2-2-2-7 Overall plan

(1) Applicable design standards and conditions

1) Road design conditions

The standards established in Ethiopia will be followed in the road design. Japanese standards (Road Structure Ordinance) will be followed where the Ethiopian standards have no provision. Table Table 2-2-9 shows the road design conditions.

Table 2-2-9 Road design conditions

Bridge name	Unit	Awash Bridge
Design elements		Mountainous area
Road standards		DS2
Design velocity	km/h	85
Minimum stopping sight distance	m	155
Minimum passing sight distance	m	340
Minimum horizontal curve radius	m	270
Need for transition (clothoid) curves		Yes
Maximum longitudinal slope (recommended)	%	6
Maximum longitudinal slope (absolute value)	%	8
Minimum longitudinal slope	%	0.5
Maximum superelevation	%	8
Minimum vertical curve radius (convex)	k	60
Minimum vertical curve radius (concave)	k	36
Standard cross slope	%	2.5
Shoulder cross slope	%	4
Right of way (ROW)	m	50

2) Bridge design conditions

i) Hydraulic conditions

a) Probability scale

In accordance with the road standards of Ethiopia, 100-year design flood discharges will be used in the design of the bridge.

b) Design flood discharges

The 100-year design flood discharge of Awash River is 1,590 m^3/s.

c) Design flood levels

The 100-year design flood level of Awash River is 800.159m.

d) Vertical clearances

The table below shows the vertical clearances stipulated in Bridge Design Manual (2002) of Ethiopia.

Discharge Q (m^3/s)	Vertical clearance (m)
0 - 3.0	0.3
3.0 - 30.0	0.6
30 to 300	0.9
> 300	1.2

Table 2-3 Vertical Clearance at Design Flood Level (DFL)

The vertical clearance required for Awash Bridge is 1.2m from the table above.

e) Revetment

The river which the planned bridge is to be built is natural river. The river channel has not been altered artificially and there is no embankment along the river. There is no revetment or bed protection work near the abutments or piers of the existing bridge or on the river banks upstream or downstream of the bridge. Bedrock is exposed on the river banks where the bridge exists. There are limited amounts of earth and stone sediment transported from the upper reaches of the river and tributaries upstream and downstream of the current bridge sites. Therefore, there is no possibility of river-bed variation caused by scour at the time of flood. In order to ensure safe and smooth flow of flood water as has been seen up to now after the bridge construction, the revetment work focused on restoration of the original conditions will be considered.

ii) Design live loads

As described in 2-1-5, Policies on Design Live Load, the figure 25 % larger than HS20 stipulated in the Ethiopian standards (Bridge Design Manual: 2002) based on AASHTO will be used as the design live load on the bridges.

iii) Seismic load

Ethiopia has Bridge Design Manual: 2002, which stipulated the seismic loads as follows:

a) Earthquake zones

The entire country is classified into five earthquake zones, ⓪ to ④, and the bridge concerned is located in Zone ④.

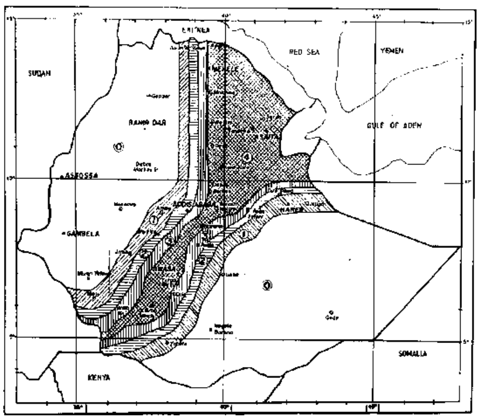


Figure 3-9 Earthquake Zones (Note: In zone 1-3 A≤0.07 and in zone 4 A≤0.10)

b) Response acceleration coefficient

Among the five earthquake zones, a response acceleration coefficient has been provided for each of the Zones 1 to 4, as shown in the table below. The coefficient for the three bridges concerned was set at A = 0.10 with safety allowance.

EBCS zone from Figure 3-9	Acceleration Coefficient
1	$A \le 0.03$
2	$0.03 < A \le 0.05$
3	$0.05 < A \le 0.07$
4	$0.07 < A \le 0.10$

c) Horizontal seismic vibration

Horizontal seismic vibration is obtained from the following equation:

$$Cm = 1.2AS / Tm^{2/3} \leqq 2.5A,$$

where:

Cm: Horizontal seismic vibration,

A: Response acceleration coefficient = 0.10,

S: Site coefficient = 1.0 (in accordance with the table below) and

Site Coefficient	Soil Profile Type			
	I	II	III	IV
S	1.0	1.2	1.5	2.0

Tm: Natural period of structure.

The maximum vibration of Cm = 2.5A = 2.5 x 0.1 = 0.25 obtained from the equation above with safety allowance will be used in the design.

iv) Material strengths

Table below shows the strengths of various materials to be used in this project.

Table 2-2-10 Materials to be used

1) PC concrete	・ Main girder σ_{ck}=35N/mm^2
2) RC concrete	・ Wall railing and substructure work : σ_{ck}=24N/mm^2
3) Plain concrete	・ Sidewalks, leveling concrete : σ_{ck}=18N/mm^2
4) Reinforcing bars	・ SD345
5) PC steel materials	・ Main cable : 12S12.7 (SWPR7BL) ・ Transverse prestressed cable : 1S21.8 (SWPR19L)

v) The specification process for span length

The specification process for the bridge span length is shown in Figure 2-2-10.

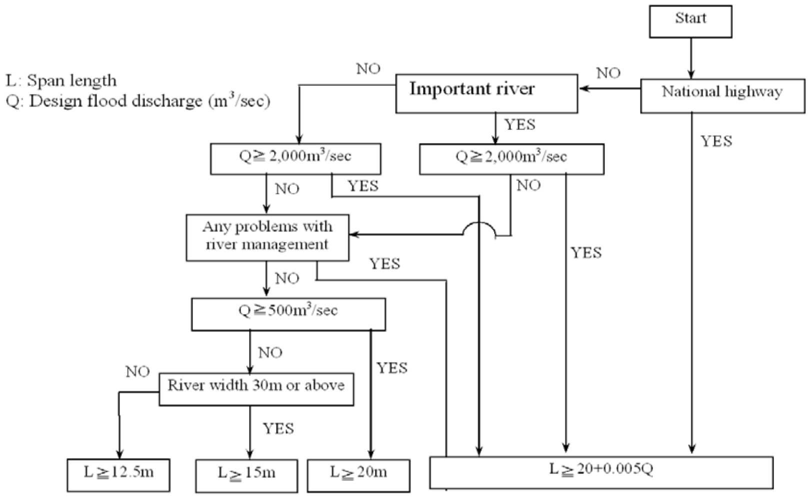


Figure 2-2-10 Specification Process for the Bridge Span Length

The table below shows the span lengths of the bridges concerned calculated in accordance with the procedures for the establishment of span lengths.

Table 2-2-11 Span length

Bridge name	Design flood discharge Q(m^3/sec)	Span length L ≧ 20＋0.005Q(m)
Awash Bridge	1,590	L≧20m (Application of a relaxed standard)

(2) Road width plan

The widths of the bridges and the access roads are as described in 2-2-1-4Policies on Bridge and Road Widths.

(3) Examination of bridge length

This bridge is located in a steep valley as shown in Figure 2-2-12. Under such a topographic condition, a bridge has side spans shorter than the center span and suffers from negative reaction force and residual stress on the piers. Therefore, balance between the lengths of the center span and side spans has to be taken into consideration in the site plan for the abutments and piers. As the substructure of this bridge allows adoption of spread foundation with either soft or hard rock as a bearing stratum, consideration should be given to ensure the clearances in front of footings shown in Figure 2-2-11.

Since the bearing stratum at the locations of the piers in the middle is of hard rock, clearance of at least 1 m is required at the bases of the piers. However, as the slopes on the valley side are extremely steep (approx. 80°), each pier is to have crown clearance of B/2 at its base, taking the result of the stability calculation into consideration, and the length of the center span has been set at 70 m.

In order to minimize occurrence of negative reaction force and residual stress on the piers, the lengths of side spans were established with the precondition that the lengths of cantilever construction were to be the same on both the center and side span sides. The lengths of the cantilever construction at the A1 side with a relatively gentle slope and the A2 side with a steep slope were established at 38 m and 28 m, respectively. The side span lengths, which allowed the abutments to be located reasonably on the existing slopes, were decided by adding the minimum length of *ca*. 4 m of the sections where side span support work was to be executed, whose exact lengths were decided by relative positions of mobile construction vehicles and abutments, to the lengths of the cantilevers.

In the end, the length of this bridge was decided at 43.0 + 70.0 + 32.0 = 145.0 m as shown in Figure 2-2-12.

Meanwhile, because of the soft rock bearing stratum, a crown clearance approx. B/2 will be required at the base of the Abutment A1 in accordance with Figure 2-2-16. The crown clearance of approx. B, equivalent to that for the bearing stratum of earth, will be required at the base of the Abutment A2, because the soft rock slope on the valley side, on which the line of the excavation for the construction of Pier P2 remains as permanent cutting, is very steep for supporting a structure and the soft rock composing the bearing stratum is rather soft and also taking the result of the stability calculation into consideration.

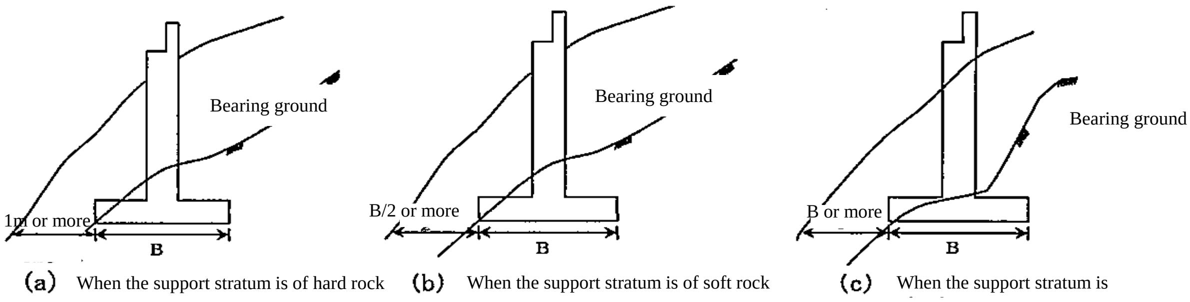


Figure 2-2-11 Clearances in front of footing

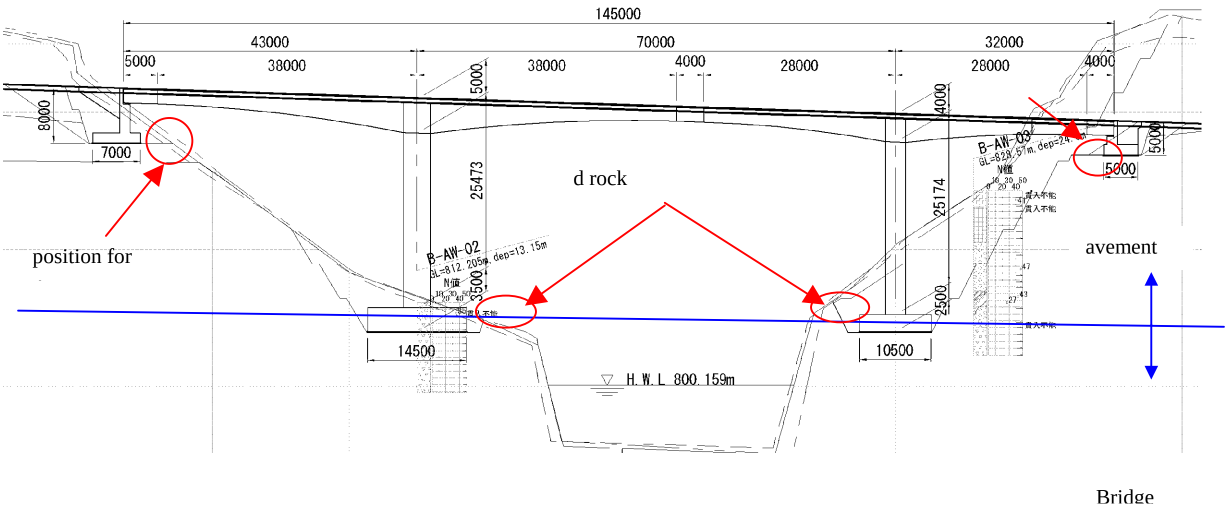


Figure 2-2-12 Criteria for the design of the new bridge

(4) Comparison of bridge structure

Since the required length and standard span length of this bridge were 145.0 m and 28.0 m, respectively, the following two alternative span lengths were considered.

- Three unequal-length span alternative (box-girder bridge): L = 43.0 + 70.0 + 32.0 = 145 m
- Three unequal-length span alternative (arch bridge): L = 25.5 + 94.0 + 25.5 = 145 m
- Three unequal-length span alternative (beam rigid-frame bridge):L = 37.5 + 70.0 +37.5 = 145 m

Applicable superstructures were identified for the three alternatives mentioned above using the "standard applicable spans," shown in Table 2-2-12, as references and the following three alternatives were selected for the comparison.

