# IMPLEMENTATION REVIEW STUDY REPORT
# ON
# THE PROJECT FOR IMPROVEMENT AND MAINTENANCE
# OF
# LUSAKA CITY ROADS (PHASE III)
# IN
# THE REPUBLIC OF ZAMBIA

**MARCH 2005**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

# PREFACE

In response to a request from the Government of the Republic of Zambia, the Government of Japan decided to conduct a implementing review study on the Project for Improvement and Maintenance of Lusaka City Roads (Phase III) and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Zambia a Study Team from September 4 to September 29, 2004.

The Team held discussions with the officials concerned of the Government of Zambia, 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 Zambia from January 24 to February 2, 2005 in order to discuss the draft implementing review 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 Zambia for their close cooperation extended to the teams.

March, 2005

Seiji Kojima
Vice President
Japan International Cooperation Agency

March, 2005

# Letter of Transmittal

We are pleased to submit to you the implementing review study report on the Project for Improvement and Maintenance of Lusaka City Roads (Phase III) in the Republic of Zambia.

This study was conducted by Japan Engineering Consultants Co., Ltd., under a contract to JICA, during the period from August, 2004 to March, 2005. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Zambia and formulated the most appropriate design for the project under Japan's grant aid scheme.

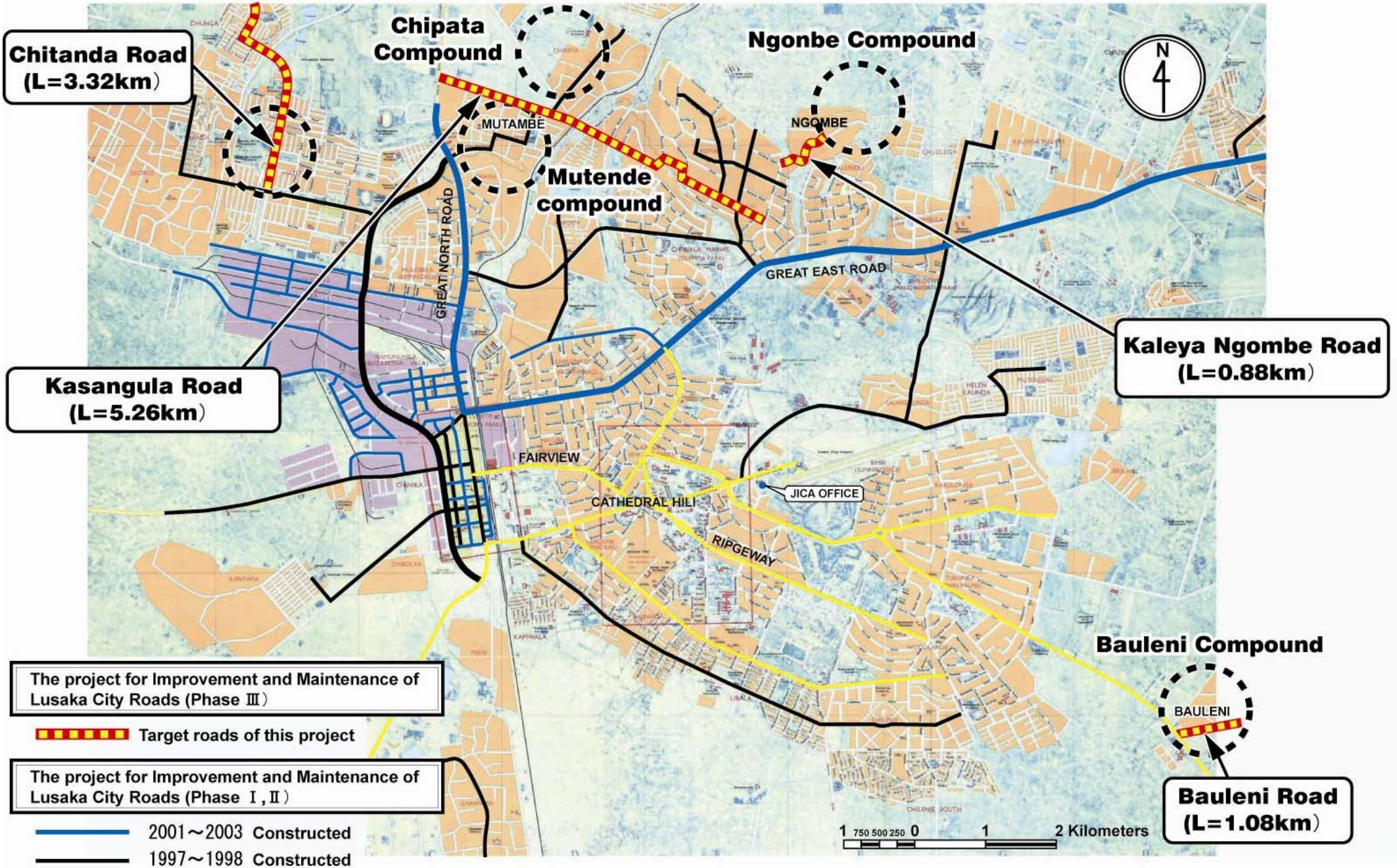
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Hisashi Muto
Project Manager,
Implementing Review Study Team on
The Project for Improvement and Maintenance
for Lusaka City Roads (Phase III)
Japan Engineering Consultants Co., Ltd.


LOCATION MAP OF
ZAMBIA-LUSAKA
ZAMBIA
TANZANIA
CONGO
MALAWI
ANGOLA
MOZAMBIQUE
NAMIBIA
BOTSWANA
ZIMBABWE
LUSAKA
ABOVESEA LEVEL
1,000m
500m
200m
N
0
200 km

# LOCATION MAP



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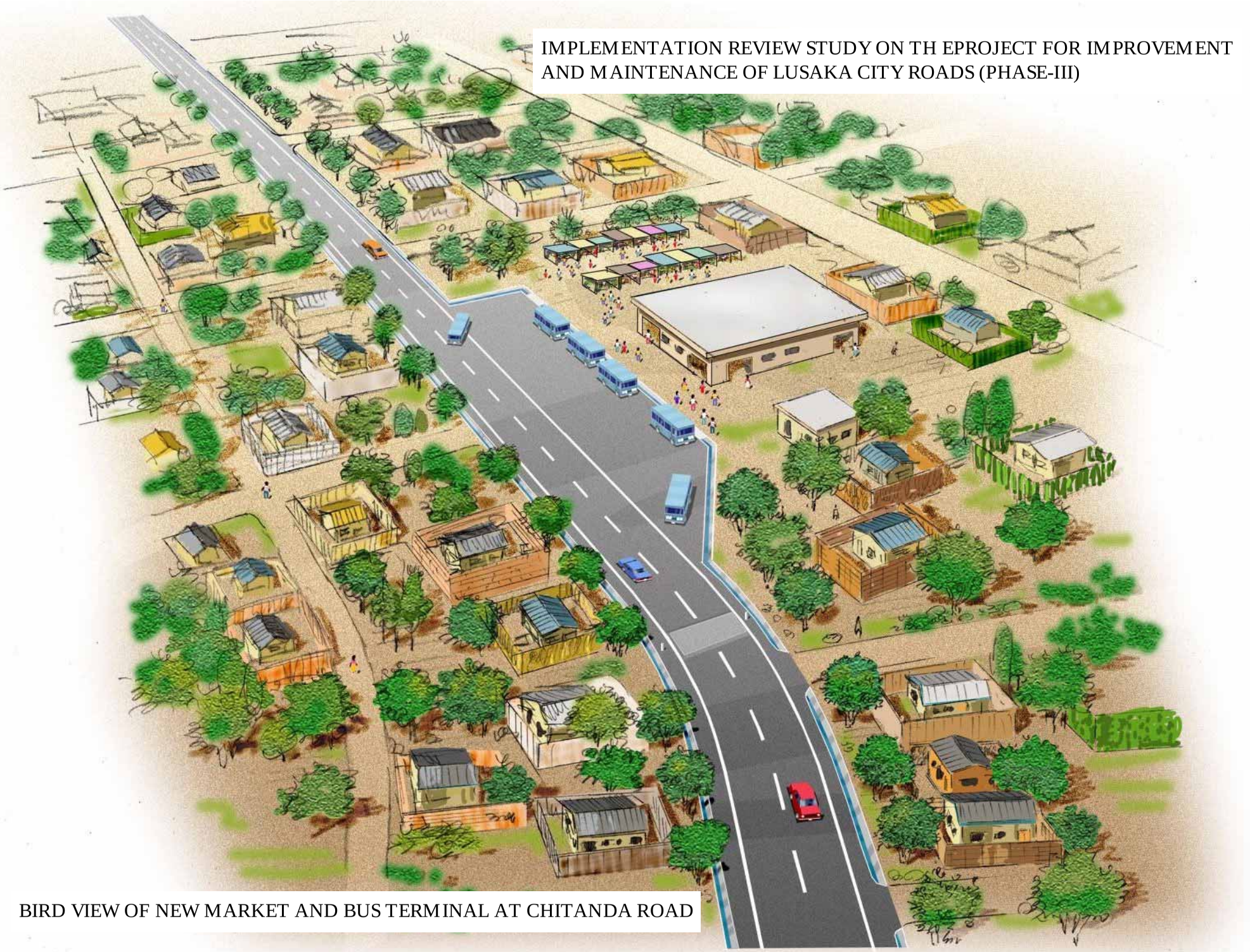

