CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

Arusha Region in the northern part of Tanzania where the subject road is located has many national parks and conservation area and comprises the central tourism area in Tanzania. Tourists from all over the world visit the area using the Makuyuni・Ngorongoro Road, the only access road to the area, and the number of tourists is increasing every year.

Arusha Region is also renowned for agricultural production and the provincial production volumes of wheat and maize are the largest among Tanzania's provinces. The area along the Makuyuni・Ngorongoro Road in particular is a major agricultural area because of its favourable natural conditions.

The Makuyuni・Ngorongoro Road is the only trunk road in the area and forms part of the national trunk road network. However, it has only a gravel surface and damaged bridges and road crossing structures due to aging and flooding, etc. Road traffic is hindered during the rainy season when the road becomes muddy.

The present Project intends improvement of the Makuyuni・Ngorongoro Road to make it passable throughout the year in view of promoting the area's agricultural potential as well as the potential of tourism, which is an important source of foreign currency in Tanzania, in an effective manner.

< Objectives of the Project >

- Upgrading of the Makuyuni・Ngorongoro Road from a gravel road to a paved road in order to make it passable throughout the year
- Improvement of the accessibility to and from nearby markets (major cities)
- Promotion of the area's agricultural and tourism potential

2.2 Basic Concept of the Project

2.2.1 Basic Concept

The Project has the following three main components to achieve its objectives.

- Review of the horizontal as well as vertical alignment and cross-section of the existing road to improve and secure a good road performance and safety
- Improvement of the present gravel road to a paved road with asphalt concrete in view of its passability throughout the year
- Improvement of the drainage facilities, shoulders and side strips for pedestrians to provide safe and comfortable travelling for a long period of time.

2.2.2 Improvement Principles for Target Road

The total length of the target road is approximately 77 km and the road can be classified into several sections based on the type of land use and the topographical conditions along the route. The following items will be determined for each section based on the improvement principles for the target road.

- Design speed and standard width
- Details of paving and drainage facilities required to maintain the road function
- Traffic safety facilities
- Mitigation of any adverse impacts on the living and natural environments

2.2.3 Principles to Determine Facility Scale

The following principles will be adopted to determine the necessary scale of the various facilities (paving, drainage facilities and safety facilities) required for road planning.

- Paving
  The required paving strength will be calculated and the paving structure will be determined based on the field survey results on the subgrade strength (CBR: California Bearing Ratio) and estimated traffic volume of large vehicles.

  Asphalt concrete will be used as the surface material in order to minimise the future maintenance cost during the road’s lifetime and in view of the fact that pozorana, a local material, can be used to reduce the construction cost.

- Drainage Facilities
  The design road height will be decided based on the past history of flooding (submerged road records) established by the field survey. Consequently, no flooding of the road will occur following the completion of the improvement work unless heavy rainfall which exceeds the past rainfall records occurs. Standing rainwater is not expected to cause any problems along the route except in the urbanised areas of Mto wa Mbu and Karatu. The drainage facility scale will, therefore, be smaller than that which is capable of draining water at the theoretically calculated design flow rate.

- Safety Facilities
  A section of some 12 km between Esilalei and the Manyara Secondary School will be established as a corridor for wild animals. Consequently, speed control facilities and speed limit signs will be installed to slow the traffic in this section. Traffic safety facilities (pavements, etc.) will be introduced

in the urbanised areas of Mto wa Mbu and Karatu, etc. in view of controlling the traffic speed to approximately 50 km/hr. At cliff sections where the road width narrows, a long distance view and a turnout will be secured to ensure the safety of oncoming traffic.

2.2.4 Measures to Reduce Construction Cost

The scale of the improvement plan for the target road is required to satisfy the necessary function at the lowest cost possible The following points will, therefore, be taken into consideration to reduce the cost.

- Utilisation of local materials, including pozorana
- Reference to past performance to decide the scale of the drainage facilities
- Minimisation of the road width with the preconditions of meeting the functional and safety requirements
- Utilisation of the existing road

2.2.5 Measures to Alleviate Adverse Impacts on Natural Environment

There are many wildlife and tourism resources, including the Lake Manyara National Park, along the target road. In addition, part of the target road functions as a corridor for wild animals. The following measures will, therefore, be introduced to protect these wild animals and existing flora.