Table 2-2-12 Standard applicable spans

Superstructure type		Recommended span (50 m / 100 m / 150 m)	Curve applicable: Main structure	Curve applicable: Bridge deck	Girder height Span ratio
Steel bridge	Simple composite plate girder		○	○	1/18
	Simple plate girder		○	○	1/17
	Continuous plate girder		○	○	1/18
	Simple box girder		○	○	1/22
	Continuous box girder		○	○	1/23
	Simple truss		×	○	1/ 9
	Continuous truss		×	○	1/10
	Reverse Langer girder		×	○	1/6,5
	Reverse Lohse girder		×	○	1/6,5
	Arch		×	○	1/6,5
PC bridge	Pretentioned girder		×	○	1/15
	Hollow slab		○	○	1/22
	Simple T girder		×	○	1/17,5
	Simple composite girder		×	○	1/15
	Continuous T girder, composite girder		×	○	1/15
	Continuous composite girder		×	○	1/16
	Simple box girder		○	○	1/20
	Continuous box girder (cantilever method)		○	○	1/18
	Continuous box girder (Push-out or support method)		○	○	1/18
	π shaped rigid frame ridge		×	○	1/32
RC Bridge	Hollow slab		○	○	1/20
	Continuous spandrel-filled arch		○	○	1/ 2

Table 2-2-13 Alternative bridge structures compared

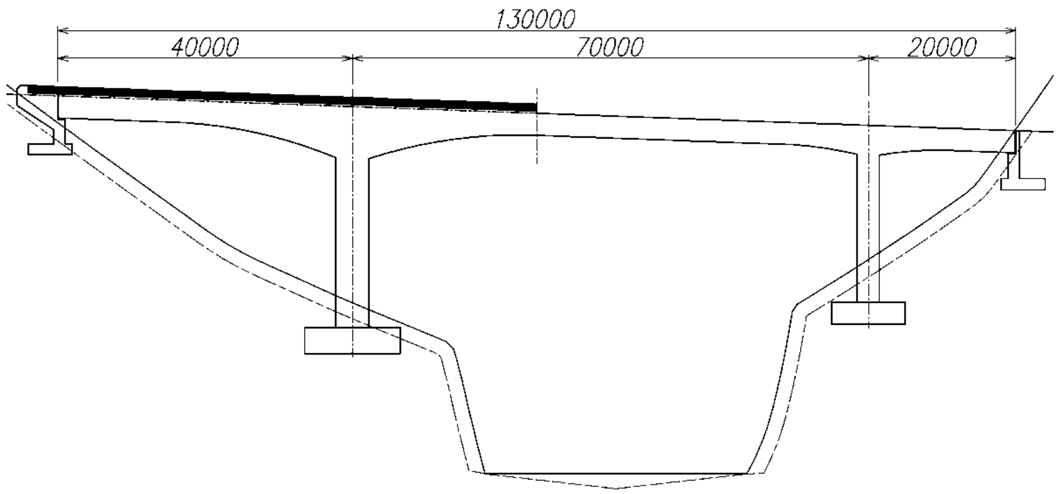
Alternative	Bridge type	Bridge structure	Number of spans	Bridge length
Alternative 1	PC bridge	3-span continuous PC box-girder bridge	3	L=43.0+70.0+32.0=145.0m
Alternative 2	PC bridge	Concrete arch bridge	3	L=25.5+94.0+25.5=145.0m
Alternative 3	RC bridge	Concrete beam rigid-frame bridge	3	L=37.5+70.0+37.5=145.0m

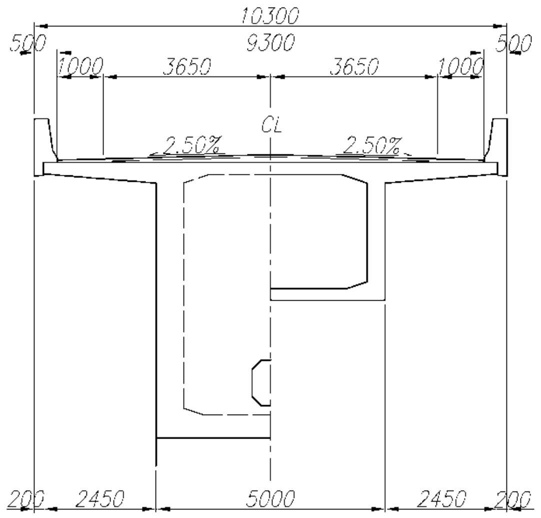
Since the comparison of the three alternatives had revealed that the Alternative 1 was the best alternative, it was selected as the structure of Awash Bridge. （SeeTable 2-2-14）

Table 2-2-14 Comparison of bridge structures

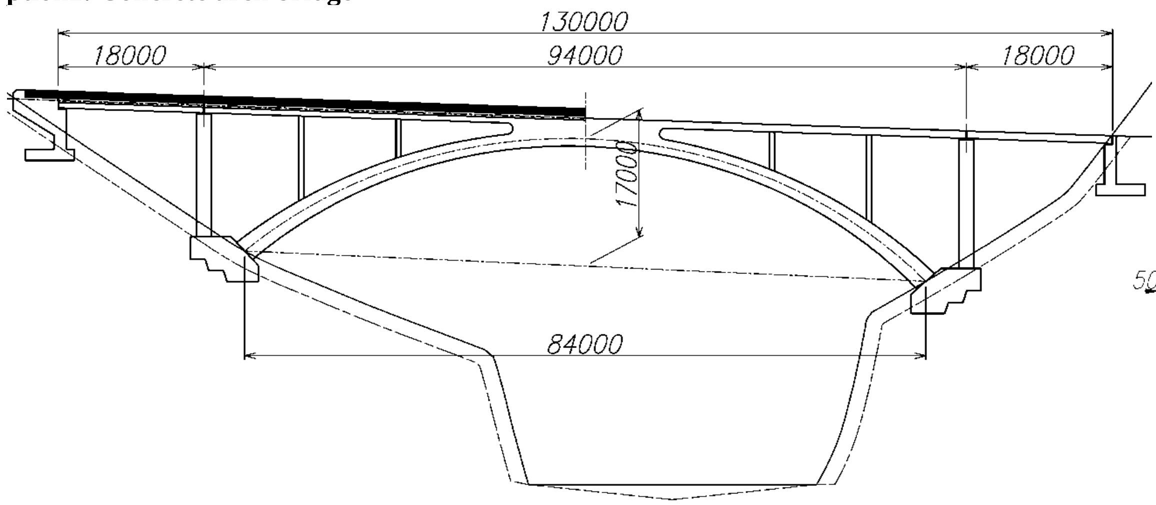
Bridge Structure	Characteristics		
Option 1: 3-span continuous PC box-girder bridge	Structure	・This PC box-girder bridge is ideal for long spans, and was used in many of the grant aid projects of the past. ・The continuous girder structure enables excellent cursoriality and seismic isolation.	
	Workability	・Cantilever erection is employed for the upper structure, which enables construction without impact of the river condition.	
	Maintenance	・The main body of the bridge does not require maintenance since the bridge is a concrete structure. ・In order to maintain durability, maintenance and management of paving, bearing, expansion joint and water discharge facility is required.	
	River characteristic	・The impact to the river is small, since the pier will not be built inside the river water.	
	Economic efficiency	・This is the best solution in terms of economic efficiency. ・Ratio to the estimated cost is 【1.00】	
	Overall evaluation	・Ideal plan due to the high economy efficiency, maintainability, and no impact to the river.	◎
Option2: Concrete arch bridge	Structure	・The cross sectional force is compressed, thus the bridge is a rational concrete arch bridge which utilizes the property of the durability of the concrete to compression. This structure is commonly employed for precipitous terrain such as valleys, etc.	
	Workability	・By employing a cantilever erection method with pylon or truss method, construction can be executed without being affected by the river.	
	Maintenance	・The main body of the bridge does not require maintenance in general, due to the structure built by concrete. ・In order to maintain durability, maintenance for ancillaries such as paving, bearing, extension joint, and water dischargers, etc. is necessary.	
	River characteristic	・No impact to the river due to not building the piers in the river water.	
	Economic efficiency	・Economic efficiency is lower than other options. ・Ratio to the estimated cost is 【1.66】	
	Overall evaluation	・The structure is ideal for precipitous landscape. ・Economic efficiency is lower than other options.	△
Option 3: Concrete beam rigid-frame bridge	Structure	・A rigid-frame bridge with pier materials aligned diagonally, which its structure enables shortened center spans. Commonly employed for precipitous terrains. ・Performance of this type of bridge is proven in Ethiopia. ・Excellent cursoriality and seismic isolation since the structure is a continuous rigid-frame.	
	Workability	・Cantilever erection is employed for the upper structure, which enables construction without impact of the river condition.	
	Maintenance	・The main body of the bridge does not require maintenance in general, due to the structure built by concrete. ・In order to maintain durability, maintenance for ancillaries such as paving, bearing, extension joint, and water dischargers, etc. is necessary.	
	River characteristic	・No impact to the river due to not building the piers in the river water.	
	Economic efficiency	・Economic efficiency is at mid-level of the three options. ・Ratio to the estimated cost is 【1.47】	
	Overall evaluation	・The structure is ideal for precipitous landscape. ・Economic efficiency is at mid-level of the three options.	○

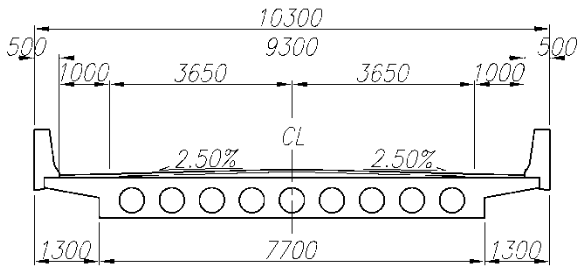
Option 1:



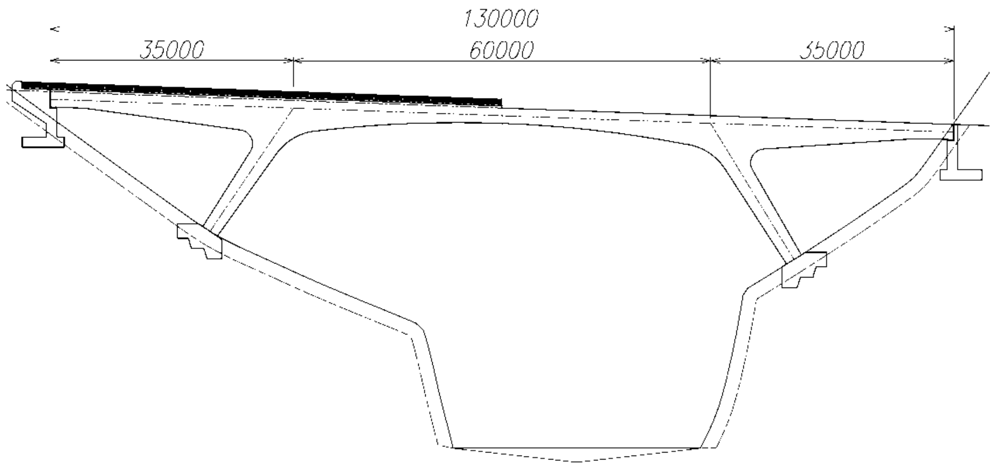


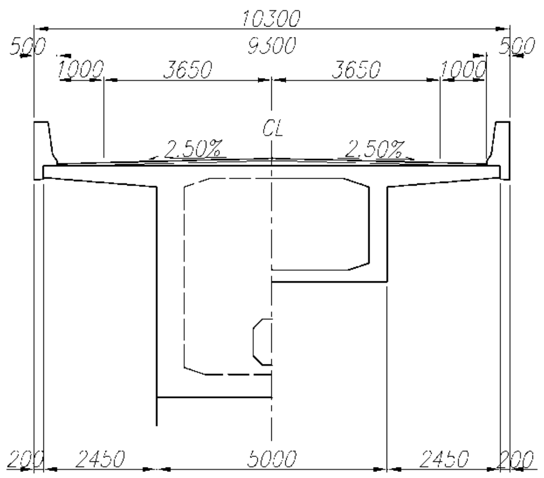
Option 2:





Option 3:





(5) Examination on structures of substructure and foundation works

1) Selection of bearing strata

The geological survey revealed the existence of an unusual ground where various layers, consisting, from the surface, of hard rock, soft rock and hard rock layers, lay almost horizontally near this bridge, as shown in Figure 2-2-13. As there are layers of relatively weathered soft rock (N value of 50 or less) within the soft rock layer, measures should be taken so that the bottom of the foundation does not reach these weathered layers.

Because of strong reaction force acting on the piers, the lower hard lock layer was selected as the bearing stratum for the piers.

The upper part of the soft rock layer where there is no weathered soft lock layer was selected as the bearing stratum for the abutments.

