals and lighting poles. However, in Malawi there is no asphalt plant that can meet the construction work requirements, and construction materials and machinery are insufficient because infrastructure-related undertakings are being developed at high speed for the 2010 FIFA World Cup to be held in South Africa. Moreover, the characteristics of the Project will be taken into account, for example, a special type of asphalt pavement will be used for the Project, so an asphalt plant will be procured from Japan.

In Malawi, the rainy season is from December to March, which is suitable for earthwork or asphalt construction. Concrete secondary products such as box culverts and gutters will be manufacture and small-scale construction such as improvement of drainage channels will be mainly carried out during the rainy season. Sub-grade and base course will be constructed during an eight-month period between April and November after the rainy season has ended. As a result, based on the execution quantities, since it is appropriate to divide the entire construction work into two phases, construction period will be based on a 2-phase system.

Improvements from the traffic origin of Larji Kuiji Roundabout to Chichiri Roundabout which will be carried out in Phase 1, and improvements from Chichiri Roundabout to the end point of Illovo Roundabout will be carried out in Phase 2.

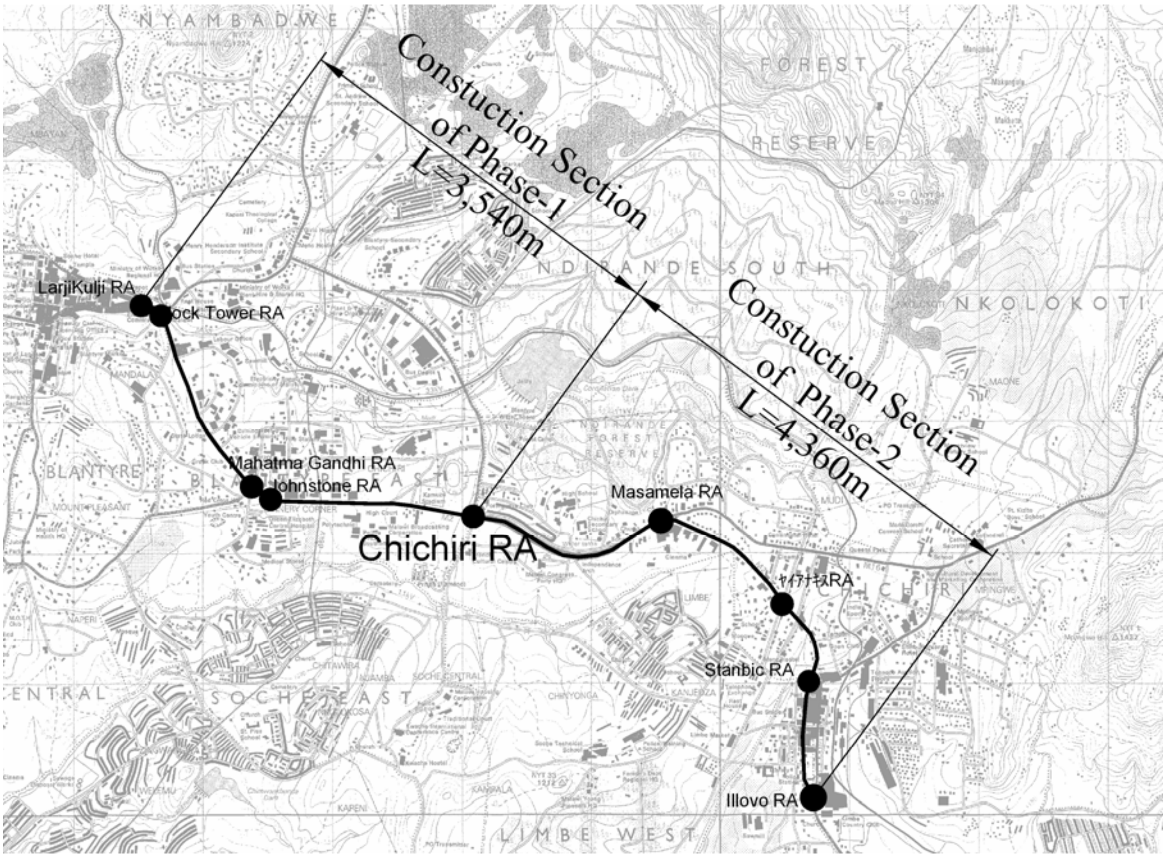


Figure 2.6 Construction Section of Each Phase

2-2-2 Basic Plan(Construction Plan/equipment Plan)

2-2-2-1 Widening Chipembere Highway to four lanes

(1) Geometric Design Standards

Geometric design standards to determine road longitudinal and vertical alignments will be established with reference to the Malawian National Roads Authority (NRA) standards, the Southern African Transport and Communications Commission (SATCC) standards and Japanese standards (Road Structure Ordinance). Under the Project, standards other than the Road Structure Ordinance mainly apply to national roads, so detailed provisions required for inter-city roads are insufficient. In principle, the Japanese Road Structure Ordinance will be applied with reference to the NRA standards. Table 2.2 indicates geometric design reference values for each standard.

Table 2.2 Comparison of Geometric Design Reference Values

Design Speed (km/h)				Road Structure Ordinance (Japan)	SATCC	NRA (Malawi)
Longitudinal Alignment (m)	Curve Radius	Desired Value Minimum Special Value		200 150 120	140 (6% Super-elevation) 125 (8% Super-elevation) 110 (10% Super-elevation)	350 (Section with no footpath) 140 (Section with footpath) —
	Minimum Curve Length	Standard Value Special Value		100 700/θ (θ＜7°)	300 150 (θ>5°)	150 (θ>5°) —
	Transition Curve	Transition Curve Length		50	About 35 to 85 ※3	Rate of Change in Acceleration $0.45m/s^3$ ※2
		Transition Curve Omission	Standard Critical	1,000 500	— —	
	Super-elevation Truncation Radius	1.5% 2.0% 3.0%		1,500 2,000 —	— — —	— — 875
Vertical Alignment (m)	Incline	Maximum (%)		5	6	5
	Vertical Curve	Convex (凸)	Minimum Desired	1,400 2,000	Stipulated by the following transition curve length	Stipulated by the following transition curve length
		Concave (凹)	Minimum Desired	1,000 1,500		
		Vertical Curve Length		50	16×Algebraic Change in Super-elevation (%)	143×Algebraic Change in Super-elevation (Minimum 35m)
Sight Distance (m)				75	80	85
Combined Gradient (%)				10.5	—	-
Super-elevation Run-off Ratio				1/125	Same as Transition Curve Length	1/200

※1 It is a standard value at 60km/hr design speed.

※2 $0.45m/S^3$ is close to the value (0.46) in the case of desired curve radium when applying Japanese standards.

※3 This can be calculated through the formula 0.0702 × design speed^3/ curve radium /rate of change in acceleration.

(2) Horizontal and Vertical Designs

In accordance with the geometric design standards shown in Table 2.2, road horizontal and vertical designs were implemented. This way, the current roads follow the existing alignment, and horizontal and vertical designs will be used for two new lanes to be constructed between Clock Tower and Chichri Roundabouts (Section 2). The results are shown in Table 2.3.

