MINISTRY OF CONSTRUCTION
THE STATE OF ERITREA

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE EQUIPMENT SUPPLY PROGRAM
FOR
ROAD IMPROVEMENT
IN
THE STATE OF ERITREA

JULY 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
CONSTRUCTION PROJECT CONSULTANTS, INC.

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PREFACE

In response to a request from the Government of the State of Eritrea the Government of Japan decided to conduct a basic design study on the Project for the Equipment Supply Program for Road Improvement in the State of Eritrea and entrusted the study to the Japan International Cooperation Agency (JICA).

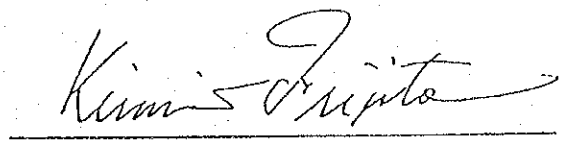
JICA sent to Eritrea a study team from April 8 to May 1, 1997.

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

July, 1997



Kimio Fujita
President
Japan International Cooperation Agency

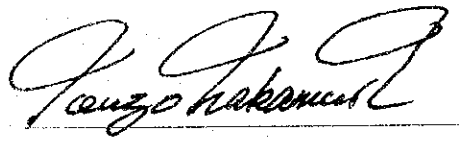
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Equipment Supply Program for Road Improvement in the State of Eritrea.

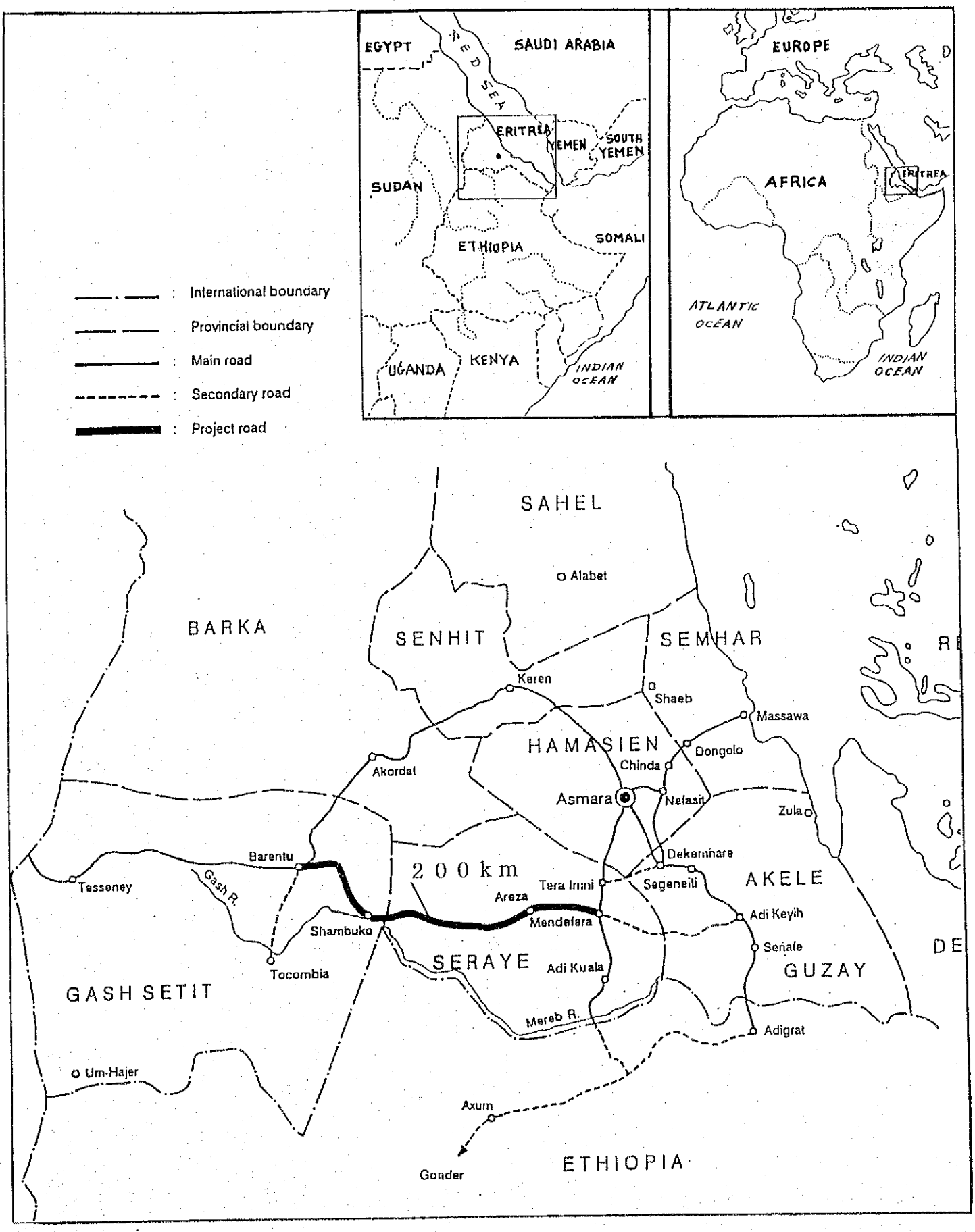
This study was conducted by Construction Project Consultants, Inc., under a contract to JICA, during the period from March 18, 1997 to August 8, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Eritrea and 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,



NAKAMURA Kenzo
Project Manager
Basic Design Study Team on
the Project for the Equipment Supply
Program for Road Improvement
the State of Eritrea



Location Map

The Project for the Equipment Supply Program for Road Improvement
in the State of Eritrea

Basic Design Study Report

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CHAPTER 1
BACKGROUND OF THE PROJECT

Chapter 1. Background of the Project

Since its independence in 1993 the Government of Eritrea has been exerting its maximum efforts for the recovery and firm establishment of the country. The Government implemented the Recovery and Rehabilitation Program in Eritrea (RRPE) in 1993, in which the recovery of production capacity and infrastructure are given the highest priority.

In spite of the fact that road transport shares 98% of the total transportation in the country for passenger and freight traffic, the condition of the road network is far below the required standards. Of a total 5,964 km of classified road network, only 8.4% are asphalt paved. Destruction and lack of appropriate maintenance during the war aggravated the situation, and the present condition is critical. The roads which are considered in comparatively fair condition now are only the Asmara - Massawa road and some limited sections of the most important trunk roads.

The Road Department, Ministry of Construction, has established the road program for the short, medium and long term in order of priority according to urgency. The short term program covers the most important trunk roads which need urgent rehabilitation to maintain traffic flow. On the other hand the medium and long term program covers the east-west and north-south trunk roads which are essential for the development of the national economy.

The targetted Mendefera-Barentu road forms a principal section of the east-west corridor (southern route) from the sea port Massawa to the Sudan border via Asmara, capital of Eritrea. The northern route, connecting Massawa, Asmara, Keren, Akrodat, then joins the Mendefera - Barentu road at Barentu. The rehabilitation project for the northern route is ongoing from Asmara up to 40 km beyond Keren, but the remaining 115 km up to Barentu is a completely deteriorated Macadam road, of which only 10-20 km/h is passable by 4WD. Regarding the southern route, the paved sections, i.e., Asmara - Mendefera section by DBST (Double Bituminous Surface Treatments) and from Mendefera the first 100 km of natural gravel are rather fair, but the remaining 100 km are not passable during rain. From Barentu to Tesseni (Sudan border) not only is the pavement in critical condition, passable only at 10-20 km/h by 4WD, but also retaining structure and several bridges are broken or have completely collapsed. Therefore, there is no reliable access to Sudan at present.