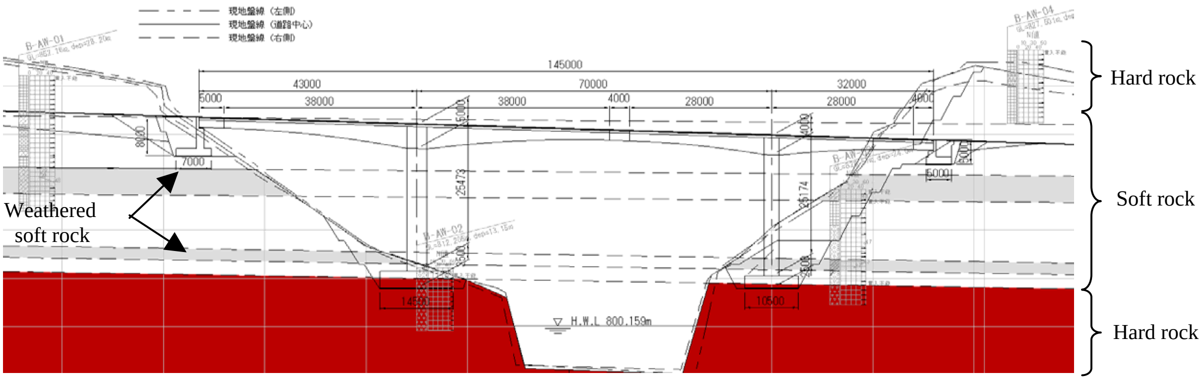


Figure 2-2-13 Location of the assumed rock surfaces of the bearing strata

2) Structures of substructure and foundation works

The height of Abutment A1 was designed at 8 m in order to have a clearance of 1/2B as shown in Figure 2-2-11. A reverse-T type abutment was selected as the structure of A1 in accordance with Table 2-2-15.

The height of Abutment A2 was designed at 5 m in order to have a 2.8 m of clearance for the construction work in front of the abutment which would allow entry of mobile construction vehicles for superstructure construction. Among the two possible alternative structures of abutment, a gravity-type abutment and a reverse-T type abutment, in accordance with Table 2-2-15, the latter was selected for its reinforced concrete construction and superior earthquake resistance.

The heights of Pier P1 and Pier P2 were designed at *ca.* 25m with the location of the bearing stratum of hard rock layer and the design heights of the piers taken into consideration. A commonly-used solid reinforced concrete structure was adopted as the structure of the piers. Because the piers are to be located above the HWL of the river, a rectangular cross section was selected as the structure of the piers for its superior workability as shown in Table 2-2-15.

Spread foundation was selected as the structure of the foundation work of each substructure work in accordance with Table 2-2-16, because the entire bridge is located on the bearing strata of bedrock.

Table 2-2-15 Selection of structure of substructure works

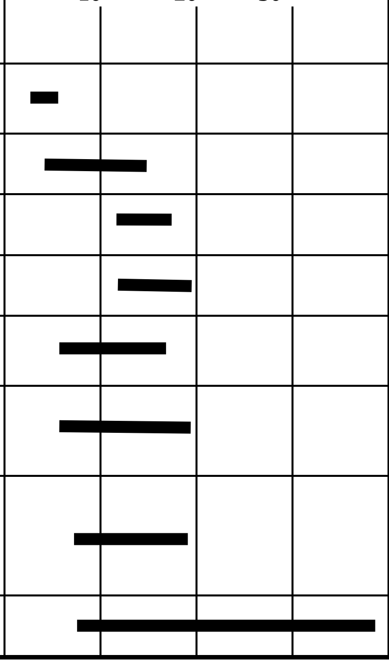
Bridge part	Structure type	Applicable height (m) 10 20 30 	Characteristics
Abutment	1. Gravity type		With shallow support ground, the gravity type is suitable for direct foundation.
	2. Reverse T-style		Used in many bridges. Suitable for direct foundation/ pile foundation.
	3. Buttressed type		Suitable for tall abutments. Few materials are used for this type, but the lead time is long.
	4. Box type		Designed for tall abutments. The lead time is slightly long.
Pier	1. Column type		Low piers. Suitable for stringent intersection conditions and installation in a river.
	2. Rigid frame type		Relatively tall piers. Suitable for wide bridges. Their installation in a river may hinder water flow in time of flooding.
	3. Pile bent type		While they are the most cost efficient piers, they are not suitable for bridges with high horizontal force. Their installation in a river may hinder water flow in time of flooding.
	4. Elliptical type		Tall bridge piers. Suitable for bridges with high external force.

Table 2-2-16 Selection of structure of foundation work

Selection requirements \ Foundation types				Direct foundation	Cast pile foundation: RC pile	Cast pile foundation: PHC pile	Cast pile foundation: Steel pipe pile	Inner excavation pile foundation, PHC pile: Final impact driving method	Inner excavation pile foundation, PHC pile: Blast agitation	Inner excavation pile foundation, PHC pile: Concrete impact	Inner excavation pile foundation, Steel pipe pile: Final impact driving method	Inner excavation pile foundation, Steel pipe pile: Blast agitation	Inner excavation pile foundation, Steel pipe pile: Concrete impact	Cast in-situ pile foundaiton: All casing	Cast in-situ pile foundaiton: Reverse	Cast in-situ pile foundaiton: Earth drill	Cast in-situ pile foundaiton: Chicago board	Caisson foundation: Pneumatic	Caisson foundation: Open	Steel pipe sheet pile foundation	**underground continuous wall foundation**
Ground requirements	Below support layer	Soft ground in the interlayer		△	○	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○	○
		An extremely hard layer inside the inter layer		○	×	△	△	○	○	○	○	○	○	△	○	△	○	○	△	△	○
		Gravel in the interlayer	Gravel size 5 cm or below	○	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			Gravel size 5 cm〜10 cm	○	×	△	△	△	△	△	△	△	△	○	○	△	○	○	○	△	○
			Gravel size 10 cm〜50 cm	○	×	×	×	×	×	×	×	×	×	△	×	×	○	○	△	×	△
		The layer has liquefiable ground		△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Conditions of the support layer	Support layer depth	Below 5 m	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
			5〜15 m	△	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	△	△
			15〜25 m	×	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			25〜40 m	×	×	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
			40〜60 m	×	×	△	○	△	△	△	○	○	○	△	○	×	×	△	○	○	○
			60 m or above	×	×	×	△	×	×	×	×	×	×	×	△	×	×	×	△	△	△
		Soil properties of the support layer	Cohesivvve soil (20 ≦ N)	○	○	○	○	○	×	△	○	×	△	○	○	○	○	○	○	○	○
			Sand/ gravel (30 N)	○	○	○	○	○	○	×	○	○	×	○	○	○	○	○	○	○	○
		High gradient (30º or above)		○	×	△	○	△	△	△	○	○	○	○	△	△	○	○	△	△	△
		The surface of the support layer is severely uneven		○	△	△	○	△	△	△	○	△	△	○	○	○	○	○	△	△	○
	Groundwater	Groundwater level is close to the ground surface		△	○	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
		Significant amount of spring water		△	○	○	○	○	○	○	○	○	○	○	○	△	×	○	○	○	△
		Artesian groundwater 2 m above the ground surface		×	○	○	○	×	×	×	×	×	×	×	×	×	×	△	△	○	×
		Groundwater velocity is 3m/ min or above		×	○	○	○	○	×	×	○	×	×	×	×	×	×	○	△	○	×
Structural properties	Load size	Low vertical load (span length 20m or below)		○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	△	×	×
		Moderate vertical load (span length 20m to 50m)		○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		High vertical load (span length 50m)		○	×	△	○	△	△	△	○	○	○	○	○	△	○	○	○	○	○
		Horizontal load is lower than vertical load		○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△
		Horizontal load is higher than vertical load		○	×	△	○	△	△	△	○	○	○	○	○	○	○	○	○	○	○
	Support type		Support pile	/	○	○	○	○	○	○	○	○	○	○	○	○	○	/	/	/	/
			Friction pile	/	○	○	/	/	/	/	/	/	/	○	○	○	/	/	/	/	/
Construction requirements	Construction on water		Water depth below 5m	○	○	○	○	△	△	△	△	△	△	×	○	△	×	△	△	○	×
			Water depth 5m or above	×	△	△	○	△	△	△	△	△	△	×	△	×	×	△	△	○	×
	Limited work space			○	△	△	△	△	△	△	△	△	△	△	△	△	○	△	△	×	△
	Batter pile construction			/	△	○	○	×	×	×	△	△	△	△	×	×	×	/	/	/	/
	Effects of toxic gas			△	○	○	○	○	○	○	○	○	○	○	○	○	×	×	○	○	○
	Surrounding environment		Oscillation noise measures	○	×	×	×	△	○	○	△	○	○	△	○	○	○	○	○	△	○
			Effects on adjacent structures	○	×	×	△	△	○	○	△	○	○	○	○	○	△	△	△	△	○

(6) Examination on revetment and bed protection works

It will not be required for the construction of the bridge because substructure works will not be constructed in the river channel.

(7) Examination on access roads

1) Examination on compositions of pavement

i) Design life

The design life of the pavement of the road concerned shall be 20 years as that of the trunk road shown in Table 2-2-24.

Road Classification	Design Period (Years)
Trunk Road	20
Link Road	20
Main Access Road	15
Other Roads	10

page2-3

Table 2-2-17 Design life of pavement

ii) Design traffic volume

As described in 3-2-1-3(3), Future Traffic Volume Estimates, A.A.D.T. traffic volume on Awash Bridge 20 years from now is estimated at 6,526 vehicles/day. The table below shows the estimates of the cumulative traffic volume (vehicle · one-way) during the design life.

Table 2-2-18 Cumulative traffic volume during the design life

	Cumulative traffic volume during the design life (T)							
	Car	S.Wagon & Pickup	S/Bus [<27 seat]	L/Bus [>27 seat]	S/Truck [< 30 Qt]	M/Truck [30-70 Qt]	H/Truck [>70 Qt]	T & T
Cumulative two-way traffic volume	652,930	3,548,000	4,211,372	407,977	3,542,116	1,229,495	1,024,579	16,568,906
Proportion of vehicles in the direction of heavier traffic	52.9%	54.9%	50.7%	51.9%	63.2%	57.4%	67.1%	58.4%
Cumulative one-way traffic volume	345,669	1,946,472	2,136,744	211,543	2,239,437	706,306	687,932	9,677,921

The average axle load of each vehicle type has been set as follows on the basis of the result of the survey of axle loads described in the F/S Survey Report on the Addis – Adama Expressway.

Table 2-2-19 Average axle load by vehicle type

	S/Truck [< 30 Qt]	M/Truck [30-70 Qt]	H/Truck [>70 Qt]	T & T
Average Load (Tn)	4.3	7.7	11.8	27.9

iii) Standards load equivalency factors

It was decided that the figures shown in the table below, which were provided in the Pavement Design Manual of Ethiopia, were to be used as factors to convert various axle loads of different types of vehicles derived from the result of the axle load survey by vehicle type to the standard load of 8.16 metric tons.

Equivalency Factors for Different Axel Loads

Wheel Load (single & Dual) (10^3kg)	Axel Load (10^3kg)	Equivalency Factor (EF)
1.5	3.0	0.01
2.0	4.0	0.04
2.5	5.0	0.11
3.0	6.0	0.25
3.5	7.0	0.50
4.0	8.0	0.91
4.5	9.0	1.55
5.0	10.0	2.50
5.5	11.0	3.93
6.0	12.0	5.67
6.5	13.0	8.13
7.0	14.0	11.30
7.5	15.0	15.50
8.0	16.0	20.70
8.5	17.0	27.20
9.0	18.0	35.20
9.5	19.0	44.90
10.0	20.0	56.50

Page2-9

The total ESAs at Awash Bridge were estimated from the cumulative traffic volume during the design life as shown in the table below.

Awash Bridge

Type of Vehicle	Equivalency Factor	Cumulative traffic volum	10^6 ESAs
Car	0	415,203	0.0
Bus	0.14	19,255	0.0
Truck	6.67	302,042	0.0
Truck-Trailer	11.47	804,458	0.3
		Total ESAs	**0.3**

The types of vehicles used in the traffic volume survey are consolidated as follows

Car	Car , S.Wagon & Pickup , S/Bus [<27 seat]
Bus	L/Bus [>27 seat]
Truck	S/Truck [< 30 Qt] , M/Truck[30-70 Qt] , H/Truck [>70 Qt]
Truck-Trailer	T & T

The figure of the one-way ESAs is to be reduced in accordance with the number of lanes in each direction. As the section of the road surveyed has one lane in each direction, the 100 % figure will be used in the pavement design.

Number of Lanes in each direction	Percent of ESAs in design Lane
1	100
2	80 - 100
3	60 - 80

As the road has one lane in each direction, the 100% ESAs will be used as the design value.

Thus, the design ESAs of 3.8 are obtained from the equation below.

3.8 * 100% ＝ 3.8

Therefore, the traffic class T5 will be applied to the pavement design of the access road to Awash Bridge.

