No.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
REHABILITATION OF TRUNK ROAD PHASE III
IN
THE FEDERAL DEMOCRATIC REPUBLIC
OF
ETHIOPIA

JUNE 2004

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.

JAPAN ENGINEERING CONSULTANTS CO., LTD.

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PREFACE

In response to a request from the Government of the Federal Democratic Republic of Ethiopia, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of Trunk Road Phase III and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Ethiopia a study team from October 26 to December 10, 2003.

The team held discussions with the officials concerned of the Government of Ethiopia, 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 Ethiopia 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 Federal Democratic Republic of Ethiopia for their close cooperation extended to the teams.

June, 2004

Sadako Ogata

President
Japan International Cooperation Agency

June, 2001

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Rehabilitation of Trunk Road Phase III in the Federal Democratic Republic of Ethiopia.

This study was conducted by the joint venture between Oriental Consultants Company Limited and Japan Engineering Consultants Company Limited, under a contract to JICA, during the period from October 2003 to June 2004. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Ethiopia 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.

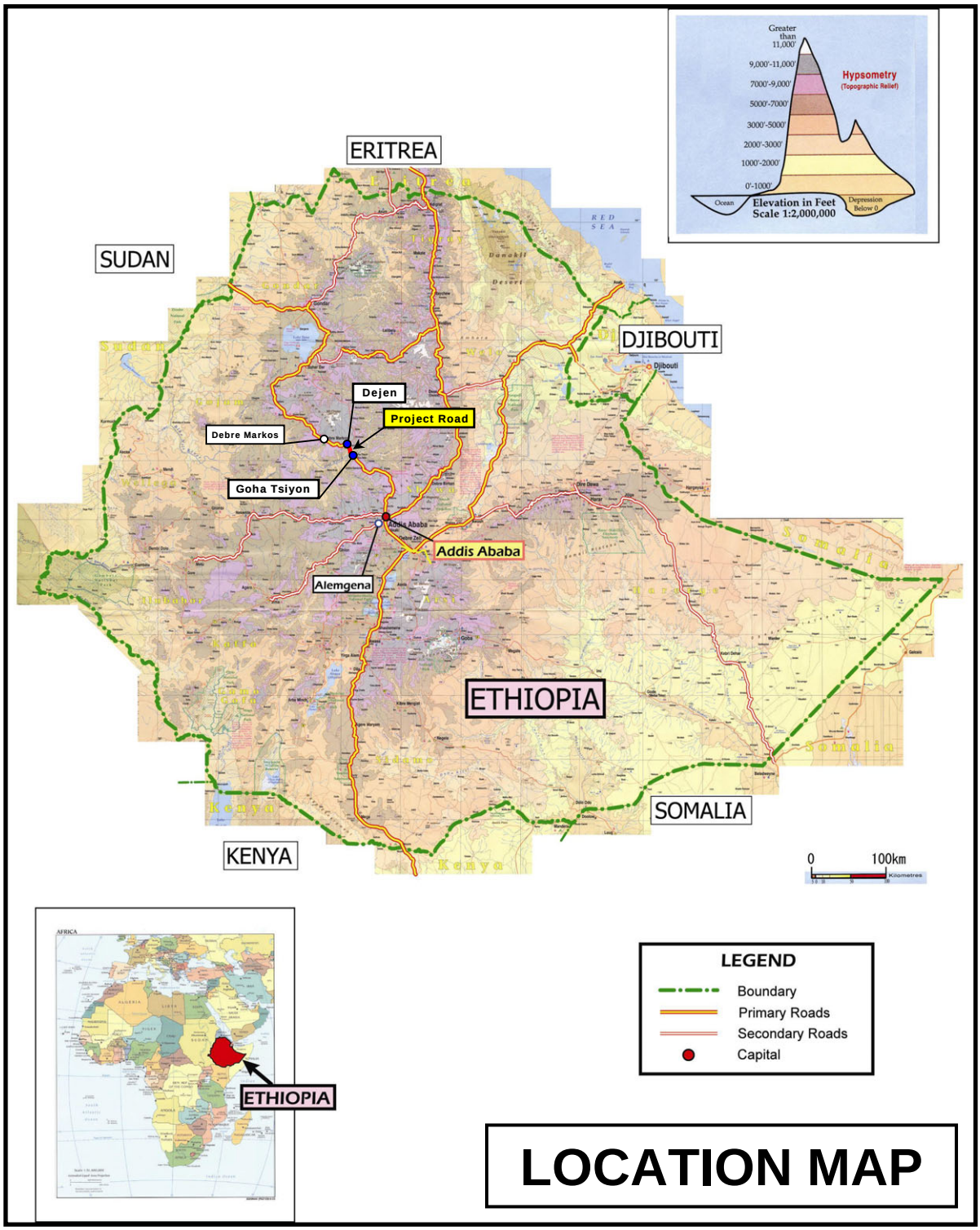
Very truly yours,

Masaaki Tatsumi

Chief Consultant,

Basic design study team on
The Project for Rehabilitation of Trunk Road Phase III

The joint venture between
Oriental Consultants Company Limited and
Japan Engineering Consultants Company Limited


Greater than 11,000'
9,000'-11,000'
7000'-9,000'
5000'-7000'
3000'-5000'
2000'-3000'
1000'-2000'
0'-1000'
Ocean
Elevation in Feet
Scale 1:2,000,000
Depression Below 0
Hypsometry
(Topographic Relief)
ERITREA
SUDAN
DJIBOUTI
Djibouti
Dejen
Project Road
Debre Markos
Goha Tsiyon
Addis Ababa
Addis Ababa
Alemgena
ETHIOPIA
SOMALIA
KENYA
0
100km
Kilometres
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Abbreviations

Authorities & Agencies

AASHTO	American Association of State Highway and Transportation Officials
AFDB	African Development Bank
ASTM	American Society for Testing and Material
DAC	Development Assistance Committee
DFID	Department for International Development
ECA	Economic Commission for Africa
EMS	Environmental Monitoring and Safety Branch
EPA	Environmental Protection Authority
ERA	Ethiopian Roads Authority
EU	European Union
IDA	International Development Association
JICA	Japan International Cooperation Agency
NGO	Non Governmental Organization
RRA	Rural Road Authority
TRL	Transport Research Laboratory

Others

AADT	Annual Average Daily Traffic
ADLI	Agricultural Development-Led Industrialization
B	B (Live load)
B/D	Basic Design
BHN	Basin Human Needs
CBR	California Bearing Ratio
cm	Centimeter
cm^2	Square centimeter
DBST	Double Bituminous Surface Treatment
$	Dollar
Ec	Young's modules of concrete
EIA	Environmental Impact Assessment
ERP	Emergency Recovery Program
Es	Young's modules of steel
Esp	Modules of elasticity
GDP	Gross Domestic Product
GNI	Gross National Income
HB	HB (Live load of BS5400)
HIV	Human Immunodeficiency Virus
HWL	High Water Level
I	Coefficient of impact
I-PRSP	Interim Poverty Reduction Strategy Paper
Km	Kilometer

Km^2	Square kilometer
Km/h	Kilometer per hour
LWL	Low Water Level
m	Meter
M	Million
m^2	Square meter
m^3	Cubic meter
m^3/s	Cubic meter per Second
MSL	Mean Sea Level
N	N-value or Number of wheel load application
n	Number of Ratio of Es to Ec
N/ mm^2	Newton force per square millimeter
KN/ mm^2	Kilo Newton force per square millimeter
%	Percent
ϕ	Diameter
PRSP	Poverty Reduction Strategy Paper
ODA	Official Development Assistance
PAPs	Project Affected Persons
PC	Pre-stressed Concrete
RC	Reinforced Concrete
RSDP	Road Sector Development Program
σck	Allowable stress of concrete
σsa	Allowable stress of steel bar
SN	Structural Number
WID	Woman in Development

SUMMARY

The Government of the Federal Democratic Republic of Ethiopia (or, GOE) has been focusing on improving its national road network in order to connect existing and potential agricultural production areas and industrial areas with markets as a major component of its development policy. However, the country's approximately 4,000km of paved road accounts for only about 12% of the nation's total road length and those roads have deteriorated due to a lack of maintenance. In order to cope with this situation, the GOE established a Road Sector Development Program (RSDP) in 1996 that set as its goal for the next 10 years the restoration of 60% of the total road network's surface to good condition.

The Project road is a part of the Northwest Trunk Road and starts from Addis Ababa and extends to the border with Eritrea, passing through the country's largest agricultural area (i.e. Oromia, Amhara, and Tigray), and is important for the following reasons:

- Transportation of agricultural products to Addis Ababa.
- Transportation of daily necessities from Addis Ababa to the Amhara area.
- Transportation of petrol products from Sudan to Ethiopia.
- Transportation of daily necessities from Ethiopia to Sudan.