The Mendefera-Barentu road traverses the western lowlands which have high potentiality for agricultural development because of proper rainfall and moderate temperature, particularly for the cultivation of export oriented crops. The area is envisaged for the settlement of returned refugees from neighboring countries. To enable reliable access to Sudan for both passenger and freight, traffic and consequently to stimulate industries (textile, cement,

fishery, etc.) and also the transportation business, the rehabilitation of the targetted road together with the Massawa-Asmara road and the Barentu-Tessency road have been given the highest priority by the Government.

The project was implemented in 1994 financed by the Government's own fund on force account basis. Of a total of 200 km, approximately 100 km of base course has been completed to date. The Government has allocated considerable resources to this project, e.g. intensive labor from National Service, intending to complete the project by the year 2000. However, due to lack of appropriate construction equipment, progress has been seriously hindered.

Under these circumstances, the Government of Eritrea requested the following construction equipment from the Government of Japan to accelerate the progress and to complete the Mendefera-Barentu road project.

Motor grader (8 units), Bulldozer (7 units), Wheel loader (10 units), Road Roller (8 units), Dump Truck (10 units), Asphalt Distributor (4 units), Water Tanker (8 units), Fuel Tanker (8 units), Mobile Workshop (5 units), Pick-up truck (10 units) and Flat-bed Truck (2 units).

CHAPTER 2
CONTENTS OF THE PROJECT

Chapter 2. Contents of the Project

2.1 Objectives of the Project

The Mendefera - Barentu road forms a principal section of the east-west corridor (southern route) from sea port Massawa to the Sudan border via Asmara, capital of Eritrea. The road traverses the western lowlands which have high potentiality for agricultural development, particularly for the cultivation of export oriented crops. The area is envisaged for settlement of returned refugees from neighboring countries.

As reliable accessibility from the center to rural areas and also to neighboring countries is essential for the socio-economic recovery of the country, the Government of Eritrea has placed the highest priority on the rehabilitation of this road. The project was implemented in 1994 financed by the Government's own fund on force account basis. Of a total of 200 km, approximately 100 km of subbase course has been completed to date.

The Government has allocated considerable resources to this project, e.g. intensive labor from National Service, intending to complete the project by the year 2000. However, due to lack of appropriate construction equipment, progress is being hindered.

The objectives of the Project for the Equipment Supply Program for Road Improvement in the State of Eritrea (hereinafter referred to as "The Project") are to assist the Road Department of the Ministry of Construction to accelerate the on-going Mendefera - Barentu road rehabilitation project through the provision of construction machinery to increase its capacity of execution.

2.2 Basic Concept of the Project

2.2.1 Mendefera - Barentu Road Rehabilitation Project

(1) Status of the Mendefera - Barentu Road Rehabilitation Project

The project comprises three phases, i.e.:

Phase 1: Earthwork, Subbase course, Bridge, Culvert, Other structures
Phase 2: Base course, Double bitumen surface treatment (DBST), Shoulder, Ancillaries
Phase 3: Asphalt concrete (according to the future traffic increase)

Preparatory work was started in 1993. In the middle of 1994, after receiving an allocation of available equipment, earthwork was started. Of a total of 200 km,

some 100 km of subbase course has been completed to date. (Of which 40 km is categorized as "rehabilitation" and 60 km as "new construction or improvement".) The Government of Eritrea intends to complete Phase 1 for the remaining 100 km by the beginning of 1999, and Phase 2 for the total 200 km by the end of 2000.

Thus, the remaining works which will be covered by the equipment to be supplied under the Project are summarized as follows:

Phase 1 works: from May - lam to Barentu (100 km)
Phase 2 works: from Mendefera to Barentu (200 km)

(2) Road Structure

As there is no detailed data regarding subgrade strength and traffic volume on the project road, the results of the feasibility study conducted in 1994 were referred to in this study as follows:

1) Cross Section

Carriageway width	3.5 m	2-lanes
Shoulder width	1.5 m	both sides

2) Pavement Structure

According to the feasibility study subgrade material with CBR > 30 is available along the entire section of the road. Traffic volume (AADT) is estimated at 60 with a growth rate of 4 - 5% per year. Under these conditions British standards for tropical area "Road Note" can be applied, thus the pavement structure will have the following characteristics:

Surface course	DBST	3 cm
Base course	Crushed stone	15 cm
Subgrade	Natural gravel	(CBR > 30)

Regarding surface course, asphalt concrete overlay may be constructed in future if the traffic volume on the road increases significantly.

(3) Estimation of Work Volume

For the estimate of work volume, the feasibility study and achievement of work to date were referred to in this study. A comparison of the estimate by this study, the Road Department and the feasibility study is shown in Table 2.1.

Cross section used for the estimate of surface course and base course is shown in Fig. 2.1 and that for earthwork volume in Fig. 2.2. Assumptions adopted for the estimates are summarized as follows:

1) Clearing

For 100 km with clearing width and depth of 15 m and 20 cm, respectively.

2) Earthwork

- Of a total of 100 km of the remaining section, 75 km to be cut/fill section and 25 km to be fill section.
- Of a total of 975,000 m^3 of excavation, 780,000 m^3 (80%) to be general excavation and 195,000 m^3 (20%) to be rock excavation, for which excavation by ripdozer is possible.
- Of a total of 950,000 m^3 of embankment, 600,000 m^3 by road cutting soil (180,000 m^3 with 1 km of hauling distance and 420,000 m^3 without hauling), and 350,000 m^3 by borrow with 2 km of hauling distance.

3) Subgrade preparation

For 200 km.

4) Subbase course

As the CBR of the subgrade material has a CBR > 30, and this material is available over the whole section, and the traffic volume is low at present, this layer may be omitted (Road Note).

5) Base course

For 200 km with a thickness of 15 cm.

6) DBST surface course

For 200 km with carriageway width and thickness of 7 m and 3 cm, respectively.

7) Bridges, box culverts and other structures and ancillaries

Estimate by Road Department

Detailed volume will be determined by the D/D, which is programmed for Mendefera - Barentu and Keren - Akrodat - Barentu - Tesseni (Sudan border) roads with finance assistance from IDA. It is probable that the estimate made by this study deviates from the results of D/D on the following points:

Volume of base course - In the case where the expected subgrade material below CBR 30 is available the thickness needs to be increased, thus the volume increases accordingly.

Regarding earthwork volume, after detailed survey it is more likely to increase.

In conclusion, regarding the equipment schedule to be proposed by this study, the equipment type is considered appropriate. Also, it is not likely that the equipment number will exceed the requirement which will be derived from the result of D/D.