Traffic classes	Range (10^6 ESAs)
T1	＜0.3
T2	0.3 - 0.7
T3	0.7 - 1.5
T4	1.5 - 3.0
T5	3.0 - 6.0
T6	6.0 - 10
T7	10 - 17
T8	17 - 30

iv) Design of subgrades

The table below shows the classification of subgrades provided in the Pavement Design Manual of Ethiopia.

Table 2-2-20 Subgrade classification

Class	Range（CBR%）
S1	2
S2	3～4
S3	5～7
S4	8～14
S5	15～29
S6	30+

Because the design elevation of the access road to Awash Bridge is significantly below the existing ground surface, it was impossible to conduct a CBR test. (It was impossible to collect samples for the test.) Meanwhile, a layer with relatively good geological characteristics was detected in the boring survey. Therefore, the CBR class S6 will be used for the design of the subgrade.

v) Establishment of pavement compositions

The design conditions examined as mentioned above were used for the examination on pavement structures.

The Pavement Design Manual of Ethiopia provides standard pavement compositions by traffic class and design CBR class. In this survey, these standard compositions were used in the estimation of the construction costs.

Meanwhile, the longitudinal slope of the access road to Awash Bridge is relatively large. Rutting has been observed in the section with a longitudinal slope of 7 %. In the Grant Aid Project, “The Project for Rehabilitation of Trunk Road, Phase III,” use of bituminous roadbase on base course was suggested as an effective measure against rutting. For these reasons, use of bituminous roadbase on base course is assumed in this survey.

A practical design of mixtures will be examined during the detailed design.

KEY TO STRUCTURAL CATALOGUE

Traffic classes
(10^6 esa)

T1 = < 0.3
T2 = 0.3 - 0.7
T3 = 0.7 - 1.5
T4 = 1.5 - 3.0
T5 = 3.0 - 6.0
T6 = 6.0 - 10
T7 = 10 - 17
T8 = 17 - 30

Subgrade strength classes
(CBR%)

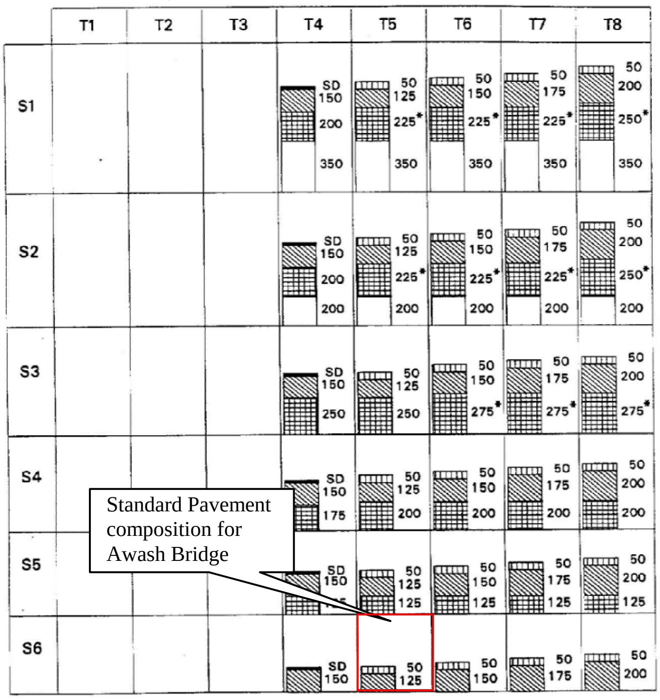
S1 = 2
S2 = 3 , 4
S3 = 5 - 7
S4 = 8 - 14
S5 = 15 - 29
S6 = 30+

Material Definitions

- Double surface dressing
- Flexible bituminous surface
- Bituminous surface (Usually a wearing course, WC, and a basecourse, BC)
- Bituminous roadbase, RB
- Granular roadbase, GB1 - GB3
- Granular sub-base, GS
- Granular capping layer or selected subgrade fill, GC
- Cement or lime-stabilised roadbase 1, CB1
- Cement or lime-stabilised roadbase 2, CB2
- Cement or lime-stabilised sub-base, CS

a) Standard pavement compositions of bituminous roadbase works

CHART 7 BITUMINOUS ROADBASE / SEMI-STRUCTURAL SURFACE



b) Examination on pavement compositions from the viewpoint of workability

The above-mentioned standard pavement compositions provided in the Ethiopian manual provide construction of bituminous roadbase directly on the surface of the existing subgrade. However, unevenness is likely to be created on the surface of the subgrade of soft rock in the sections of the road concerned. Therefore, it was decided to include construction of a subbase course as a leveling layer in the design.

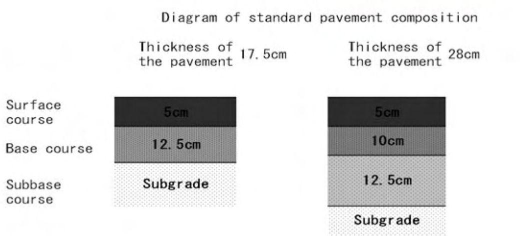
In order not to over-design the pavement structure in the design, the thickness of pavement in the modified composition was designed in such a way that the modified composition should have a TA value almost the same as that of the standard composition.

After the examination on the pavement thickness, it was decided that, while reducing the thickness of the base course from what provided in the standard pavement composition, *i.e.* 125 mm, to 100 mm, a 125 mm-thick subbase course was to be constructed with crusher-run.

The thickness of the subbase course is designed at 125 mm as it satisfies the condition for the minimum thickness of base course of three times the maximum grain size of pavement material (provided in the Asphalt Pavement Manual), *i.e.* crusher-run 40 – 0.

The table below shows the calculated TA values for the two pavement compositions.

Layer	Material	Equivalency factor	① Ethiopian Manual Original composition		② Workability considered Improved composition	
			Thickness (m)	TA value	Thickness (m)	TA value
Surface course	Hot asphalt mixture	1.00	0.05	0.05	0.05	0.05
Base course	Asphalt stabilized roadbase (hot)	0.80	0.125	0.10	0.10	0.08
	Mechanically stabilized crushed stone roadbase	0.35				
Subbase course	Crusher-run	0.20			0.125	0.03
		Cumulative TA value		0.15	≦	0.16



2) Thoughts on various types of pavement works

Use of asphalt concrete pavement, which has been used in most of the pavement works in Ethiopia, will be the basic policy for the pavement work on three bridges surveyed in this survey and the access roads on both sides of them.

Cement concrete pavement has been used in few projects and the system to maintain such pavement has problems in Ethiopia. Therefore, an agreement has been reached with ERA on adoption of asphalt concrete pavement for the project during the field survey.

Nonetheless, cement concrete pavement has been adopted for construction of some of the access roads to the construction sites for construction vehicles, which will be put into use for short periods of time, for efficient operation of the plant in accordance with the execution schedule.

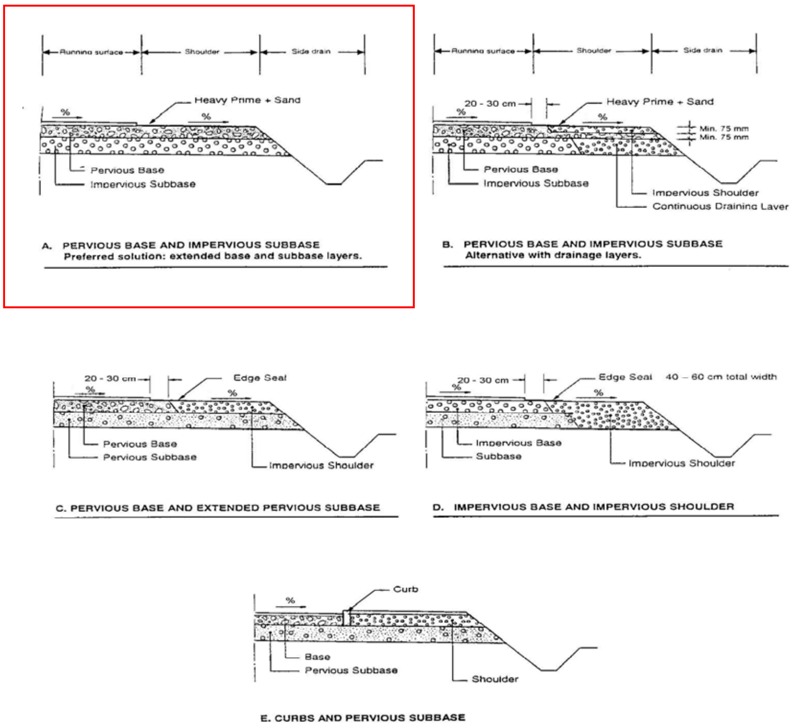
The manuals of Ethiopia mentioned below were followed in the selection of the pavement structures:

- Pavement Design Manual - Volume I – Flexible pavements and gravel roads; and
- Pavement Design Manual - Volume II – Rigid pavements.

3) Structure at the edge of pavement

Structure A with surface course only on the carriageway and base course exposed on the shoulders was selected among the options below, for economic efficiency and ease of maintenance. This is also the structure provided in the Ethiopian manual.

The same structure is used on the existing roads to which the access roads to the bridges are to be connected.



4) Examination on slope protection work

i) Gradients of slopes

In compliance with the Ethiopian manual, the gradients of slopes of embankment and cutting executed in the earthwork for the construction of the access roads have been designed as follows:

a) Embankment

The table below shows the standards for gradients of embankment slopes provided in the Ethiopian manual, which are to be followed. As the design embankment heights exceed 2 m on the front and the back of the abutments, gradient of 1:2.0 was adopted as a principle.

Table 6-1: Slope Ratio Table – Vertical to Horizontal

Material	Height of Slope	Side Slope		Back Slope	Zone Description
		Cut	Fill		
Earth or Soil	0.0 - 1.0m	1:4	1:4	1:3	Recoverable
	1.0 - 2.0m	1:3	1:3	1:2	Non-recoverable
	Over 2.0m	1:2	1:2	1:1.5	Critical
Rock	Any height	See Standard Details			Critical
Black Cotton Soil*	0.0 - 2.0m	-	1:6	-	Recoverable
	Over 2.0m		1:4		

*Move ditch away from fill as shown in Figure 6-2

b) Cutting

A gradient of 1:1.0 for a back slope shown in the table below will be used as the standard for the gradient of slope of cutting.

Table 1: Side Slope and Back Slope

Material	Height of slope (H)	Side Slope (V to H)		Back Slope (V to H)	Zone
		Cut	Fill		
Earth or Soil	0.0 – 1.0 m	1:4	1:4	1:3	Recoverable
	1.0 – 2.0 m	1:3	1:3	1:2	Non – Recoverable
	Over 2.0 m	1:2	1:2	1:1.5	Critical
Rock	0.0 – 2.0 m	1:3	1:3	4:5	Non – Recoverable
	Over 2.0 m	1:2	1:2	1:1	Critical

Meanwhile, a gradient of 1:0.8, the median value for soft rock provided in Road Earth Work Manual – Slope Protection and Slope Stabilization Work Manual of Japan, was adopted for the access roads on both side of Awash Bridge on the basis of the large-scale cutting required in the sections of road adjacent to the access road, appearance of soft rock of relatively good quality after the cutting and the gradient of the slope of the existing road.

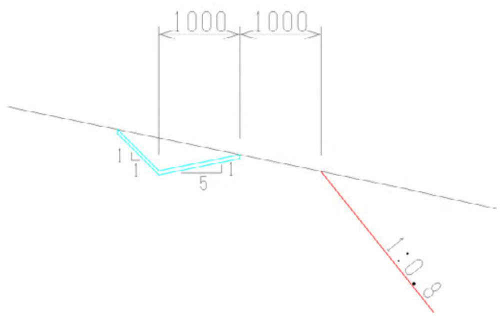
Table 3-1 Standard slope gradients for cutting

Soil of natural ground		Height of cutting	Gradient
Hard rock			1:0.3 – 1:0.8
Soft rock			1:0.5 – 1:1.2
Sand	Low density and poor grain size distribution		1:1.5 –
Sandy soil	High density	5 m or less	1:0.8 – 1:1.0
		5 m to 10 m	1:1.0 – 1:1.2
	Low density	5 m or less	1:1.0 – 1:1.2
		5 m to 10 m	1:1.2 – 1:1.5
Sandy soil mixed with gravel and blocks of rock	High density or good grain size distribution	10 m or less	1:0.8 – 1:1.0
		10 m to 15 m	1:1.0 – 1:1.2
	Low density or poor grain size distribution	10 m or less	1:1.0 – 1:1.2
		10 m to 15 m	1:1.2 – 1:1.5
Clay soil		10 m or less	1:0.8 – 1:1.2
Clay soil mixed with blocks of rock and cobbles		5 m or less	1:1.0 – 1:1.2
		5 m to 10 m	1:1.2 – 1:1.5

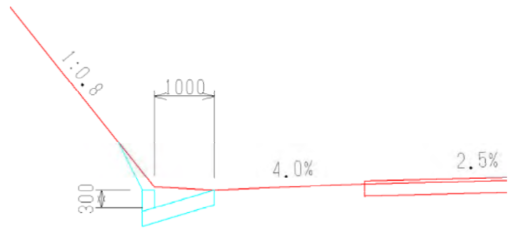
ii) Slope drainage work

A good drainage plan will be required for maintenance of the stability of the slopes in future. Installation of appropriate drainage structures will be required in particular at the sections on both sides of Awash Bridge where a large-scale cutting is to be implemented.