BIRD VIEW OF NEW MARKET AND BUS TERMINAL AT CHITANDA ROAD

# ABBRIVIATIONS

| | |
|---|---|
| AADT | : Average Annual Daily Traffic |
| AASHTO | : American Association of State Highway and Transportation Officials |
| AC | : Asphalt Concrete |
| ADT | : Average Daily Traffic |
| AI | : Asphalt Institute |
| A/P | : Authorization to Pay |
| BHN | : Basic Human Needs |
| CBD | : Central Business District |
| CBR | : California Bearing Ratio |
| DBST | : Double Bituminous Surface Treatment |
| DCP | : Dynamic Cone Penetration |
| DTN | : Design Traffic Number |
| E/N | : Exchange of Note |
| GDP | : Gross Domestic Product |
| GNP | : Gross National Product |
| GOZ | : Government of Zambia |
| IDT | : Initial Daily Traffic |
| ITN | : Initial Traffic Number |
| JICA | : Japan International Cooperation Agency |
| LCC | : Lusaka City Council |
| LWSC | : Lusaka Water & Sewerage Company |
| MCT | : Ministry of Communication and Transport |
| MLGH | : Ministry of Local Government and Housing |
| MOL | : Ministry of Land |
| MWS | : Ministry of Works and Supply |
| NRB | : National Roads Board |
| ODA | : Official Development Assistance |
| p.c.u | : Passenger Car Unit |
| PI | : Plasticity Index |
| PSI | : Present Serviceability Index |
| ROADSIP | : Road Sector Investment Programe |
| ZAMTEL | : Zambia Telecommunication Company |
| ZESCO | : Zambia Electricity Supply Company |
| ZMK | : Zambian Kwacha |
| ZR | : Zambian Railway |
| VAT | : Value Added Tax |

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# Summary

Since its independence in 1964, the primary aim of the Government of the Republic of Zambia has been to construct roads between neighboring countries and trunk roads between the capital and local areas. Consequently, the aggregate road length has increased. However, due to budgetary appropriation for road maintenance had been insufficient, a progressive deterioration of roads have been created.

On the other hand, the city of Lusaka has an aggregate road length of 1,600km, of which approximately 750 km (47%) are unpaved, and the remaining approximately 850 km (53%) of bituminous surface built some 25 years ago.

All urban roads in Lusaka had been experiencing rapid damage to the increasing population and traffic in recent years, inadequate maintenance budget and manpower to the extent that the damage was beyond normal maintenance and repair.

Consequently, in 1997 the Government of Zambia made a request to the Japanese Government for the upgrading of 77.6 km of urban roads due to remarkable damage and the impact of socioeconomic activities and the daily lives of its people. In response to this request, the Government of Japan decided to implement a basic design study and from December 1999 to May 2002 the Japan International Cooperation Agency (JICA) conducted the Basic Design Study of priority routes for a total of 60.7 km.

However, 4 routes in unplanned residential districts (compounds) were excluded from the grant aid scheme due to a drastic change in exchange rates during the detailed design which commenced in 2000, and the scale of the project grew significantly, so that the estimated cost has exceeded the budget that was established and committed in the Exchange of Note of the project.

Therefore, in 2002 the Government of Zambia made a request to the Government of Japan for the improvement of 4 collector roads left in the compounds. In response to this request, the Government of Japan decided to carry out an Implementation Review Study and the JICA conducted an Implementation Review Study on 4 proposed routes from September 2004 to March 2005.

The Study Team examined the components for rehabilitation of routes subject to the request, the scope and the components appropriate to the grant aid scheme by collecting materials through a project site survey, including natural conditions and traffic volume, a survey of the state of development in the Lusaka road network, the current state of pavement on the proposed routes, conditions for procuring construction equipment and materials, and the construction situation. The Minutes of Discussions (M/D) were concluded through discussions by the Study Team on these components with the Government of Zambia, and the scope of work to be undertaken by the Zambian side was also clarified.

In due consideration of the results of the field survey, the appropriateness (relevance) of the road rehabilitation project was examined through the work conducted in Japan after the Study Team returned to Japan. In addition to a further examination of the components and the scale of road rehabilitation, a basic design including a road paving design and implementation plan were formulated and the Project was evaluated.

Based on the results of these examinations, the Study Team explained and discussed a draft summary of the Basic Design in Zambia in January 2004.

The Project is designed for the purpose of improving (mainly pavement) 2-lane collector roads that provide access to the compounds. Considering the relevance to the grant aid scheme including 4 routes of the initial request with a total extension of approximately 9.4 km, subsequent drainage routes and the extension of roads additionally requested, in the end, 4 roads with a total length of approximately 10.5 km were selected after evaluating the priority of these routes from the technical and socioeconomic points of views.

The selected routes are subject to the improvement of pavement, shoulders, drainage channels, bus stops and terminals, and safety facilities on Bauleni Road (1.08 km) accessing the Bauleni compound, Kaleya-N'gombe Road (0.88 km) accessing the N'gombe compound, Kasangula Road (5.26 km) accessing the Mutambe, Chipata and Roma compounds, and Chitanda Road (3.32 km) accessing the Matero and Chunga compounds.

Road improvement measures for the target routes are described as follows.

| Road Classification | Cross Section to be Improved | Paving Improvement Measures | Drainage System | Incidental Facilities |
|---|---|---|---|---|
| Collector Road | ・Improvement of 2-lane roads (Pavement of carriageway of 6.1m in road width) and shoulders (Surface Treatment of 1.5m per side width) (9.1m in total standard width) → Improvement of traffic safety and securing traffic capacity | ・Rebuilding of pavement(from base course/from sub-base course) → Permanency of road functions by building appropriate paving. | ・Installation of open channels → Prolongation of life of paving structure by improving a drainage system | ・Installation of carriageway markings and bumps →Improvement of traffic safety and securing traffic capacity |

The Project will cover 4 routes of a total length of approximately 10.5 km. In due consideration of urgency, scale and components, the Project will be implemented in a single year and in one phase, thus regarding the overall project as one package.

The estimated project cost for implementation of the Project is expected to be ¥706.4 million.

Of that, the amount to be taken by the Japanese side will be ¥706.0 million; whereas, the amount to be taken by the Zambian side will be ¥400,000 needed for the transfer of buried structures. This cost estimate is provisional and will be further examined by the Government of Japan for the approval of the Grant. The total construction period of the Project is estimated to be 16 months including the preparation of tender documentation.

In addition, the maintenance cost to be taken by the Zambian side after completion of the Project will be approximately ¥1.36 million/year, which falls within their budget.

The effects to be expected through the implementation of the Project are described as follows.

**(1) Improvement in Commuting to Schools and Workplaces by Upgrading Roads for Public Welfare**

It is difficult for buses commuting to schools and workplaces to pass due to pavement damage or inadequate drainage and it is impossible to pass due to muddy surface during the rainy season. Through the implementation of the Project, two-lane paved roads, bus stops and terminals, shoulders for pedestrians, and bus routes will be improved and the travel speed for residents in the compounds commuting to schools and workplaces by bus will be sharply increased from the current 20km/h to over 40km/h. In addition, reliable commuting will be ensured even during the rainy season.

**(2) Improvement in Basic Human Needs (BHN)**

It is difficult for emergency vehicles to provide services in the target roadside areas due to road damage or traffic difficulties during the rainy season. By improving paved 2-lane roads through the Project, it will become feasible for emergency vehicles at fire stations at 2 locations or the police stations in each area to provide services. In addition, if residents in high-density unplanned residential districts (compounds) utilize busses, accessibility to 33 hospitals and clinics within the city will be possible. Moreover, social services facilities such as schools, and in turn, the improvement of BHN can be expected. Furthermore, since district drainage channels will be improved through the implementation of the Project, this will contribute to controlling outbreaks of contagious diseases, i.e. malaria, associated with environmental improvement.

**(3) Improvement of Traffic Safety Awareness in Lusaka**

Since the proposed roads contain narrow carriageways which are experiencing conspicuous pavement damage, there are many bottlenecks in local traffic. In addition, to avoid potholes vehicles often pass suddenly, so vehicle safety cannot be guaranteed. To make matters worse, since road crossing points for pedestrians have not been established, there is a high risk of traffic accidents and the pedestrian safety at crossings cannot be secured. If target roads are designed as 2-lane roads and shoulders for pedestrians are secured, intersections are improved, and pedestrian crossings, bumps or indicators to control speed near schools and churches or signs are improved, improvements in traffic safety awareness for pedestrians and vehicles can be expected.

In addition to the above-mentioned effects, since approximately 200,000 people in urban areas subject to the benefits are poor, the overall goal is to improve living conditions in the poor districts and to correct the gap. Therefore, the Project will contribute to the improvement of living conditions, and in principle the resettlement of residents or land acquisition will be not taken. In addition, consideration to the environment and to society will given, the relevance of the implementation through Japan's grant aid scheme is high.