Table 2.3 Horizontal and Vertical Alignments between Clock Tower and Chichri Roundabouts on Chipembere Highway

【Horizontal Alignment】

Element No.	Survey Point	Transition Curve	Simple Circular Curve	Transition Curve
1	0+25.191 to 2+93.303	100	200	100
2	4+62.207 to 5+52.377		−600	
3	8＋46.675 to 9+36.901		600	
4	9+50.864 to 11+16.250	130	−290	130
5	12+3.100 to 13+6.669		−1200	
6	16+55.093 to 20+1.001	140	−360	140
7	28+37.459 to 30+19.641		1000	

※ A left curve is indicated with the sign minus (−) in the simple circular curve.

【Vertical Alignment】

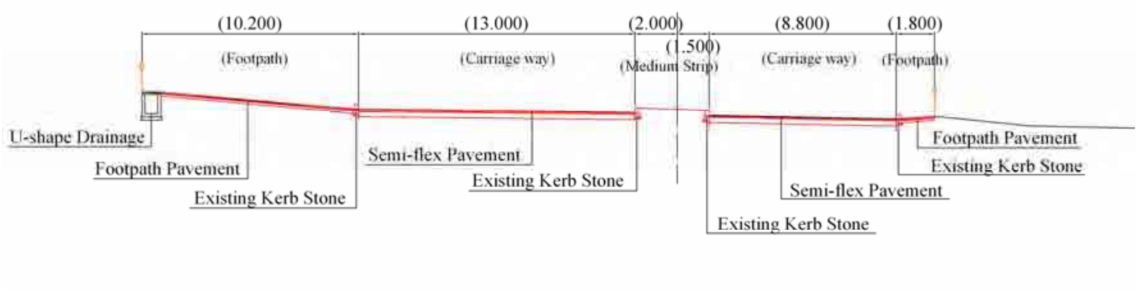
Element No.	VP Point	Front Slope (%)	Transition Curve Length /Curve Radium	Back Slope (%)
1	1+80	−4.700	VCL=90／VCR=1100	3.450
2	5+50	3.450	VCL=50／VCR=5300	4.400
3	8+00	2.400	VCL=70／VCR=2300	5.400
4	9+15	5.400	VCL=50／VCR=3600	4.000
5	12+10	4.000	VCL=110／VCR=1500	−3.200
6	14+00	−3.200	VCL=150／VCR=1900	4.700
7	16+20	4.700	VCL=60／VCR=1500	0.800
8	17+80	0.800	VCL=50／VCR=2300	3.000
9	18+80	3.000	VCL=60／VCR=1600	-0.800
10	23+00	−0.800	VCL=180／VCR=5500	2.500
11	27+20	2.500	VCL=120／VCR=5500	4.700
12	29+60	4.700	VCL=120／VCR=1600	−2.600
13	32+00	−2.600	VCL=220／VCR=3000	4.666

※ Downhill grade in the direction of the End Point is indicated with the sign minus (−).

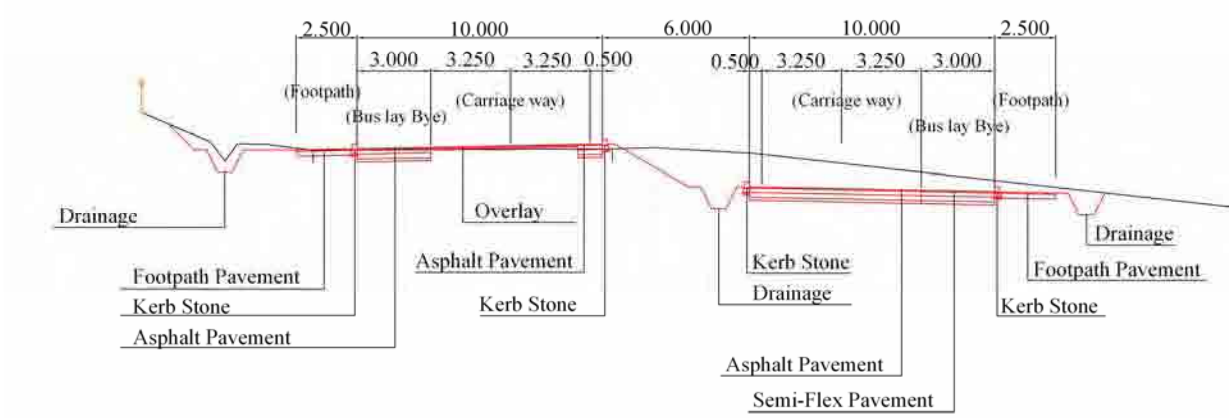
(3) Cross Section

As a standard, the width of one-lane carriageway will be 3.25 meters in accordance with discussions held with the Blantyre City Assembly (BCA). A width of 0.5 meters is considered to be the necessary, but minimal, value for urban areas and shall be applied to shoulders. Accordingly, the configurations of Typical Cross Sections are shown in Figure 3.2. However, the existing width will be applied to current roads. Design width will suit the geometric design standards of Japanese roads (Road Structure Ordinance). In this sense, 3.25 meters are prescribed as the width for a major trunk road in an urban area.

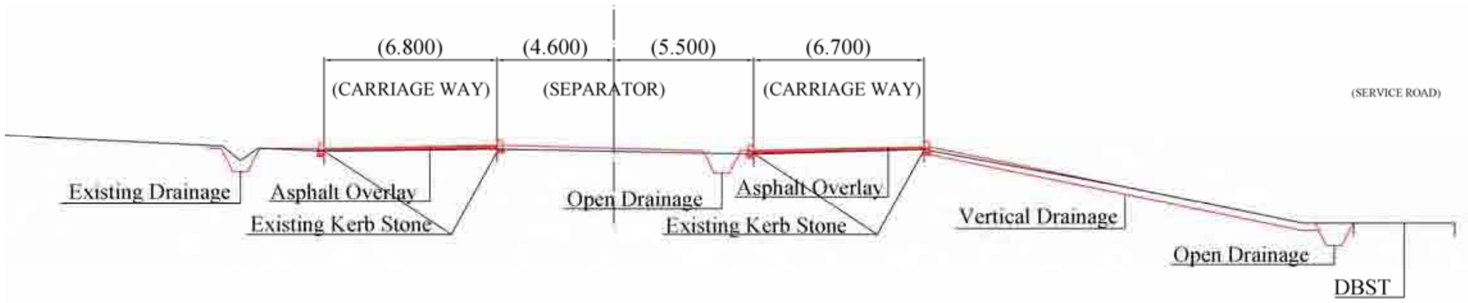
Although the National Roads Authority establishes 3.0% of the cross fall in the Malawian standards, since the height of the roadside or pedestrian crossing should be taken into account in urban areas, 2% of the Japanese standard value for a four-lane road will be adopted.