Drainage facilities shall be constructed on the top the slopes in order to prevent drainage from the surrounding area from flowing down the slopes and at the bottom of the slope in order to prevent rainwater fallen on the slopes from flowing onto the road surface.
With a principle of following the drainage structures provided in the Ethiopian manual, the basic structures shown below were included in the design



Drainage on the top of a slope



Drainage at the bottom of a slope

(8) Outlines of the facilities

The table below summarizes the outlines of the facilities in this project derived from the above-mentioned examinations.

Table 2-2-21 Facility outlines

Bridge structure		PC continuous rigid-frame box-girder bridge with three spans connected
Bridge length		43.0m + 70.0 m + 32.0 m = 145.0 m
Width		Carriageway: 3.65 m × 2 = 7.3 m, Shoulders: 1.0 m × 2 = 2.0 m, Total: 9.3 m (effective width), (gross width: 10.3 m)
Surface type		Asphalt pavement (70 mm on the carriageway)
Abutment structure		Abutment A1: Reverse-T type (with spread foundation) Abutment A2: Reverse-T type (with spread foundation)
Pier structure		Pier P1: Rectangular-shaped cross-section (with spread foundation) Pier P2: Rectangular-shaped cross-section (with spread foundation)
Access road	Total length	On the starting point (Addis Ababa) side: *ca.* 527 m, on the terminal point (Djibouti) side: *ca*. 408m, total: 935 m
	Width	Carriageway: 3.65 m × 2 = 7.3 m, Shoulders: 2.5 m × 2 = 5.0 m, Total: 12.3 m (effective width) Soft shoulders: 1.0 m × 2 = 2.0 m, Total: 14.3 m (gross width)
	Surface	Asphalt pavement (surface course: 50 mm, base course: 200 mm, Subgrade: 100 cm)

2-2-3 Outline design drawings

The outline design drawing prepared on the basis of the basic design mentioned above are shown in the following pages

- Figure 2-2-14 Plan of Access Road
- Figure 2-2-15 Profile of Access Road
- Figure 2-2-16 Standard Cross-section
- Figure 2-2-17 General View of Awash Bridge (1)
- Figure 2-2-18 General View of Awash Bridge (2)