In the future, the Government of Zambia should implement the following work prior to the implementation of the Project.

- To transfer public facilities and buried structures prior to the commencement of construction work,
- To remove existing gavages within the proposed road reserve and
- To request the neighboring people cooperate the construction work during construction period.

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THE PROJECT FOR IMPROVEMENT AND MAINTENANCE OF
LUSAKA CITY ROADS (PHASE III) IN
THE REPUBLIC OF ZAMBIA

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# CHAPTER 1 BACKGROUND OF THE PROJECT

The transport network in Zambia consists of roads, railways, aviation, inland shipping and pipelines. Road transport is the most important mode of transportation. Of the aggregate road length of 36,000 km, only 6,500 km are paved and the remaining is either gravel or earth.

Since its independence in 1964, the primary aim of the Government of the Republic of Zambia has been to build linking roads to neighboring countries and trunk roads between the capital and local areas. Consequently, the aggregate road length has increased.

However, due to that budgetary appropriation for road maintenance had been insufficient, a progressive deterioration of roads have been crealed.

In view of this situation, the Government of Zambia formulated re-organization policy of a road sector in the form of an Action Program in its Fifth National Development Plan. Under the Action Program, the 10-year Road Sector Improvement Program (ROADSIP) from 1997 to 2007 was initiated in 1997 for the purpose of facilitating the growth of all social and economic sectors, particularly the agricultural sector, through appropriate investment in repair and maintenance work for the road infrastructure.

Meanwhile, urban Lusaka has an aggregate road length of 1,600 km, of which some 850 km (53%) are paved by bituminous surface dressing method, leaving a total 47% unpaved. To make matters worse, most asphalt paved (black top) roads were constructed some 25 years ago. All urban roads are rapidly becoming damaged from the increasing population and traffic in recent years and inadequate maintenance budget and manpower to the extent that the damage is now beyond normal maintenance and repair.

Faced with the poor urban road conditions, in 1997 the Government of Zambia made a request to the Government of Japan for assistance in the rehabilitation of urban roads in Lusaka. In response to this request, the Government of Japan decided to implement the Project for Improvement and Maintenance of Lusaka City Roads (Phase II), and from December 1999 to May 2000 the Japan International Cooperation Agency (JICA) conducted the Basic Design Study. As a result, 44 routes of a total length 60.7 km were selected for the requested rehabilitation.

However, due to a drastic change in exchange rates during the Detailed Design which commenced in 2000, the scale of the project grew significantly, so that the estimated cost has exceeded the budget that was established and committed in the Exchange of Notes of the project. Consequently, the improvement of four collector roads which provide access to residential areas and which fall outside the scope of urban planning subject to this study was excluded from the grand aid scheme. Subsequently, Phase II Project for Improvement and Maintenance of Lusaka City Roads covering 40 routes of total length 51.3 km was implemented from 2001 to 2003 and has been highly praised by the Government of Zambia and various other nations.

In view of the highly evaluation, the Government of Zambia then made a request to the Government of Japan for a grant aid scheme to improve four collector roads which provide access to residential areas outside the scope of urban planning which was excluded from the implementation of the Project in July 2002.

In response to this request, the Government of Japan decided to implement the Phase III Project for Improvement and Maintenance of Lusaka City Roads following which JICA conducted an Implementation Review Study in September 2004. The Lusaka City Council made following additional requests, due to the significant damage to the proposed four routes and surrounding roads and to ensure the effects of improvement in the project implementation.

As a result of evaluating the necessity and appropriateness (relevance) of the request, JICA judged it to be appropriate. The following components will be subject to this study.

**A. Roads Subject to the Basic Request**

A.1: Bauleni Road: Extension of 1.0km
A.2: Kaleya-Ngombe Road: Extension of 0.9 km
A.3: Kasangula Road: Extension of 5.0 km
A.4: Chitanda Road: Extension of 2.5 km
Total: Four (4) roads, total extension of 9.4 km

**B. Additional Request at the time of the Field Survey**

B.1: Additional improvement of approximately 500m from the end of Chitanda Road to the elementary school built under Japan's grant aid scheme by passing through the district center in which a market, clinic and the police station are located.
B.2: Improvement of two drainage systems in the Bauleni compound.
B.3: The extension of drainage channels from the end of Kaleya-Ngombe Road to the stream and additional drainage improvement of existing natural stream.
B.4: Improvement of concrete side gutters for easy maintenance.
B.5: A channelized intersection at the beginning of Kassangula Road.
B.6: Improvement of approximately 100m of the road accessing the clinic along Kasanagula Road.
B.7: Improvement of signs, poles, road signs and bumps for improved safety.
B.8: Bus stops and terminals for buses which are the primary form of pubic transportation.

**C Additional Request during the Explanation of the Draft Summary Report**

Minor components additionally requested include the installation of safety facilities such as traffic signs at bus stops and terminals, railroad crossings and steep curves as well as pedestrian crossings at schools, hospitals, markets, bus stops and terminal and side drainage at about 3.6km to 3.7km along Kasangula Road.

# CHAPTER 2 CONTENTS OF THE PROJECT

## 2-1 Basic Concept of the Project

### (1) Objectives of the Project

Urban road transport in Lusaka, the capital of Zambia, has been experiencing rapid growth of the traffic volume due to increasing socioeconomic activities in recent years. However, the urban road network which should provide the basis for urban activities is experiencing significant damage to its paving due to the structural shortcoming of bituminous surface dressing and the passed insufficient allocation of road maintenance budget with the resulting disruption of the operation of urban road transport and massive adverse impacts on socioeconomic activities and life in the city. The Project aims at vitalizing socioeconomic activities and improving urban life by means of eradicating the road transport problems in Lusaka through the rehabilitation/upgrading of those routes in the municipal road network requiring urgent improvement. The concrete objectives of the Project is to contribute to the improvement of the basic human needs (BHN) of Lusaka's citizens through the improved paving of roads connecting with the compounds where many of Lusaka's middle class as well as relatively poor people live.

### (2) Basic Concepts of the Project

The Project consists of two major components, both of which are designed to improve the collector roads in the compounds:

(i) Application of asphalt concrete paving to target roads which have deteriorated due to the structural lacking of the paving for the remarkable increase of the traffic volume and load; and
(ii) Improvement of various road facilities, including drainage facilities and traffic safety facilities, etc., in view of the safe use of the improved roads in a durable manner over a long period of time.

### (3) Improvement Principles for the Target Roads

Improvement principles which meet the following requirements for the target roads shall be adopted;

1) To establish the required road functions (design speed and standard road width)
2) To sustain the required road functions (improvement principles for paving and drainage)
3) To increase road traffic safety
4) To provide sufficient ancillary road facilities
5) To identify undertakings by the Government
6) To mitigate public and environmental impact
7) To procure local construction materials and equipments
8) To utilize local contractors
9) Improvement Measures to meet local maintenance capacity.
10) Construction Period fitting for local seasonal variation.

## 2-2 Basic Design of the Target Roads by Requested Japanese Assistance

### 2-2-1 Design Policy

### (1) Establishment of the Required Road Functions

#### a) Design Speed

The standard design speed for the target roads as collector roads and district roads is set at 40 km/hour.

#### b) Standard road width

The road width for each target road is determined here in accordance with the Road Design Standards in Zambia.

The Road Design Standards in Zambia set forth the standard road width separately for the construction of new roads with a desirable road width and the improvement of existing roads (Table 2-1). Under the Project, since the target roads will be improvement of existing roads, the standard width for improvement of existing road shall be applied.

**Table 2.1-(1) and (2) Standard Road Width in Zambia**

(for new construction)

| Road type | No. of lanes | Lane width (m) | Carriageway width (m) | Edge strip (m) | Shoulder width (m) | Median Formation (m) | Formation width (m) | Road Reserve width (m) |
|---|---|---|---|---|---|---|---|---|
| I | 4 | 3.5 | 2 x 7.5 | 0.2 | 3.0 | 3.0 | 24.0 | 2 x 60 |
| IA | 2 | 3.5 | 7.5 | 0.25 | 3.0 | — | 13.5 | 100 |
| IB | 2 | 3.5 | 7.0 | — | 2.5 | — | 12.7 | 100 |
| **IC** | **2** | **3.25** | **6.5** | **—** | **2.0** | **—** | **10.5** | **100** |
| **II (ID)** | **2** | **3.25** | **6.5** | **—** | **1.5** | **—** | **9.5** | **100** |
| III | 1 | 5.5 | 5.5 (min) | — | 1.0 | — | 7.5 | 100 |
| Unclas sifted | — | — | 5.5 (min) | — | — | — | (1) | (1) |

(for improvement of existing road)

| Road type | No. of lanes | Lane width (m) | Carriageway width (m) | Edge strip (m) | Shoulder width (m) | Median Formation (m) | Formation width (m) | Road Reserve width (m) |
|---|---|---|---|---|---|---|---|---|
| I | 4 | 3.5 | 2 x 7.4 | 0.2 | 3.0 | 3.0 | 23.8 | 2 x 60 |
| IA | 2 | 3.65 | 7.3 | — | 3.0 | — | 13.3 | 100 |
| IB | 2 | 3.35 | 6.7 | — | 2.5 | — | 12.0 | 100 |
| **IC** | **2** | **3.05** | **6.1** | **—** | **2.0** | **—** | **10.1** | **100** |
| **II (ID)** | **2** | **3.05** | **6.1** | **—** | **1.5** | **—** | **9.1** | **100** |
| III | 1 | 5.5 (min) | 5.5 (min) | — | 1.0 | — | 7.5 | 100 |
| Unclas sifted | — | — | 5.5 (min) | — | — | — | (1) | (1) |

The following considerations are also made for the specific target roads under the present conditions:

- The typical shoulder width shall be 1.50m for the pedestrians.
- The shoulder width shall be partially reduced in order to avoid any land acquisitions or relocation of public utilities.
- The side ditches shall be reduced by means of super-elevation except for steep gradient sections where tends to erode due to the surface water.