Furthermore international traffic will increase with the improvement of the Northwest Trunk Road, as it is part of the Trans-East African Highway, which is being promoted by the ECA (Economic Commission for Africa). Given the importance of the road, its entire length has been targeted for improvement as part of the RSDP. In 1996, the GOE conducted a detailed design study from Addis Ababa to Debre Markos (L=288.5km) with its own funding, and then requested the implementation of a Grant Aid Project by the Government of Japan (or, GOJ). In response to this request, the GOJ conducted a basic design study from Addis Ababa to Goha Tsiyon (L=182.5km) in 1997 and the Grant Aid Project has been ongoing since 1998, which is scheduled for completion in FY2004.

On the other hand, the existing Abay Bridge (L=207m) on the Northwest Trunk Road is superannuated, and there are restrictions on traffic to prevent it from collapsing. That is, only one vehicle can use the bridge one at a time, resulting in the bridge becoming a serious traffic bottleneck. Given this situation, the GOE also requested assistance from the GOJ in 2001 to replace Abay Bridge. This request, which is being dealt with by the Study, includes improvement of the road from Goha Tsiyon to Debre

Markos (L=106km). Note that based on the findings of a preliminary survey executed in March 2003, the GOJ suggested that the following components comprise the Project scope:

- Reconstruction of the Abay Bridge (207 m).
- Rehabilitation of the road section between Goha Tsiyon and Dejen (approximately 39 km in length).
- Improvement work on the road section between Dejen and Debre Markos (approximately 67 km in length) consisting of the following:
    a) Spot road improvement (approximately 4 km in length) at sections troubled by flooding (around Ieda River) and loose subgrade materials (black cotton soil), etc.
    b) Replacement of 8 small bridges (22.6 m in length on average) suffering from extreme deterioration.
    c) Procurement of construction materials necessary to maintain the remaining sections of road between Goha Tsiyon and Debre Markos.

In response to the survey result, the GOJ dispatched a basic design study team for a period from October 26 to December 10, 2003 to Ethiopia, which conducted field survey and discussions with their Ethiopian counterparts. Based on the discussion through the study, the road improvement section was modified between Goha Tsiyon and Dejen including construction of a new Abay Bridge.

After return to Japan, the study team performed in-depth studies further concerning road alignment, road structure, pavement type, bridge location, bridge length, bridge type and construction method on the basis of in-situ study results. The team performed the basic design of road and bridge, calculation of the approximate work quantity, development of the implementation plan and estimation of the approximate project cost. During a period from May 16 to 29 2004, the study team held a briefing of the basic design and compiled the result in the basic design study report.

The basic construction of road and new Abay Bridge is outlined below on the basis of this basic design study results.

Contents of Road Improvement Work

Type of Facilities		Road (National Road No.3) Oromia Region Goha Tsiyon ～Amhara Region Dejen
Contents of Project	Road Length	Goha Tsiyon – Dejen: 40.60km (Length confirmed in basic design study)
	Width	Type (1) Shoulder: 1.5m＋Carriageway: 3.5m x 2＋Shoulder: 1.5m = 10.0m Type (2) Shoulder: 0.5m＋Carriageway: 3.5m x 2＋Shoulder: 1.5m = 9.0m Type (3) Shoulder: 0.5m＋Carriageway: 3.5m x 2＋Shoulder: 0.5m = 8.0m Type (4) Dejen Town (Town Center): Shoulder: 2.5m＋Parking Lane: 3.5m＋Carriageway: 3.5m x 2＋Parking Lane: 3.5m＋Shoulder: 2.5m=19.0m Type (5) Dejen Town (Out of Town Center): Shoulder: 2.5m＋Carriageway: 3.5m x 2＋Shoulder: 2.5m=12.0m
	Earthworks	(1) Cut 1. Hard Rock: 22,380m3, 2. Weathered Rock: 33,150m3, 3. Soil: 204,150m3, Total: 259,680m3 (2) Embankment: 199,270m3
	Pavement	Section (1)-1 (CBR5): Surface (50mm)＋Base (350mm)＋Subbase (100mm) Section (1)-2 (CBR5): Surface (50mm)＋Asphalt Stabilization (50mm)＋Base (250mm)＋Subbase (100mm) Section (2) (CBR33): Surface (50mm)＋Asphalt Stabilization (50mm)＋Base (150mm) Section (3)-1 (CBR7): Surface (50mm)＋Base (300mm)＋Subbase (100mm) Section (3)-2 (CBR7): Surface (50mm)＋Asphalt Stabilization (50mm)＋Base (200mm)＋Base (100mm) Section (4)-1 (CBR15): Surface (50mm)＋Base (300mm) Section (4)-2 (CBR15): Surface (50mm)＋Asphalt Stabilization (50mm)＋Base (200mm)
	Drainage	(1) Pipe Culvert (D900-1200): L=1,241m (2)-1: Side Ditch (U Shaped) (600x600): L=43,120m (2)-2: Side Ditch (Stone Masonry Type): L=4,600m
	Others	Retaining Wall, Guard Post, Traffic Sign, Widening of Narrow Bridge

Contents of New Abay Bridge Construction Work

Type of Facilities		New Abay Bridge Amhara Region
Contents of Project	Type of Bridge	Simple RC 2 Room Box Girder Bridge＋PC3 Span Continuous Box Girder Extradosed Type Bridge
	Length	18m＋ (70m＋145m＋70m) = 303m
	Width	1.0m (Shoulder)＋2×3.5m(Carriageway)＋1.0m (Shoulder) = 9.0m
	Construction	(1) Foundation: Spread Foundation (All) (2) Substructure: Rigid Frame Type (A1), Wall Type (P1), V-Type (P2, P3), Reversed T-Type (A2) (3) Superstructure: Simple RC 2 Room Box Girder Bridge＋PC3 Span Continuous Box Girder Extradosed Type Bridge (4) Auxiliary Works: Handrail (Wall Type), Expansion Joint, Drainage Facilities (5) Bridge Surface Work: Asphalt Pavement (t=5cm)
	Others	Revetment: 1 set (Stone Masonry/Around P2 & P3)

If the Project were implemented under Japanese Grant Aid Program scheme, the implementation schedule would consist of some 8 months of the detailed design phase, and some 42.5 months of construction phase including tendering process. The approximate project costs is expected to be 5,085 million Japanese Yen, including 5,075 million Japanese Yen borne by Japanese Grant Aid, and 10 million Japanese Yen borne by Ethiopian Government side.

On the other hand, the annual operation and maintenance costs for the road and a new Abay bridge is estimated to be some 430 thousand Birr (some 5.6 million Japanese

Yen), amounting to about 1.5 % of the budget currently allocated to the Alemgena District Office. In addition, as no more than daily inspection & cleaning-up tasks, small-scale repair works, and the repair works held in every ten years like overlaying of road & bridge pavement, and repair of revetment is included in the operation and maintenance works, the requirement for technical skill is not so high. Thus, it can be said that the Ethiopian Government can afford to handle these kinds of operation and maintenance works fully.

Direct and indirect effects of this project are as shown in the table below.

1) Direct Effects

Direct Project Effects

Present status & issues	Proposed countermeasures	Expected effects & degree of improvement
1) Only 1 vehicle can use the existing Abay Bridge one at a time because it is superannuated.	New bridge to be constructed away from the existing bridge on the upstream side. Existing bridge will be utilized for pedestrians.	New bridge will eliminate traffic bottleneck.
2) Narrow width, steep gradient & sharp curves of the existing road restrict the flow of traffic.	Improvement of road alignment & widening will be implemented. Concrete guard post shall be installed on the gorge side.	Traffic accidents will be greatly reduced. Travel time will be shortened.
3) Road structure is easily damaged because of DBST or cold asphalt paving.	Hot asphalt pavement (with an asphalt stabilization layer for high priority trouble spots) will be adopted for the carriageway. Shoulder shall be simply paved (DBST) to protect road structure against erosion from surface runoff.	Strengthening of pavement structure will ensure smooth traffic flows & access throughout the year.
4) Road structure is damaged by malfunctioning or inadequate drainage facilities (e.g. facilities too small or clogged)	New facilities with adequate scale & easy to maintain to be installed to prevent flowing of rainwater onto road structure.	Proper treatment of rainwater flows on slopes & road surface to minimize damage to road structure.
5) Rock falls, avalanches, slope failures block road frequently.	Loose rocks will be removed. Groundwater drain holes will be installed to accelerate groundwater drainage.	Safe travel & access throughout the year will be secured.

2) Indirect Effects

Indirect Project Effects

Present status & issues	Proposed countermeasure	Expected effects & degree of improvement
1) Due to poor road conditions and slow travel time, physical distribution via land transport is severely restricted. Presently, trunk roads in Ethiopia only play an important roleas access for importing crude oil from Sudan and exporting grain to Sudan, as well as for the domestic transportation of grain to Addis Ababaand the domestic transportation of bus passengers.	Project road to be improved using the same specifications for the road sections being improved on either end of the Project road.	This trunk road is a part of the East African Highway. Therefore, the Project will not only impact Ethiopia but also neighboring countries.
2) Access to education, job opportunities and medical care is poor and is one of the reasons for high illiteracy & death rates.	Road improvement & replacement of the Abay Bridge will be carried out.	By providing road access to schools and medical facilities, the likelihood of children attending school and residents reaching medical facilities in a timely fashion increases; thereby, reducing illiteracy and death rates.
3) The lack of jobs is chronic.	Consider the employment of local residents in implementing simple tasks for the project road improvement works.	Creation of an income generation opportunity for local residents.