- Implementation of traffic calming measure(s) at the corridor section for wild animals
- Adoption of a road structure which allows road crossing by wild animals (low banking height)
- Minimisation of alterations to the natural environment through the adoption of a low banking structure
- Adoption of a road structure using trees to form a control zone
- The vacant lot of borrow pit is utilized as reservoir
- Continuous environmental impacts assessment by means of environmental monitoring

2.2.6 Measures to Maintain Function As Tourism Road

The target road functions as an access road to such world-class tourism resources as the Ngoro Ngoro crater and the Lake Manyara National Park. While restaurants and souvenir shops along the route have toilet facilities, tourists are forced to use open fields or bushes in those sections where toilet facilities are unavailable. Many tourists stop at a particular point to enjoy a panoramic view of the Lake Manyara National Park. However, there are safety concerns at this point as it is located at a cliff section with many sharp curves.

Given the above situation, the introduction of the following measures should be considered.

- At the scenery viewing spot, part of the road space which will not be used for passing traffic following the completion of the improvement work under the Project will be converted into a paved pedestrian area so that pedestrians (tourists) are separated from passing vehicles. In addition, paving will be conducted to create parking space.

2.2.7 Principles of Construction Schedule

The Project aims at improving an existing road for some 77 km and the main work components will be civil engineering work, paving work and drainage work. As banking materials and aggregate are commonly available along the route, it is unlikely that the construction schedule will be significantly determined by the civil engineering work, drainage work and auxiliary work. The procurement situation of transportation machinery further supports this view. Accordingly, the construction schedule for the Project will mainly be decided based on the local asphalt mixture production capacity.

2.3 Basic Design

2.3.1 Design Conditions

(1) Natural Conditions

The Project Area belongs to the savannah climate zone. Based on monthly rainfall data for the last 10 years, the rainy season lasts from November to May while the dry season lasts from June to October.

The annual rainfall is less than 500 mm at Mto wa Mbu (El. 1,000 m) which is located at the bottom of the Rift Valley and 700 mm at Karatu (El. 1,500 m). The number of rainy days per month show a similar pattern at these two sites with an average of approximately 4 - 5 rainy days/month from November to May.

Table 2-1 Monthly Rainfall in the Project Area (Period: 1990 - 1999) (Unit: mm)

Site	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep.	Oct.	Nov.	Dec.	Total
Mto wa Mbu	61	61	107	123	45	0	0	0	0	5	32	40	472
Karatu	102	75	139	151	80	6	2	2	0	9	57	79	702
Kongoni	92	100	127	196	89	12	2	2	0	6	62	93	781

Table 2-2 Number of Rainy Days/Month in the Project Area (Unit: day)

Site	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mto wa Mbu	4	3	5	7	3	0	0	0	0	1	3	4
Karatu	4	5	7	10	6	1	0	0	0	1	4	4

Note: Based on data for 27 years for Mto wa Mbu and data for 56 years for Karatu.

The annual maximum temperature and minimum temperature are approximately 29°C and 13°C respectively with much temperature fluctuation throughout the day. The temperature at Mto wa Mbu is higher than that at Arusha because of the lower elevation by some 200 m. The wind velocity is generally 0.89 m/sec. The dominant wind direction is from east to west from November to June and from west to east from July to October.

Table 2-3 Mean Monthly Maximum and Minimum Temperatures at Arusha (Period: 1989 - 1999)

(Unit: °C)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum	28.3	29.3	28.2	25.3	23.1	21.9	21.7	23.0	25.5	27.3	27.6	27.9
Minimum	14.3	14.7	15.6	16.6	15.8	13.6	12.7	13.1	13.5	14.3	15.3	15.4

Table 2-4 Mean Daily Wind Velocity at Arusha in 1988

(Unit: m/s)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
67	74	68	46	42	58	73	87	102	118	106	94

Given the above climatic data, it is inferred that there are no special natural conditions to be used as a design condition in the Project Area.

(3) Construction Work Situation

The target road stretches approximately 77 km and there is no power supply system which covers the entire route. Power supply is only available at Mto wa Mbu and Karatu, making the use of power generators necessary to supply the required power for the implementation of the Project. Water supply is also limited to Makuyuni, Mto wa Mbu and Karatu. At Mto wa Mbu, the only water supply sources are local wells which cannot be expected to supply a large amount of water for road work. It will, therefore, be necessary to construct boreholes to supply water for the road work.