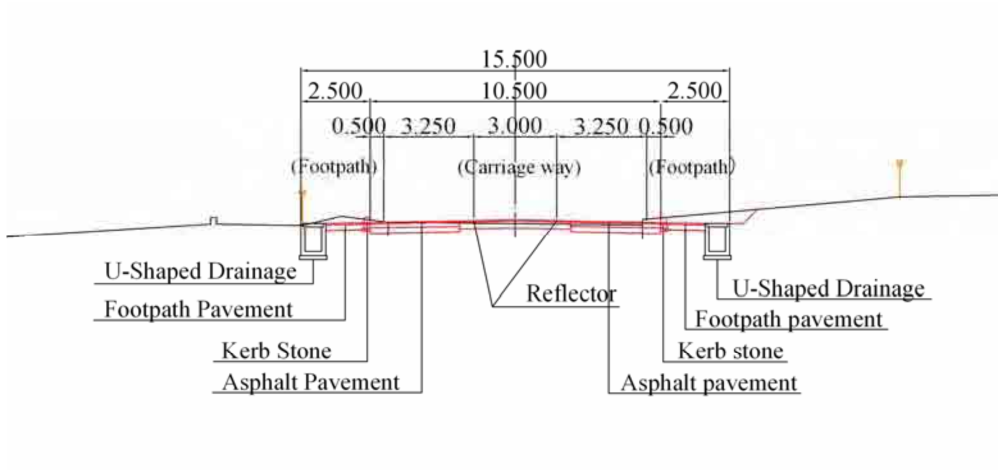
(a) Chipembere Highway Section-1 (Larji Kulji RA to Clock Tower RA)



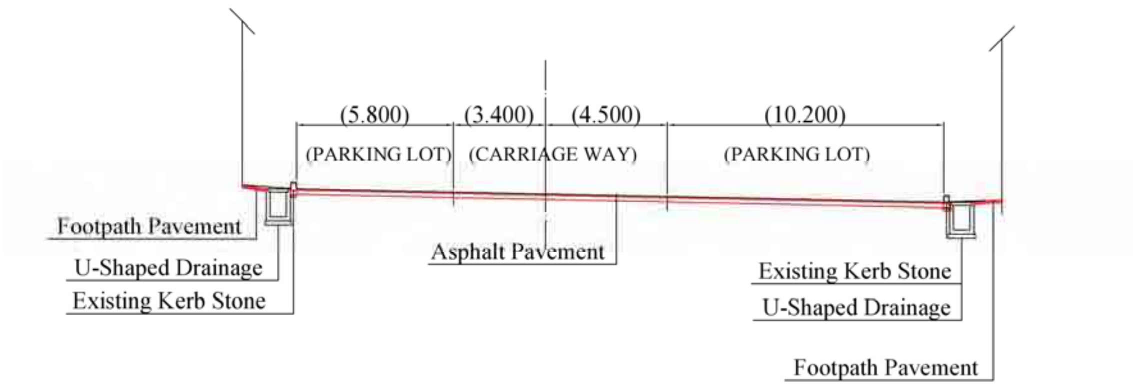
(b) Chipembere Highway Section-2 (Clock Tower to Chichiri RA)



(c) Chipembere Highway Section-3 (Chichiri RA to Yaianakis RA)



(d) Chipembere Highway Section-4 (Yaianakis RA to Stanbic RA)



(e) Livingstone Avenue

Figure 2.7 Typical Cross Section

2-2-2-2 Pavement Design

(1) Design CBR (California Bearing Ratio) Setting

The pavement structure is determined based on the traffic volume (load) registered on the pavement as well as on the ground intensity supporting sub-grade. Therefore, the California Bearing Ratio (CBR) is generally used as an index to represent ground intensity. In addition, assuming the existence of fragile subgrade, laboratory testing of water immersion CBR will be applied instead of onsite CBR. The measured water immersion CBR will be set through statistical processing taking reliability indexes into consideration. The CBR by section for the planned road is shown in Table 2.4.

Table 2.4 Calculation of Design CBR

Section	Pit No.	Water Immersion CBR (%)	Judgment of Rejection	Average CBR (%)	Standard Deviation σn-1	Design CBR (%)
Section 1 (Larji Kulji RA)	1-1	—	Maximum: None Minimum: None	10.9	4.4	6.5
Section 2 (Clock Tower RA to Chichri RA)	2-1	8				
	2-2	17				
	2-3	9				
	2-4	4				
	2-5	14				
	2-6	14				
	2-7	10				
Section 3 (Chichri RA to Yianakis RA)	3-1	5	Maximum: 20 is rejected Minimum: None	5.4	1.1	4.3
	3-2	7				
	3-3	4				
	3-4	5				
	3-5	20				
	3-6	6				
Section 4 (Yianakis RA to Stanbic IC)	4-1	21	Maximum: None Minimum: None	19.5	2.2	17.3
	4-2	18				
Livingstone Avenue	5-1	21	Maximum: None Minimum: None	19.5	2.2	17.3
	5-2	18				

※ Pavement Design Application Guidelines (Japan Road Association)

(2) Future Planned Traffic Volume

The future planned traffic volume, which is one factor that determines pavement structure, will expand during 15 years. Table 2.5 shows a future forecast of planned traffic volume of large-scale vehicles 15 years from now based on the findings of the traffic count (survey) in the Basic Design Study. The estimated value will be 3.7% of the annual growth of traffic volume adopted during a project financed by the World Bank based on recently registered trends. The National Roads Authority has established a growth rate of 9%.

Table 2.5 Planned Traffic Volume (24-hour Large Vehicle Spot Traffic Volume)

S/N	FY	Section-1	Section-2	Section-3	Section-4	Livingstone-1	Livingstone-2
1	2006	1,371	962	1,442	1,065	87	329
2	2007	1,422	998	1,495	1,104	90	342
3	2008	1,475	1,035	1,551	1,145	94	354
4	2009	1,529	1,073	1,608	1,188	97	367
5	2010	1,586	1,113	1,668	1,232	101	381
6	2011	1,644	1,154	1,729	1,277	104	395
7	2012	1,705	1,197	1,793	1,324	108	410
8	2013	1,768	1,241	1,860	1,373	112	425
9	2014	1,834	1,287	1,928	1,424	116	441
10	2015	1,902	1,334	2,000	1,477	121	457
11	2016	1,972	1,384	2,074	1,532	125	474
12	2017	2,045	1,435	2,151	1,588	130	491
13	2018	2,121	1,488	2,230	1,647	135	509
14	2019	2,199	1,543	2,313	1,708	140	528
15	2020	2,280	1,600	2,398	1,771	145	548
Per one way (×0.55)		1,254	880	1,319	974	80	301

※ 3.7% of annual traffic growth (World Bank Data)

(3) Selection of Repair Work Items for Existing Roads

As work items to be taken into account in the selection of applicable standards for pavement structure, the existing pavement can be effectively used. In other words, instead of applying new materials, if recyclable materials can be employed after examining their soundness, it will be possible to repair, or newly construct, work items as much as possible. Consequently, during the Study, necessary repair work items were selected by evaluating road conditions at 200 m intervals after determining the crack rate and pothole rate on pavement surface through visual observation. The findings are shown in Table 2.8.