The GOE should undertake adequate maintenance work of the project road and bridge after they are open to the public in order to ensure that these structures produce the maximum intended benefits. Especially, efficient implementation of routine maintenance work (i.e., daily inspection and light repairs of pavement, shoulders, drainage facilities, cut slopes and traffic safety facilities) is important to maximize the life of a road structure. Note that the cooperation of local residents in carrying out this work is important. Also, the regulation of overloaded vehicles should be strengthened, since such vehicles seriously damage the pavement structure.

Regarding the new Abay Bridge, it should not experience any damage or problems in the near future. However, routine maintenance work such as the daily inspection and cleaning of drainage facilities and expansion joints should be carried out. Furthermore, inspection of the whole bridge structure, including the stone masonry around piers and partial repairs, should be executed at the end of each rainy season. This work is effective for maximizing the life of the bridge. The use of inspection manuals and inspection sheets will also promote the efficiency and quality of maintenance work.

In conclusion, because significant benefits can be expected from the Project, it is highly recommended that it be implemented under the Japan Grand Aid Cooperation Program. Furthermore, in regards to management and maintenance, the Ethiopian Government seems able to secure the necessary personal and financial resources

therefore ensuring sustainability. However, it is important for the Ethiopian government to consider the following matters in order to implement the Project in a more effective manner:

(1) Establishment of a system to clean road drainage facilities

Accumulated sediment in drains such as side gutters and ditches will cause water to overflow onto road surfaces that will speed-up the deterioration of pavement. Thus, the cleaning of road drainage facilities is very important for preventing pavement deterioration. On the other hand, it is difficult for only the staff of the Ethiopian Roads Authority to undertake all of the drainage cleaning work for the 40km Project road. Therefore, it is advisory to take the following actions:

> Drainage cleaning should be implemented with the cooperation and participation of local residents along the Project road. As for section demarcation, those sections with large residential populations shall have drainage cleaned by the local residents, while the Ethiopian Roads Authority would handle drainage for the other sections . It is advisable to allocate part of the maintenance budget for remuneration to engage local residents. This would also promote income generation opportunities for local residents.

(2) Regulation against overloaded vehicles

One major cause of pavement and structure deterioration is overloaded vehicles. Therefore, it is necessary for the Alemgena District Office to install a facility for weighing vehicles and to regulate heavy vehicles.

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CHAPTER 1

BACKGROUND OF THE PROJECT

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The Project road is a part of the Northwest Trunk Road and starts from Addis Ababa and extends to the border with Eritrea, passing through the country's largest agricultural area (i.e. Oromia, Amhara, and Tigray), and is important for the following reasons:

- Transportation of agricultural products to Addis Ababa.
- Transportation of daily necessities from Addis Ababa to the Amhara area.
- Transportation of petrol products from Sudan to Ethiopia.
- Transportation of daily necessities from Ethiopia to Sudan.

Furthermore international traffic will increase with the improvement of the Northwest Trunk Road, as it is part of the Trans-East African Highway, which is being promoted by the ECA (Economic Commission for Africa). Given the importance of the road, its entire length has been targeted for improvement as part of the RSDP. In 1996, the Ethiopian Government conducted a detailed design study from Addis Ababa to Debre Markos (L=288.5km) with its own funding, and then requested the implementation of a Grant Aid Project by the Government of Japan. In response to this request, the Government of Japan conducted a basic design study from Addis Ababa to Goha Tsiyon (L=182.5km) in 1997 and the Grant Aid Project has been ongoing since 1998, which is scheduled for completion in FY2004.

On the other hand, the existing Abay Bridge (L=207m) on the Northwest Trunk Road is superannuated, and there are restrictions on traffic to prevent it from collapsing. That is, only one vehicle can use the bridge one at a time, resulting in the bridge becoming a serious traffic bottleneck. Given this situation, the Ethiopian Government also requested assistance from the Japanese Government in 2001 to reconstruct Abay Bridge. This request, which is being dealt with by the Study, includes improvement of the road from Goha Tsiyon to Debre Markos (L=106km). Note that based on the findings of a preliminary survey executed in March 2003, the Japanese Government suggested that the following components comprise the Project scope:

- Reconstruction of the Abay Bridge (207 m).
- Rehabilitation of the road section between Goha Tsiyon and Dejen (approximately 39 km in length).
- Improvement work on the road section between Dejen and Debre Markos (approximately 67 km in length) consisting of the following:
  a) Spot road improvement (approximately 4 km in length) at sections troubled by flooding (around Ieda River) and loose subgrade materials (black cotton

soil), etc.

b) Replacement of 8 small bridges (22.6 m in length on average) suffering from extreme deterioration.
c) Procurement of construction materials necessary to maintain the remaining sections of road between Goha Tsiyon and Debre Markos.

Based on the discussion through the basic design study, the road improvement section was modified between Goha Tsiyon and Dejen including construction of a new Abay Bridge.

The Study will review the feasibility of the Project proposed in the preparatory survey, and compare its economic and technical feasibility with other donor projects. The Study will also examine the content and scale of the Project as part of a Japanese Grant Aid scheme in order to implement an appropriate basic design.

CHAPTER 2

CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Basic Concept of the Project

Based on the findings of a preliminary survey executed in March 2003, the Japanese Government suggested that the following road components be included in the Project scope:

- Reconstruction of the Abay Bridge (207 m)
- Rehabilitation of the road section between Goha Tsiyon and Dejen (approximately 39 km in length)
- Improvement work on the road section between Dejen and Debre Markos (approximately 67 km in length) consisting of the following:
  a) Spot road improvement (approximately 4 km in length) at sections troubled by flooding (around Ieda River) and loose subgrade materials (black cotton soil), etc.
  b) Replacement of 8 small bridges (22.6 m in length on average) suffering from extreme deterioration.
  c) Procurement of construction materials necessary to maintain the remaining sections of road between Goha Tsiyon and Debre Markos.

As for the section between Dejen and Debre Markos, the above scope was suggested because the road surface condition is relatively good except for 4 km of problem section. In discussions concerning the Project scope, which was held after completion of the actual site survey, the Ethiopian side strongly requested full-scale improvement of the section between Dejen and Debre Markos (about 67km). In addition, the JICA Study Team recognized that it was advisable to re-examine the necessity of improving the section between Dejen and Debre Markos as the results of the site survey, which indicated that the amount of black cotton soil was greater then that described in the Terms of References for the Study and that the emergency reconstruction of small bridges was insufficient.

The above was recorded in the minutes and brought back to Japan for further consideration. However, it was decided to remove the Dejen-Debre Markos component from the final request and the Ethiopian side has consented with this decision. The components for achieving the objective as well as the goals of the Project and RSDP are:

- Construction of a new Abay Bridge (207m).
- Rehabilitation of the road section between Goha Tsiyon and Dejen using asphalt pavement.

Given that the existing Abay Bridge is superannuated, the construction of a new Abay Bridge will minimize the risks of travelers and residents being cut off from the capital as well as strengthen transport capacity. Furthermore, rehabilitation of the Project road to an all-weather road will contribute to ensuring access throughout the year and shorten travel times and reduce vehicle operating costs.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

(1) Roads

1) Concept Regarding Natural Conditions

a) Rehabilitation needs arising from precipitous terrain (escarpments, sharp curves)

The vast majority of the Project road passes through the precipitous Abay gorge, and the characteristics of the current road and its natural conditions can be summed up as follows:

- Numerous escarpments and sharp curves (average gradient 7.5%, 22 points with a curve radius of 50 m or less)
- Steep cliffs on both the mountain and gorge side of the Project road
- Frequent and torrential rainfall during the rainy season (mid-June to Mid-September)

As a result of these harsh topographical and natural conditions, the following kinds of road structural damage and traffic safety problems exist:

- Fast-flowing rainwater during the rainy season erodes the road structure and damages the road.
- Frequent vehicle braking due to the steep gradient of the Project roaddamages the road surface.
- Sharp curves sometimes result in vehicles going over or a cliff.

In response to the above problems, it is intended to carry out the following road rehabilitation work:

I. Adoption of a road structure resistant to erosion caused by rainwater runoff as well as to frequent vehicle braking.
II. Provision of drainage facilities with sufficient capacity to prevent erosion by rainwater.
III. Provision of sufficient road width and sight distance, together with the installation of safety facilities, to improve road safety.

b) Countermeasures against falling rock, slope failure and landslides

A site survey found the Project road to be at risk from falling rock, slope failure, and landslide in various places. Since it would be prohibitively expensive to deal with all the problem spots, the following countermeasures shall be implemented for selected high-priority areas only:

- Removal of loose rock at risk of falling.
- Alteration of slope gradients and installation of small retaining walls where slope failure and small rock falls are likely.
- Removal of groundwater via horizontal boreholes to reduce the risk of landslides.