(4) Procurement Situation

Although the Project Area is located inland of Tanzania, most materials can be procured locally from nearby Arusha, the country's second largest city. Imported materials can be transported by road from Port Dar es Salaam.

(5) Labour Situation

The general capability of local workers and engineers who can be recruited in and around Arusha in terms of reliability for continued work, diligence and technical expertise, etc. is assessed as 0.2 - 0.5 with an average of 0.34 compared to the corresponding capability of Japanese workers which have a value of 1. Based on this assessment, the technical level of local workers is judged to be capable of conducting minor road work.

2.3.2 Basic Plan

(1) Road Design Standards

The geometric design standards of Tanzania (Draft Road Manual 1989) will be used to determine the geometric structure for road design. In regard to your inquiry about Design Standards values in design speeds of 90 and 70,

- Values in minimum radius of curve are calculated in accordance with Road Design Standard of Tanzania.
- Values in others for 90km/h and 70km/h are applied from values for 100km/h and 80km/h respectively, in consideration of safety.
- Values in maximum grade are derived from Japanese Design Standard in consideration of safety.

The Road Structure Ordinance of Japan will be referred to for those items which are not clearly indicated in this Manual.

Table 2-5 Geometric Design Standards of Tanzania

Design Speed (km/hr)			100	90	80	70	65	60	50	40	30
Min. Radius of Curves (m)	Desirable		450	390	300	300	200	150	100	75	50
	Absolute		380	270	230	170	145	125	85	50	30
Min. Radius for No Transition	e^o=0.020		1,600	-	1,100	-	700	600	400	250	150
	e^o=0.025		1,300	1,200	900	1,200	600	500	350	200	120
Max. Grade (%)	Flat/Rolling		3		4		5	5	5	6	6
	Rolling/Hilly		4	7	5	7	6	6	7	8	8
	Mountainous		6		7		8	8	9	10	10
Min. Vertical Curve Length (m)	To meet Stopping Sight Distance	Crest	60A	60A	32A	32A	17A	14A	10A	6A	4A
		Sag	40A	40A	25A	25A	17A	16A	12A	8A	6A
	To meet Passing Sight Distance		495A	495A	325A	325A	205A	170A	115A	70A	35A
Min. Sight Distance (m)	Stopping Sight Distance		160	160	115	115	85	75	55	40	30
	Passing Sight distance		680	680	550	550	440	440	330	250	180

A: algebraic difference in grade (%)

(2) Design Traffic Volume

The design traffic volume which will comprise the basis for the road design and paving design will be calculated based on the following conditions.

- The peak traffic in the tourist season will be considered as the results of the two surveys do not include the effects of the tourist season.
- The traffic growth rate indicated in the D/D report will be adopted as the design traffic growth rate for the Project.

Table 2-6 Design on Standard Traffic Volume

Item		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep.	Oct.	Nov.	Dec.	Total
Tourists ('000)		21.8	22.6	22.8	24.7	25.7	27.2	45.6	54.2	52.1	57.9	47.5	38.2	450.3
Ratio (%)		5	5	5	5	6	6	10	12	14	13	11	8	100
Vehicles Entering NgoroNgoro	No.	133	142	139	155	156	171	277	329	390	352	289	232	
	x 2	265	286	277	310	312	342	554	659	781	704	578	464	
'99 Survey Results								533						
'00 Survey Results							321							
Standard Traffic Volume										781				

Notes
1. Number of tourists: 1998 figure (nationwide)
2. Number of vehicles entering Ngoro Ngoro: 1999 figure

Table 2-7 Average Annual Traffic Volume Increase Rate

(Unit: %)

Vehicle Type	1999 - 2002	2003 - 2012	2013 - 2022
Passenger Car	5.8	4.0	3.0
Bus	3.6	3.0	3.0
Truck	4.0	3.0	2.5

Table 2-8 Design Standard Traffic Volume

Vehicle Type		Passenger Car/Taxi	Small Bus	Large Bus	Small/Medium Truck	Large Truck	Total	Remarks
Vehicle Ratio (%)		43	17	2	30	9	100	
Traffic Volume	2000	333	131	17	231	71	781	Present
	2005	419	154	20	273	84	950	After improvement
	2015	603	206	27	362	111	1,309	Paving Guideline Standards
	2025	810	277	36	463	142	1,729	Tanzanian Standards

Note: The vehicle ratio is based on the results of the crater survey conducted on 29th June, 2000.