The typical lane width and shoulder width of the target roads shall be 3.05m and 1.50m respectively in accordance with the above-mentioned Road Design Standards and considerations.

**(2) Sustenance of the Required Road Functions**

Although the state of paving damage varies from one target road to another, all roads require urgent improvement. Road maintenance will be the most important issue to sustain the required road function after improvement and this sustaining of the road function should be ensured by the application of appropriate measures which are described next.

**a) To set-up Required Improvement Measures of Pavement**

Different stages of damaged roads demand different paving improvement measures. For this purpose, an appropriate improvement measure should be selected based on the survey results on the Paving Service Index (PSI) for each existing road as shown in Table 2-2.

**Table 2.2 Required Improvement Measures of Pavement**

| PSI | Improvement Measure |
|---|---|
| Very Bad | Reconstruction from Sub-base Course |
| Bad | Reconstruction from Base Course |
| Fair | Overlay |
| Good | Pot-hole patching |
| Very Good | Ordinary maintenance work |

The pavement on the target roads have been progressively deteriorated in recent years due to passed insufficient maintenance and shortage of budget. However, since it was found that some portion of the base and sub-base materials are still in good condition through the subsoil survey (laboratory tests for sampled materials and DCP tests for each 200m), the existing base and/or sub-base layers shall be utilized for the project cost saving.

**b) To Introduce Sustainable Design Life of Pavement**

A design period of 20 years was adopted for reconstruction and 10 years for overlay by the Roads Improvement Project in Lusaka (Phase I) which is related to the present Project. These periods were adopted to include a large safety margin, i.e. longer life, because of the insufficient maintenance capability and system in Zambia at the time.

At present, the Government of Zambia is implementing the 10 year ROADSIP which aims at consolidating the maintenance of existing roads nationwide. To be more precise,

progress is being made in terms of private consignment involving private construction companies, supplementing the traditional system whereby road maintenance is directly conducted by public organizations. A petrol tax has been introduced as a new source of revenue for road maintenance together with the road account. This new revenue source has not yet been able to meet the all demand but it is expected that some 70% of the road maintenance cost will be covered in the long term.

Given the prospect of the implementation of regular maintenance in the coming years, it is now deemed more rational to decide the design life for improved paving from a more realistic economic point of view.

The Government of Zambia has stated that the design life for paving should be at least 10 years

Based on the above results, the design life for road paving under the Project is set at 10 years for the target roads on the grounds that (i) the road maintenance regime of the Government of Zambia is strengthened, (ii) on the viewpoint of the project ownership by the government.

**c) To Ensure Drainage Network**

The construction of drainage channels is essential to ensure the long life of road paving after improvement. For the rapid drainage of rainwater on roads, the construction of complete drainage channels up to outlet to rivers, etc. is required in addition to the construction of side ditches. For those road sections where there is no outlet nearby, drainage channel will be constructed to the nearest point of outlet.

It is desirable for these drainage facilities to have a structure which is not damaged by rainwater. In addition, they should be easy to maintain and require as little investment as possible. Therefore, the drainage facilities shall have the following conditions:

1) The minimum width of the drainage shall be 600mm in order to clean by manpower.
2) The open ditches shall be lined by concrete in order to prevent drainage closure due to erosion or sedimentation.
3) The sub-surface drainage shall be pipe culvert with 600mm diameter. The important facilities such as cross drain at outlet shall be box culvert.

**(3) Increase of Road Traffic Safety**

There is concern in regard to the occurrence of many traffic accidents on the target roads due to the higher driving speed beyond the legal limit after the improvement of the roads.

The introduction of the following measures will be necessary to prevent traffic accidents.

- To facilitate appropriate intersection and pedestrian crossings
  Appropriate junctions and pedestrian crossings shall be introduced to ensure safe lines of flow for pedestrians to public facilities along each target road.

- To facilitate appropriate public transport facilities
  Appropriate facilities shall be introduced at bus stops so that traffic on the carriageway is not disrupted.
- To install suitable signs
  The barriers (buffer stops) shall be installed at sharp bends and humps for proper driving. The stop signs and information board showing name of the road shall be installed at the beginning and end point.

**(4) Provision of Sufficient Ancillary Road Facilities**

- Humps shall have size enough for most of vehicles having 4m length in order to avoid the wheel tracks.
- Barrier (Buffer Stop) shall be the type utilized steel pipes to be same as previous project (Lusaka City Roads Phase 2).
- 80% of the full design discharge and 10% of the sediment ratio shall be applied to the design opening of the existing box culvert on Kasangula Road.
- Grid fabricated by reinforcing bars shall be installed at outlets flowing to private land on Kasangula Road for the safety.
- Stone pitching which is frequently utilized at any sites shall be applied on river protection.

**(5) Identification for undertakings by the Government**

Undertakings by the Government will be as follows:

1) **Relocation of public utilities**
   Only two electric poles on Kasangula Road should be relocated. The actual relocations will be carried out by ZESCO. The other relocations may proceed after completion of the design, if necessary. However, concrete protection without relocation shall be made for the shallow underground utilities.
2) **Agreement with bus companies and the authorities concerned**
   The agreement for location of bus stops and bus terminals will be made after completion of the design. The cooperation with the police department will be required for the traffic and the pedestrian safety during the construction of the project.

**(6) Mitigating Public and Environmental Impact**

It will be necessary for the road improvement measures discussed above to be accompanied by the following measures to mitigate adverse impacts on public facilities and the environment.

- To adjust road width for minimizing of resettlement
  The target road width should be within the limits of the current right of way in order to keep compensation for house relocation to a minimum and to ensure the smooth progress of the Project.
- To reduce relocation of public utilities

Horizontal alignment to minimize the forced relocation of existing public utilities should be adopted. There should be a strip of land for public utilities at the end of each right of way to prevent any unnecessary digging of the road.

- To preserve the existing trees
  Horizontal alignment capable of preserving existing trees should be adopted.

**(7) Procurement of Construction Equipment and Materials**

Most of construction materials can be procured in Zambia. Construction equipment is also available through the several lease companies in Zambia. Therefore, procurement of construction materials and equipment shall be made in Zambia. Only special materials and equipment which is not available in Zambia shall be procured from Japan or South Africa.

**(8) Utilization of Local Contractors**

There are several construction companies in Lusaka which are largely classified into local companies and local subsidiaries of foreign companies. Even though local companies are subcontracted to conduct paving work for trunk roads, they do not sufficiently possess the necessary equipment. Coupled with their insufficient finance, such problems as delayed completion and defective quality can be pointed out with the work conducted by local companies, suggesting that no local company is capable of conducting road paving work to full satisfaction without supervision. Meanwhile, local subsidiaries of foreign companies commonly establish joint ventures with local or other foreign subsidiaries to be awarded major road work by the Ministry of Public Works and Supply. Local companies appear to work as subcontractors to conduct simple work or to act as the suppliers of labour for these joint ventures. For the implementation of the Project, assuming the approval of Japanese grant aid, the construction work will be directly conducted by a Japanese construction company (the Contractor). Local companies will be employed as subcontractors to conduct simple work while the Contractor will be responsible for work management, the provision of technical guidance and work supervision with a view to enhancing the expertise of local companies.

**(9) Maintenance Capability of the Implementing Agency**

The Government of Zambia is currently implementing the 10 Year ROADSIP Project designed to strengthen the maintenance system for existing roads as part of a nationwide construction plan. To be more precise, the process of private consignment is in progress to replace that maintenance work directly conducted by the public sector with private construction companies. A road user tax (petrol tax) and a road account have been newly established to finance such private contracting. Even though these new finance sources have not yet been fully met to the demand, it is expected that they will finance some 70% of the road maintenance cost in the long term. Regular maintenance work is, therefore, expected to be conducted in the coming years.

**(10) Construction Schedule**

Since November to March will be in rainy season, pre-fabrication works and drainage works shall be proceeded. After entering dry season (from April), earth works including construction of sub-grade, sub-base and base course layers shall be started.

### 2-2-2 Basic Design

#### (1) Design Criteria

##### (1)-1 Pavement Design Standards

The Project will adopt the criteria of the Asphalt Institute (AI) in the United States for the following reasons.