Table 2.1 Estimation of Work Volume

Item	Work Category	Unit	Estimation by the Basic Design Study				by Road Department		by FS
			Phase 1 100km	Phase 2 200km	Total	Remarks	Achievement 100 km	Scheduled 100 km	
1.	Clearing	m^2	1,500,000	–	1,500,000	15m × 100km	568,000	2,400,000	
	(Stripping)	m^3	300,000	–	300,000	20cm			
2.	Road Cutting								(Cut&Fill)
	– General soil	m^3	780,000	–	780,000	$13m^3 \times 75km \times 80\%$	543,636	500,000	2,062,560
	– Rock	m^3	195,000	–	195,000	$13m^3 \times 75km \times 20\%$	122,488	60,000	
3.	Road Filling								
	– Filling from cutting	m^3	600,000	–	600,000	$8m^3 \times 75km$	–	–	
	– Filling from borrow	m^3	350,000	–	350,000	$14m^3 \times 25km$	450,000	315,000	
4.	Subgrade Preparation	m^2	–	1,090,000	1,090,000	$10.9m^2 \times 100km$	–	750,000	
5.	Subbase Course	m^3	–	–	–		175,000	700,000	(Base&Subbase)
6.	Base Course	m^3	–	313,500	313,500	10.45m × 15cm × 200km	–	750,000	677,959
7.	Surface Course								
	– Prime Coat	kg	–	1,890,000	1,890,000	1.261 × 7.5m × 200km	–	2,500,000	
	– AC (Base layer)	m^3	–	–	–		–	90,000	
	– Tackcoat	kg	–	–	–		–	750,000	
	– AC (Wearing layer)	m^3	–	–	–		–	100,000	(TBST)
	– DBST	m^2	–	1,400,000	1,400,000	7.0 × 200km	–	1,000,000	1,355,919
8.	Concrete Structure								
	–Plain concrete	m^3	3,500	–	3,500	by Road Dep.	9,200	3,500	
	– Boxculvert	m^3	14,000	–	14,000	by Road Dep.	8,500	14,000	
	– Bridge	m^3	3,000	–	3,000	by Road Dep.		3,000	
9.	Retaining Wall (Masonry)	m^3	98,200	1,500	99,700	by Road Dep.	26,730	99,700	
10.	Filter	m^2	–	25,000	25,000	by Road Dep.	–	25,000	
11.	Ditch Lining	m^2	–	300,000	300,000	by Road Dep.	–	300,000	
12.	Guardrail	m	–	20,000	20,000	by Road Dep.	–	20,000	
13.	Road Marking	m^2	–	80,000	80,000	by Road Dep.	–	80,000	
14.	Traffic Sign	Unit	–	400	400	by Road Dep.	–	400	

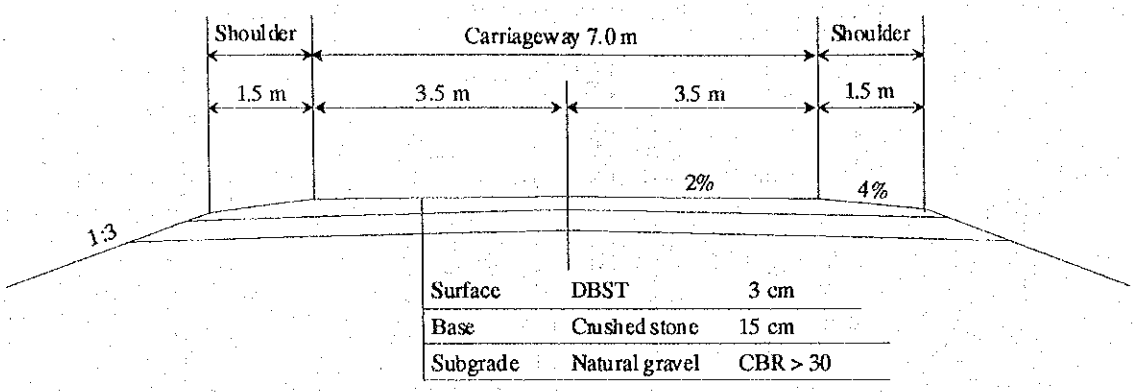

Fig. 2.1 Cross Section

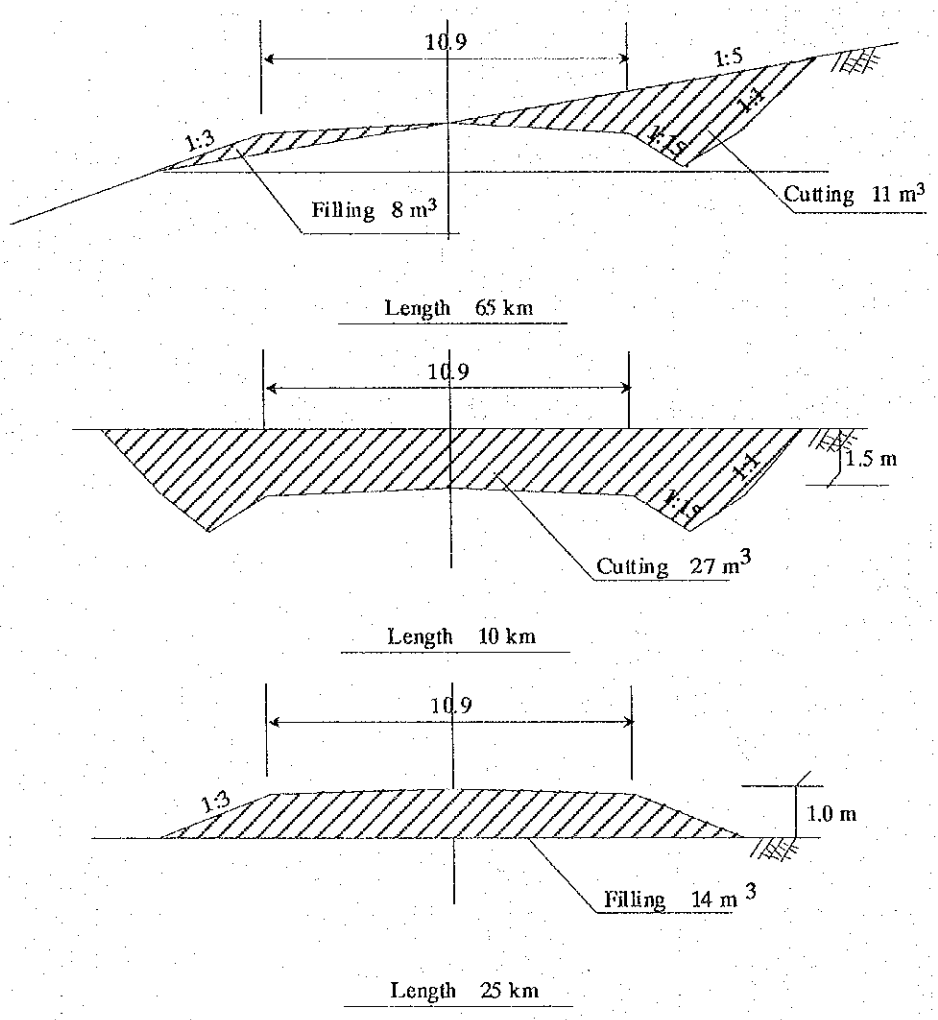

Fig. 2.2 Typical Cross Section of Earth Work

(5) Construction Schedule

Available resources (funds and workforce) of the Road Department are one of the determinants for construction period, i.e. the period necessary for the completion of Phase 2 for all sections. Since the start of this road project in 1994 about Birr 93 million, including engineering costs were allocated for the project. This means that about Birr 31 million were disbursed annually in the last three years. On the other hand, the necessary funding required for the completion is estimated at about Birr 410 million of which savings due to this equipment supply program are estimated at about Birr 105-125 million. Thus, about Birr 285-305 million is required.