(3) Design Speed

The design speed adopted in the D/D Report will remain the same. However, a speed reduction to 40 km/hr - 50 km/hr will be considered for the wild animal corridor section and urbanised areas as described in 2.2.5.

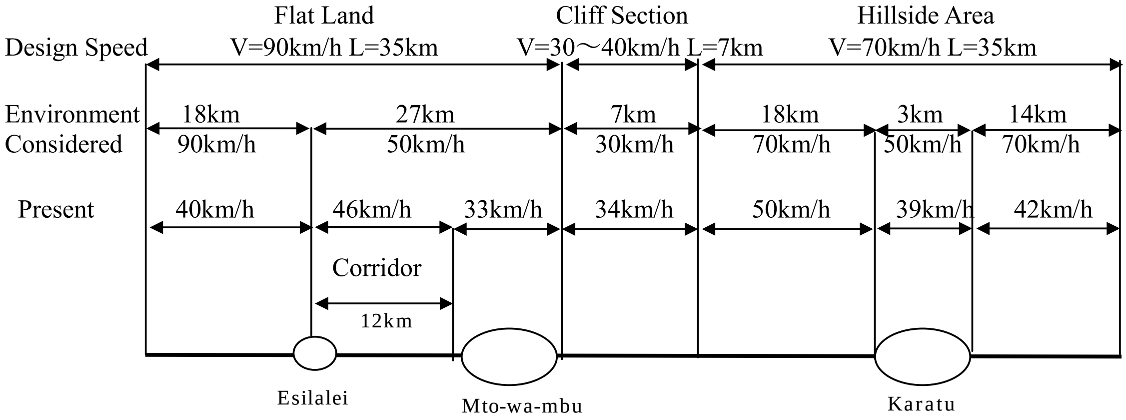

Fig. 2-1 Design Speed

(4) Standard Cross-Section

The standard cross-section shown in Fig. 2-2 is decided based on the trunk road standard cross-section, taking the local and topographical conditions into consideration.

(5) Paving Design

1) Selection of Paving Type

In regard to selection of the paving type, the selected paving type must prove to be the most economical during its service period. It has been decided to adopt full-scale paving under the Project in view of (i) the calculated unit cost of paving based on the field survey results, (ii) the cost-benefit calculation results based on the unit paving cost, (iii) the required road function and (iv) the possibility of reducing the unit cost through the use of pozorana, a local material. The distribution situation of pozorana, the optimal construction method and road service conditions will be determined through trial paving at the designed design stage.

2) Design Period

The design period for paving means that the paving will be designed to serve the maximum traffic volume during the period to be addressed by the design. Given the fact that the Project will be implemented with grant aid, the design period for the Project is set at 10 years. According to the paving standards in Tanzania, the same category covers the design periods of 10 years and 20 years.

3) Design Standards

The Pavement and Materials Design Manual 1999 (Tanzania) is used to set the paving design standards for the Project. The Manual stipulates separate paving design methods for new roads and existing roads. As the Project intends the rehabilitation of an existing road, the design method will follow that for the rehabilitation of existing roads as described below.

SN = (a_1X_{11} + a_2X_{12} x a_3X_{13} ... _ anXm)/25.4

SN: structure number

	Required Structure Number: SN						
Sub-Grade	Traffic Load Classes						
CBR	TLCO2	TLCO5	TLC1	TLC3	TLC10	TCL20	TLC50
≥30	1.10	1.25	1.60	1.90	2.35	3.00	3.50
15 - 20	1.35	1.50	1.80	2.20	2.75	3.80	4.20
10 - 14	1.60	1.80	2.10	2.50	3.00	4.10	4.50
7 - 9	1.90	2.00	2.30	2.75	3.30	4.30	4.70
5 - 6	2.10	2.20	2.50	2.90	3.50	4.50	5.00
3 - 4	2.40	2.80	3.10	3.40	4.00	5.00	5.50

Material Coefficients (a) for New Pavement Layer

Type of Material	Material Coefficient
Surfacing	
Asphalt Concrete Surfacing (A)	0.40
Base Course	
Granular, Crushed Basic Course Materials, CRR	0.15
Subbase	
Pozzolan(Lime:Pozzolan:agg(tuff)=2%:60%:38%	0.15