- These are recognized as international standards and are approved under the Zambian criteria.
- Their design life is set at 10 years which conforms to the conditions of Japan's grant aid scheme.
- The Zambian criteria and the American Association of State Highway and Transportation Officials (AASHHTO) are subject to the design of new pavement and do not cover the rehabilitation of existing roads.
- The criteria were adopted during the first and second studies and so there are no particular concerns.

##### (1)-2 Geometric Design Standards

The Project is design for the purpose of upgrading the current roads. Therefore horizontal alignment and vertical alignment are unassociated in the design. However, this does not apply if some alignment problems in existing roads are present. In the case of such alignment, the geometric design standards of the Japanese Road Structure Ordinance will be used as reference.

#### (2) Alignment Design

The Project will repair and upgrade the current roads so that the present road alignments will be inherited. However, since the carriageway width of the existing box culvert at the river crossing at the 2.5km point on Kasangula Road has only a single-lane, alignment will be improved by building a new box culvert. At that time, based on the roadside surroundings and topographic features the design speed is determined to be 40km/hr, which satisfies Japanese Road Structure Ordinance. The existing box culverts will be reused for pedestrians. Then by improving only the carriageway width the project cost will be saved.

Although the current road height will be generally applied to the vertical alignment, in some sections base course materials are eroded by surface water due to inadequate drainage. Vertical alignment will be set to the ground height of roadside

houses.

With respect to cross slope, since the proposed routes at this time are roads within residential areas, convenience and ease of access will be emphasized more than speed. Consequently, a cross super-elevation will not be applied. However, a curved in-plan widening of roads will be installed so that vehicles can pass. The transition area for widening of roads will be designed within a transition section. In addition, main line paving will extend 0.15m on both sides of the carriageway width of 3.05 m × 2 lanes. If the paved shoulder has deteriorated, consideration should be given to preventing erosion to the carriageway.

**(3) Pavement Design**

The proposed pavement structure is established based on the analysis of the design traffic volume and the design CBR value. The design traffic volume is established by multiplying the exiting traffic volume and the annual traffic growth of 6% recommended in the design criteria of AI under the existing traffic conditions on the Project roads.

In the site reconnaissance, the design CBR was set by grasping the state of the roadbed through the implementation of a 500meter-pitch laboratory CBR test and 200meter-pitch DCP test. The results of the DCP and CBR tests are shown on the appendices. Through this, the design CRR of 4% to 15% per section was established.

A paving structure (design Ta-value) design based on the required Ta-value obtained and on traffic volume is shown on the following page. Here, the existing base course materials are evaluated to be equivalent to sub-base course materials. Therefore, materials will be newly applied to insufficient Ta. In addition, based on the site reconnaissance carriageway width where existing base course materials are recognized is set to approximately 5m. Since an existing base course does not exist in the outer side of this, sub-base course materials equivalent to the existing base course will be newly installed. Under these conditions, the most economic paving structure was examined.

Since the surface course at bus stops is expected to wear faster than at other places due to the sudden stopping and departure of buses, a semi-flexible pavement by applying cement milk to the surface course will be applied.

## Table-2.3 Pavement design

| Road name | Section | Num. of Large vehical | Large vehical per lane | Average Gross Mass | Initial traffic volume | Annual grow ratio | Design Traffic Number | Design CBR | Required Ta(cm) | New construction | | | | | | Existing Base | | Total thickness (cm) | Tao (cm) | remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Surfacew As | Equivalent exchange coefficient(As) | Base course | Equivalent exchange coefficient(B) | Sub base course | Equivalent exchange coefficient(SB) | Existing Base | Equivalent exchange coefficient(E-SB) | | | |
| Bauleni Road | 0+200 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 6.0 | 16.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 20 | 0.25 | 39.0 | 16.5 | |
| | 0+400 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 6.0 | 16.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 20 | 0.25 | 39.0 | 16.5 | |
| | 0+600 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 6.0 | 16.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 20 | 0.25 | 39.0 | 16.5 | |
| | 0+800 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 6.0 | 16.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 20 | 0.25 | 39.0 | 16.5 | |
| | 1+000 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 6.0 | 16.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 20 | 0.25 | 39.0 | 16.5 | |
| Kaleya-N'gonbe | 0+200 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 5.5 | 16.5 | 4 | 1.0 | 15 | 0.50 | 10 | 0.25 | 10 | 0.25 | 39.0 | 16.5 | |
| | 0+400 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 5.5 | 16.5 | 4 | 1.0 | 15 | 0.50 | 10 | 0.25 | 10 | 0.25 | 39.0 | 16.5 | |
| | 0+600 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 5.5 | 16.5 | 4 | 1.0 | 15 | 0.50 | 10 | 0.25 | 10 | 0.25 | 39.0 | 16.5 | |
| | 0+800 | 100 | 50 | 10 | 15 | 0.66 | 9.9 | 5.5 | 16.5 | 4 | 1.0 | 15 | 0.50 | 10 | 0.25 | 10 | 0.25 | 39.0 | 16.5 | |
| Chitanda Road | 0+200 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 10.0 | 15.5 | 4 | 1.0 | 15 | 0.50 | 20 | 0.25 | 0 | 0.25 | 39.0 | 16.5 | |
| | 0+400 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 10.0 | 15.5 | 4 | 1.0 | ~~15~~ | ~~0.50~~ | ~~20~~ | ~~0.25~~ | ~~0~~ | ~~0.25~~ | ~~39.0~~ | ~~16.5~~ | overlay |
| | 0+600 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 10.0 | 15.5 | 4 | 1.0 | ~~15~~ | ~~0.50~~ | ~~20~~ | ~~0.25~~ | ~~0~~ | ~~0.25~~ | ~~39.0~~ | ~~16.5~~ | overlay |
| | 0+800 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 4.0 | 21.0 | 4 | 1.0 | 20 | 0.50 | 30 | 0.25 | 0 | 0.25 | 54.0 | 21.5 | |
| | 1+000 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 15.0 | 12.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 10 | 0.25 | 29.0 | 14.0 | |
| | 1+200 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 15.0 | 12.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 10 | 0.25 | 29.0 | 14.0 | |
| | 1+400 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 15.0 | 12.0 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 10 | 0.25 | 29.0 | 14.0 | |
| | 1+600 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 5.0 | 18.0 | 4 | 1.0 | 20 | 0.50 | 20 | 0.25 | 0 | 0.25 | 44.0 | 19.0 | |
| | 1+800 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 5.0 | 18.0 | 4 | 1.0 | 20 | 0.50 | 20 | 0.25 | 0 | 0.25 | 44.0 | 19.0 | |
| | 2+000 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 5.0 | 18.0 | 4 | 1.0 | 20 | 0.50 | 20 | 0.25 | 0 | 0.25 | 44.0 | 19.0 | |
| | 2+200 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 4.0 | 21.0 | 4 | 1.0 | 20 | 0.50 | 20 | 0.25 | 10 | 0.25 | 54.0 | 21.5 | |
| | 2+400 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 4.0 | 21.0 | 4 | 1.0 | 20 | 0.50 | 20 | 0.25 | 10 | 0.25 | 54.0 | 21.5 | |
| | 2+600 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 4.0 | 21.0 | 4 | 1.0 | 20 | 0.50 | 20 | 0.25 | 10 | 0.25 | 54.0 | 21.5 | |
| | 2+800 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 10.0 | 15.5 | 4 | 1.0 | 15 | 0.50 | 20 | 0.25 | 0 | 0.25 | 39.0 | 16.5 | |
| | 3+0 | 168 | 84 | 10 | 25 | 0.66 | 16.5 | 10.0 | 15.5 | 4 | 1.0 | 15 | 0.50 | 20 | 0.25 | 0 | 0.25 | 39.0 | 16.5 | |
| Kasangula Road | 0+200 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 8.0 | 16.5 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 0+400 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 8.0 | 16.5 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 0+600 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 0+800 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 1+000 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 1+200 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 1+400 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 1+600 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 1+800 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 2+000 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 2+200 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 5.0 | 20.0 | 4 | 1.0 | 20 | 0.50 | 25 | 0.25 | 0 | 0.25 | 49.0 | 20.3 | |
| | 2+400 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 9.0 | 14.5 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 15 | 0.25 | 34.0 | 15.3 | |
| | 2+600 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 9.0 | 14.5 | 4 | 1.0 | 15 | 0.50 | 0 | 0.25 | 15 | 0.25 | 34.0 | 15.3 | |
| | 2+800 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 9.0 | 14.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 15 | 0.25 | 34.0 | 15.3 | |
| | 3+0 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 20.0 | 11.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 3+200 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 20.0 | 11.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 3+400 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 20.0 | 11.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 3+600 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 20.0 | 11.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 3+800 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 20.0 | 11.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 4+00 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 20.0 | 11.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 0 | 0.25 | 19.0 | 11.5 | |
| | 4+200 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 7.0 | 17.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 25 | 0.25 | 44.0 | 17.8 | |
| | 4+400 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 7.0 | 17.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 25 | 0.25 | 44.0 | 17.8 | |
| | 4+600 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 7.0 | 17.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 25 | 0.25 | 44.0 | 17.8 | |
| | 4+800 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 7.0 | 17.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 25 | 0.25 | 44.0 | 17.8 | |
| | 5+00 | 330 | 165 | 10 | 50 | 0.66 | 33.0 | 7.0 | 17.5 | 4 | 1.0 | 15 | 0.5 | 0 | 0.25 | 25 | 0.25 | 44.0 | 17.8 | |
| Great North Road | | 1250 | 625 | 13 | 600 | 0.66 | 396.0 | 8.0 | 22.0 | 8 | 1.0 | 20 | 0.5 | 20 | 0.25 | 0 | 0.25 | 48.0 | 23.0 | |

## (4) Drainage Design

### (4)-1 Design Conditions

Drainage design was formulated in accordance with drainage guidelines (Japan Road Association). Major planning and design conditions are described as follows.