In regards to dealing with landslides, since the causes are not fully understood further site surveys, and countermeasures when possible, will be carried out during the detailed design stage.

c) Consideration regarding the impact of the rainy season

According to local meteorological data, the rainy season in the Project area lasts approximately 3 months from mid-June to mid-September, during which time approximately 70% of the annual rainfall of 1300~1600 mm falls. Since this will place constraints on the road works, in particular earthworks, paving works and drainage works, this needs to be properly reflected in the work process.

d) Environmental impact

Since there have been no confirmed sightings of the rare Gedara baboon around the Project road, no special consideration is required concerning wildlife. However, since rare flora have been confirmed in the area, it will be necessary to transfer and replant such flora.

2) Concept Regarding Socioeconomic Conditions

a) Securing the northwest arterial road

Since the Project road is an important link connecting the capital Addis Ababa to neighboring Sudan and the northern grain belt, and the only alternative route is approximately 200 km downstream from Abay Bridge, it will be difficult to stop traffic in order to implement road rehabilitation work. Moreover, the Project road passes through Abay gorge and is surrounded by steep cliffs on both sides and therefore offers no possible diversion for traffic during the works. Accordingly, road rehabilitation work shall basically be implemented on one side of the road with traffic passing on the other side.

b) Consideration regarding roadside communities

Along the Project route starting at Goha Tsiyon (not including the urbanized area) and ending at Dejen (including the urbanized area), the communities of Filcrik Village and Crula are located at points No. 9 +200 and No. 32 respectively. Dejen, which developed as a stopover for long-distance trucks, is a reasonably sized town with a population of around 11,000. In light of this, consideration shall be given to widening the road shoulder near Dejen so that it can serve both as a sidewalk and as parking space within the road reserve. Moreover, consideration shall also be given to traffic safety by providing pedestrian crossings and traffic safety signs, etc. As for Filcrik Village since it also has a high concentration of population, the Ethiopian side has requested that bus stop facilities be provided. Therefore, bus-parking strips will be provided on both sides of the road in the center of the village.

c) Resident relocation, land acquisition and transfer of public facilities

Since it is intended to fully utilize the existing road to execute road rehabilitation, resident relocation, land acquisition and the transfer of public facilities will be minimized

3) Concept Regarding Construction Conditions

a) Utilization of Ethiopian national highway design standards

Based on the AASHTO and British Standards, Ethiopia has the following design manuals:

- Geometric Design Manual (Draft) 2001
- Pavement Design Manual (Draft) 2001
- Drainage Design Manual (Draft) 2001

These manuals have been prepared taking into consideration the natural and road conditions of Ethiopia. However, they do not necessarily cover all aspects required for road design. In terms of content, although these manuals are still in the draft stage and have some room for improvement regarding geometric structure, they shall be adhered to when designing the Project road. In cases where these standards are unclear or inadequate, the local side has agreed to apply AASHTO and Japanese standards. Note, however, that the strict application of these standards to sections of the Project road with sharp curves and escarpments would entail massive rehabilitation beyond the scope of Japan's Grant Aid Scheme. Therefore, for these sections of road, a lower standard in accordance with the said manuals will be applied.

b) Concept regarding procurement of construction equipment and materials

Since it is intended to maximize use of local equipment and materials, major materials shall be procured in Ethiopia. However, considering that it is difficult in terms of availability, cost and quality to locally procure construction machinery, in particular pavement-related machinery, such items as a rule shall be procured from Japan or a third country.

Moreover, since the Project road is some 200 km away from the capital of Addis Ababa, it is not possible to purchase locally crushed stone, sand and asphalt compound. Accordingly, the local contractor shall secure a plant and produce these materials independently.

4) Concept Regarding Utilization of Local Contractors

The construction industry in Ethiopia has failed to acquire sufficient competitiveness largely due to the socialist administration banishing major private sector contractors after it came to power in 1991. As a result, various donors are striving to nurture the local private sector construction industry. In the field of road works, too, local contractors are able to perform small-scale road works and maintenance. However, they have no experience with large-scale paving works entailing the use of heated asphalt like that planned in the Project. Therefore, the utilization of local firms will probably be limited to subcontractors and the supply of laborer and materials. However, from the viewpoint of technology transfer, Japanese contractors will be encouraged to utilize local construction firms as much as possible.

5) Concept Regarding Operation and Maintenance Capacity of Implementing Agencies

The agency in charge of maintaining the Project road is the Alem Genha Regional Office, which is a local branch office of the ERA. This agency implements daily and periodic maintenance and possesses ample technical capacity to handle most work except for the maintenance of heated asphalt. Moreover, a budget of US$ 310,000 (2002/2003) is allocated to road maintenance for the Project road, which is equivalent to approximately 10% of the total maintenance budget of the Alem Genha Regional Office. This indicates that much effort is being put into maintaining the Project road. In addition, the UK's DFID is planning to carry out staff training regarding maintenance requiring heated asphalt. It is anticipated that the local side will therefore possess sufficient technical capacity to maintain roads using heated asphalt by the end of the Project.

Note, however, that numerous water collection inlets and lateral drains were found blocked by sediment in this survey. It will be necessary therefore to propose a system whereby roadside residents can be mobilized in order to implement daily maintenance flexibly. In addition, care shall be taken to design drainage structures that can be easily maintained.

6) Concept Regarding Setting of the Facilities Grade

a) Current and design traffic volume

Data concerning current traffic volumes, which will provide the basis for calculating future traffic volumes and the basic design of road rehabilitation, have been obtained from a traffic forecast for Goha Tsiyon ~ Dejen Road (2003) from the ERA (see Table 2.2.1).

I. Current traffic volume

Table 2.2.1 Current Traffic Volume

Type of Vehicle	Design AADT (Y2003)
Cars	76
Buses	46
Trucks	191
T-Trailers	47
Total	360

II. Future traffic volume

Traffic volumes shall be projected 20 years into the future and serve as a design reference point in accordance with AASHTO, which is one of the basis for ERA's design criteria. The rate of increase in traffic volume, which is used for design purposes, is as indicated below.

Table 2.2.2 Rate of Increase in Future Traffic Volumes

Type of Vehicle	Phase I,II[*1]		Phase III[*2]					
	- 2000	- 2020	2004-2010			2011-2023		
			Low	Middle	High	Low	Middle	High
Car	1%	4%	6%	7%	8%	5%	6%	7%
Buses	1%	4%	6%	7%	8%	5%	6%	7%
Trucks	1%	6%	6%	7%	8%	5%	6%	7%

*1: Project for Rehabilitation of Trunk Road Phase I & II (Addis Ababa – Goha Tsiyon)
*2: Project for Rehabilitation of Trunk Road Phase III (Goha Tsiyon - Dejen)

Assuming the Project road will commence service from 2009, traffic volume in the next 20 years (until 2028) will be as indicated below. Concerning the rate of increase from 2024 onwards, it is assumed to be half the rate presented by the ERA.

Table 2.2.3 Traffic Volume for the Project Road in 2028

Case	Traffic volume in 2028 (vehicles/day)			
	Car	Buses	Trucks	Total
Low	244	148	763	1155
Middle	289	174	901	1,364
High	392	237	1,224	1,853

b) Geometric standards

Road geometric standards are basically dependent on road classification, which is determined by daily traffic volume and the designated design velocity. However, since much of the Project road passes through a gorge comprising escarpments with a gradient of 15% or more and sharp curves with a turning radius of around 15 m, it is difficult to implement a major realignment. Accordingly, rehabilitation work shall basically be implemented utilizing the existing road. For this reason, rather than applying a set design velocity or geometric structure criteria to the whole Project road, a geometric structure with a minimum design velocity of 30 km/h (in unavoidable circumstances 20km/h) shall be applied. Tables 2.2.4, 5, and 6 indicate the Ethiopian National Highway Geometric Structure Standards.