Fig. 2-2 Typical Cross Section and Paving Type

Table 2-9 Design Traffic Roading

Table 2-10 Pavement Structure Design In put data

4) Adoption of Semi-Flexible Paving

At cliff sections, etc. with a sharp vertical gradient, there is concern in regard to the early damage of the paving due to rutting caused by fluidation. Accordingly, semi-flexible paving will be used for these sections. Semi-flexible paving means that the asphalt mixture for semi-flexible paving with a large pore ratio will be infiltrated with cement milk which mainly consists of cement in order to make the best use of the combination of the flexibility of asphalt paving and the rigidity as well as durability of cement concrete paving. This type of paving is commonly used in the following places where durability is required or where there is concern in regard to fluidation.

- Bus terminals and bus stops
- Inflow sections of road junctions
- Inside tunnels
- Rising slope sections

This type of paving will be adopted under the Project at cliff sections characterised by a steep vertical gradient.

(6) Drainage Design

1) Probable Daily Rainfall

The following probable daily rainfall is established for Mto wa Mbu, Karatu and Kongoni by the probability analysis using the longitudinal method based on the maximum daily rainfall data. The daily rainfall which caused flooding in 1995 was 165 mm at Mto wa Mbu and the return period for this rainfall level is 25 years or more.

Table 2-11 Probable Daily Rainfall in the Project Area

Station No.	Location	Return Period			
		5 Years	10 Years	25 Years	50 Years
9335030	Mto wa Mbu	100	125	158	184
9335007	Karatu	91	108	129	144
9335010	Kongoni	81	95	114	127

Note: Data collection period - 30 - 40 years

2) Rainfall Intensity

The rainfall intensity is estimated by correcting the formula established for Dar es Salaam with the probable daily rainfall factor.

Table 2-12 Short-Time Rainfall Intensity at Dar es Salaam

Return Period	Duration					
	30 Mins.	1 Hour	3 Hours	5 Hours	7 Hours	24 Hours
5 Years	84	50	17	12.2	10.4	96.6
10 Years	97	58	20	14.4	12.3	111.0
25 Years	(112)	(68)	(23)	(16.8)	(14.4)	128.5
50 Years	126	75	26	19.1	16.5	141.2

Source: Water Resources Laboratory, Dar es Salaam University
Note: Figures in brackets are estimates based on interpolation.

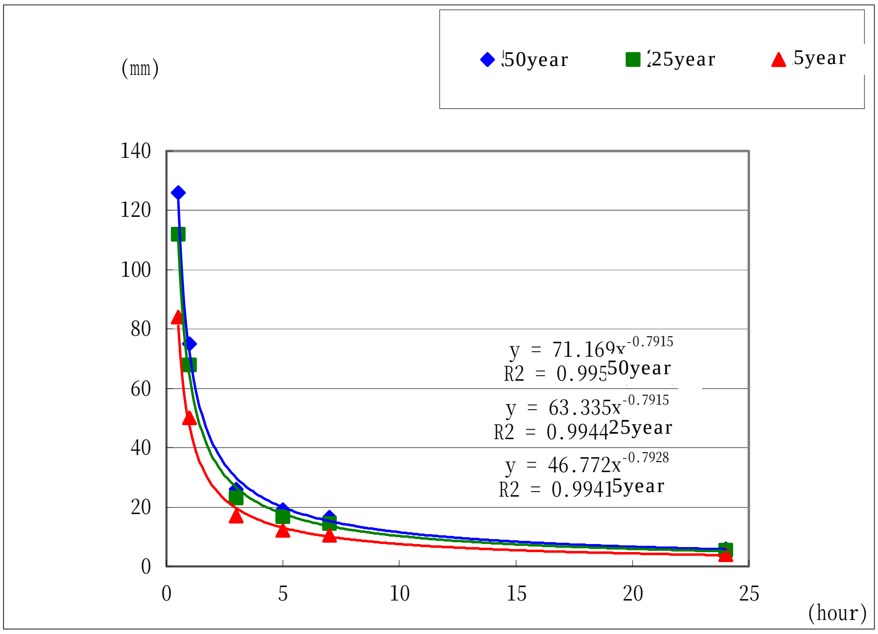

Fig. 2-3 Rainfall Intensity at Dar es Salaam (mm/hr)

3) Discharge Rate Calculation Method

The peak discharge which causes flooding is calculated by the TRRL method which is popularly used in East Africa (Kenya, Uganda and Tanzania, etc.) This method is proposed by Dr. D. Fiddes of the British Transport and Road Research Institute based on the run-off test results for 12 test watersheds in Kenya and Uganda. The average run-off is calculated using such factors as the daily rainfall, river gradient, watershed area, soil and land use, etc. to estimate the peak discharge.