1) Return Period of Rainfall

The return period of rainfall refers to “rainfall once in which year is subject to a design”. Therefore, as the degree of importance of facility increases, the return period of rainfall increases, as illustrated below.

① Side ditches: 3 years
② Cross culverts: 5 years
③ Cross-river culverts: 10 years

2) Manning Roughness Coefficient

The ease of water flow is dependant on lining type, the lower the value the easier flow.

① Field concrete: 0.015
② Pre-cast concrete: 0.013
③ Stone concrete: 0.025

### (4)-2 Calculation of Runoff

#### 1) Rainfall Data

Runoff is determined by obtaining the rainfall intensity based on rainfall data observed near Lusaka City and multiplying it by drainage area. Table 2.4 shows the rainfall data observed.

**Table 2.4 Annual Maximum Daily Rainfall**

| Year | Lusaka-1 | Lusaka-2 | Mtmaku-1 |
|---|---|---|---|
| 1989 | 104.4 | 105.1 | 125.0 |
| 1990 | 55.6 | 83.5 | 56.2 |
| 1991 | 133.0 | 56.4 | 88.6 |
| 1992 | 42.0 | 46.5 | 49.5 |
| 1993 | 55.4 | - | 60.4 |
| 1994 | 42.1 | 23.0 | 57.7 |
| 1995 | 32.1 | 50.4 | 58.6 |
| 1996 | 38.1 | 81.0 | 60.4 |
| 1997 | 76.4 | 91.2 | 70.0 |
| 1998 | 84.5 | 110.1 | 52.1 |
| 1999 | 49.0 | 111.5 | 49.9 |
| 2000 | 42.3 | 110.1 | 48.3 |
| 2001 | 83.2 | 115.5 | 54.8 |
| 2002 | 35.3 | 75.3 | 35.4 |
| 2003 | 52.4 | 40.3 | 41.7 |

Data Source: Lusaka Meteorological Bureau

**2) Rainfall by return period**

A rainfall per return period of rainfall is obtained by Gumbel's method utilizing the maximum annual rainfall data.

**Table 2.5 Probable Maximum Daily Rainfall（mm/day）**

| Return Period (year) | 1 | 2 | 3 | 5 | 10 | 20 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| Rainfall (mm/day) | 18.0 | 64.5 | 77.7 | 92.3 | 110.7 | 128.3 | 151.2 | 168.4 |

**3) Hourly Rainfall Intensity**

Rainfall intensity per unit hour can be obtained by the Monobe method using the following formula.

$$R_t = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3}$$

Here, Rt : Hourly rainfall intensity (mm/hr)

R24 : Daily rainfall (mm)

t : Reaching time (hr) ＝ inlet time＋ efflux time

Reaching time can be obtained by adding inlet time (t1) and efflux time (t2),

which is defined as follows.

$t_1$ : 20 minutes for side ditches, 30 minutes for cross culverts

$t_2$ : Obtained by either Manning method or Rziha's method

**4) Calculation of Runoff**

The following Rational method can be applied for runoff.

$$Q = \frac{CIA}{3.6}$$

Here, Q : Runoff ($m^3/s$)

C : Runoff coefficient

I : Rainfall intensity (mm/hr)

A : Catchment area ($km^2$)

### (5) Shoulder Design

The shoulder is the part of the road width to protect carriageway pavement on which wheel load is not normally anticipated. Consequently, it is sufficient enough to just apply a coating to the surface to prevent erosion from surface water. The Project will adopt the Double Bitumen Surface Treatment (DBST) applied in the first and second phases.

Although some shoulders constructed in past projects have deteriorated, this appears to have been cause by illegal parking and inadequate drainage. Therefore, a more effective approach would be recommended the Government during the project implementation to control illegal parking, to encourage factories and shops that generate an illegal parking problem to create parking lots, to widen entrances for easier access to parking lots, and to clean side gutters.

### (6) Design of Intersections

The design vehicle shall apply Dump truck in the design of intersections between 2-lane roads (district trunk roads). At the intersection of Kasangula Road and Great and North Road, since the Great North Road are international trunk road, the design vehicle shall apply semi-trailer. Although full-sized trailers and semi-trailers can be often seen in Zambia, the running track of semi-trailers is larger. So if semi-trailers are planned, full-sized trailers can also be included. Moreover, normal passenger cars will be included in the design for access roads and residences. The individual design elements are described below.

**Table 2.6 Turning Radius of Vehicles**

| | Normal Passenger Car | Dump Truck | Semi-trailer (and Full-trailer) |
|---|---|---|---|
| Outer Turning Radius | 7.0 | 10.5 | 13.0 |
| Difference in Intrados | 3.5 | 4.5 | 8.5 |
| Inner Turning Radius | 4.5 | 6.0 | 4.5 |

(Unit: m)

*Although the size of the turning radius either semi-trailer or full trailer is same, the requested total turning space for semi-trailer is larger than that of full- trailer due to the difference of the vehicle structure.

## (7) Ancillary Road Facilities

### (7)-1 Humps

Speed humps will be installed at various locations such as close to schools, hospitals and intersections. Barriers (Buffer stops) will be installed on the shoulder part of each hump in a traverse direction in order to prevent vehicles from passing on the shoulders.

### (7)-2 Signs

To improve traffic safety, traffic signs will be installed at the following locations.

- Stop: Route origin and terminus
- Railway Crossing: Railway intersections
- Bus stop: Bus stops and terminals

### (7)-3 Lane Markings

The following lane markings will be installed.

- Center lines (dashed line)
- Marginal strip lines (solid line)
- Right and left broken arrows
- Stop lines
- Pedestrian crossings

### (7)-4 Facility to Prevent Trespassing on Private Land

Drainage in the vicinity of 4.0 km along Kasangula Road will be coursed to a river using side ditches on private land. In the case of installing side ditches on private land, it is necessary to go under existing block fences along the boundary between the public and private land. Although the drainage structure will involve the extension of concrete side ditches and block fences installed on top, during the extension of side ditches on private land a mesh with reinforcing bars will be installed in order to prevent trespassing by unauthorized persons at the boundary between the public and private land. In addition, the demolition and re-installation of block fences will be carried out by local governments.

### (7)-5 Barriers (Buffer Stop)

For the purpose of preventing vehicle collisions or to alert attention, protection polls will be installed at the following locations.

- Shoulder part where speed humps are installed
- Sections where have sharp bend alignment on Kasangula Road

### (8) Bus Stop Design

Bus stop locations were based on a survey carried out by local bus companies and LCC personnel after taking the site reconnaissance into consideration. As a result, bus stops will be installed at an interval of approximately 500m.

Each bus stop structure is 30m long to ensure that 5 buses will be able to drop off and take on passengers at the same time (mini buses). Furthermore, the design of the bus terminal which is the end of the bus routes will also include enough space for 10 buses to wait and turn simultaneously.

### (9) Structure Design

Box culverts on Kasangula Road can be listed as large-sale structures under the Project. The box culverts will be installed at river crossings and are described below.

For design standards, the Japanese road civil engineering retaining wall and culvert works guidelines (Japan Road Association) were adopted. Although a limit design method is adopted in the Zambian standards, this limit design method is not general used in Japan because the Japanese design standards are based on existing allowable stress designs. Compared to the limit design method, the existing allowable stress design method is safer (despite the fact that Japanese companies are involve). In due consideration of the level of local workers, it is more appropriate to use the allowable stress design method with a higher safety ratio. Standards that meet full-sized trailers for the design load will be applied.

The larger inner space cross section was adopted through a comparison of existing boxes and flow rates. As a result, it will be 4.0m in width × 2.5m in height × 7.5m in depth by inheriting the inner space cross section of the existing boxes. In addition, collapse can be seen on some slopes along the river section, which will be protected through stone pitch construction by burying fist-sized stones into the slope together with concrete.

In addition, box culverts of 1.0 × 1.0m cross section will be applied to road crossing drainage near outlets for easier maintenance. The structural drawing was based on standard design drawings of the Ministry of Land, Infrastructure and Transport of Japan.

### (10) Design of Railway Crossing

With respect to a structure of railway crossings, discussions were held with the railway company concerning the improvement of Lumumba Road (Phase I). Accordingly, the Project will also comply with such discussions.

### (11) Relocation and Protection of Public Facilities including underground utilities

The Project will include a plan to prevent the relocation of public facilities from arising as much as possible. Consequently, although it is necessary to move electric poles at the two following locations on Kasangula Road, it appears no other public facilities will be affected.