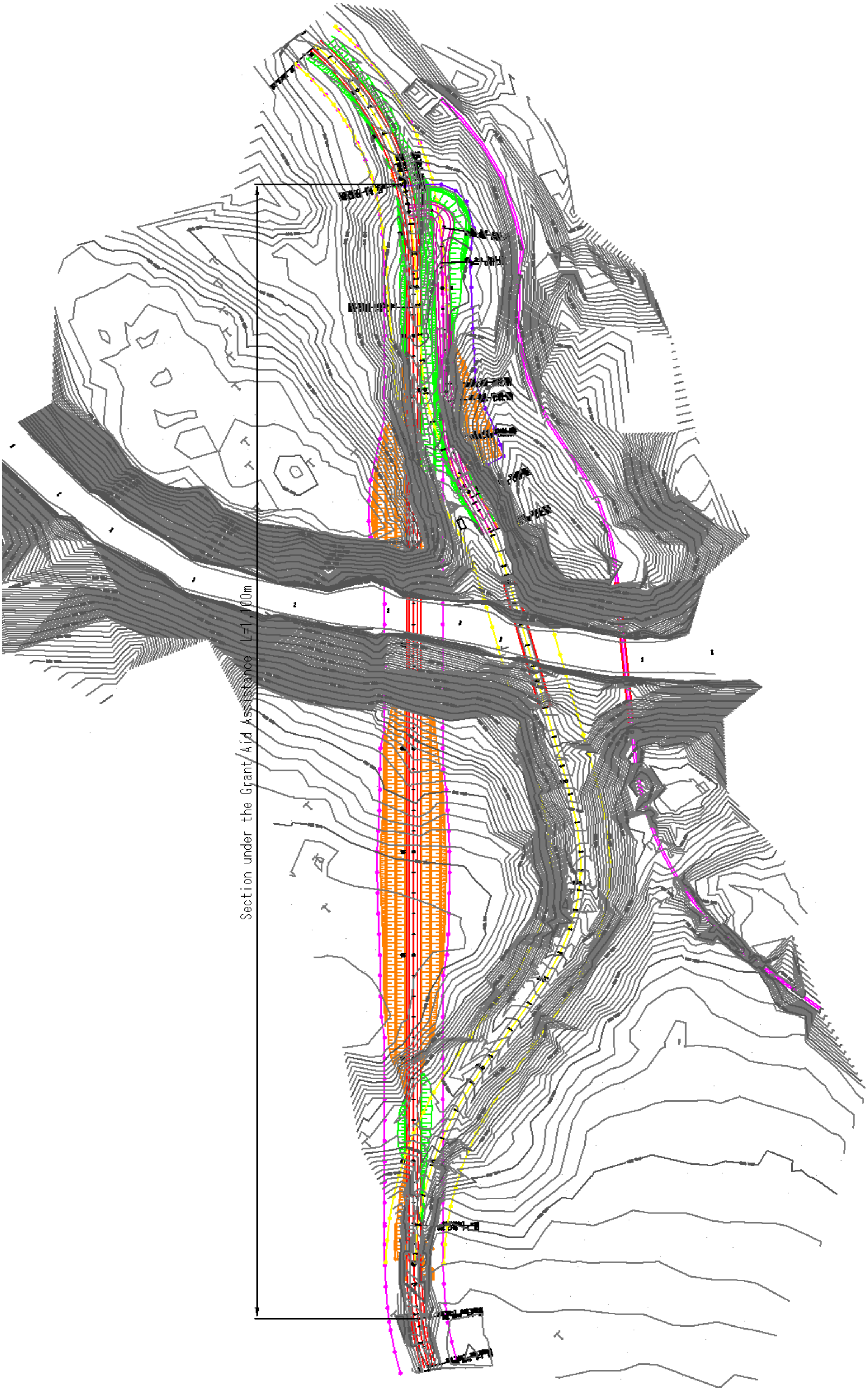


Figure 2-2-14 Plan of Access Road

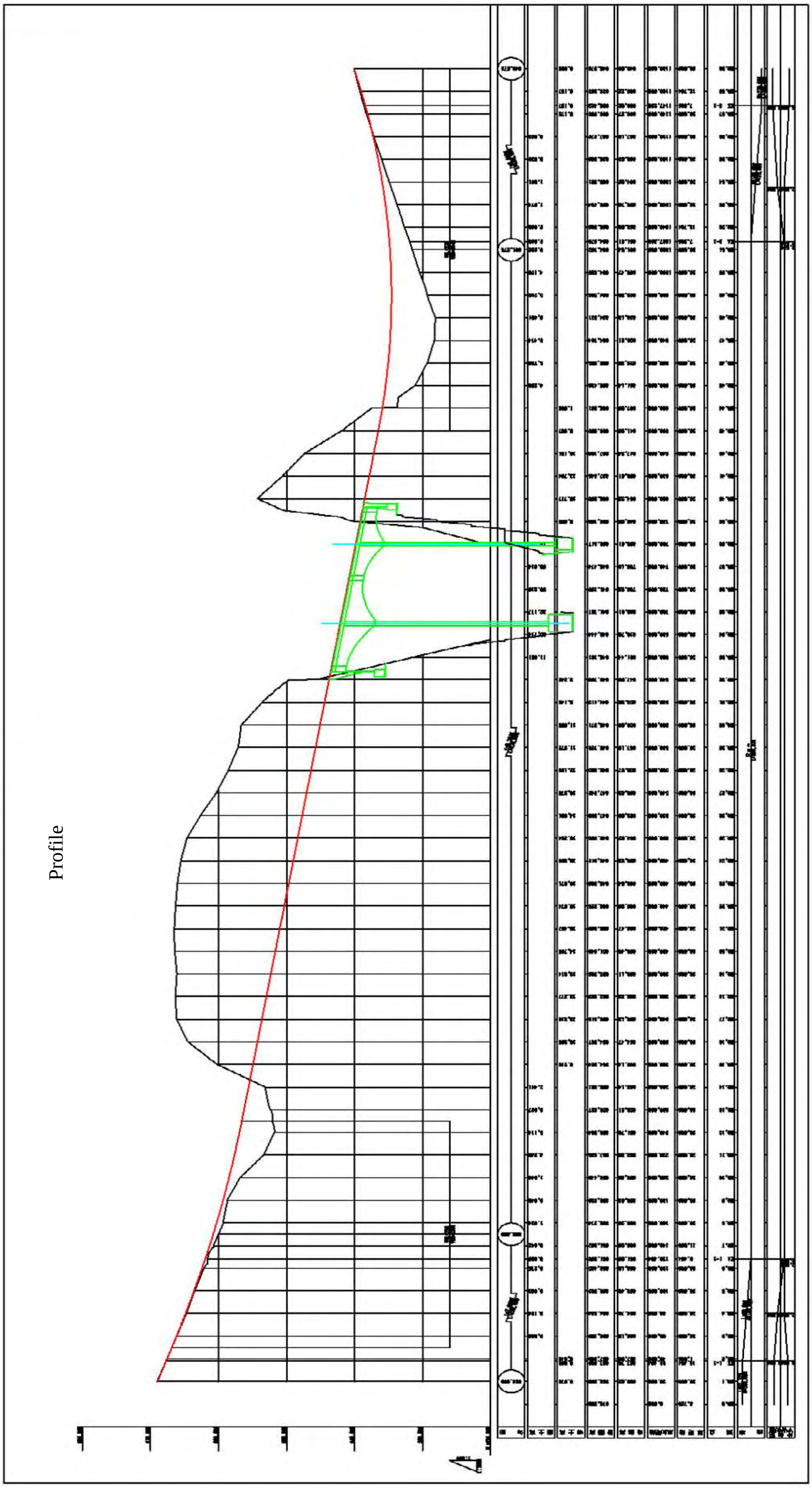


Figure 2-2-15 Profile of Access Road

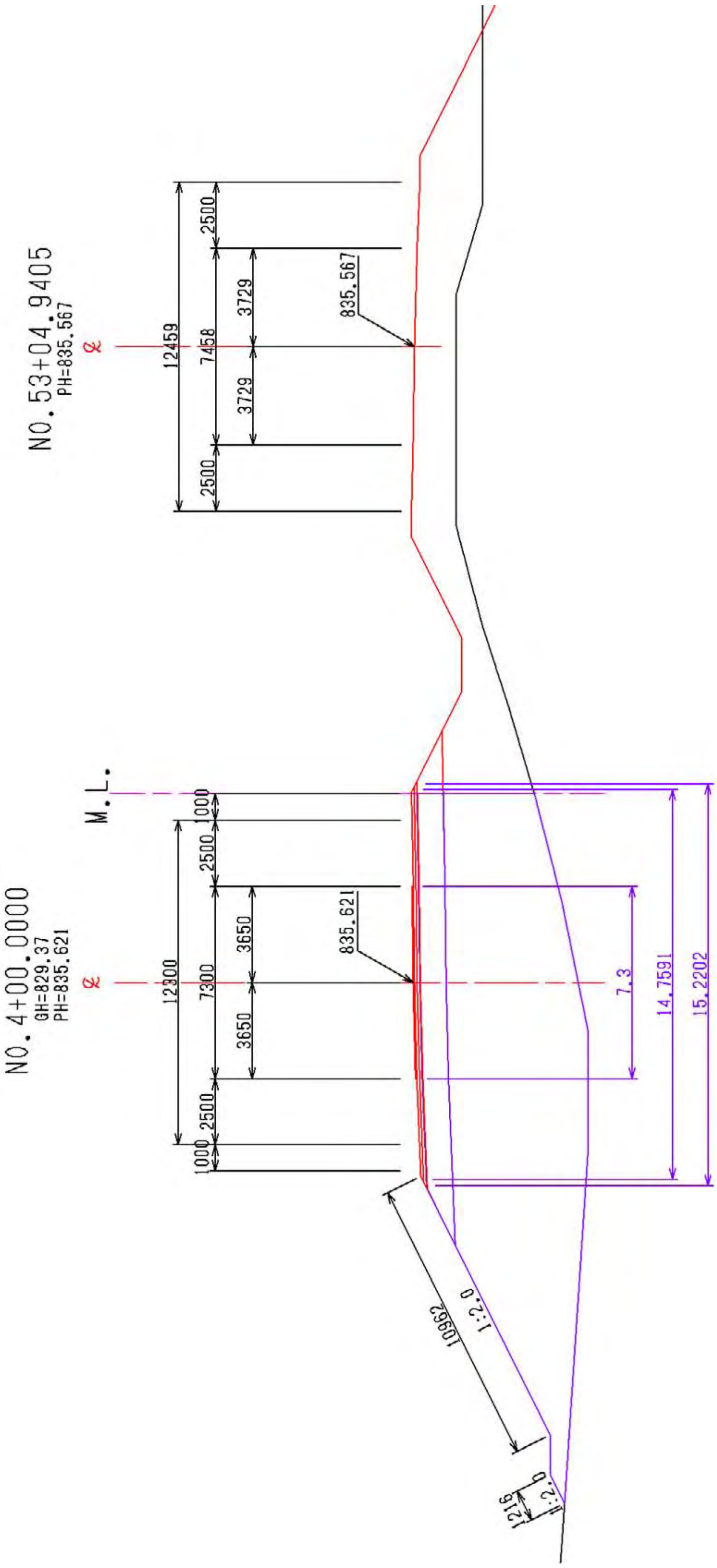


Figure 2-2-16 Standard Cross-section

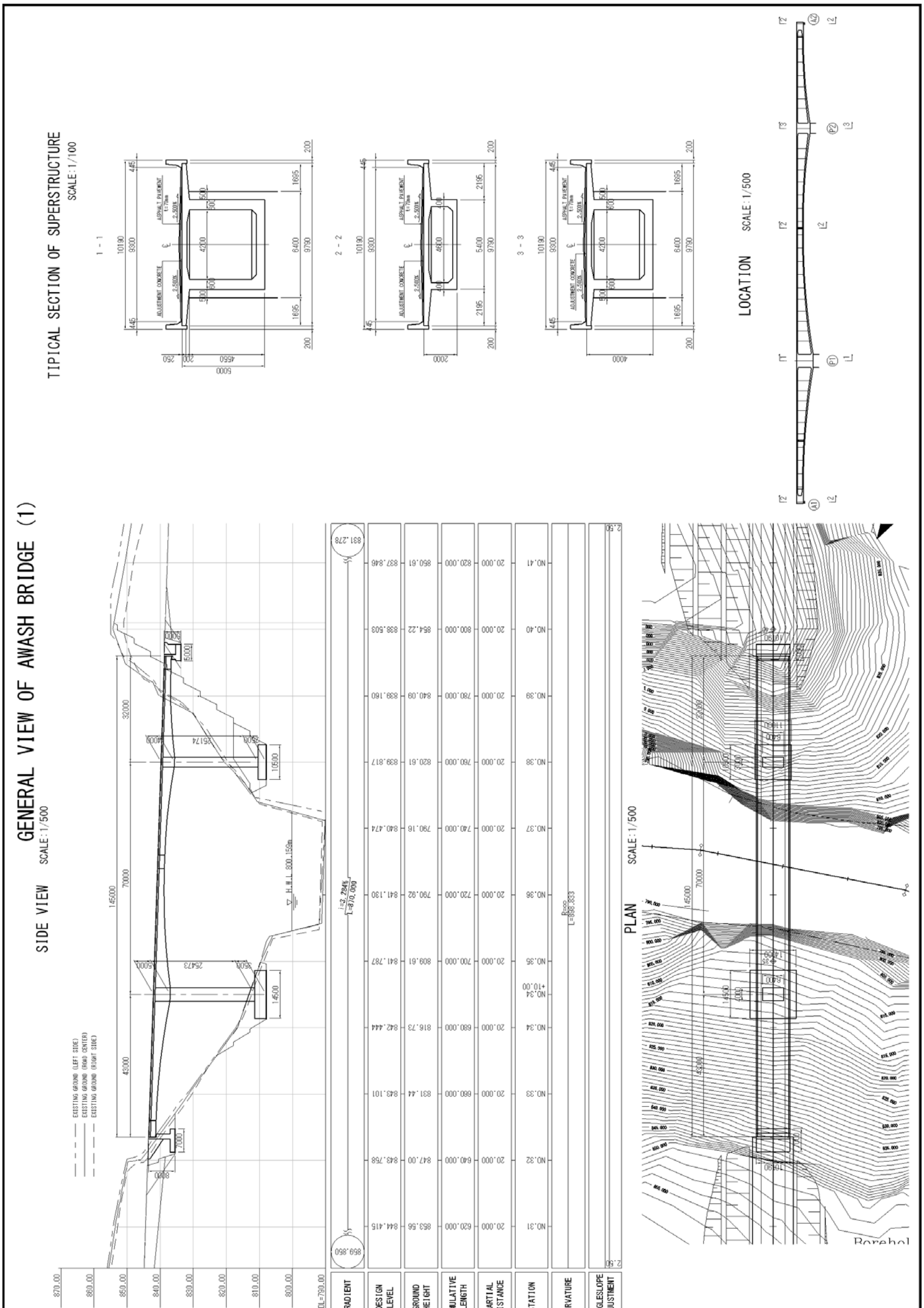


Figure 2-2-17 General View of Awash Bridge (1)

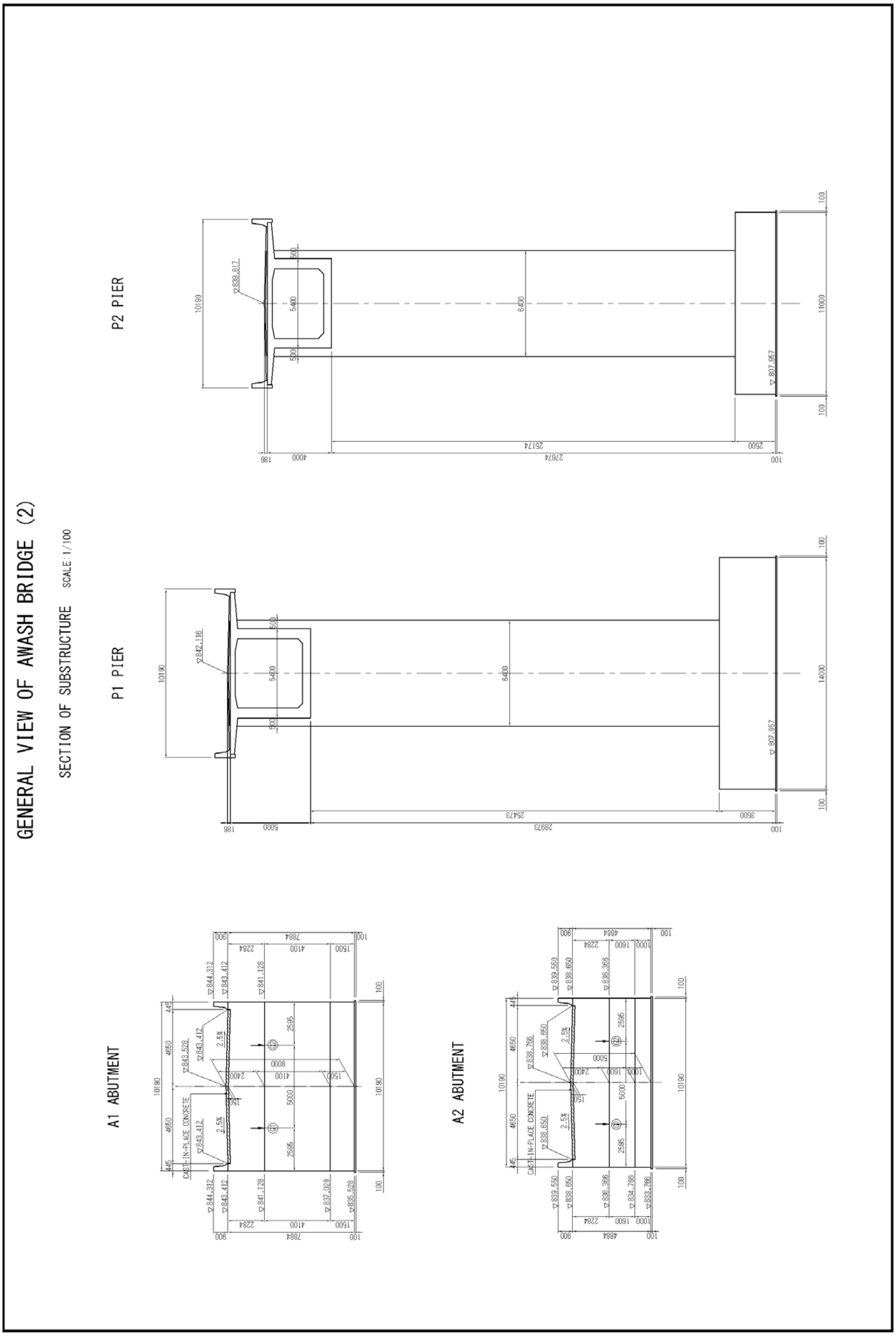


Figure 2-2-18 General View of Awash Bridge (2)

2-2-4 Implementation Plan

2-2-4-1 Implementation policies

Under the assumption that this project is to be implemented within the framework of the Japanese Grant Aid, the following will be considered as the basic policies for the examination on construction methods.

① In order to contribute to creation of employment opportunities and promotion of technology transfer, the project shall utilize local engineers, laborers, materials and equipment as much as possible.

② Close communication shall be established between the Government of the Federal Democratic Republic of Ethiopia (Ethiopian Government), the consultant and the contractor for smooth implementation of this project.

③ The Ethiopian Government shall be requested to secure land required for the implementation of this project (removal of houses and compensation for land expropriation) by its commencement as a work in the scope of works of the recipient country.

④ Steep slopes and exposed rock surface characterizes the natural condition of the construction sites. At such sites, there is a high risk of workers and equipment at work slipping down slopes in the rainy seasons. Appropriate construction methods and implementation schedule shall be designed with such a risk taken into consideration.

⑤ A practicable implementation schedule incorporating all possible measures for safety management during the construction shall be designed with the periods required for procurement of materials and equipment and adoption of appropriate construction methods under the restrictive topographic condition of landlocked Ethiopia taken into consideration.

2-2-4-2 Implementation Conditions

(1) Maintenance of safety during the construction period

The following are the principal measures for the maintenance of safety during the construction period.

- Since the access roads to the construction sites for the construction vehicles diverge from the existing A1 Trunk Road at all three sites, traffic controllers shall be stationed at the junctions of the access roads and the trunk road and sufficient numbers of construction signboards, traffic signs and traffic safety equipment shall be installed at appropriate locations.
- At sites where certain work has to be implemented in a river, implementation of work near a river should be minimized in the rainy seasons because the water level may rise suddenly at some of these sites.

(2) Environmental conservation during the construction period

The following are the principal measures for environmental conservation during the construction period.

- Creation of dust by the traffic of construction vehicles shall be suppressed with measures such as spraying water and imposing speed limit.
- Because of noise and vibration created by construction machinery, construction work shall not be implemented in the early morning or in the night.
- Since the construction vehicles will use the detours, measures shall be taken to minimize adverse effects caused by the traffic of vehicles and machinery involved in this project on the traffic of ordinary vehicles.

(3) Strict adherence to the Labor Standard Act

The contractor shall adhere to the laws and regulations on construction work which are in force in Ethiopia, respect appropriate labor conditions and customs associated with employment, prevent conflicts with laborers and maintain the safety of work with them.

(4) Strong awareness against danger at the project sites

Landmines were laid around the existing Awash Bridge and Railway Bridge during the civil war in Ethiopia. Demining activities has been conducted in the area.

The construction site is far from the presumed mined area and has been searched for landmines. The construction will commence under the assumption that the site is free of landmines. Nevertheless, people involved in the construction work shall always remain on the watch for landmines with the above-mentioned fact in mind.

(5) Customs clearance

All construction materials and equipment procured from Japan and third countries (including South Africa) will be transported to and unloaded in Djibouti and cleared customs. Therefore, the number of days required for the transport, unloading and customs clearance shall be estimated and the estimated number of days shall be taken into consideration when designing the implementation plan.

(6) Emphasis on quality control of concrete

The substructure work of constructing Abutments A1 and A2 and Piers P1 and P2 and the superstructure work of constructing concrete girders are considered principal construction works in this project of constructing the three bridges. In short, the concrete work is considered as the principal work. Therefore, the construction shall have to be executed with the highest priority on the quality control of concrete, including quality control of materials such as aggregate, sand, water and cement, regulations on specifications of a concrete mixing plant, regulations on transport of concrete and management of concrete casting and curing.