Table 2.2.4 Ethiopia National Highway Geometric Standards

					Escarpment							Urban/Peri-Urban						
Function	Design Standard	Design Traffic Flow (AADT)	Surface Type	Carriageway Width	shoulder Width	Design Speed	Min. Horizontal Curve Radius	Max. desirable Gradient	Max. Absolute Gradient	Right of Way	Footway	Parking Lane	Design Speed	Min. Horizontal Curve Radius	Max. desirable Gradient	Max. Absolute Gradient	Right of Way
Unit				m	m	km/h	m	%	%	m	m	m	km/h	m	%	%	m
Trunk	DS1	10000～15000	Paved	Dual2*7.3	0.5～2.5	70	175	6	8	50	2.5	3.5	50	85	6	8	50
	DS2	5000～10000	Paved	7.3	0.5～2.5	70	175	6	8	50	2.5	3.5	50	85	6	8	50
	DS3	1000～5000	Paved	7	0.5～1.5	60	125	6	8	50	2.5	3.5	50	85	6	8	50
	DS4	200～1000	Paved	6.7	0.5	50	85	7	9	50	2.5	3.5	50	85	7	9	50
	DS5	100～200	Unpaved	7	0	40	50	7	9	50	2.5	3.5	50	85	7	9	50
Feeder	DS6	50～100	Unpaved	6	0	30	30	10	12	30	2.5	3.5	50	85	7	9	40
	DS7	30～75	Unpaved	4	1	30	30	10	12	30	-	-	50	85	7	9	30
	DS8	25～50	Unpaved	4	0	30	30	10	12	20	-	-	50	85	7	9	20
	DS9	0～20	Unpaved	4	0	20	15	13	15	20	-	-	40	50	7	9	20
	DS10	0～15	Unpaved	3.3	0	20	15	13	15	20	-	-	40	50	7	9	20

Table 2.2.5 Road Width Regulations in Ethiopia

Road Functional Classification	Design Standard	Design Traffic Flow (AADT)*	Width (m)					
			Escarpment		Town Section			
			Carriageway	Shoulder	Shoulder	Parking	Footway	Median
TRUNK	DS1	10000–15000	Dual 2 x 7.3	0.5 –2.5	N/a	3.5	2.5	5.0
LINK	DS2	5000–10000	7.3	0.5 –2.5	N/a	3.5	2.5	Barrier
	DS3	1000–5000	7.0	0.5 –1.5	N/a	3.5	2.5	N/a
MAINACCESS	DS4	200–1000	6.7	0.5	N/a	3.5	2.5	N/a
COLECTORS	DS5	100– 200	7.0	0.0	N/a	3.5	2.5	N/a
FEEDER	DS6	50–100	6.0	0.0	N/a	3.5	2.5	N/a
	DS7	30–75	4.0	1.0(earth)	N/a	N/a	N/a	N/a
	DS8	25–50	4.0	0.0	N/a	N/a	N/a	N/a
	DS9	0–25	4.0	0.0	N/a	N/a	N/a	N/a
	DS10	0–15	3.3	0.0	N/a	N/a	N/a	N/a

Table 2.2.6 Geometric Standards for the Project Road

(Gorge) (8% Super Elevation)

Design Element	Unit	Goha Tisyon – Dejen Escarpment	Goha Tisyon – Dejen Escarpment
Design Speed	km/h	30 (Target)	20 (Absolute)
Min. Stopping Sight Distance	m	30	20
Min. Passing Sight Distance	m	75	50
% Passing Opportunity	%	0	0
Min. Horizontal Curve Radius	m	30	15
Side Friction Factor (f)		0.18	0.18
Transition Curves Required*		No	No
Max. Gradient (desirable)	%	10	13
Max. Gradient (absolute)	%	12	15
Minimum Gradient	%	0.5	0.5
Maximum Superelevation	%	8	8
Crest Vertical Curve	k	3	2
Sag Vertical Curve	k	4	2
Normal Crossfall	%	2.5	2.5
Shoulder Crossfall	%	4.0	4.0
Right of Way	m	Vary	Vary

*: The Japanese standard is adopted because the ERA draft standard does not contain the relevant regulation.

c) Road classification over the Project road

Since the Project road is composed of sections with differing topographical conditions and road functions, differing geometric structures and road width shall be applied based on function.

d) Width

In view of the differing road functions mentioned above, width is examined separately for escarpment and urban sections.

I. Basic cross section for escarpment sections

Various factors determine road width. A report by the British TRL states that the following items are important for determining carriageway width:

- Traffic volume (As a rule a carriageway width of 3.5 m is required for 1000 vehicles/day.)
- Road grade (Roads are classified according to their function in the road network.)
- Vehicle dimensions (Sections frequented by large trucks may require widening.)
- Travel speed (It is necessary to widen the road in line with faster travel speeds.)

Concerning the future traffic volume of the Project road, it will differ depending on the year, which will have an impact on road width. The procedure for determining Project road width is indicated in Figure 2.2.1.

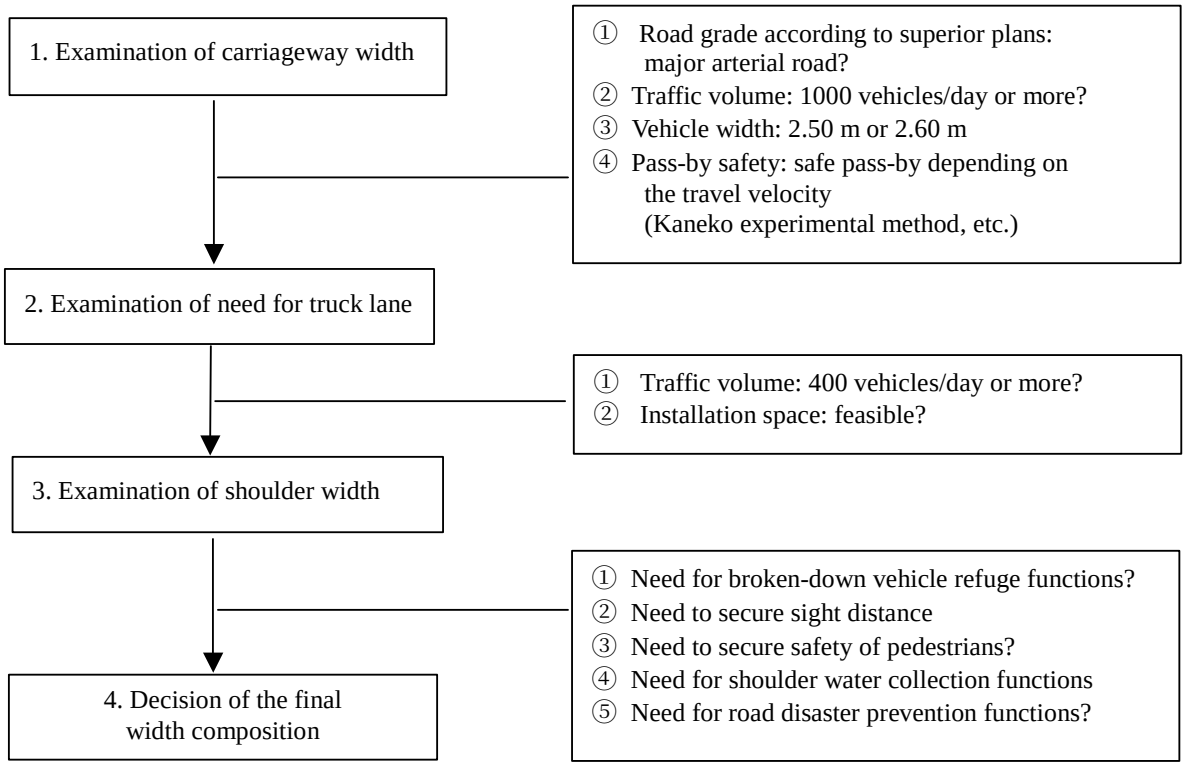
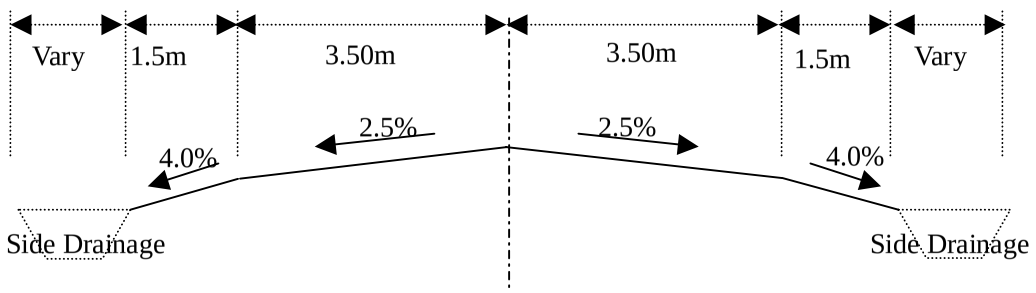
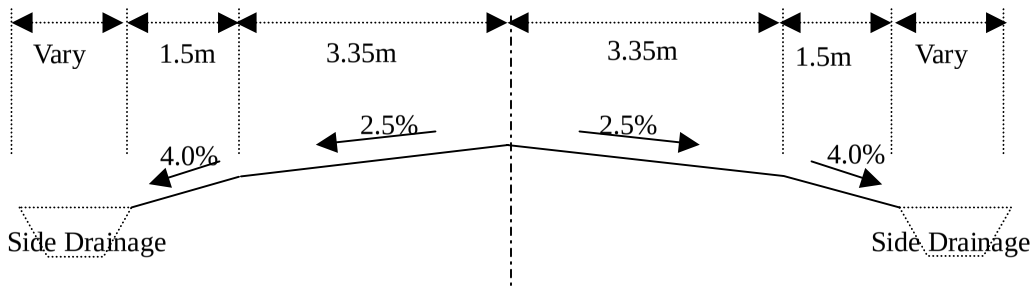


Figure 2.2.1 Examination Flow for Escarpment Road Width

As a result of conducting a comparative examination shown in Table 2.2.7, basic road widthon escarpment sections was determined.