- Location approximately 18km from the beginning point
- Intersection at the end point

Underground utilities such as water supply pipes should not be relocated and should be protected with concrete.

### (12) Land Acquisition and Relocation of Houses, etc.

Since the Project plans to utilize the current right-of-way, land acquisition and relocation of residences will not occur.

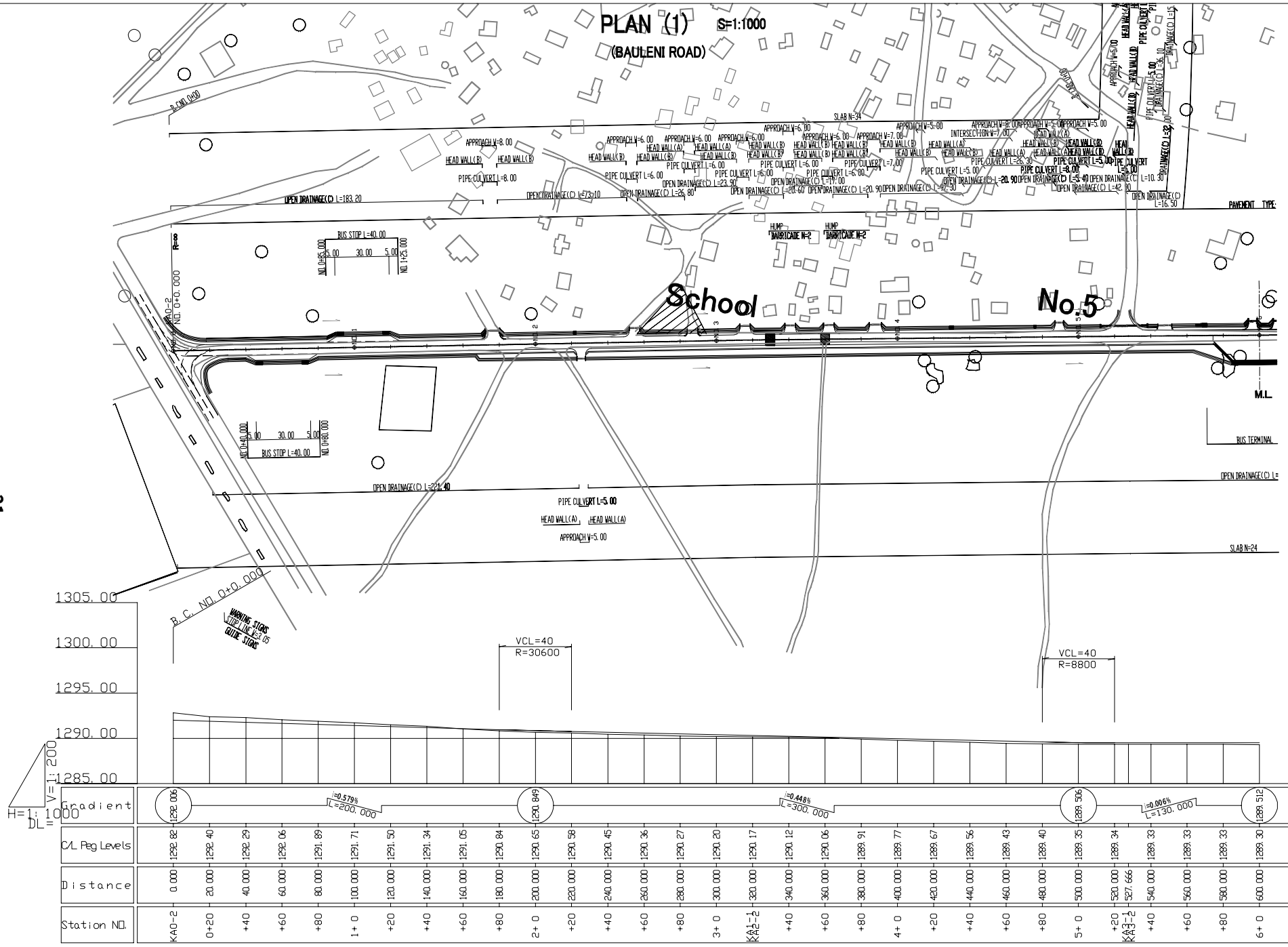
### (13) Work Quantity

**Table 2.7 Work quantity of general items**

| Item | Detail | Unit | Quantity |
|---|---|---|---|
| Earth Work | Excavation | Cu-m | 18,600 |
| | Embankment | ditto | 14,400 |
| | Soil Replacement | ditto | 1,700 |
| Slope Work | Cut | Sq-m | 2,800 |
| | Embankment | Sq-m | 6,700 |
| Drainage work | Open Drainage | m | 17,000 |
| | U-shape | m | 600 |
| | Pipe Culvert | m | 2,700 |
| | Box(1.0*1.0) | m | 40 |
| | Slab | No. | 560 |
| | Pile Cleaning | m | 90 |
| | Box Cleaning | m | 40 |
| Pavement work | Sub base course (t=100) | Sq-m | 8,900 |
| | Sub base course (t=150) | ditto | 3,100 |
| | Sub base course (t=200) | ditto | 28,000 |
| | Sub base course (t=250) | ditto | 22,000 |
| | Sub base course (t=300) | ditto | 4,200 |
| | Base course (t=100) | ditto | 8,500 |
| | Base course (t=150) | ditto | 61,000 |
| | Base course (t=200) | ditto | 30,000 |
| | Asphalt surface course (t=40) | ditto | 95,000 |
| | Semi flexible pavement (t=40) | ditto | 5,600 |
| | Gravel (t=200) | ditto | 3,700 |
| | DBST | ditto | 19,000 |
| Marking | Center line (full line) | m | 31,300 |
| Structure | Box culvert (4.9*2.3) | No. | 1 |
| Miscellaneous Work | Hump | No. | 26 |
| | Barricade | No. | 52 |
| | Sign post | No. | 50 |
| | Security Protection | No. | 1 |

## 2-2-3 Basic Design Drawings

Basic Design Drawing shall be shown on the next pages.

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| MINISTRY OF LOCAL GOVERMENT AND HOUSING THE REPUBLIC OF ZAMBIA | THE PROJECT FOR IMPROVEMENT AND MAINTENANCE OF LUSAKA CITY ROADS (PHASE III) IN THE REPUBLIC OF ZAMBIA | JAPAN ENGINEERING CONSULTANTS CO.,LTD | BAULENI ROAD | SCALE | MINISTRY OF LOCAL GOVERMENT AND HOUSING THE REPUBLIC OF ZAMBIA | APPROVED | JAPAN ENGINEERING CONSULTANTS CO.,LTD | PREPARED CHECKED | DATE |
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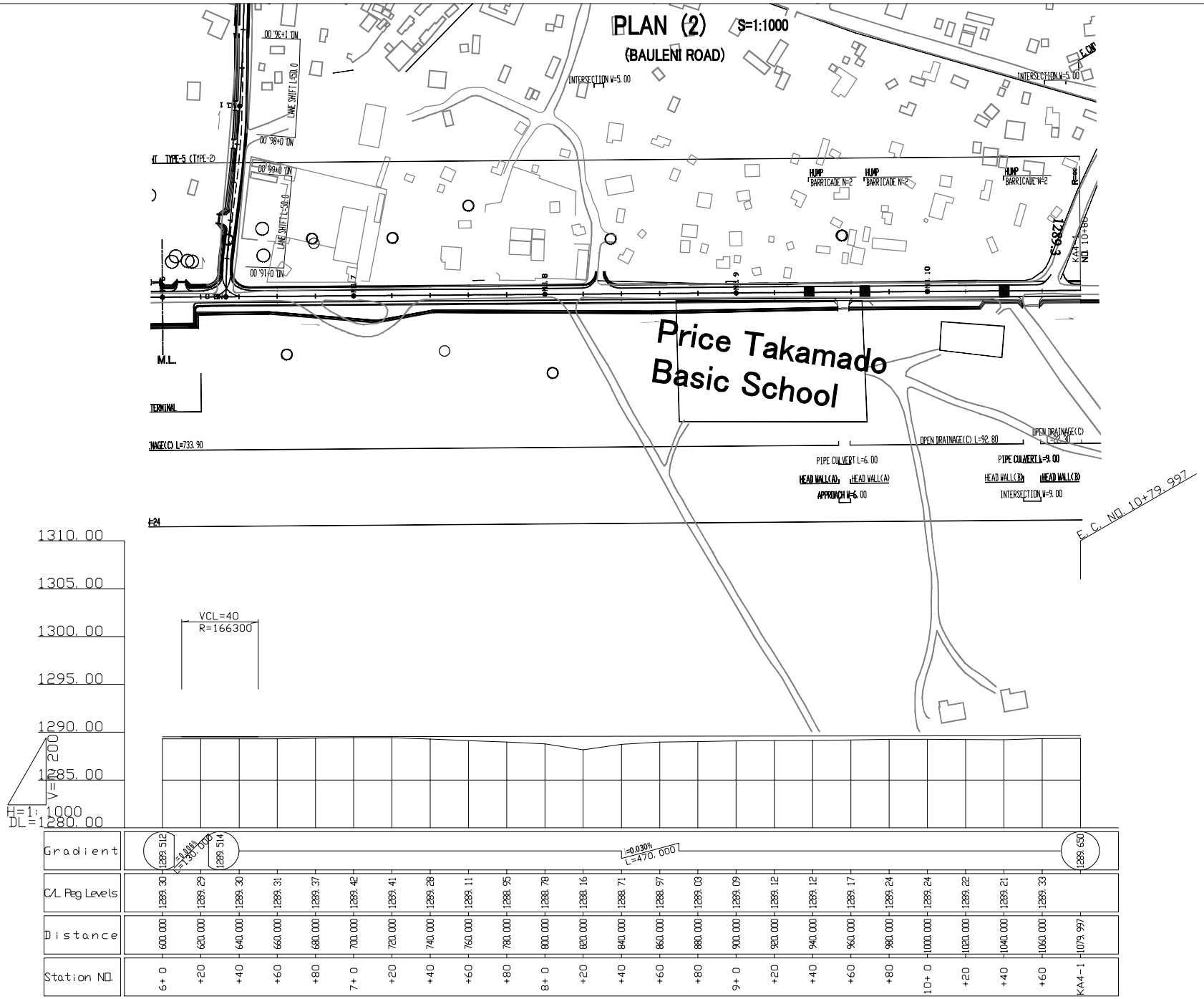