PSI value was adopted as one factor in determining the selection of preventive steps. PSI was evaluated by four members of the Study Team. Evaluated indexes adopted here are shown in Table 2.6 and Table 2.7.

Table 2.6 Evaluated PSI Value

Evaluation	PSI Value
Extremely good	5
Good	4
Normal	3
Poor	2
Extremely poor	1

Table 2.7 Preventive Step Judged by PSI

PSI Value	Preventive Step
5	Routine control
4 to 5	Routine control ＋ Culmination observation
3 to 4	Surface treatment
2 to 3	Overlay
1 to 2	Replacing

Table 2.8 Evaluation of Existing Road Pavement

Section	Survey Point	Left Traffic Lane			Right Traffic Lane			Remarks
		Pavement Evaluation	PSI Value	Preventive Step	Pavement Evaluation	PSI Value	Preventive Step	
Section 1	2+00	C20%+P60%	1.4	Replacing	C40%+ P40%	1.4	Replacing	Larji Kulji RA Clock Tower RA
	4+00	C30%＋P60%	1.4	Replacing	C30%+ P30%	1.6	Replacing	
Section 2	6+00	Left lane already sealed	2.4	O V	—			
	8+00	C10%	2.3	O V	—			
	10+00	C5%	2.4	O V	—			
	12+00	C10%	2.4	O V	—			
	14+00	C5%	2.4	O V	—			
	16+00	C5%	2.4	O V	—			Mahatma Gandhi IC
	18+00	C5%	2.5	O V	—			Jonstone IC
	20+00	C5%	2.4	O V	—			
	22+00	C5%	2.4	O V	—			
	24+00	C5%	2.4	O V	—			
	26+00	C5%	2.4	O V	—			
	28+00	C5%	2.5	O V	—			
	30+00	C5%	2.4	O V	—			
	32+00	C5%	2.5	O V	—			
	34+00	C5%	2.4	O V	—			Chichri RA
Section 3	36+00	C10%+P10%	2.3	O V	C10%	2.3	O V	
	38+00	C5%	2.4	O V	C5%	2.4	O V	
	40+00	C5%	2.5	O V	C5%	2.4	O V	
	42+00	C5%	2.5	O V	C5%	2.5	O V	
	44+00	C5%	2.5	O V	C5%	2.5	O V	
	46+00	C5%＋P5%	2.4	O V	C5%	2.5	O V	
	48+00	C5%＋P10%	2.2	O V	C5%	2.4	O V	
	50+00	C5%＋P10%	2.2	O V	C10%	2.4	O V	
	52+00	C5%	2.3	O V	C0%＋P10%	2.3	O V	Maselema RA
	54+00	C100%＋P30%	1.2	Replacing	C50% ＋ P20%	1.5	O V	
	56+00	C5%	2.4	O V	C5%	2.5	O V	
	58+00	C5%	2.5	O V	C5%	2.6	O V	Yianakis RA
Section 4	60+00	C5% Wheel truck depth: 0.5cm	2.4	O V	—			
	62+00	C30% Wheel truck depth: 1.5cm	1.4	Replacing	—			
	64+00	C30% Wheel truck depth: 1.5cm	1.4	Replacing	—			
	66+00	C20%＋P50% Wheel truck depth: 2cm	1.2	Replacing	—			Stanbic IC
Livingstone Ave.	68+00	C20%＋P50% Wheel truck depth: 2cm	1.2	Replacing				
	70+00	C20%＋P100% Wheel truck depth: 2cm	1.1	Replacing				Excessive cross slope (over 5%)
	72+00	C50% Wheel truck depth: 2cm	1.5	Replacing				Excessive cross slope (over 5%)
	76+00	C50% Wheel truck depth: 2cm	1.5	Replacing				Excessive cross slope (over 5%)
	78+00	C80% Wheel truck depth: 2cm	1.4	Replacing				Illovo RA

※1 C: Crack rate, P: Pot hall rate
※2 OV: Overlay

(4) Applicable Standards

Whether or not existing materials can be effectively utilized should be taken into account when deciding on the pavement structure. The Japanese standards (Pavement Design Application Guidelines) are mainly applied in new road construction, so it is difficult to say whether or not the standards are sufficient enough for repair work. Moreover, Malawian standards stipulated by the National Roads Authority (NRA) are mainly applied to simple bituminous pavement, so it is inappropriate to apply the standards in the Project when utilizing an asphalt mixture. Accordingly, under the Project, the Southern African Transport and Communications Commission (SATCC) standards to which the Malawian standards refer will be applied when deciding the pavement structure of new roads.

SATCC standards will be applied to the existing roads in principle, whereas, Tanzanian standards, which are the most advanced of neighboring nations, will be adopted with respect to improvement of existing pavement.

(5) Pavement Structure

The pavement structure under the Project is shown in Table 2.10. As a reference, pavement structure in accordance with Japanese standards (Pavement Design Application Guideline) is shown in Table 2.9.

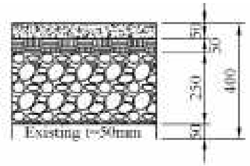
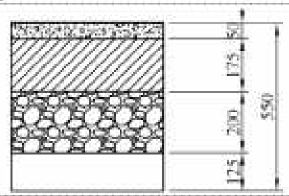
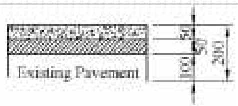
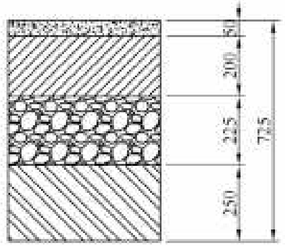
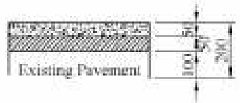
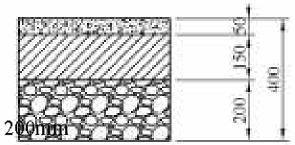
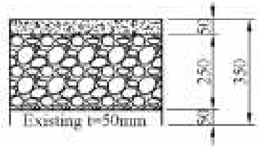
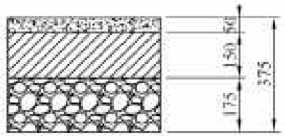
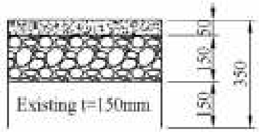
Table 2.9 Model Pavement Structure based on Japanese Standards (Reference)