The Eritrean side intends to complete the project by the end of 2000(24 months after introduction of the equipment under the Project). According to its schedule, Birr 140-150 million is required annually, i.e., about 5 times the achievement of the last three years. The same applies to the workforce.

The Government confirms that resources will be allocated to this road project with the highest priority. However, considering the present situation of the road sector, where many projects are being implemented, it seems difficult to expect such an available workforce in the near future. This basic design study considers that assuming a workforce about 2.5 to 3 times the present workforce is reasonable.

On the other hand, from the view-point of work productivity during the last three years, the appropriate period can be derived as follows:

Period for completion of Phase 1 (remaining 100 km)

Of the 100 km of completed section only 60 km is considered as new construction or improvement. Thus the average progress during 36 months is estimated at 1.7 km/month. Provided the same productivity is maintained, it takes 60 months for the completion. On the other hand, through the introduction of new equipment under the Project it is possible to upgrade the productivity by 1.5 to 2 times the present level, i.e. Phase 1 can be completed in 36 months. Estimate by work item of Phase 1 is as follows:

Table 2.2 Construction Period Estimate

Work item	Estimated Quantity	Achievement			Estimated month		
		Q'ty	Months elapsed	Productivity per month	by Present Productivity	Increase of Productivity	by Increased Productivity
Clearing	1,500,000 m²	568,000 m²	18	31,556 m²/month	48 months	2.0	24 months
Cutting	975,000 m³	666,124 m³	36	18,503 m³/month	53 months	1.5	36 months
Filling (including borrow)	950,000 m³	450,000 m³	36	12,500 m³/month	76 months	2.1	36 months

Period for Phase 2 (200 km)

Phase 2 can be started soon after the delivery of the equipment under the Project starting from the completed section of Phase 1. In other words it is necessary to start Phase 2 as soon as possible from the view-point of protecting completed sections of subgrade from deterioration and reducing maintenance costs. For this reason the same productivity as phase 1 is required, i.e. it is necessary to complete in 36 months in parallel with the Phase 1 work.

Total Period

Considering the above mentioned 36 months for both Phase 1 and Phase 2 works a total period of 40 months is required as shown in Fig. 2.3.

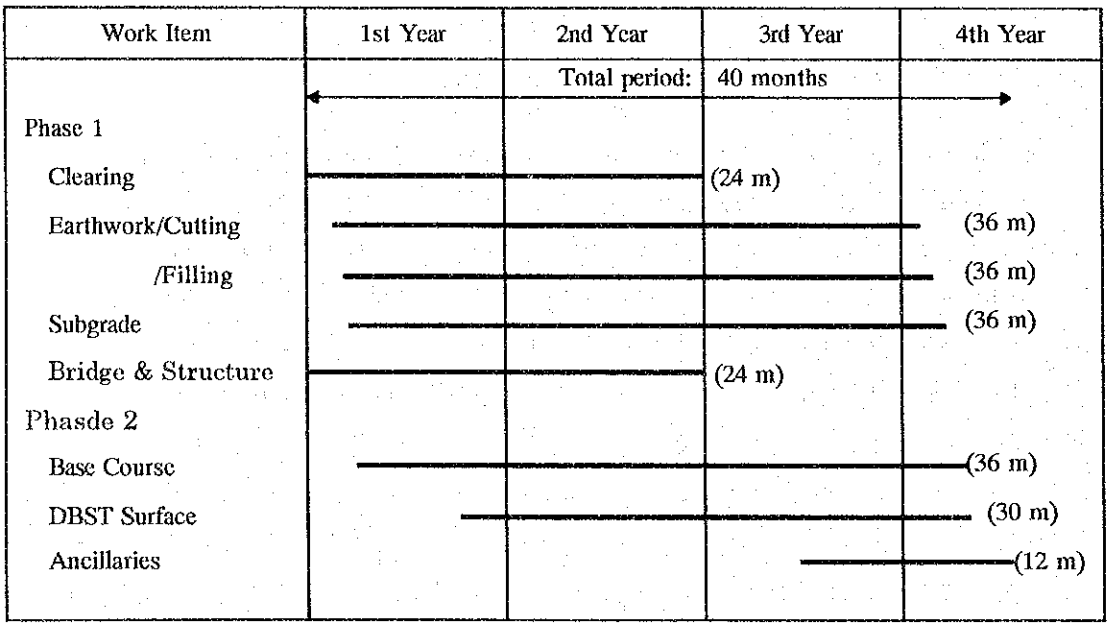

Fig. 2.3 Construction Schedule

2.2.2 Examination of the Content of the Project

(1) Examination of the Equipment Schedule

Through the discussion with the basic design study team the Eritrea side proposed a revised equipment schedule to the original request in respect of equipment type and number, because of the progress of work achieved since the above mentioned original request. Individual equipment requested by the revised schedule was examined by this study in view point of construction schedule, present performance of work and achievement to date.

Most of the equipment in the original request is categorized as for earthwork, although type and number is not necessarily balanced. Since then, several types of equipment for earthwork were procured under Government funding during the last three years. But the equipment available on site is below the requirement for completion of the remaining works of Phase 1. Moreover, there is no equipment available for Phase 2 works, such as stone crusher, asphalt distributor, chip spreader, etc.

The result of discussions and examination with the Eritrean side is summarized in Table 2.3.

(2) Equipment Schedule

1) Examination of the equipment required

The following steps were taken for determination of equipment type and number:

- Determine equipment type for every work category and calculate productivity of the equipment considering site conditions.
- Divide the estimated work volume by the above productivity and possible work days/hours during the work period to get gross equipment number required.
- Scheduling the equipment by work category with bar-chart.
- Derive the least required number of equipment.

The calculation is summarized in Table 2.4 to Table 2.5.

2) Equipment Schedule

The equipment number to be supplied under the Project was derived by deducting the existing number from the above mentioned least required number.

The result is shown in Table 2.6.

Table 2.3 Equipment of Final Request by Eritrean Government

Item	Request Before Discussion		Nos.	Amended Request through Discussion		Nos.	Uses (U) and Reason of Selection (R)
1.	Motor Grader	200HP	5	Motor Grader	200-220HP 4.3m³ Steel cab.	5	U: Spreading and grading of base course and slope shaping. R: High power is necessary for works in rocky and high altitude areas. Steel cabin for protection from dust.
2.	Bulldozer	320HP	2	- to be omitted -			U: Earth, quarry and borrow pit excavation R: Unified to 220-235 HP class below.
3.	Bulldozer	220HP	2	Bulldozer	220-235HP Ripper ROPS	4	U: Earth, quarry and borrow pit excavation R: High power is necessary for works in rocky and high altitude areas. Steel cabin for protection from dust.
4.	Wheel Loader	220HP	6	Wheel Loader	200-220HP 3.5m³ Steel cab.	6	U: Loading of excavated soil, blasted or crushed rock R: 3.5m³ bucket volume for speedy operation with dump trucks of 9m³ capacity.
5.	Wheel type Hyd. Excavator with Hyd. Breaker	0.7m³	1	Wheel type Hyd. Excavator Wheel type	150HP class 0.7m³	1	U: Structural excavation R: Wheel type for fast movement on site and 150 HP for hard earth. Hydraulic breaker is cancelled due to minor use of rock digging.
6.	Stabilizer Wheel type	355HP	1	- to be omitted -			U: Soil stabilization with cement, lime or bitumen. R: Deleted due to surcharge banking which is more recommendable for an embankment of soft ground than stabilization using agents.
7.	Vibration roller	8ton Front drum with Water Sprayer	2	Vibration roller	10ton class Front drum with Water Sprayer	3	U: Compaction of embanked soil, base material and backfilled soil. R: 10 ton class is suitable for wide compacting on base course.
8.	Vibration roller	10ton Front/Rear drum with Water Sprayer	4	Vibration roller	9.5ton class Front/Rear drum with Water Sprayer	4	U: Compaction of surface course R: 9.5 ton is the most popular standard widely manufactured.