Table 2.2.7 Comparison of Road Width for Escarpments

			First Proposal: Carriageway Width 3.5 m		Second Proposal: Carriageway Width 3.35 m		Notes
Outline drawing							
Summary			In consideration of road grade, vehicle dimensions and overtaking, etc. based on the superior Road Sector Development Plan (RSDP), this proposed road width by the Study Team incorporates compatibility with projects by other donors.		This proposed road width is prescribed in the Ethiopian manual based on the projected traffic volume five years after the start of service according to the basic concept of the Grant Aid Scheme		
(1) Superior plan			Regarded as a main arterial road (road width 3.5 m) in the RSDP	◎	Regarded as a main arterial road (road width 3.5 m) in the RSDP	△	
(2) Technical factors	Road width determinants	①Traffic volume	Assuming future plans cover 10~20 years into the future, road width of 3.5 m is appropriate to handle traffic volume of 800~1060 vehicles/day in 10 years and 1155~1853 vehicles/day in 20 years.	○	Assuming the traffic volume 5 years after the start of use, this is 630~760 vehicles/day and the road grade is D4 with road width of 3.35 m.	△	The Ethiopian standard and international standards like AASTO, etc. adopt 20 years into the future as the project year.
		② Road grade	The target road is regarded as the northwest arterial road (A3) in the RSDP. Moreover, since DS3 gauge is suggested judging from the above traffic volume, 3.5 m is appropriate.	○	Since the target road is regarded as the northwest arterial road (A3) in the RSDP, 3.35 m is a little too narrow.	△	
		③Traffic safety: passing-by	The average travel speed of large vehicles is 30~40 km/h, and the road width required to enable safe passing-by is 3.30 m minimum. (According to Kaneko experimentation, with a large vehicle content of 80% and vehicle width of 2.60 m).	△	The average travel speed of large vehicles is 30~40 km/h, and the road width required to enable safe passing-by is 3.30 m minimum. (According to Kaneko experimentation, with a large vehicle content of 80% and vehicle width of 2.60 m).	○	
		④Traffic safety: overtaking	According to Ethiopian regulations, it is necessary to install an overtaking lane when traffic volume is 400 vehicles/day or more. If it is not possible to provide a truck lane but the oncoming traffic lane is regarded as the overtaking lane, minimum width of 3.45 m is required.	○	According to Ethiopian regulations, it is necessary to install an overtaking lane when traffic volume is 400 vehicles/day or more. If it is not possible to provide a truck lane but the oncoming traffic lane is regarded as the overtaking lane, minimum width of 3.45 m is required.	×	
	Road shoulder determinants	① Broken-down car refuge	Car breakdowns are frequent. However, since topographical constraints make it impossible to secure refuge area for broken-down vehicles, a wide shoulder is desirable.	○	Car breakdowns are frequent, however, since topographical constraints make it impossible to secure refuge area for broken-down vehicles, a wide shoulder is desirable.	○	
		② Traffic safety	The road has many curves, however, cuttings will improve visibility and therefore lead to better traffic safety.	○	The road has many curves, however, cuttings will improve visibility and therefore lead to better traffic safety.	○	
		③ Pedestrian safety	Since there are many livestock and pedestrians collecting firewood or going to draw water in rural community areas, pedestrian safety can be secured.	○	Since there are many livestock and pedestrians collecting firewood or going to draw water in rural community areas, pedestrian safety can be secured.	○	
		④ Drainage functions	Although side ditches sometimes overflow, road pavement degradation can be prevented because the wide shoulder means that only a small amount of water percolates into the paving.	○	Although side ditches sometimes overflow, road pavement degradation can be prevented because the wide shoulder means that only a small amount of water percolates into the paving.	○	Rainwater erosion prevention based on shoulder paving (DBST)
		⑤ Road disaster prevention	There is risk of slope failure, falling rock, etc. Accordingly, a wide road shoulder is desired to provide room on the mountain side of the road especially.	○	There is risk of slope failure and falling rocks, etc. Accordingly, wide road shoulder is desired to provide room on the mountain side of the road especially.	○	
(3) Other factors		① Compatibility with before and after sections	The plan is compatible with the width of 3.5 m in the first and second phase roads and the IDA section going north from Debre Markos.	○	The plan is not compatible with the width of 3.5 m in the first and second phase roads and the IDA section going north from Debre Markos.	△	
		② Compatibility with projects by other donors	Road width of 3.5 m is adopted in major road projects implemented under IDA, Germany and EU funds.	○	Road width of 3.5 m is adopted in major road projects implemented under IDA, Germany and EU funds.	△	
		③ Ethiopian side's wishes	Since this is a main arterial road according to the superior plan and the target road carries a lot of heavy vehicles, the local side wants 3.5 m.	○	Since this is a main arterial road according to the superior plan and the target road carries a lot of heavy vehicles, the local side wants 3.5 m.	△	
Construction cost (pavement works only)			986million yen (1.03)	△	959 million yen (1.00)	○	
Overall assessment			Considering status as a main arterial road, the fact that traffic volume from the 10th year onwards will exceed 1,000 vehicles/day, the need to secure traffic safety (overtaking, etc.), the need for compatibility with before and after sections and roads by other donors, and the fact that the Ethiopian side has voiced a strong desire, road width composition of 3.5 m carriageway and 1.5 m paved shoulder shall be adopted.	◎	Considering status as a main arterial road, the fact that traffic volume from the 10th year onwards will exceed 1,000 vehicles/day, and the need to secure traffic safety (overtaking on mountain sections, etc.), the need for compatibility with before and after sections and roads by other donors, carriageway width of 3.35 m is slightly inferior to the proposal for 3.5 m.	○	

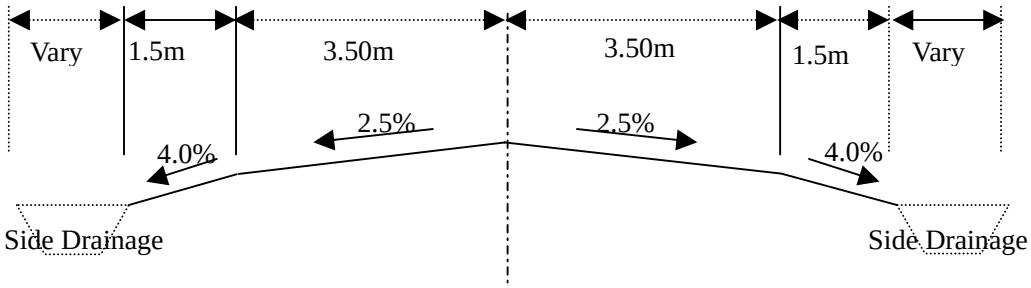


Figure 2.2.2 Escarpment Width Composition

II. Dejen town section

Road width in the urbanized part of Dejen (approximately 2.3 km) shall be the same as that on escarpment sections (i.e. 3.5 m). However, since Dejen contains primary and junior high schools and has many pedestrians, shoulders (2.5 m) with sidewalk functions shall be installed on both sides in order to secure traffic safety. Moreover, since Dejen serves as an overnight stop for long-distance buses and freight vehicles, a 3.5 m parking strip shall be provided between the carriageway and sidewalk over a 900 m section in the center of the town.

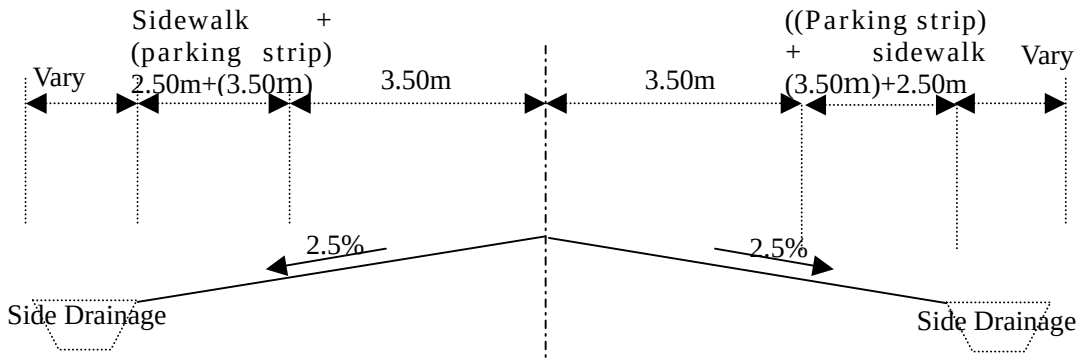


Figure 2.2.3 Standard Cross Section in Dejen

e) Pavement Design Concept

I. Important points in pavement design

On-site surveys revealed that the major causes of pavement damage on escarpment sections are 1) erosion caused by rainwater runoff and 2) excessive braking by heavy vehicles climbing hills at slow speeds and turning on sharp curves. Accordingly, it is necessary to adopt pavement structure that is resistant to these causes of damage. The following table summarizes important pavement design points in consideration of the structural characteristics and traffic characteristics of the Project road.