	Section 1 (Repair)	Section 2 (Repair)	Section 2 (New Construction)	Section 3 (Repair)	Section 3 (New Construction)	Section 4 (Repair)	Livingstone (Repair)
Design Ta	26	19	19	29	29	14	8
Work Item	Replacing	Overlay	Replacing	Overlay	Replacing	Replacing	Replacing
Existing Pavement Structure	—	As 3cm＋Roadbed 30cm	—	As 5cm＋Roadbed 30cm	—	Roadbed 30cm	Roadbed 30cm
Pavement Structure	As 5cm＋As 5c＋As stabilization 20cm＋Existing Roadbed	As 4cm＋As 4cm＋Existing Roadbed	As 4cm＋As 4cm＋mechanically stabilized base 15cm＋crusher run 25cm	As 5cm＋As 5cm＋As 5cm＋Existing Pavement	As 5cm＋As 5cm＋As stabilization 15cm＋crusher run 30cm	As 5cm＋mechanically stabilized base 15cm＋Existing Roadbed	As5cm＋crusher run 15cm＋Existing Roadbed
Remarks							Crusher run will be applied to flatten uneven cross section

(6) Sections where Semi-flexible Pavement will be Used

The target Chipembere Highway and Livingstone Avenue are international truck routes, which means that physical distribution is mainly implemented by large-scale trucks or trailers. Consequently, pavement flow failure resulting from high torque could be often observed at some locations such as roundabouts or climbing lanes where the speed of large-scale trucks drops. Therefore, semi-flexible pavement will be adopted at roundabouts and other locations with more than 5% longitudinal slope. 5% is the standard value that determines whether or not preventive steps for large-scale vehicles reducing the speed should be examined.

Table 2.10 Pavement Structure in Accordance with SATCC and Tanzanian Standards

		Construction (SATCC)	Rehabilitation (Tanzania)
Chipembere Highway	Section-1 Design CBR=6.5%		 Surface: Asphalt 50mm Binder Course: Asphalt 50mm Upper Sub-base: Stabilized cement 250mm Hereinafter, existing base 50mm or over
	Section-2 Design CBR=6.5%	 Surface: Asphalt 50mm Upper Sub base: Stabilized cement 200mm Lower Sub base: Stabilized cement 175mm Lower Sub base: Stabilized cement 125mm	 Surface: Asphalt 50mm Binder Course: Asphalt 50mm Hereinafter, existing asphalt pavement
	Section-3 Design CBR=4.3%	 Surface: Asphalt 50mm Upper Sub base: Stabilized cement 200mm Lower Sub base: Stabilized cement 225mm Lower Sub base: Stabilized cement 250mm	 Surface: Asphalt 50mm Binder Course: Asphalt 50mm Hereinafter, existing asphalt pavement
	Section-4 Design CBR=17.3%	 200mm Surface: Asphalt 50mm Upper Sub base: Stabilized cement 150mm Lower Sub base: Stabilized cement	 Surface: Asphalt 50mm Upper Sub-base: Stabilized cement 250mm Hereinafter, existing base 50mm or over
Livingstone Avenue Design CBR=17.3%		 Surface: Asphalt 50mm Upper Sub base: Stabilized cement 150mm Lower Sub base: Stabilized cement 200mm	 Surface: Asphalt 50mm Upper Sub base: Stabilized cement 150mm Hereinafter, existing base 50mm or over

※ Stabilized cement of upper and lower sub-bases should satisfy 2Mpa or more and 1Mpa or more respectively.
※ Existing aggregate is stabilized during rehabilitation using stabilized cement.

2-2-2-3 Roundabouts

Although traffic at the Mahatma Gandhi and Johnstone intersections are controlled by signals, due to the burden of maintenance such as bulb replacement or adjustment of traffic signal phase (ratio of red to green), the intersections will be converted to roundabout intersections.

In the planning of the roundabouts, assuming that the Mahatma Gandhi Intersection will be upgraded to four lanes in the future, the necessary traffic capacity will be secured and roundabouts will be improved within the existing road lots.

(1) Geometric Structure

Since the width of the existing road reserve is 46m for Chipembere Highway and 36m for Mahatma Gandhi Avenue, a roundabout will be scheduled within the reserve. The roundabout will have two lanes, so it is assumed an outer traffic lane with a large radius of turn will be provided for large-scale trailers which requires a much larger difference in inner ring, while the inner traffic lane with a small radius of turn will be used for regular automobiles (2-wheel drive trucks) which requires a relatively small difference in inner ring. Accordingly, the inner radius and outer radius will be 15m and 25m respectively. Other structural details will be prescribed through standard drawings by the city of Blantyre. The plan for the roundabouts is illustrated in Figure 2.8.

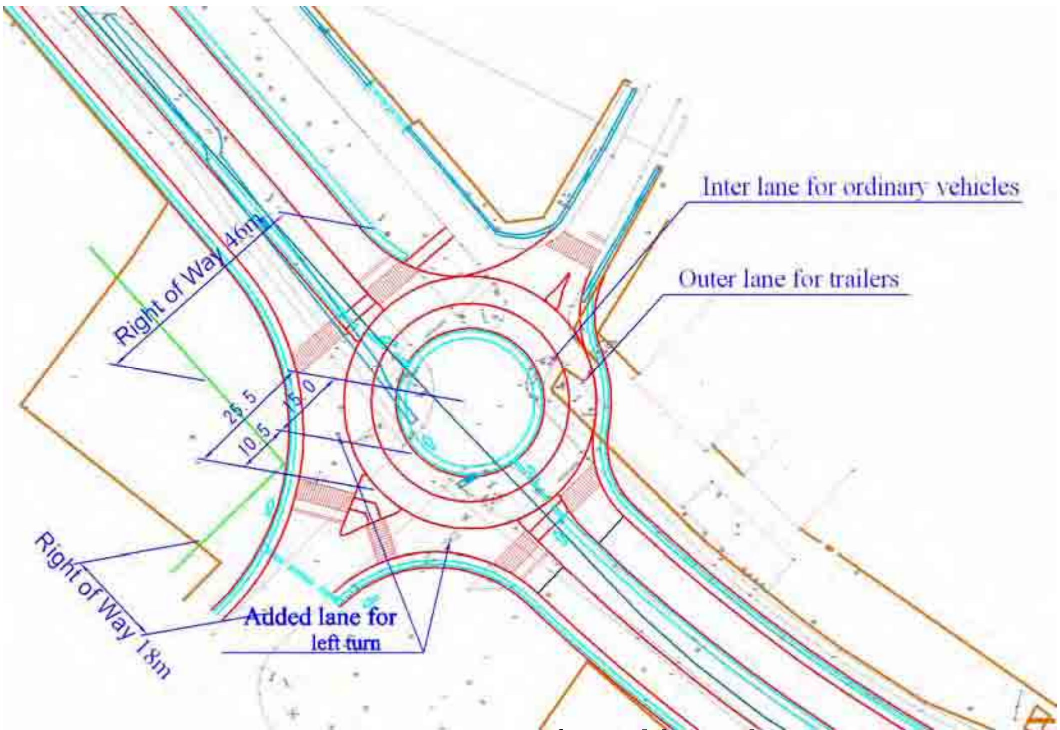


Figure 2.8 Overview of Roundabouts Plan

(2) Confirmation of Traffic Capacity

Traffic capacity at each roundabout will be inspected in accordance with British standards. The parameters necessary for calculation of traffic capacity are shown as follows:

- Qp (veh/hr): Traffic volume at peak inflow
- W1 (m): Roundabout width
- W2 (m): Width of inflow section
- L (m): Weaving length

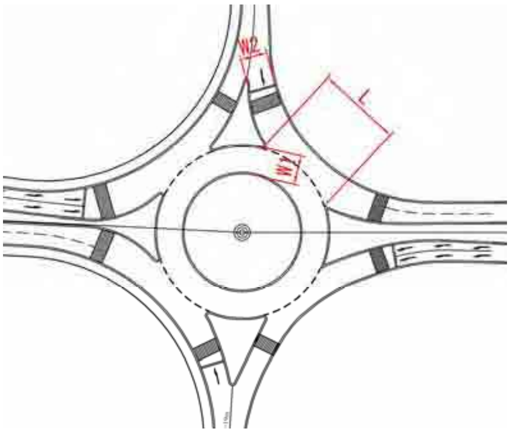


Table 2.11 lists the values for parameters and traffic capacity. As indicated, traffic volume at peak time can be handled.