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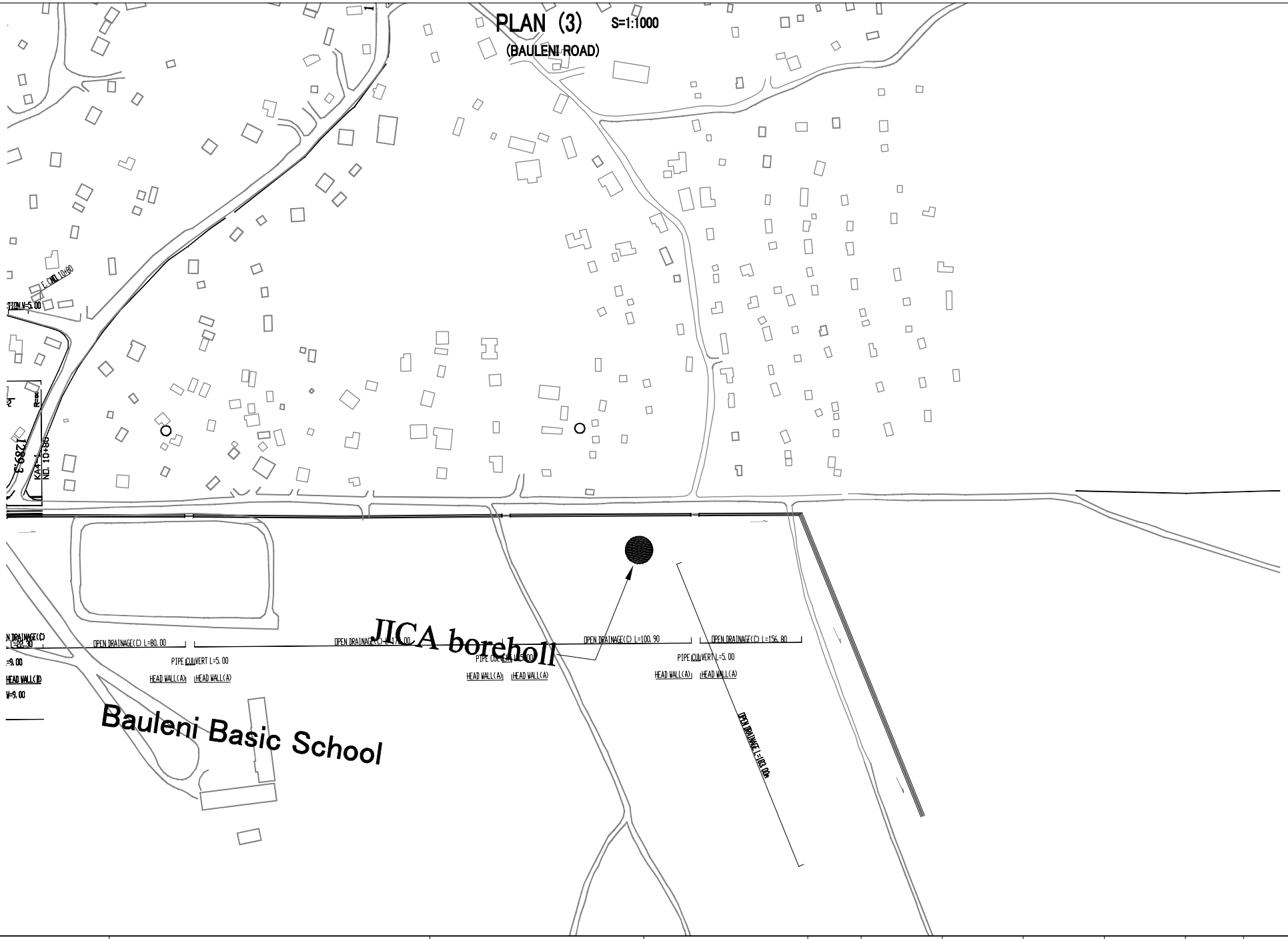
# PLAN (3) S=1:1000

(BAULENI ROAD)

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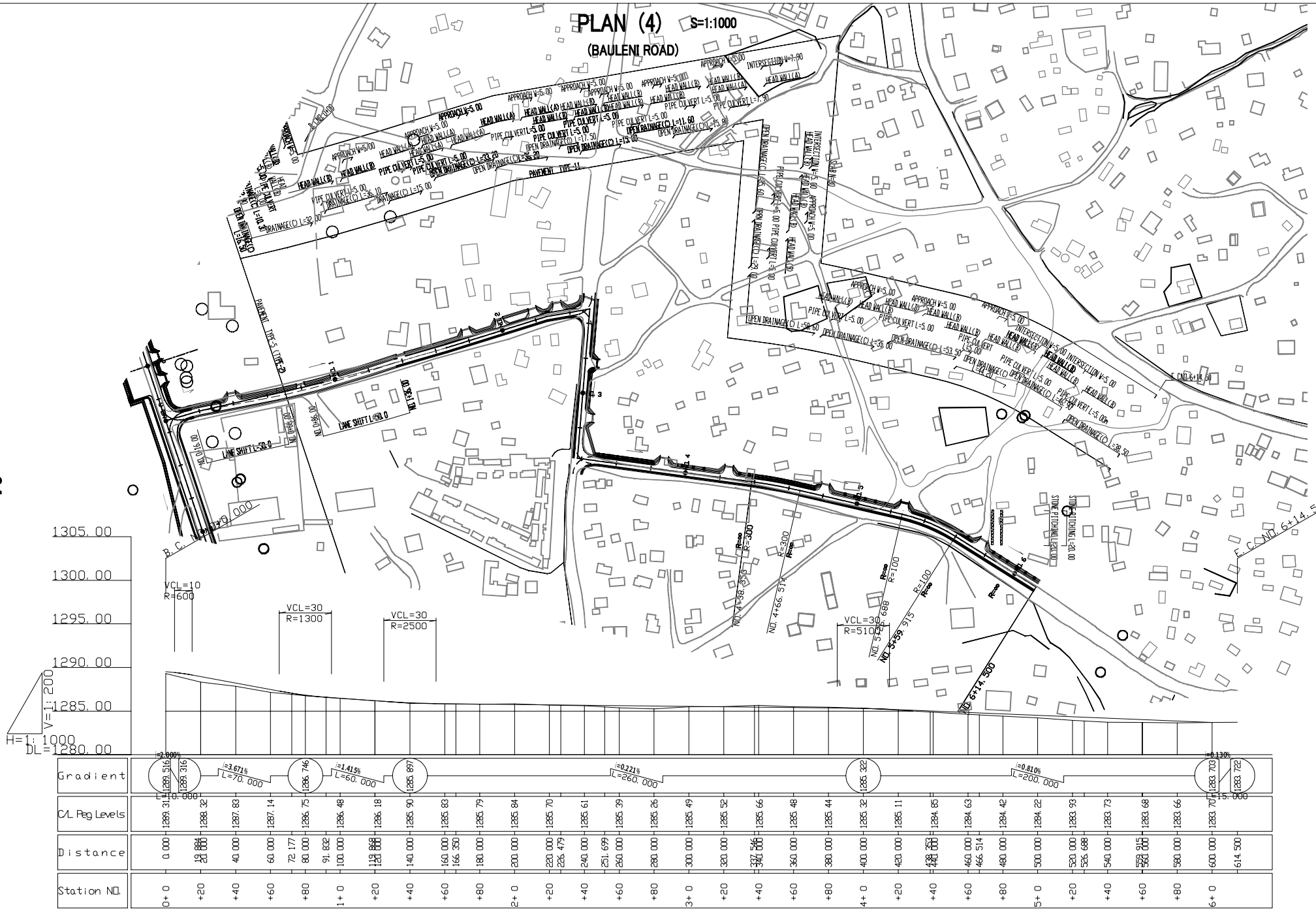
# PLAN (4) S=1:1000

## (BAULENI ROAD)

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