Table 2.2.8 Important Characteristics and Countermeasures in Pavement Structure

Road Characteristics	Traffic Characteristics	Issues	Countermeasure
- Steep vertical slope imparts greater load on the pavement and makes the pavement more prone to rutting. - There are numerous curves with small curvature, and lateral flow is apt to occur on such sections. - The road is mountainous with steep gradients and sharp curves, and rainwater runoff on such sections is apt to erode the road structure.	- This is a key transportation route; thus it bears a high percentage of large vehicles (approx. 80%).	In execution: - Execution accuracy on steep slopes and curve sections (securing of flatness) - Quality on steep slopes and curve sections (compaction at depth under pavement) - Hardness of aggregate stone (high hardness)	In execution: - Adoption of the execution reference plane (adoption of an asphalt stabilization layer) - Adoption of top 20 aggregate
		After start of service: - Rutting and lateral flows caused by large vehicles on steep slopes and curve sections - Maintenance and repair of such damage	At start of service: - Prevention of early destruction through adoption of an asphalt stabilization layer and top 20 aggregate

II. Thinking regarding design life

As a rule pavement is designed to have a life of 20 years, which was the case for rehabilitation projects and arterial road projects by other donors and adequate maintenance work shall also be implemented after the construction.

III. Pavement specifications and application classifications

In consideration of the issues described in I. above and the harsh road and traffic characteristics that exist on the Project road, resistance to erosion by rainwater and the braking loads of large vehicles shall be enhanced by providing an asphalt stabilization layer (t = 5 cm) on the upper subbase directly under the surface course. However, since the asphalt stabilization layer is more expensive than a graded stone layer, standard specifications (asphalt surface course of t = 5 cm) of the type adopted in the first and second phase projects shall be adopted on the following sections where the road and traffic conditions are relatively sedate.

- An asphalt stabilization layer shall be added on sections with a steep gradient (8% or more) and at sharp curves (R < 50 m).
- Standard pavement specifications shall be adopted in cases where sections other than those described in I. run continuously for 500 m or more.

IV. Shoulder pavement

As was mentioned above, in order to protect the road structure against erosion caused by the surface runoff of rainwater, road shoulders shall be simply paved (DBST).

f) Drainage Facilities

I. Concept for the installation of drainage facilities

Much of the current road damage is due to the malfunctioning of drainage facilities that are blocked up by sediment, etc. Note that it is important to ensure the proper treatment of rainwater flows on slopes and the road surface to minimize road structure damage. In consideration of this, the basic concept for drainage facilities shall be as follows:

- Prevent erosion by stopping rainwater from flowing onto road structures or taking measures to reduce flow velocity.
- Adopt drainage facility structures that are easy to maintain and can be installed one side at a time.
- Prevent slope erosion by carrying out appropriate treatment at flow destinations.

II. Criteria for calculating the scale and structure of necessary drainage facilities

The necessary scale of drainage facilities will basically be determined by the following method according to the ERA design manual.

Table 2.2.9 Drainage Scale Calculation Standard

	"Design Manual - 2001of ERA"	BASIC DESIGN (PHASE III)
Flood runoff calculation method	- Catchment area of 0.5 km2 or less: rational method	Section between Goha Tsiyon ~ Dejen: rational method
	- Catchment area of more than 0.5 km2: unit hydrograph method, etc.	
Design scale (Design Period)	Basic: set the design scale (Design Period) according to 10 classifications of design traffic volume and 9 structural types.	Basis: according to the ERA Design Manual – 2001
		Ordinary Culvert: 25 years
	According to the design traffic volume (2,000~5,000 vehicles/day: DS3):	(Calculate the 3-year and 5-year values together)
	Span < 2 m culverts and pipes: 10 years	Culverts: 25 years
	2 m < span < 6 m culverts: 25 years	Medium-scale bridges: 50 years
	6 m < span < 15 m bridges: 50 years	Large-scale bridges: 100 years
	15 m < span < 50 m bridges: 50 years	
	Span > 50 m bridges: 100 years	
Probability calculation method	Log Pearson III Analysis	Log Pearson III Analysis
Flow capacity calculation method	Basically use Manning's formula	Basically use Manning's formula
Other		1) Concerning the flood flow between Goha Tsiyon ~ Dejen, to the flow estimated by the combined method, add an additional rate arising from sediment inflow.

In cases where the cross-sectional area of flow is insufficient with respect to the flow rate calculated by the above method, or in cases where structures are damaged, lateral drainage structures shall be installed according to the following concept.

- Adoption of precast concrete pipes (ϕ1200 or less)

Rather than adopting in-situ concrete box structures, which entail deep excavation and enable shorter traffic regulation times when it is difficult to secure diversions, precast concrete pipes shall be used and temporary bridges shall be installed during works in order to speed up execution. Maximum pipe diameter shall be limited to ϕ1200 mm in order to minimize the excavation depth, and new pipes shall be added on sections where capacity cannot be secured.

- Adoption of minimum diameter φ900 mm

In the basic design study phase, new or substitute lateral structures were configured to have a minimum diameter of φ900 mm. This adoption was based in consideration of the minimum diameter required for manual cleaning, taking into account the frequent problems concerning the cleaning and maintenance of drainage structures in African countries in recent years. Note that a number of countries has regulations stipulating 900 mm as the minimum allowable diameter. However, because the Ethiopian Government has requested a minimum diameter of 1,000 mm, the detailed design phase shall examine this and re-confirm drainage capacity.

- Adoption of three-way lined ditches

For the drainage facilities design here, stone-lined or concrete-lined ditches shall be adopted in order to prevent erosion by rainwater.

g) Traffic Safety Facilities, etc.

Site surveys revealed cases of vehicles turning over or falling down cliffs on escarpments and sharp curves of the Project road. In view of this, and in order to secure the safety of pedestrians, consideration shall be given to installing the following:

i) Guard posts
ii) Road traffic signs (e.g. speed restriction signs, warning signs)
iii) Demarcation lines (e.g. center lines, roadside lines, pedestrian crossings)

h) Slope Protection Facilities

The Project road at escarpment sections contains numerous points with sharp cliff faces on both sides. However, it will be difficult to improve safety at all danger spots because of the costs involved. Accordingly, slope protection facilities shall be provided at points considered to be at highest risk based on the findings of the site surveys.

Table 2.2.10 Main Countermeasures

Main Slope Protection Works	Contents
① Loose rock removal	Remove loose rocks from mountain cliffs at high risk of collapse.
② Installation of groundwater drain holes	Install groundwater drain holes in areas at risk from landslides in order to accelerate groundwater drainage and reduce the risk of landslides.
③ Installation of gorge blocks	Install gorge blocks at points that currently have no slope drainage facilities and suffer from slope erosion, in order to prevent sediment runoff onto the road.
④ Installation of small rock protection walls	Erect a retaining wall around 2 m high on the roadside at points where there is evidence of minor rock falls, in order to prevent rocks from falling onto the road.

7) Concept Regarding the Works Method and Works Period

a) Setting of an Appropriate Procurement Period

Since Ethiopia is a landlocked country, it is necessary to import equipment and materials at a port in neighboring Djibouti and transport them some 970 km overland to the construction site. Based on the first two work phases, including the procurement time in Japan (approximately 1 month), about a month each is needed for marine transportation (including landing), customs clearance procedures, etc., requiring a total of around 3 to 4 months for materials to reach their destination. When calculating the work period, it will be necessary to appropriately reflect this procurement period in the planning.

b) Impact of the Rainy Season

As was mentioned in the section on the concept regarding natural conditions, the Project area has a 3-month rainy season during which operating rates fall dramatically, and there are some works that cannot be executed during or immediately after the rainy season. Therefore, the rainy season is a major factor in the calculation of the work period. It will be necessary therefore to appropriately reflect the impact of the rainy season in the work processes and scheduling.

c) Impact of Single Side Works on the Works Period

Since diversion routes cannot be secured, it will be necessary to execute works on one side of the road while allowing traffic to pass on the opposite side on escarpment sections. Since this will slow work down, this will also need to be taken into account.

d) Implementation Timing of the Project and Works Period

The rehabilitation work of the second phase arterial road works currently in progress is scheduled to finish in February 2005. From the viewpoint of overall project continuity and efficiency, it is desirable to implement the third phase of rehabilitation work as early as possible. The Ethiopian side is also hoping for the early commencement of this work.

(2) Bridge

1) Natural Conditions & Bridge Planning

Taking into account natural conditions is crucial when building a new bridge. This is particularly true for the Abay River, which is a relatively large river with its head at Lake Tana. In the dry season, the river dries up, while in the rainy season there are heavy flows containing a mix of soil and gravel. Written records state that the water level in the rainy season can be up to 10.0m higher than that in the dry season. Given these circumstances, it is highly important to take this into account when planning the bridge. In addition, since the Project area has also suffered from seismic threats, the Ethiopian Bridge Design Manual (2001) shall be referred to in the bridge's planning. As for wind load and direction, there are no records and a 20m/sec velocity shall be applied based on data from the observatory at Debre Markos.

a) Flooding

There is no record of the existing Abay Bridge of ever being shut down to traffic due to flooding since it was opened to service in 1948. A hearing survey with military guards who have been in charge of bridge's surveillance also reported that there has been no interruption to traffic caused by flooding. It is therefore concluded that the discharge volume and/or flooding in the rainy season of the Abay River will not have a severe impact on the new bridge.

b) Pier location for new bridge

The piers of the new bridge will be located so as not to affect the river current during the dry season. The actual topography of the riverbed, which has been examined in the dry season, indicates a silty sand layer 1.0m thick piled up on the right-hand side of the river, where the piers will be located 1020m – 1021m above sea level and approximately 25m away from the riverbank. On left-hand side of the river, there are sand bars more than 2m thick with boulders and the pier edges will be approximately 5m away the riverbank.