Table 2.11 Parameter Value and Traffic Capacity

Roundabout	Inflow Section	Inflow Traffic Volume Qp (veh/hr)	Width of Inflow Section W2 (m)	Roundabout Width W1 (m)	Weaving Length L (m)	Traffic Capacity Cp (veh/hr)
Mahatma Gandhi	A (North→South)	216	6.0	10	38	1,800>216・・OK
	B (East→West)	1,624	6.5	10	35	1,700>1,624・・OK
	C (South→North)	218	6.0	10	27	1,700>218・・OK
	D (West→East)	501	6.5	10	27	1,600>501・・OK
Johnstone IC	A (North→South)	630	6.0	10	27	1,800>630・・OK
	B (East→West)	1,118	6.5	10	49	1,800>1,118・・OK
	C (West→East)	1,138	6.5	10	32	1,800>1,138・・OK

※ Inflow traffic volume indicated is the value between 17:00 and 18:00 at peak time based on findings of a recent traffic survey.

2-2-2-4 Drainage Design

(1) Calculation of Rainfall Intensity

Rainfall intensity is deemed to be as one of the basic data in calculating outflow and is set as shown in Table 2.12 in accordance with NRA standards in Malawi.

Table 2.12　Raining Time and Rainfall Intensity (NRA standards)

Recurrence Probability	Raining Time (Hour)							
	0.25	0.5	1	2	3	4	5	6
	Rainfall Intensity (mm/hr)							
2	91	76	50	23	15	13	11	11
5	114	95	62	29	19	16	14	14
50	152	127	83	39	25	21	19	18

※ Data at the project site "Shire Highland"

Since the design will mainly be applied to box culverts and drainage gutters under the Project, the Return Period will be set as follows in accordance with the National Roads Authority standards in due consideration of importance.

- Culvert: Ten-year probability
- Gutter: Five-year probability

Accordingly, 62mm/hr will be applied to rainfall intensity for gutter design.　With respect to ten-year probability for culverts, since this will be converted to 80% of the 50-year probability, it will be 66 mm/hr.　Rainfall intensity adopted in a project financed by the World Bank is 61 mm/hr for a five-year probability, which nearly conforms to the value in this time.

(2) Calculation of Outflow

In the calculation of outflow, the rational formula below shall apply.　"C" stands for run-off coefficient; "I" stands for rainfall intensity (mm/hr); and "A" means area (square km).

$$Q = C\ I\ A$$

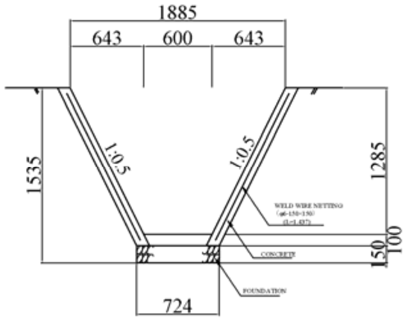
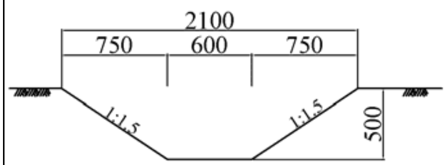
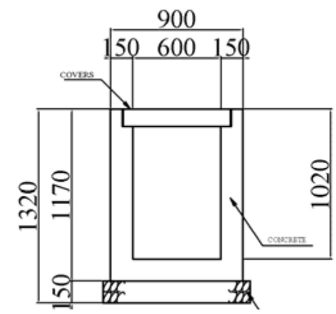
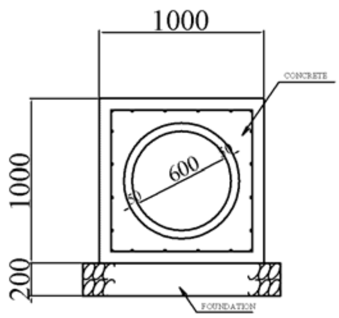
(3) Drainage Facilities Design

In designing drainage facilities, forms will be selected in accordance with the following principles:

- Outflow to be calculated based on the above-mentioned conditions can be disposed of.
- Due to a significant burden from machinery required for maintenance, it is assumed that maintenance through manpower will be the premise.　Consequently, since φ600 is considered to be the minimum radius in order to allow cleaning, gutters with a simple cover for easy cleaning should be used as much as possible.
- By installing concrete linings on the sides of gutters, soil deposit can be prevented and break down of the gutters themselves can be also avoided.

In due consideration of the above-mentioned principles, the basic forms of drainage facilities under the Project are described as follows:

Table 2.13 Structure of Drainage Facilities

Drainage Type	Basic formation	Characteristic
Trapezoid Gutter		It is the most basic form. As manual cleaning is deemed to be standard, 600 mm will be adopted for a bottom plate width to prescribe a depth conforming to a pipe culvert. The slope is covered with concrete to prevent it from breaking down.
Unsupported Gutters		Compared with trapezoid gutters, it is a type with little land restrictions. To prevent earth and sand from caving-in, the gradient of the slope should be 1：1.5 or more.
U-shape Gutters with Covers		It is a type used under especially severe land limitations. By installing a cover, not only can it handle wheel load from vehicles, but maintenance is also easier by removing the cover. However, it is unsuitable for crossing sections due to relatively early deterioration resulting from repeated load.
Pipe Culverts		It is a type used at locations which should be covered perfectly such as crossing sections. Of all the above mentioned types, this is the most difficult to clean. Therefore, it can easily cause damage to the road because sand becomes clogged forcing water onto the roadbed. To reduce the maintenance burden, since cleaning is generally done manually, Ø600 should be the minimum radius.

(4) Drainage System and Flow End

It was confirmed that End of Flow on Chipembere Highway and Livingstone Avenue as shown in Figure-2.9 is based on the site survey and discussions with the Blantyre City Assembly (BCA). In particular, the drainage system on Livingstone Avenue until the river, which is to be the drain end, has not yet been improved, and water still runs onto the road. Thereby, a specific drainage route should be ensured by improving the gutter from Livingstone Avenue to the river.