Table 2.3 Equipment of Final Request by Eritrean Government

Item	Request Before Discussion		Nos.	Amended Request through Discussion		Nos.	Uses (U) and Reason of Selection (R)
9.	Dump truck	16m3	9	Dump truck	$9m^3$, 6x4	16	U: Transport of excavated earth, base material, blasted rock and chip for surface course. R: $16m^2$ lorry is considered inadequate for transport on public roads in Eritrea and $9m^3$ is the largest size widely manufactured as on-road type.
10.	Water Tanker Truck	12000 lt	6	Water Tanker Truck	12000 lt	6	U: Water pumping, transport and sprinking for earth and rock material compaction. R: Larger truck capacity is economical for long distance hauling due to remote water resources.
11.	Fuel Tanker Truck	18000 lt	2	Fuel Tanker Truck	16000 lt	1	U: Transport of fuel from Massawa to the site, approx. 300 km. R: Two days for a return trip and max. daily fuel consumption 8,000 lit. on site.
12.	Fuel Tanker Truck	12000 lt	2	Fuel Tanker Truck	8000 lt	2	U: Distribution of fuel from base camp to equipment on site R: Two directions to job site from base camp and max. daily consumption of 8,000 lit.
13.	Asphalt Distributor	12000 lt	2	Asphalt Distributor	6000 lt	2	U: Boiled bitumen spreading for surface course. R: Average daily use of heated bitumen by a surfacing brigade is 12,000 lit. then 2 return trips from asphalt boiler to the site a day on 30 km hauling.
14.	Asphalt Boiler with Strong Tank	6000 lt 16000 lt	2	Asphalt Boiler with Storage Tank	6000 lt 16000 lt	1	U: Bitumen heating and storage for surface course. R: Average daily use of boiled bitumen is 16,000 lit. Short boiling time for 6,000 lit. bitumen is required for loading to distributor.
15.	Chip Spreader Spreading width Hopper	Self propelled 4m 6m3	2	Chip Spreader Spreading width	Self propelled 4m	2	U: Chip laying for surface course. R: Halfway surfacing requires max. 4.0 m width (3.5 m + 0.5 m widening on curves)

Table 2.3 Equipment of Final Request by Eritrean Government

Item	Request Before Discussion		Nos.	Amended Request through Discussion		Nos.	Uses (U) and Reason of Selection (R)
16.	Lowbed Trailer Tractor	60ton	1	Lowbed Trailer Tractor Bed length	40ton 8m	1	U: Transport of heavy equipment R: The largest size of 8m long, motorgrader, and heaviest weight of 38t bulldozer define the trailer's capacity, and low bed type is necessary due to low clearance of bridges on public roads.
17.	Pickup Truck	4x4 85HP	4	Pickup Truck	4x4 Double cab.	4	U: Inspection of conditions and light repair of equipment on site. R: Two cars for each direction from base camp. Four seats required for a driver, two mechanics and a service man. Loading capacity of 500 kg is minimum requirement for tools and spare parts.
18.	Mobile Rock Crusher Self propelled crawler type Secondary crusher screen: 25,19,10,5mm with Generator and Belt conveyer	150HP 0-70mm 60t/h	2	Mobile Rock Crusher Mobile type screen: 40,25,19,10,5mm	120t/h	1	U: Production of crushed aggregate for base and surface course. R: Average daily production capacity of 120 ton is required. One set of 120 ton/hr is recommendable for reduction of number of quarrying equipment. Mobile crusher on wheels is more suitable than self-propelled type for 3-4 relocations of crushing plant.
19.	Hydraulic Excavator Crawler type	150HP 22t 1.0m3	2	Hydraulic Excavator Crawler type	150HP class 1.0m^3 Hyd. Breaker	1	U: Loading of blasted rock to dump trucks. R: 1.0 m^3 bucket for loading and 150 HP for hydraulic breaker is necessary for secondary cracking of large boulder.
20.	Air Compressor Jack Hammer x 3 sets	small size	2	Air Compressor Jack Hammer x 3 sets	7.5m^3/min	2	U: Rock excavation for structural foundation and secondary cracking of middle size boulder. R: Jack hammer 3 set for secondary cracking.
21.	Crawler Drill with Air Compressor	30-84mm	1	Crawler Drill with Air Compressor	65-90mm 5.0ton 20m^3/min	1	U: Drilling holes for blasting. R: Air compressor of 20 m/min. for crawler drill.

Table 2.3 Equipment of Final Request by Eritrean Government

Item	Request Before Discussion		Nos.	Amended Request through Discussion		Nos.	Uses (U) and Reason of Selection (R)
22.	Pre-fabrication garage Garage facilities and tools Container for tools Material for garage		1	Repair Tool Sets		1	U: Repair of equipment on site. R: Site garage is to be arranged by the construction team. Hand tools, welders, repair tools for tires are included.
23.	Mobile Workshop		2	- to be omitted -			R: Replaced to service cars, item 17.
24.	Truck Crane	25ton	1	Truck Crane	25ton	1	U: Installation of pre-casted concrete slabs for drainage structures, stone crushing plant assembling and dismantling, and loading and unloading of heavy goods and materials. R: The capacity of 25 ton lifting at 3.0 m boom radius is required.
25.	Lubrication Truck	4x2	2	Lubrication Truck	6ton 4x4	2	U: Grease up and changing for equipment on site. R: 4 x 4 type truck with 6 ton loading capacity is required for grease supply for a number of equipment on rough surface site conditions.
26.	Generator for garage	80KW	1	Generator for garage	100KVA	1	U: At base camp R: For the workshop and garages at base camp of construction, at least 100 kVA power is required.
27.	Generator for site camp	18KW	1	Generator for site camp	30KVA	1	U: At base camp R: For site offices and accommodations at base camp 30 kVA power is considered adequate.
28.	Personal Computer with printer		5	- to be omitted -			U: Progress/quality control of the works and spare parts filing. R: Cancelled because the Road Department is able to arrange.
29.	Spare parts		15%	Spare parts		8%	Remarks: A weighted average of 8.0% of the total cost of equipment above is considered sufficient for 1~2 years equipment operation.