The above-mentioned planning concept will result in the piers of the new bridge being located with the same span arrangement as the existing bridge piers. Note that the piers will be covered by water only for a mere 3 months during the rainy season, from the middle of June to the middle of September. As in the case of the existing piers, it is assumed that the new bridge piers will not impact on the flow of the Abay River. Scouring around piers will, however, be taken into consideration in theplanning of the new bridge.

c) Location of the new bridge

The new bridge shall be located upstream of the existing bridge in order to accommodate the approach to the existing road. The planning of the new bridge shall consider i) the minimum distance required between it and the existing bridge, ii) span arrangement and balance, and iii) geometric alignment.

I. Minimum distance to the existing bridge

It is necessary to consider the standard for the minimum distance between the new and existing bridges, taking into consideration the possibility of the river channelbeing clogged by debris such as trees, soils, stones, etc. during a flood. This will be determined in accordance with the Japanese River Engineering Ordinance. In this analysis a 100-year return period shall be applied, because the Project road is part of the Ethiopian trunk road network and because the Abay Bridge is a large-scale structure (Ethiopian Bridge Design Manual).

- The regulation requires that the reference span length serve as the minimum

distance between the 2 bridges. The reference span length is derived as follows:

L = 20 + 0.005Q

L: reference span length (m)

Q: discharge volume (m3/sec.)=16,599 m3/sec. (Refer to Table 2.2.11)

Accordingly,

L = 20+0.005*16.599=20+83.00=103.0m

The reference span was calculated as being 103.0m in length. This means that the minimum distance between the new and existing bridges shall be at least 103.0m.

- The regulation also requires that the distance between the new and existing bridges be greater than the river's width. Since river width at the existing bridge is 120m, the minimum distance between the two bridges will be greater than this value.

II. Span arrangement and balance

Bridge span arrangement is roughly estimated via pier location and approach run-off. Note, however, that span arrangement and balance is also one of the major factors for determining bridge type and will be considered in the planning of the new bridge.

III. Geometric alignment

In principle, the new bridge shall have a straight alignment and the approach road shall have a curvature less than that of the existing bridge.

d) Environmental conservation

I. Flora preservation

- To minimize felling when the yard and site access roads are prepared.
- To restore topography and to carry out reforestation when construction is completed.
- To involve with local residents, NGO and the Natural Resources Bureau in the event of selection of plants and vegetation to be reforested.
- To clarify beforehand the cost arisen for restoration and reforestation.

II. Fauna preservation

- To pay attention to prevent water pollution of the Abay River in order to preserve aquatic fauna and flora.
- To analysis the actual muddy water and obtain data of the water quality at the detailed design stage in order to settle a quality criteria as monitoring reference.
- To pay attention with the piers not to invade habitat of the Nile Crocodile
- Gelada Baboon, unconfirmed its habitant around objective area

2) On Socio-Economic Basis

A sidewalk will not be installed on the new bridge, since it is planned to have the existing bridge serve as a pedestrian crossing. The Ethiopian government will continue to maintain the existing bridge.

3) Local Standards and the Status of the Construction Industry

a) Ethiopian design standards and their application

In Ethiopia there is a standard bridge text known as the “Bridge Design Manual: 2001” and is based on AASHTO standards. However, not all of the contents have been completely understood nor applied in practice by local bridge engineers, due to a lack of technical education and/or training.

The new bridge project shall apply the “Bridge Design Manual: 2001”. In particular, providing feedback to the Ethiopian Government while using the “Manual” will be a

highly efficient manner in understanding on the contents of the “Manual”.

b) Capacity of local contractors

Ethiopian engineers are well experienced in small-scale conventional RC bridges. On the other hand, large-scale bridges with PC girders have only been introduced in two recent projects. In both projects, foreign contractors were in charge of the construction of the bridges and there was almost no technical transfer to local contractors. The Ethiopian Government is therefore keen on having Japanese technical knowledge and skills regarding bridge engineering transferred to local engineers.

c) Construction market and procurement

I. Construction equipment & machinery

It is well known that cranes are vital in bridge construction. ERA, who is the commissioning entity and beneficiary of the new bridge Project, possesses small-scale equipment and machinery unsuitable for bridge construction.

Vernaro Co., Ltd., who is the sole foreign company registered in Ethiopia among foreign contractors, possesses machinery that can be utilized for road construction, such as a road roller, backhoe, and bulldozers. Five 16-20t class cranes shall also be available for bridge construction, but there is still a lack of equipment. For example, there is no concrete mixing plant. It is therefore suggested that the necessary major machinery be transported from Japan and/or a third country.

II. Construction materials

Construction materials not readily available on the local market shall be imported. Table 2.2.11 indicates the construction materials that can be procured locally. Note that the quality of local materials should be tested prior to usage via sampling.

Table2.2.11 Procurement List of Major Materials

Materials	Local	Japan or a Third Country	Remarks
Cement	○		
Concrete admixture		○	
Reinforcement	○	○	Up to size D25 available locally. Thick diameter type available from Japan.
Pre-stressed wires & bars		○	
Staying Cable		○	
Bituminous materials		○	
Forms	○	○	Timber panel available but at a high cost.
Formwork & scaffolding		○	
Expansion joint		○	
Bearings		○	

d) Employment of Local Contractors

As mentioned in “b) Capacity of Local Contractors”, the fact that local contractors are not technically experienced nor trained in the construction of large-scale structures and/or PC girder bridges, requires careful consideration in regards to employment. It is important therefore to survey in advance the skills of the technicians, such as carpenters, plasterers, electricians, who will work for the local contractors and who reside in the capital. Note, however, that OJT can be highly effective for providing the necessary technical training.

e) Capacity of the Commissioning Entity for Bridge Management and Maintenance

ERA, the commissioning entity, administrates and supervises district offices who are in charge of bridge maintenance. However, a limited budget results in many small and medium size bridges not being properly repaired and maintained.

Under the direction of a JICA expert, who is stationed in the Bridge Engineering Department of ERA Headquarters, a nationwide survey for bridges was carried out and

this data is now being input into a bridge management system. Note that some of the Ethiopian engineers have already obtained basic knowledge and skills on bridge design and management through the JICA training program in Japan. To enhance and accelerate the on-going technical transfer by Japan, it will be important for the new bridge project to incorporate training throughout the whole project cycle, starting from the planning and design phases and going through to the construction and up maintenance phases.

f) Planning Criteria

The new bridge shall possess many advantages over the existing bridge in terms of bridge management and maintenance and shall therefore facilitate and simplify maintenance activities, such as periodic inspection of drainage, expansion joints, and inside girders. The following criteria shall be taken into consideration in the construction of the new bridge:

I. Cost efficiency

i) A cost-efficient bridge type, in consideration of Japan's Grant Aid, shall be chosen.

II. Simple and easy maintenance

i) A concrete structure shall be examined to take advantage of its high maintenance efficiency.

ii) Drainage slopes shall be considered for both the cross section and longitudinal section to prevent storm water from coming form the approach roads. Replacement of drainage pipes shall also be considered.

iii) Expansion joints that are cleanable shall be applied.

iv) An inspection hatch shall be installed at the bottom slab in order to facilitate maintenance of the inside of girders.

v) A rigid-framed structure for the A1 abutment shall be selected in order that pedestrians and maintenance vehicles can pass through and inspection for the

existing bridge can be easily carried out.

III. Enhancement of function grades

i) Cross sections shall be composed of “shoulder + carriageway + carriageway + shoulder”.

IV. To enhance safety grades

i) Scouring protection shall be planned for the piers, which will be located in the River.

ii) A 10cm thick wearing course will be applied to piers in the river from the footing top up to flooding levels to prevent erosion and damage by debris flows to the piers.

V. Aesthetics and environmental preservation

i) The Ethiopian Government has requested that the selection of the bridge type for the new bridge also take into aesthetics and environmental preservation elements.

ii) Lighting facilities shall not be installed in order to prevent impacts on wildlife.

g) Construction Method and Period

I. Complexity on the import procedure

Since there are no port facilities in Ethiopia, the port in neighboring Djibouti shall be utilized for importing. Note that the Embassy of Japan shall formally request the Ethiopian Government to make arrangements with Djibouti regarding the facilitation of import procedures, which it seem are quite complicated.

II. Flooding in the rainy season

The biggest concern for the construction of the new bridge is pier work during the rainy season, which starts from the middle of June and continues to the middle of September.