2-2-4-3 Scopes of Works

If this Grand Aid project is to be implemented, the scopes of works of the Japanese side and the Ethiopian Government will be as follows:

Table 2-2-22 Scopes of works of the Japanese side ant the Ethiopian Government

Scope of works of the Japanese side	Scope of works of the Ethiopian side
・Implementation of the cooperation project described in the "Basic Plan," *i. e.* construction of new Awash Bridge (bridge length = 145 m) with access road (950 m) ・Construction and removal of temporary facilities (material/equipment yards, offices, etc.) ・Safety measures for the works and general traffic passing through the construction areas during the construction period ・Measures to prevent environmental pollution by the construction work during the construction period ・Procurement, import and transport of construction materials and equipment described in "Procurement Plan": Re-export of imported equipment ・Preparation of implementation design, tender documents and agreements, assistance in tender and supervision of the construction work described in "Consultant Supervision", including monitoring of the environment management plan	・Land expropriation required for this project, removal of facilities and houses to be affected by the project and smooth relocation of residents ・Provision of lots for the temporary facilities required for this cooperation project free of charge ・Issuance of IDs to the people involved in the construction and stickers to construction vehicles ・Provision of a waste material disposal plant required for this project ・General monitoring of the construction areas during the construction period ・Supervision by relevant personnel of the Government of Ethiopia during the construction period ・Removal of the existing bridges ・Exemption from customs duties, domestic taxes and other levies in the taxation system imposed by the Ethiopian Government ・Assistance to Japanese nationals and nationals of third countries involved in the project in their entry and stay in Ethiopia ・Payment of bank commissions (opening of a bank account and processes of authorization to pay (AP))

2-2-4-4 Consultant Supervision

(1) Basic policies for the consultant supervision

Under the assumption that this project is to be implemented within the framework of the Japanese Grant Aid, the following have been selected as the basic policies for the consultant supervision.

- Since quality of construction work affect the life and durability of the completed facilities significantly, the consultant shall perform supervision with quality control as the highest priority issue. Since the Awash is long bridge (145 m) and uses the box-girder structure, the concrete work for superstructure and substructure works should be closely monitored.
- The next highest priority shall be placed on the supervision of the progress of the project, safety and payment.
- In order to perform the supervision mentioned above, the contractor and the consultant shall inspect the construction sites together and hold a regular meeting every week to verify problems and discuss measures against the problems.

- In addition, representatives of the client of the project/the office in charge of road construction and maintenance, the Ethiopian Roads Authority, the contractor and the consultant hold regular monthly meetings to verify problems and discuss measures against them.
- The consultant shall employ a local engineer as an assistant to the full-time on-site supervisor and facilitate technology transfer in consultant supervision, including methods for quality control, progress management and safety management.
- Instruction to the contractor and minutes of all the meetings shall be recorded in writing and reporting to the client shall be done in writing.

(2) Consultant's supervisory work

The major components of the works included in the Consultancy Agreement are as follows:

1) Tender document preparation stage

The consultant will prepare implementation design of each facility in accordance with the conclusions of the outline design survey report. Subsequently, the consultant will prepare construction agreement documents and obtain approval for the following documents from ERA of the Ethiopian Government.

- Design Report
- Drawings
- Tender documents

2) Construction tender stage

ERA, with assistance from the consultant, will select a Japanese contractor in an open tender. The agent selected by the Ethiopian Government who takes part in the processes from the open tender to the conclusion of a construction agreement shall be authorized to give approval to all the matters concerning the construction agreement. The consultant shall provide assistance to ERA in the following services:

- Tender notice
- Pre-qualification
- Tender and evaluation of bids

3) Construction supervision stage

After the conclusion of a construction agreement between the contractor selected in the tender and the representative of the Ethiopian Government, ERA, the consultant will issue an order to commence the construction to the contractor and commence construction supervision. The consultant will report progress of the construction directly to ERA, the Embassy of Japan and JICA Office in Ethiopia and send monthly reports by mail to other relevant personnel and offices, if necessary. The consultant will supervise the contractor in administrative activities related to the progress and quality of the work, safety and payment and in the technical aspect including provision of measures and suggestions to improve the construction work.

The consultant will conduct a defect inspection a year after the completion of the supervision. This inspection will be the last of the consultancy services.

(3) Personnel plan

The personnel required in each of the detailed design, construction tender and construction supervision stages and their duties are as follows:

1) Detailed design stage

- The Project Manager will supervise the technical aspect and general coordination of the detailed design and act as the primary contact person for the client
- A bridge engineer (superstructure work) will carry out field surveys, structural calculation, preparation of drawings and quantity surveying for the superstructure design
- A bridge engineer (substructure work) will carry out field surveys, structural calculation, stability calculation, preparation of drawings and quantity surveying for the substructure design
- A road engineer will carry out linearity calculation, selection of the final standard section, examination on slope protection work, road drainage design, preparation of drawings and quantity surveying for the road design
- A river engineer will carry out field surveys, structural calculation, stability calculation, preparation of drawings and quantity surveying for the river structure design
- A person in charge of implementation schedule and estimation will prepare an implementation schedule and carry out estimation using design quantities and unit prices of works derived from the outcome of the detailed design.
- A person in charge of tender documents will prepare tender documents

2) Construction tender stage

The consultant will provide assistance to ERA in finalization of pre-qualification and tender documents, implementation of the pre-qualification and evaluation of bids.

- The Project Manager will supervise the above-mentioned consultancy services throughout the tender process
- A bridge engineer will approve tender documents and provide assistance in bid evaluation.

3) Construction supervision stage

- Project Manager will supervise the consultancy services in general in the construction supervision
- A full-time on-site engineer will take overall responsibility of the on-site construction supervision, report the progress of the construction to the relevant Ethiopian authorities and hold discussion with them
- A structural engineer will revise the implementation schedule for the bridge and revetment works, supervise the concrete work and control PC tension in superstructures. (S)He will verify the bottom surface for the foundation work to be revealed after excavation and, if necessary, take charge of adjustment on-site of the foundation work.

2-2-4-5 Quality control plan

The following table shows the quality control plan for this project.

Table 2-2-23 List of quality control items (draft)

Item			Test Method	Frequency of Test
Subgrade (macadam)	Blended material		Liquid limit, plasticity index (<sieve No. 4)	For each blend
			Particle-size distribution (blending)	〃
			Aggregate abrasion loss test	〃
			Aggregate density test	〃
			Maximum dry density (compaction test)	〃
	Laying		Density test (compaction rate)	Once/day
Prime coat / tack coat	Material	Bituminous material	Quality certificate	For each material
			Application amount	Per 500 m^2
Asphalt	Material	Bituminous material	Quality certificate, ingredient analysis table	For each material
		Aggregates	Particle-size distribution (blending)	For each blend, once/month
			Water absorption	For each material
			Aggregate abrasion loss test	〃
	Blending test		Stability	For each blend
			Flow value	〃
			Porosity	〃
			Aggregate porosity	〃
			Tensile strength (indirect)	〃
			Residual stability	〃
			Design asphalt amount	〃
	Laying		Mixing temperature	As needed
			Rolling temperature	For each transport
			Marshall test	About once/day
Concrete	Material	Cement	Quality certificate, chemical & physical test results	For each material
		Water	Ingredient test result	For each material
		Admixture	Quality certificate, ingredient analysis table	For each material
		Fine aggregates	Oven dry density	For each material
			Grain size distribution, fineness modulus	〃
			Percentages of clay lumps and soft particles	〃
		Coarse aggregates	Oven dry density	For each material
			Flake content	〃
			Particle-size distribution (mix)	〃
			Sodium sulfide diagnosis (missing mass)	〃
	At the time of blend test		Compressive strength test	For each blend
	At the time of laying		Slump	Once/batch
			Temperature	Once/day
	Strength		Compressive strength test (7 days, 28 days)	Once/day or = 50 m^3
Steel bars	Material		Quality certificate, tensile test result	For each lot
Structural steel	Material		Mill sheet	For each lot
Coating	Material		Quality certificate, ingredient table	For each lot
Bearing	Material		Quality certificate, strength test result	For each lot
Lighting equipment	Material		Quality certificate, strength test result	For each lot

2-2-4-6 Procurement Plan

(1) Procurement of construction materials

Construction materials which can be produce locally include sand, aggregate, base course materials. The rest will be imports.

The basic policies for the procurement of materials are as follows:

- An imported material will be procured if it is always available at the market and has sufficient quality.
- A product which cannot be procured locally will be procured from Japan or a third country. Decision on procurement sources will be made after comparing such factors as prices, qualities and periods required for customs clearance.

The table below shows potential sources of procurement of major construction materials.

Table 2-2-24 Possible Procurement Sources of Main Construction Materials

Item	Source			Reason for choosing procurement from Japan
	Local	Japan	Third country	
PC steel		○		Not marketed in the country. Although procurement from a neighboring third country is possible, specifications may not be satisfied.
Steel handrail		○		Because handrails are highly visible to users, products from a neighboring third country may result in uneven quality and inferior workmanship.
Steel for temporary works		○		Leased products that cannot be procured locally will be procured from Japan.
Rubber bearing		○		Not marketed in the country. Although procurement from a neighboring third country is possible, quality of material (rubber) is uneven and specifications of this project may not be satisfied.
Shape steel		○		Not marketed in the country. Although procurement from a neighboring third country is possible, specifications may not be satisfied.
Bituminous material	○			
Aggregate	○			
Asphalt bituminous material	○			
Portland cement (blended cement)	○			
Expansion device		○		Not marketed in the country. Although procurement from a neighboring third country is possible, quality of material is significantly uneven and specifications of this project may not be satisfied.
Cement additive		○		Procured from Japan considering quality.
Steel bars			○	Scarcely marketed in the country. Procured from South Africa considering quality and supply quantities.
Timber for formwork	○			
Diesel oil	○			
Gasoline	○			
Bridge deck waterproof materials		○		Procurement from local sources and neighboring countries is difficult. When used locally, these are usually imported from Japan, Europe, or the US.

(2) Construction machinery

Local offices of ERA and local construction companies own general construction machinery used for road repair. However, construction machinery including large cranes and cantilever erection equipment used for bridge construction and equipment for casting concrete including concrete mixer trucks and concrete pump trucks, an asphalt plant, a concrete plant and a crusher plant for aggregate production will be procured from Japan.

There are several companies leasing construction machinery. However, none has been found in either Nazret City, the city closest to the construction sites, or in the neighborhood of the sites. These companies have only small numbers of equipment and demand for them reportedly peaks at the beginning of the dry season. Nonetheless, possibility of procuring general-purpose bulldozers, back hoes and damp trucks, etc. on a rental basis will be investigated.

A large construction company owns its own asphalt-cement plant and concrete plant in Addis Ababa and sells asphalt mixture and ready-mixed concrete. However, it is not possible to rent these plants in any form.

The survey team confirmed several crusher plants owned by aggregate manufactures in operation in the suburbs of Addis Ababa. They are of fixed type for the companies' use and none can be considered for procurement. Table below shows the possible sources of the main construction machinery and reasons for procurement in Japan.

Table 2-2-25 Possible Procurement Sources of Main Construction Machines

Type	Specifications	Source			Reason for choosing procurement from Japan
		Local	Japan	Third country	
Bulldozer	15t	○			
Backhoe	0.6m3	○			
Dump truck	10t	○			
Wheelloader	1.2m3	○			
Truck crane	20 t			○	
Crawler crane	60～80 t		○		Procured from Japan because local procurement is difficult and leasing from a third country (South Africa) is impossible.
Motor grader	3.1m	○			
Road roller	10-12 t	○			
Tire roller	8-12 t	○			
Vibrating roller	0.8-1.1 t	○			
Tamper	60-100kg		○		Procured from Japan because local procurement is difficult and leasing from a third country (South Africa) is impossible.
Large breaker (attachment)	1,300kg			○	
Concrete plant	0.5m3	○	○		Procured from Japan because local procurement is difficult and leasing from a third country (South Africa) is impossible.
Road sprinkler	5500-6000lit	○			
Steel wire jack	225 t	○			
Erection girder			○		Procured from Japan because local procurement is difficult and leasing from a third country (South Africa) is impossible.

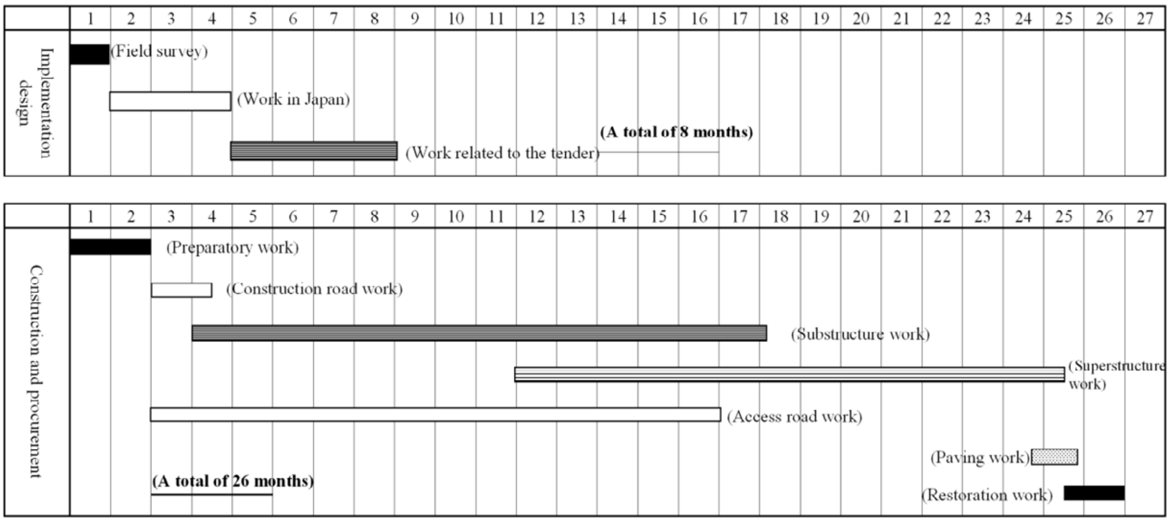
2-2-5 Implementation Schedule

The consultant will conclude a consultancy agreement with the Ethiopian government after conclusion of the exchange of note (E/N) on the implementation design of this project and commence implementation design of this project as a Grant Aid project. After the commencement of the design, the consultant will conduct a field survey for the implementation design for *ca.* three weeks and later prepare detailed design and tender documents in Japan.