4) Design Discharge

The following return periods are used to estimate the design discharge based on the results of consultations with the Ministry of Works.

Table 2-13 Design Return Periods

Structure	Return Period	Remarks
Bridges	50 years	
Other Crossing Structures	50 years 25 years	Watershed (large) Watershed (medium and small)
Road Drainage Structures	3 - 5 years	Side ditches and cross pipes

5) Discharge Calculation Using Rational Formula

At each of the major water discharge points, the probable flood discharge (for 5, 15 and 25 year periods) is calculated by the rainfall intensity formula for East Africa Three Countries established by DSM University with the probably daily rainfall factor while taking the flood arrival time, rainfall reduction factor based on the watershed size and run-off coefficient based on the land use type into consideration.

* Rainfall Intensity in the Project Area

$Ix = ARF * Dx / Dd * I_D$ (convert Dar es Salaam into object area)

Where,

Ix	:	rainfall intensity within the flood arrival time in the Project Area
ARF	:	area reduction factor
Dx	:	probably daily rainfall (Mto wa Mbu or Karatu)
Dd	:	probable daily rainfall at Dar es Salaam
I_D	:	rainfall intensity at Dar es Salaam

o Estimation of Flood Arrival Time (Based on Method Used by Public Works Research Institute)

$T = 1.67 \text{ x } (LI \sqrt{s})$

Where,

L	:	channel length (m)
S	:	mean gradient

o ARF (Area Reduction Factor)

$ARF = 1 - 0.04 \text{ x } T^{-1/3} \sqrt{A}$

Where,

T	:	flood arrival time
A	:	drainage area

o Run-off Coefficient

Sandy soil, cultivated or light growth	:	0.15
Sandy soil, woods or heavy brush	:	0.15
Gravel, bare or light growth	:	0.20
Gravel, woods or heavy brush	:	0.15
Clayey soil, bare or light growth	:	0.35
Clayey soil, woods or heavy growth	:	0.35
Moderately previous soils with a slope of 1 - 2 %	:	0.05

(Hydraulics Research, Wallingford, England)

Table 2-14 Comparison with Flow rate of Main point (Unit:m3/h)