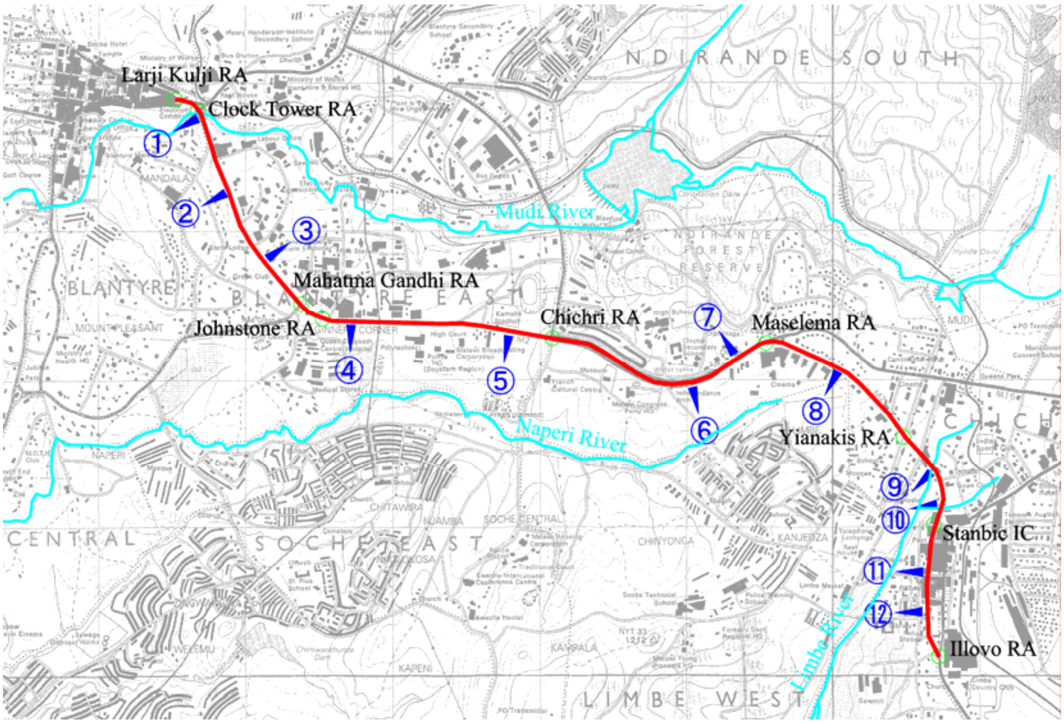


Figure 2.9 Drain End Map (Number indicates the position of the End of Flow)

Figure 2.10 Drainage System on Livingstone Avenue (U Shape Gutter with Cover)

(5) Box Culverts

Since there are two river crossings on Limber River within Section 4 of Chipembere Highway, box culvert construction is necessary. The size of a box culvert will be 1.5m high × 1.5m wide. A box culvert structure was decided by referring to standard drawings of the Ministry of Land, Infrastructure and Transport of Japan.

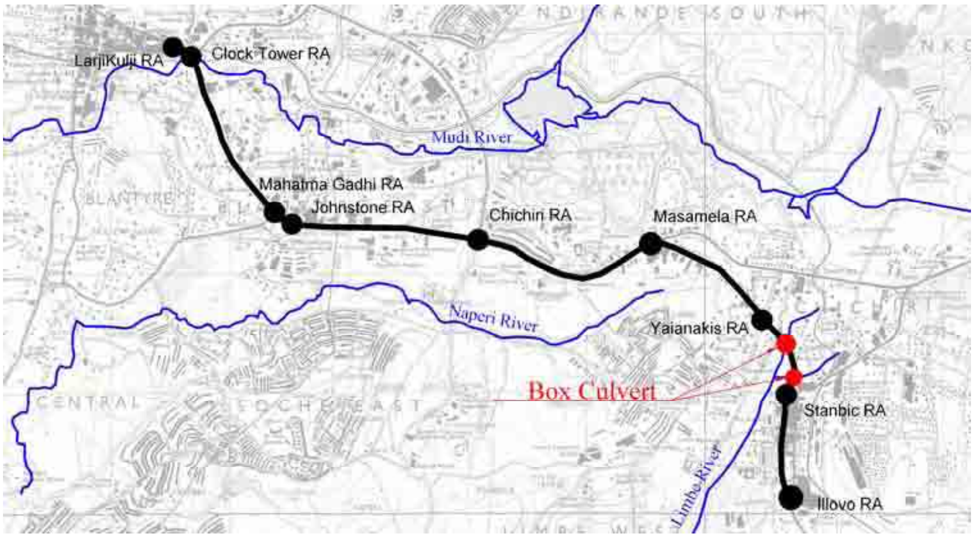


Figure 2.11 Locations For Installing Box Culverts

2-2-2-5 Bus Lay Byes

The retention space will be 30m assuming that five mini buses will be able to load and unload at the same time. In addition, since pavement here is damaged more quickly than at other locations due to vehicles stopping and starting everyday, semi-flexible pavement will be used for asphalt surfaces.

2-2-2-6 Footpaths

Footpaths will be constructed on sections other than the sections where services roads are located side by side. A footpath width of 2.5m will be provided assuming they will be utilized by both bicycles and pedestrians. This width will enable bicycles to pass by two pedestrians, assuming that the exclusive width for one pedestrian is 0.75m/person and the exclusive width for one bicycle is 1.0m/unit.

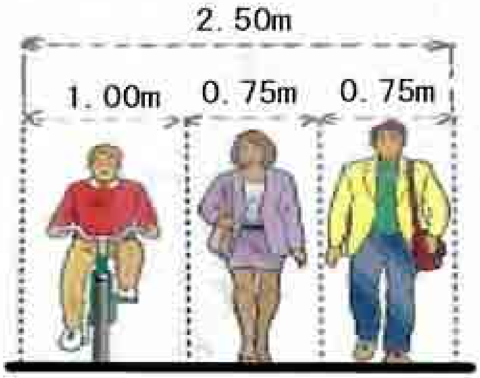
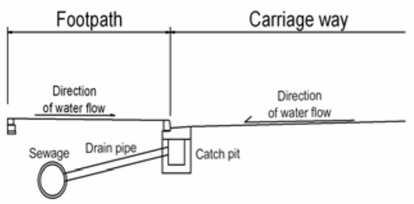
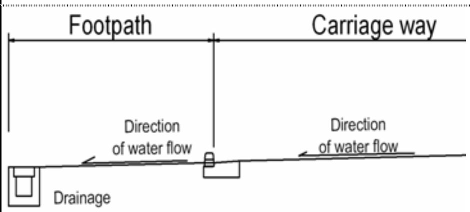


Figure 2.12 Concept of Footpath Width

Footpaths are roughly classified as mount-up type and flat type. A flat type will be adopted considering their easy maintenance of drainage. Their respective characteristics are shown in Table 2.14.