Table 2.4 Equipment Required by Work Item

Average workday/mon. 20 days Workhour/d 5.0 hours

Work Category			Equipment	Spec.	Quantity	Unit	Productivity /unit/h	Total hrs required unit-h	Total months	Work ing ms	Numbe required
Clearing		Excavation	Bulldozer	28-30 t	300,000	m^3	168.7	1,778	18	24	1
		Loading	Wheel Loader	3.5 m^3	60,000	m^3	119.2	503	5	24	–
		Transport	Dump Truck	14 t	12,000	m^3	22.1	543	5	24	–
		Disposing	Bulldozer	28 - 30 t	2,400	m^3	168.7	14	0	24	–
Cutting	Soil	Excavation	Bulldozer	28 - 30 t	780,000	m^3	168.7	4,624	46	36	1
		Loading	Wheel Loader	3.5m^3	180,000	m^3	119.2	1,510	15	36	1
		Transport	Dump Truck	14 t	180,000	m^3	22.1	8,145	81	36	2
	Rock	Ripping	Bulldozer	28 - 30 t	195,000	m^3	53.9	3,618	36	36	1
Filling	Borrow	Excavation	Bulldozer	28 - 30 t	350,000	m^3	151.9	2,304	23	36	1
		Loading	Wheel Loader	3.5 m^3	350,000	m^3	107.3	3,262	33	36	1
		Transport	Dump Truck	14 t	350,000	m^3	16.0	21,875	219	36	5
	Fill	Spreading	Bulldozer	28 - 30 t	950,000	m^3	104.4	9,100	91	36	2
		Compaction	Viv. Roller (F)	10 t	950,000	m^3	176.4	5,385	54	36	2
		Watering	Water Tanker	12,000 ℓ	76,000	kℓ	6.3	12,063	121	36	4
Subgrade		Grading	Motor Grader	4.3 m	2,180,000	m^2	312.5	6,976	70	36	2
		Compaction	Vib. Roller (F)	10 t	2,180,000	m^2	294.1	7,412	74	36	1
		Watering	Water Tanker	12,000 ℓ	52,320	m^3	6.3	8,305	83	36	2
Ditch・Slope		Shaping	Motor Grader	4.3 m	760,000	m^2	384.6	1,976	20	36	1
Base Course		Spreading	Motor Grader	4.3 m	2,090,000	m^2	312.5	6,688	67	36	2
		Compaction	Vib. Roller (F)	10 t	2,090,000	m^2	243.9	8,569	86	36	2
		Compaction	Vib. Roller (F/R)	9.5 t	2,090,000	m^2	243.9	8,569	86	36	2
		Watering	Water Tanker	12,000 ℓ	46,085	m^2	6.3	7,315	73	36	2
		Loading	Wheel Loader	3.5 m^3	313,500	m^3	102.2	3,068	31	36	1
		Transport	Dump Truck	14 t	313,500	m^3	10.1	31,040	310	36	8
DBST Surface	1st	Primecoat	Distributor	6,000 ℓ	2,381	kℓ	1.2	1,985	20	30	1
		As Spraying	Distributor	6,000 ℓ	1,610	kℓ	1.1	1,464	15	30	1
		Loading	Wheel Loader	3.5m^3	28,000	m^3	102.2	274	3	30	1
		Transport	Dump Truck	14 t	28,000	m^3	6.9	4,058	41	30	2
		Chipping	Chip Spreader		1,400,000	m^2	1,050.0	1,333	13	30	1
		Compaction	Vib. Roller (F/R)	9.5 t	1,400,000	m^2	480.0	2,917	29	30	1
	2nd	As Spraying	Distributor	6,000 ℓ	2,100	kℓ	1.2	1,750	18	30	–
		Loading	Wheel Loader	3.5 m^3	14,000	m^3	102.2	137	1	30	–
		Transport	Dump Truck	14 t	14,000	m^3	6.9	2,029	20	30	2
		Chipping	Chip Spreader		1,400,000	m^2	1,500.0	933	9	30	1
		Compaction	Vib. Roller (F/R)	9.5 t	1,400,000	m^2	400.0	3,500	35	30	1
		As heating	As Boiler	6,000 ℓ /h	6,091	kℓ	6.0	–	–	30	2
Culvert		Excavation	Wheel Excavator	0.7 m^3	47,000	m^3	37.0	1,270	13	24	1
Bridge		Rock Excava.	Air Compressor	7.5 m^3/min	–	–	–	–	–	24	2
Structure		Lifting	Truck Crane	25 t	–	–	–	–	–	24	1
		Transport	Wheel Loader	3.5 m^3	–	–	–	–	–	24	1
	Borrow	Excavation	Bulldozer	28 - 30 t	47,000	m^3	151.9	309	3	24	–
		Loading	Wheel Loader	3.5 m^3	47,000	m^3	107.3	438	4	24	–
		Transport	Dump Truck	14 t	47,000	m^3	16.0	2,938	29	24	–
		Backfilling	Bulldozer	28 - 30 t	47,000	m^3	87.6	537	5	24	1
		Compaction	Vib. Roller (F)	10 t	47,000	m^3	176.4	266	3	24	–
Concrete		Mixing	Mixing Truck	4.5 m^3	20,500	m^3	3.4	6,029	60	24	–
Production		Loading	Wheel Loader	3.5 m^3	20,500	m^3	112.4	182	2	24	–
		Transport a	Dump Truck	14 t	20,500	m^3	22.1	928	9	24	1
		Transport s	Dump Truck	14 t	20,500	m^3	22.1	928	9	24	–
Quarry		Drilling	Crawler Drill	5 t	541,440	m^3	76.9	7,041	70	40	1
		Drilling	Air Compressor	20 m^3/min	541,440	m^3	74.1	7,307	73	40	1
		Breaking	Hyd. Excavator	1.0 m^3	451,200	m^3	76.9	5,867	59	40	1
		Breaking	Hyd. Breaker		451,200	m^3	76.9	5,867	59	40	1
		Ripping	Bulldozer	28 - 30 t	451,200	m^3	53.9	8,371	84	40	2
		Loading	Wheel Loader	3.5 m^3	451,200	m^3	85.1	5,302	53	40	1
		Transport	Dump Truck	14 t	451,200	m^3	14.7	30,694	307	40	6
Crushed Stone		Production	Rock Crusher	120 t/h	376,000	m^3	108.0	3,481	35	40	1
		Loading	Wheel Loader	3.5 m^3	376,000	m^3	102.2	3,679	37	40	1
Transport		Material	Pick-up Truck	ﾀﾞﾝﾌﾟﾄﾗｯｸ	–	–	–	–	–	40	4
		Fuel	Fuel Tanker	16,000 ℓ	–	–	–	–	–	40	1
		Fuel	Fuel Tanker	8,000 ℓ	–	–	–	–	–	40	2
		Equipment	Lowbed Trailer	40 t	–	–	–	–	–	40	1
		Oil-Lubrica.	Lub. Truck	6 t	–	–	–	–	–	40	2
Equipment		Maintenance	Repair Tool Set		–	–	–	–	–	40	1
Maintenance		Power	Generator	100 kVA	–	–	–	–	–	40	1
		Power	Generator	30 kVA	–	–	–	–	–	40	1