Then, after conclusion of E/N on assistance in tender, consultant supervision and construction of bridges and roads, the consultant will provide assistance in works related to the tender to be implemented by the Ethiopian Government, *e.g.* preparation of tender documents, pre-qualification of bidders, tender, selection of the contractor and preparation of a construction agreement.

After the tender, the selected contractor will conclude a construction agreement with the Ethiopian Government. After receiving approval for the agreement from the Japanese Government, the contractor will commence the construction upon receipt of the order to commence construction issued by the consultant. Table 2-4-5 shows the implementation schedule for the above-mentioned works.

Table 2-2-26 Work Implementation Schedule



2-3 Obligations of the Recipient Country

The duties to be performed by the Ethiopian Government with regard to the implementation of this project are as follows:

2-3-1 General matters in the Japanese Grant Aid

- To provide data and information required for the project implementation
- To secure land required for the project implementation (land for road construction, work areas, camp yards and material/equipment depots)
- To level each construction site before commencement of the construction
- To open an account under the name of the Ethiopian Government with a bank in Japan and issue Authorization to pay"
- To unload goods destined for Ethiopia quickly at the unloading sites and process application for tax and customs duties exemption appropriately
- To exempt Japanese corporations and nationals involved in this project from customs duties, domestic taxes or any other taxes imposed upon provision of products or services described in the authenticated agreement.
- To allow people involved in the project entry into Ethiopia and their stay in Ethiopia and Japan for the implementation of the work, in accordance with the approve agreement or with regard to the service provision
- To grant permission or other authorization for the project implementation, if necessary.
- To maintain, manage and protect the facilities to be constructed in the project correctly and effectively.
- To bear the all the costs within the scope of works of the project except those which should be borne by the Japanese Grant Aid

2-3-2 Matters specific to this project

- Removal of facilities and houses affected by the construction
- Securing of land required for this project in addition to the sites of the existing roads
- Provision and leveling of lots for the temporary yards
- Places to collect construction materials
- Provision of place to dispose of waste soil and a waste material disposal plant
- General monitoring of the construction areas during the construction

(To be completed prior to the Prequalification (PQ) notice)

2-4 Project Operation and Maintenance Plan

The Ethiopian Government will supervise implementation and maintenance of this project. The Road Network Management Division in the Engineering and Regulatory Department has jurisdiction over maintenance of bridges and roads and the Bridge Management Section in the same division is in charge of maintenance of bridges and structures. The Pavement Management Section in the Road Network Management Division is responsible for road maintenance except for those on brides and structures.

In the implementation structure for the maintenance of the new bridge, ERA Head Office carries out surveys of current situation, prepares a repair and renovation plan and applies for budgetary funding and ERA local offices repair and renovate the bridges. Dire Dawa Regional Office is responsible for the new bridge. The maintenance works after the completion of this project are classified into those to be implemented every year on a regular basis and those to be implemented once in several years. The works mentioned below are required for this project.

(1) Inspection and maintenance required to be implemented every year

- Removal of sand and waste accumulated in drain pipes, near bearings and in drain ditches including side ditches on the bridge surface and cleaning of the pipes, bearings and ditches
- Maintenance of the traffic safety works, such as reapplication of paint on signs on road surface.
- Inspection and repair of the revetment and bed protection works after flood.
- Removal of stones fallen down and washed-away trees after the flood
- Weeding on shoulders and slopes

(2) Maintenance to be implemented once in several years

- Patching or overlaying of pavement on the bridge surface and access roads to be implemented every five years or so
- Replacement of expansion joints every 10 years or so

In this project, the revetment and bed protection works play an important role in protecting the bridges. These works are designed to stand the 100-year design flood discharge. However, these structures may collapse or be washed away because of unpredictable local erosion or a flood larger than the 100-year flood. The survey team requests ERA to establish a system in which a section in charge of the revetment and bed protection works inspects bridges immediately after flood and, if damage or collapse has been confirmed on these works, ERA is able to repair damage or collapse immediately. If such damage or collapse is left unrepaired, the back-filled earth behind an abutment may be washed away and the loss of the earth may develop into subsidence of the abutment and shut-off of traffic, in the worst case scenario.

2-5 Project Cost Estimation

2-5-1 Initial Project Cost

(1) Cost Born by the Government of Japan

The project will be implemented in accordance with the Japan's Grant Aid scheme and the cost will be determined before concluding the Exchange of Note for the project.

(2) Cost Born by the Government of Ethiopia

Table 2-5-1 Costs borne by the Ethiopian side

Work to be implemented by the Ethiopian side	Costs to be borne (Thousand Birr)	Yen equivalent (Thousand Yen)
(1) Relocation of power poles	7.02	49.26
(2) Relocation of telegram poles	2.72	19.09
(3) Bank services charges	184.12	1,291.97
Total	193.86	1,360.32

(3) Estimation Conditions

- Time of Estimation : July 2010
- Exchange rate of Ethiopian Birr (ETB) : 1.0 ETB = 0.07598US$ (=7.0168 yen)
- Construction period : 26 months
- Other issues : This project will be implemented in accordance with the Guidelines of the Japan's Grant Aid.

2-5-2 Operation and maintenance costs

The main maintenance works for the new bridges and the access roads to be developed in this project are daily inspection, cleaning and repair as described in Table 2-5-2. Ethiopian Roads Authority (ERA) will be responsible for the maintenance works. The maintenance costs (as an annual average) are estimated at 270,000 birr. Since this figure is 0.22 % of the maintenance budget of ERA of 125.4 million birr (for Fiscal 2008/2009), it has been concluded that ERA is capable of providing sufficient maintenance.

Table 2-5-2 Main maintenance items and costs

Classification	Frequency	Inspection part	Work content	Estimated costs (birr)		Remarks
				per work	per annum	
Maintenance of drain ditches	Twice a year	Drainage on the bridge surface	Removal of sand deposit	5,438	10,876	
		Side ditches	Removal of sand deposit	14,729	29,458	
Maintenance of the traffic safety works	Once a year	Marking	Re-application of paint	2,849	2,849	Estimated with 40 % of the miscellaneous expenses
Road maintenance	Twice a year	Shoulders and slopes	Weeding	49,289	98,578	
Maintenance and repair of pavement	Every five years	Pavement surface	Repair of overlays and cracks	301,022	60,204	Estimated at 10 % of direct construction costs (miscellaneous expenses: 40%)
Replacement of bearings and expansion joints	Every ten years			701,896	70,190	Removal costs estimated at 10 % of the direct construction costs (miscellaneous expenses: 40%)
Annual average of the above-mentioned maintenance costs (birr)					272,156	

2-6 Other Relevant Issues

The following points should be noted by the Ethiopian side to implement the requested Japanese assistance smoothly and make it effective in the long term.

- Removing facilities and houses affected by the construction prior to the Prequalification (PQ) notice
- Securing of land required for this project including that for the bridge, access roads and detours of the existing roads, in addition to the sites of the existing roads prior to the Prequalification (PQ) notice
- Providing and leveling of lots for the temporary yards
- Providing places to collect construction materials
- Providing place to dispose of waste soil and a waste material disposal plant
- Implementing general monitoring of the construction areas during the construction

Chapter 3

Project Evaluation

Chapter 3 Project Evaluation

3-1 Preconditions for the Project

3-1-1 Preconditions for Project Implementation

The following are the preconditions for project implementation.

① It will be necessary to remove and relocate the hut for monitoring vehicles crossing the bridge on the slope on the downstream side near Abutment A2 (on the Djibouti side) of the existing Awash Bridge.
The relocation of the hut will have to be completed before commencement of the bridge construction.

② It will be necessary to relocate the power and telephone lines and water pipes which may obstruct the bridge construction.
The relocation will have to be completed before commencement of the bridge construction.

③ The construction of the new Awash Bridge will require acquisition of 42,963 m^2 of land for constructing the bridge and access road and the detour for the existing road.
The land acquisition will have to be completed before commencement of the bridge construction.

④ During the construction of the Awash Bridge, it will be necessary to rent 40,000 m^2 of land temporarily for the temporary yard, etc.
Renting of the land will have to be completed before commencement of the bridge construction.

⑤ Permission/Approval of IEIA (Initial Environmental Impact Assessment) will be required for the bridge construction.
Environmental permission and approval for road projects fall under the jurisdiction of the ERA in Ethiopia. Permission and approval for this project were obtained on December 3rd, 2010.

⑥ It will be necessary to obtain permission to excavate at the borrow pits and quarries and permission to fell trees.

3-1-2 Preconditions and External Conditions for Achieving the Overall Goal of the Project

(1) Preconditions

Realization and maintenance of the effects of this project in full after completion of the construction of the new Awash Bridge and access road will require not only maintenance of smooth traffic flow but also management of the bridge and road required for extending the lifetime of the accessories and the pavement on the bridge and access road. It will be necessary not only to remove obstacles to the traffic and clean the structures in daily management, but also to ensure that regular inspection is carried out appropriately and to repair/reinforce the bridge and pavement appropriately immediately after any damage/degradation is found on them. Therefore, the required preconditions are to secure the estimated annual budget (of 272,156 birr) required for management and repair/reinforcement and to implement management continuously and regularly.

As described in ・ "Operation/Management Plan," it is considered possible for the Ethiopian side to secure this amount of budget.

(2) External Conditions

The following are the external conditions required for realization and maintenance of the effects of this project.

- Although the new bridge and access road were designed with a design speed of 85 km/h, a speed limit and other traffic safety regulations should be enforced for accident prevention.
- Although the new bridge and access road were designed with a design load of 41 t, overloading of vehicles should be prohibited and a load limit should be enforced so that the bridge and access road can be used for a prolonged lifetime.

3-2 Project Evaluation

3-2-1 Relevance

The relevance of implementing this project under Japanese Grant Aid is justified for the following reasons.

① The number of beneficiaries of this project is expected to be very large as the project is expected to benefit Ethiopians at large, including the poor in the north (82,820,000 Ethiopians as the direct beneficiaries and 820,000 Djiboutians as the indirect beneficiaries).

② Implementation of the project is urgently required to improve the livelihood of the people because of the expected effects which include strengthening of the international trunk road transport network with improvement of the most important route in Ethiopia, stable and more efficient road traffic, promotion of social and economic activities and poverty reduction among the people living along the road.

③ Since the operation and management of the bridge and access road to be constructed will not require excessively sophisticated technologies, it will be possible for the Ethiopian side to operate and manage them with its own financial and human resources and technical capacity.

④ RSDP considers this project to be a concrete strategy and the Awash Bridge is the most important facility for the project to improve the A1 Trunk Road, an international trunk road in Ethiopia.

⑤ This project is expected to have little negative environmental impact.

⑥ It will be possible to use the Japanese Grant Aid scheme for the implementation of this project without any particular problem.

⑦ It is necessary and advantageous to use Japanese technologies in the construction of the bridge because it is technically difficult for the Ethiopian side to design and construct such a long PC bridge (bridge length: 145 m).

3-2-2 Effectiveness

(1) Quantitative Effects

① While traffic on the bridge is restricted to only one vehicle in one direction at a time and vehicles have to stop before the bridge for an average of three minutes/vehicle at the existing Awash Bridge, the construction of the new Awash Bridge will enable vehicles to cross the bridge in either direction without stopping before the bridge.

② The weight limit of vehicles permitted to cross the bridge will be increased from the current 32.6 tons to 40.8 tons. Thus, it will be possible to respond to the increase in the traffic volume of large trucks in particular.

③ While the speed limit is placed on vehicles at the existing Awash Bridge at present, the construction of the new bridge will enable the speed limit of the vehicles on the bridge to be increased to 85 km/h from the current 20 km/h.

(2) Qualitative Effects

① The improvement of the A1 Trunk Road, an international trunk road, will enable stable and quick access to the Port of Djibouti, which handles 90% of Ethiopia's exports and imports, and, thus, contribute to the economic development of Ethiopia and Djibouti.

② This access for the northern region, which is less developed than the southern region, will be facilitated as the improvement of the load-carrying capacity of the bridge concerned will establish a reliable transport route. This will contribute to the economic development poverty reduction in the region.

③ As the existing bridge will be used as a pedestrian bridge, the new bridge will be restricted to vehicles, which separates pedestrian and vehicle traffic completely. Thus, the risk of traffic accidents involving pedestrians and livestock will be reduced.

④ While there is no detour for the existing bridge at present, it will be possible to use the existing bridge as an emergency detour/ evacuation route after the construction of the new bridge near the existing bridge has been completed.