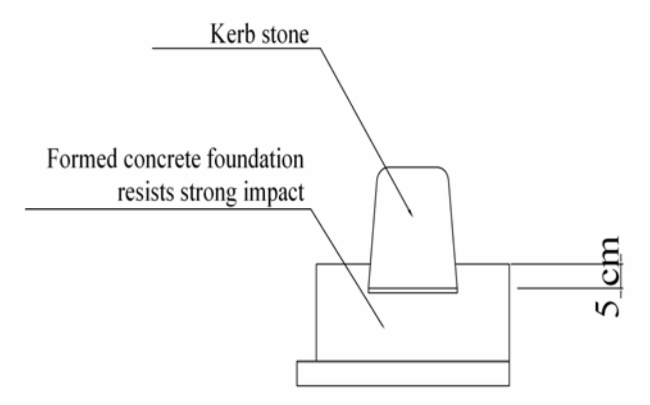
Table 2.14 Footpath Types and Characteristics

	Mount-up Type	Flat Type
Overview	・Overall footpath height is raised 15 to 20cm above the height of the carriageway.	・The heights of footpath and carriageway are the same.
Fabric		
Advantages	・Since it is clearly separate from the carriageway, it is easy to see pedestrians, so traffic safety is superior. ・As the carriageway and footpath drainage are separate, pedestrian services can be easily ensured during rain.	・The drainage facility is very simple and maintenance is therefore easy. ・Regardless of gateways, footpath type is very constant so that pedestrian services cannot be lost. Its structure is also very simple so that workability is superior.
Disadvantages	・The drainage facility structure is very complicated increasing the maintenance burden. ・The footpath height should conform to the carriageway per gateway, in particular in an urban area where gateways are concentrated, the footpath continues up and down so pedestrian services can be easily lost.	・As the height of footpath and carriageway are same level, pedestrians can be easily seen from the carriageway and visibility is inferior compared with the mount-up type. ・Water on the carriageway crosses the footpaths and is disposed, so pedestrian services can be easily lost.
Evaluation in the Plan	・In the city of Blantyre, maintenance for drainage facilities is one task, so a flat type for easy maintenance is more appropriate. ・The targeted routes are located in an urban center and there are many gateways. A flat type is therefore most appropriate in order to ensure pedestrians services.	

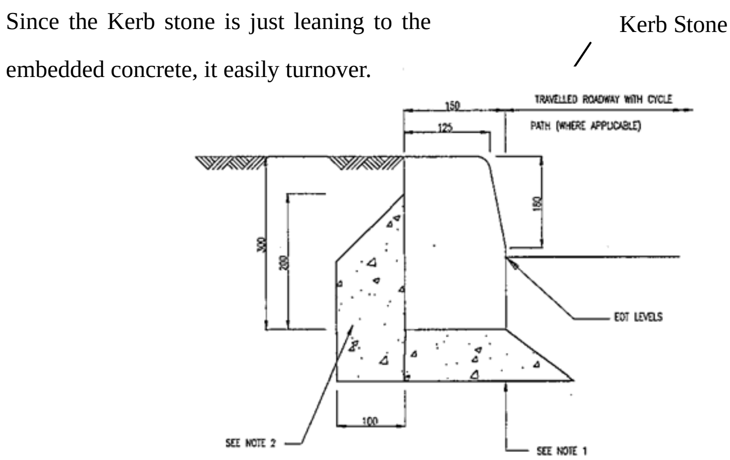
Since the city of Blantyre is very familiar with footpath pavement, a method of concrete slabs will be applied for easy maintenance in the future.

2-2-2-7 Kerb Stones

Although kerb stones that meet Malawian standards are embedded ten centimeters in the ground, since they are formed concrete, they fall relatively easily at the time of a collision. Consequently, with reference to Japanese standards, they will be secured using five centimeter-thick concrete. Figure-2.13 shows the structure of kerb stones.



(a) Japanese Standard



(b) Malawian Standard

Figure 2.13 Kerb Stone Structure

2-2-2-8 Miscellaneous Works

(1) Traffic Sign Work

The following traffic signs will be installed in due consideration of traffic safety:

Table 2.15 Traffic Signs to be Installed

Traffic Sign	Installed Spot
Stop	Traffic origin・terminus, access road connected section, etc.
Roundabout	In front of roundabout
Pedestrian Crossing	In front of crosswalk
School	Near elementary and junior high schools
Bus Stop	In front of bus lay bye (bus stop)
Guide Sign (Place Name・Route Name・Area Map)	Installed mainly near roundabout at need
Hump	In front of hump
Direction (Left Turn・Right Turn)	Access road connecting section, etc.

(2) Road Marking Work

The following road markings will be provided:

- Carriageway center lines
- Carriageway outer lines
- Directional arrows
- Stop lines
- Pedestrian crossings

(3) Buffer Stops and Barricades

Buffer stops will be installed at the cut-down section of pedestrian crossings and other required points in order to prevent vehicles from encroaching onto footpaths.

(4) Hump Work

Humps are raised wart-like sections built into the road with a considerable expected effect on enhancing traffic safety. Under the Project, humps will be constructed at exits of service roads and major connecting spots, among other places.

2-2-2-9 Lighting Facilities

Lighting will be installed at locations with relevant degrees of human concentration such as bus lay byes or roundabouts and intersections. In addition, existing lighting poles will be repaired and then relocated. The existing lighting poles were installed in the 1970s and appear to be deteriorated due to aging. Under the Project, the recyclable number of existing lighting poles to be removed after repair is judged to be 50%. Additional new poles will be installed.

As intervals to install lighting poles will be "four times pole height," lighting poles will be installed at a travel distance of three minutes in front of bus lay byes. The "three minutes" distance is supposed to be the time required for a driver to complete a physical action after recognition. As the existing pole height is regarded to be six meters, the interval of installation will be 24 meters. However, eight poles per location will be installed at roundabouts. Accordingly, the layout of the existing lighting poles is described in Figure-2.14

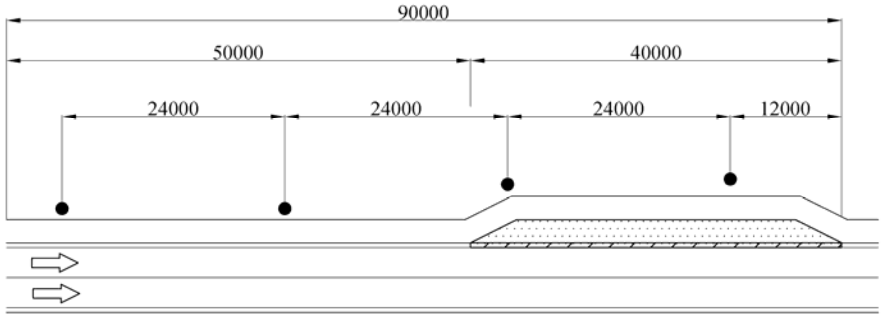


Figure 2.14 Interval and Scope of Installing Lighting Poles at Bus Lay Byes
(50 meters is the distance traveled during three minutes at the design speed of 60 km/hr.)

2-2-3 Basic Design Drawings

Basic design drawings are shown on the following pages.