Table 2.5.1 Examination of Equipment Schedule

Work Item		Equipment	Spec.	1st Year												2nd Year												3rd Year												4th Year												Total Unit	Working Days
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48		
Clearing	Excavation	Bulldozer	28-30t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																							24	24
	Loading	Wheel Loader	3.5m³																																														0	
	Transport	Dump Truck	14t																																													0	
	Disposing	Bulldozer	28-30t																																													0	
Cutting Soil	Excavation	Bulldozer	28-30t		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											36	36
	Loading	Wheel Loader	3.5m³		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											36	36
	Transport	Dump Truck	14t		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											72	36
	Ripping	Bulldozer	28-30t		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											36	36
Filling Borrow	Excavation	Bulldozer	28-30t			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											36	36
	Loading	Wheel Loader	3.5m³			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											36	36
	Transport	Dump Truck	14t			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5											180	36
Fill	Spreading	Bulldozer	28-30t			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											72	36
	Compaction	Vib.Roller(F)	10t			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											72	36
	Watering	Water Tanker	12000l			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4											144	36
Subgrade	Grading	Motor Grader	4.3m				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											70	35
	Compaction	Vib.Roller(F)	10t				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											35	35
	Watering	Water Tanker	12000l				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											70	35
Ditch-Slope	Shaping	Motor Grader	4.3m				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											35	35
Base Course	Spreading	Motor Grader	4.3m				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											72	36
	Compaction	Vib.Roller(F)	10t				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											72	36
	Compaction	Vib.Roller(F,R)	8.5t				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											72	36
	Watering	Water Tanker	12000l				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											72	36
	Loading	Wheel Loader	3.5m³				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											36	36
	Transport	Dump Truck	14t				8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8											288	36
DBST 1st	Primecoat	Distributor	6000l											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
	As Spraying	Distributor	6000l											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
	Loading	Wheel Loader	3.5m³											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
	Transport	Dump Truck	14t											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2									60	30
	Chipping	Chip Spreader												1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
	Compaction	Vib.Roller(F,R)	8.5t											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
2nd	As Spraying	Distributor	6000l																																														-	-
	Loading	Wheel Loader	3.5m³																																														-	-
	Transport	Dump Truck	14t											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2									60	30
	Chipping	Chip Spreader												1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
	Compaction	Vib.Roller(F,R)	8.5t											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
	As heating	As Boiler	6000l/h											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30	30
Culvert	Excavation	Wheel Excavator	0.7m³	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																							24	24
Structure	Rock Excava.	Air Compressor	7.5m³/min	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																							48	24
	Lifting	Truck Crane	25t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																							24	24
	Transport	Wheel Loader	3.5m³	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																							24	24
Borrow	Excavation	Bulldozer	28-30t																																														-	-
	Loading	Wheel Loader	3.5m³																																														-	-
	Transport	Dump Truck	14t																																														-	-
	Backfilling	Bulldozer	28-30t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																							24	24
	Compaction	Vib.Roller(F)	10t																																														-	-
Concrete	Mixing	Mixing Truck	4.5m³																																														-	-
	Loading	Wheel Loader	3.5m³																																														-	-
	Transport a	Dump Truck	14t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																							24	24
	Transport s	Dump Truck	14t																																														-	-
Quarry	Drilling	Crawler Drill	5t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Drilling	Air Compressor	20m³/min	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Breaking	Hyd.Excavator	1.0m³	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Breaking	Hyd.Breaker		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Ripping	Bulldozer	28-30t	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2								80	40
	Loading	Wheel Loader	3.5m³	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Transport	Dump truck	14t	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6								240	40
Crushed Stone	Production	Rock Crusher	120t/h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Loading	Wheel Loader	3.5m³	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Material	Pick-up Truck	double	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4								160	40
	Fuel	Fuel Tanker	10000l	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Fuel	Fuel Tanker	8000l	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2								80	40
	Equipment	Lowbed Trailer	40t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Oil-Lubrica	Lub.Truck	6t	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2								80	40
Equipment	Maintenance	Repair Tool Set		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Power	Generator	100KVA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40
	Power	Generator	30kVA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								40	40

Table 2.5.2 Examination of Equipment Schedule

Equipment	Spec.	1st Year												2nd Year												3rd Year												4th Year												Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
Motor Grader	4.3m				5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2										177
Bulldozer	28-30t	4	6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	7	7	7	7	7	7	7	7	7	7	7	7	7	5	2	2									306
Wheel Loader	3.5m³	3	4	5	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	8	8	8	6	5	4	3									242
Wheel Excavator	0.7m³	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																									24
Vib. Roller (F)	10t			2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2										179
Vib. Roller (F.R)	9.5t				2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2								132
Dump truck	14t	7	9	14	22	22	22	22	22	22	22	25	26	26	26	26	26	26	25	26	26	26	26	26	26	25	25	25	25	25	25	25	25	25	25	25	25	25	23	18	10									924
Water Tanker T	12000l			4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	2										286
Fuel Tanker T	16000l	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Fuel Tanker T	8000l	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2									80
Fuel Tanker T	6000l											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2									60
As. Distributer	6000l											1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									30
As. Boiler	6000l											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2									60
Chip Spreader												2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2									40
Lowbed Trailer	40t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Pick-up Truck	5'7"A4-17"	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4									160
Rock Crusher	120t/h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Hyd. Excavator	1.0m³	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Air Compressor	7.5m³/min	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																								48
Crawler Drill	5t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Hyd. Breaker	1200kg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Air Compressor	20m³/min	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Repair Tool Set		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																								24
Truck Crane	25t	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									80
Lub. Truck	6t	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2									40
Generator	100KVA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Generator	30KVA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									40
Spareparts		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									

Table 2.6 Equipment Schedule

Item	Equipment	Main specification	Required equipment	Existing available number	Plan
1	Motor Grader	4.3 m	5		5
2	Bulldozer	28-30t	9	5	4
3	Wheel Loader	3.5 m^3	7	1	6
4	Hydraulic Excavator Wheel type	0.7 m^3	1		1
5	Vibration Roller (Front drum)	10t	5	2	3
6	Vibration Roller (Front/Rear drum)	9.5t	4		4
7	Dump Truck	14t	26	10	16
8	Water Truck	12,000 ltr	8	2	6
9	Fuel Tanker Truck	16,000 ltr	1		1
10	Fuel Tanker Truck	8,000 ltr	2		2
11	Asphalt Distributor	6,000 ltr/hr	2		2
12	Asphalt Boiler	6,000 ltr	1		1
13	Chip Spreader (Self propelled)	width 4 m	2		2
14	Low bed Trailer Tractor	40 t	1		1
15	Pick up Truck	double cab.	4		4
16	Mobile Rock Crusher	120 t/h	1		1
17	Hydraulic Excavator Crawler type	1.0 m^3	1		1
	Hyd. Breaker (attached to Hyd. Excavator)	1,200 kg	(1)		(1)
18	Air Compressor Tractor	7.5 m^3/min	2		2
19	Crawler Drill	5 t	1		1
20	Air Compressor	20 m^3/min	1		1
21	Repair Tool Set		1		1
22	Truck Crane	25 t	1		1
23	Lubrication Truck	6 t	2		2
24	Generator for garage	100 KVA	1		1
25	Generator for site camp.	30 KVA	1		1
26	Spare parts				8%
Total			90	20	70

2.2.3 Result of Examination

Through the above examinations the basic concept of the Project formulated is summarized to provide construction equipment necessary for the completion of the Mendefera - Barentu road project phase 1 and phase 2 by year 2002. The works comprise earthwork and structure/bridge work for approximately 100 km, and base course work and DBST surface course for approximately 200 km.

2.3 Basic Design

2.3.1 Design Concept

(1) Natural Condition

Climatic condition of the project area is semi-arid with altitude 1,000-2,000m above sea level. Annual average rainfall ranges 500 - 700 mm, and annual average temperature 20-30°c. Topography of the project site is steep mountainous or hilly. Geologically, rocky and conglomerate layers are observed. Therefore, high altitude, desert, severe and dangerous conditions shall be considered for the equipment specification.

(2) Capability of work execution and equipment maintenance of the Road Department

Through examination of the achievement of approximately 100 km from Mendefera to Mai-Lam, where difficult natural and transport conditions pertain, it can be said that the capability of the Road Department for the execution of civil work, equipment maintenance and management is adequate.

Implementation of road projects-except routine maintenance-is directly controlled by the Operation Division of the Road Department. A site office is established for each project. In the case of Mendefera - Barentu road project the existing Maidema office will be strengthened.

As for equipment maintenance, regular maintenance such as daily check, preventive maintenance, replacement of worn parts, and other minor repair work are carried out on site. For this purpose a mobile workshop is now attached to Mai-Lam camp (middle point of the project road.). In case the cause of defects can not be identified on site, mechanics will be despatched from the Road Department Mendefera Office to the site for investigation. If necessary, the equipment can be transported to the Central Workshop in Asmara for repair.

In general, it can be said that the equipment is well managed and maintained, so that all equipment including old types are in good condition or remain repairable.

(3) Criteria for Selection of the Equipment

The equipment was selected as follows:

- Although the Eritrean side requested large sizes for all equipment, this is not always appropriate from the view-point of work efficiency on site. It is important that equipment combinations are balanced among themselves. Accordingly, a reasonable combination is one of the most important factors for the selection of model and number.
- Although the Eritrean side requested a large size off-road type vehicle, this causes severe damage to the road structure. Accordingly, the largest size on-road type vehicle was selected.
- As for spare parts, consumable parts and regular maintenance parts were given priority. Regarding other spare parts, an appropriate ratio to the cost of equipment was set out.

(4) Criteria on Country of Origin of the Equipment

1) Equipment to be procured from Japan

Criteria on country of origin is as follows:

- Product Qualities
- Parts service system/organization
- Eligible third countries to be US, UK, Germany & Sweden

2) Equipment to be procured in Eritrea

- Nothing due to lack of production and availability

(5) Criteria for Procurement Schedule

Although the Eritrean side intends to complete Phase 2 for all 200km by year 2000, the basic design set out a 40 months construction period after delivery of the equipment. Based on this construction schedule all the equipment to be supplied under the Project will be operated soon after delivery.

Therefore, the equipment procurement schedule shall be completed in 12 months.

(6) Criteria for Hand-over

All the equipment to be procured under the Project will be imported at Massawa port, then transported to Asmara by road. Place of hand-over for all equipment will be Road Department in Asmara. Transport from Asmara to the construction site is the responsibility of the Eritrean Government.

Maximum draft of Massawa port is 8.5 - 8.7 m, therefore 20,000 - 25,000 ton class vessel is possible. However, the unloading facilities have insufficient capacity for unloading 30 ton class construction equipment such as bulldozer. Therefore, such equipment will be trans-shipped to a vessel equipped with derrick crane at Assab (Eritrea), Djibuti (Djibuti)or Jeddah (Saudi Arabia) ports.

2.3.2 Basic Design

(1) Design Policy

The work units to be formed by the equipment under the Project will be as follows:

Work category		Number of units	Operator	Driver	Mechanic	Worker
Clearing work		1	1			20
Road Cutting	General excavation	1	2	2		20
	Rock excavation	1	1			20
Road Filling	Embankment	1	4	4		20
	Borrow excavation	2	2	5		10
Subgrade Preparation		2	3	2		50
Side ditch/slope shaping		1	1			20
Base course		2	9	8		50
Surface course	1st layer	1	3	4		30
	2nd layer	1	2	2		30
	Asphalt Boiler	1	1			20
Bridge, culvert & structure		1	6			200
Cement concrete production (site camp)		1		1		20
Stone quarry		1	7	6		10
Crushing plant		1	2			20
Transport service (site camp)		1		10		20
Maintenance service (site camp)		1	3		5	20
	Total	19	47	44	5	580

Outline of the construction activities by the above mentioned work units will be as follows:

Earthwork will be continued up to Barentu (PK200) together with the existing unit. Regarding bridge, culvert and structure works, the work efficiency and safety will be upgraded significantly, such as excavation, lifting and placing of RC slab or stones for masonry work.

Base course work will be started from Mendefera (PK0) soon after the production of crushed stone, which will be produced by the stone crusher to be introduced under the Project.

Crushing plant will be established near quarries which will be developed along the route in parallel with work progress. Several possible locations for quarries are being examined by the Road Department. Of these, locations near PK50 and PK150 are considered appropriate from the view-point of hauling distance (approximately 25km).

Preparatory works such as clearing, construction of foundations and other related facilities will be started in accordance with the equipment supply schedule, which will enable the crusher to be set-up soon after its delivery.

(2) Equipment plan

Deployment schedule of the equipment to be supplied to the above mentioned work units are shown in table 2.7.

Table 2.8 shows a summary giving equipment name, major specification, required number and main purpose of use.

(3) Procurement plan

The eligible source country of the equipment is summarized in table 2.9.

Italian products will be eliminated from list of eligible countries because their parts service system is considered insufficient. The major construction equipment and vehicles should be procured from Japan from the view-point of quality and parts service system.

Eligible source countries for vibration rollers, air compressors and generators will be Japan, US, UK, Germany and Sweden from the view-point of product quality, parts service and price competitiveness, and those for asphalt boiler and chip spreader will be US, UK, Germany and Sweden from the view-point of availability.

Table 2.7 Eligible Source Plan

Equipment	Main Spec.	Eligible source	Reason
Motor Grader	200-220HP	Japan	In view of quality and parts service
Bulldozer	220-235HP	Japan	In view of quality and parts service
Wheel Loader	200-220HP	Japan	In view of quality and parts service
Hyd. Excavator Wheel type	150HP class	Japan / third countries	Only one source in Japan, many sources in third countries
Vibration Roller	10t class	Japan / third countries	Good quality and price can be also expected in third countries.
Vibration Roller	9.5t class	Japan / third countries	Good quality and price can be also expected in third countries.
Dump Truck	$9m^3$, 6x4	Japan	In view of quality and parts service
Water Tanker Truck	12,000 Ltr	Japan	In view of quality and parts service
Fuel Tanker Truck	16,000 Ltr	Japan	In view of quality and parts service
Fuel Tanker Truck	8,000 Ltr	Japan	In view of quality and parts service
Asphalt Distributor	6,000 Ltr	Japan	In view of quality and parts service
Asphalt Boiler	6,000 Ltr/h	third countries	Difficult procurement in Japan
Chip Spreader	4m	third countries	Difficult procurement in Japan
Low Bed Trailer Tractor	4 0t, 8m	Japan	In view of quality and parts service
Pick-up Truck	4x4, double cab	Japan	In view of quality and parts service
Mobile Rock Crusher	120 t/h	Japan	In view of quality and parts service
Hyd. Excavator Crawler type	150HP class	Japan	In view of quality and parts service
Air Compressor	$7.5m^3$/min	Japan / third countries	Good quality and price can be also expected in third countries.
Crawler Drill	5t	Japan	In view of quality and parts service
Air Compressor	$20m^3$/min	Japan	To be attached to crawler drill
Repair Tool Set	for repairs	Japan	In view of quality and parts service
Truck Crane	25t	Japan	In view of quality and parts service
Lubrication Truck	4 x 4	Japan	In view of quality and parts service
Generator	100kVA	Japan / third countries	Good quality and price can be also expected in third countries.
Generator	30kVA	Japan / third countries	Good quality and price can be also expected in third countries.