No.	Watershed Name	Chainage (Km)	Drainage (Km2)	TRRL Method 5	TRRL Method 25	TRRL Method 50	Rational Method 5	Rational Method 25	Rational Method 50
A	Makuyuni1	0+750	48.14	11.48	18.33	21.38	21.3	34.7	45.6
X1		1+400	0.36	0.21	0.34	0.39	0.3	0.5	0.6
X2		2+500	0.4	0.24	0.38	0.44	0.4	0.6	0.7
B		3+460	2.49	1.21	1.93	2.24	1.1	1.8	2.1
C	Makuyuni2	5+350	96.51	25.13	40.07	46.72	34.9	56.9	75.1
D		6+850	1.12	0.71	1.13	1.31	2.7	4.4	5.2
E		10+250	3.52	1.71	2.74	3.2	0.7	1.2	1.5
F1		11+170	6.28	3.48	5.56	6.49	6.7	10.9	13.7
X3		12+400	1.6	0.94	1.48	1.72	1.0	1.7	2.0
F2		13+900	23.21	12.05	19.28	22.51	18.9	30.7	39.2
X5		15+500	2.4	0.97	1.53	1.77	6.7	10.7	12.5
X6		16+700	0.97	0.48	0.76	0.88	3.9	6.3	7.2
X7		17+600	3.84	1.83	2.88	3.35	8.2	13.2	15.7
X8		18+900	2.68	1.71	2.7	3.14	6.4	10.2	12.2
X9		19+800	3.75	2.26	3.59	4.18	6.0	9.6	11.8
X10		21+850	5.27	3.12	4.97	5.79	7.3	11.8	14.6
X11		22+900	10.27	5.71	9.12	10.63	10.9	17.6	22.1
X12		24+100	23.63	10.59	17.02	19.88	17.2	28.0	36.1
X13		25+080	15.49	6.84	11.03	12.91	2.8	4.5	5.8
X14		26+450	49.71	19.01	30.8	36.09	6.1	10.0	13.2
X15		29+800	25.36	7.1	11.85	14.02	2.2	3.6	4.9
X16		33+300	9.15	4.21	6.78	7.93	1.9	3.1	4.0
G	Mto Wa Mbu	34+750	159.25	102.66	163.9	191.16	60.9	99.6	133.2
H	Mto Wa Simba	35+925	175.13	106.7	171	199.68	58.6	96.0	129.9
I	Kirurumo	37+000	74.37	48.38	77.93	91.14	29.3	48.0	65.0
X17		39+150	1.15	0.62	0.97	1.13	7.4	11.2	12.3
J	Kibaone	42+650	31.5	15.49	24.82	28.99	17.0	26.3	34.1
K		47+900	2.56	1.6	2.53	2.94	5.1	7.8	9.2
X18		48+750	1.18	0.7	1.1	1.27	4.2	6.4	7.3
L	Lambo	52+250	10.89	5.73	8.15	9.15	11.0	16.0	19.3
M	Marera	57+650	108.71	11.15	15.89	17.85	34.6	50.5	64.5
M1		59+000	20.01	3.37	4.8	5.39	16.3	23.6	29.1
N		61+550	24.68	4.11	5.86	6.58	17.6	25.6	32.0
X20		64+050	1.21	0.65	0.91	1.02	4.2	5.9	6.6
O		65+350	23.57	4.76	6.78	7.61	17.4	25.2	31.4
P		65+500	11.16	5.83	8.29	9.31	10.7	15.5	18.8
Q	Bashai	69+850	13.66	6.93	9.87	11.09	12.5	18.1	22.2
V		71+675	0.93	0.43	0.61	0.68	2.2	3.1	3.5
W	Gara	71+700	7.97	1.12	1.6	1.79	7.4	10.7	13.1

*Include the Run off

6) Decision on Drainage Facility Scale at Major River Crossing Points

The design water level for each river crossing point is decided taking the flooding situation and actual flood water level of each river and Manning's theoretical water level into consideration. The present river width is used as the river width for design purposes.

- A: Makuyuni 1
  There is a pipe culvert at this point. Noticeable sedimentation is taking place in the upstream of this structure, causing a dip in the elevation vis-a-vis the downstream side of the culvert. The road floods here because of the insufficient drainage capacity of the pipe used. Drainage through the culvert will be planned while fixing the riverbed.

- C: Makuyuni 2 (5 km + 350)
  The design discharge will be calculated using Manning's formula. Drainage through the culvert will be planned in view of the present river width.

- G: Mto wa Mbu River
  Because of the water storage effect of the low plain (natural flood plain) around the upstream, the flood run-off at the crossing point is reduced. The actual flood water level is, therefore, adopted as the design water level. Clearance of some 30 cm will be required to allow the smooth passage of driftwood, etc.

- H: Mto wa Simba River
  Because of the water storage effect of the low plain (natural flood plain) behind the left bank in the upstream, the flood run-off at the crossing point is reduced. While adopting the actual flood level as the design flood level, similar clearance to that in above will be required to prevent the adverse impacts of back water on nearby villages caused by disruption of the water flow due to the piling up of driftwood, etc.

- I: Kiruromo River (Debris Flow Control Measure
  Kiruromo River located at the starting point of the cliff section caused a large-scale debris flow due to a downpour (165 mm) in 1995, blocking the road traffic for approximately one month. Even today, many deposited boulders make up a complicated channel in the upstream. As one of the objectives of the Project is to secure road traffic throughout the year, the design of the river crossing structure at this point will be determined with reference to data on this debris flow.

- M: Marera River
  The present cross-section will be maintained to protect farmland in the upstream of the planned crossing point in view of the facts that the elevation of this farmland is lower than the present road surface and that the flow capacity is larger than the design flood run-off (18 m^3/sec).

The straightening of river alignment is considered at "only" cross sections with the project road. Therefore there are few affects on the river. The contractor shall pay its attention to the erosion of riverbank and take proper measures, if necessary.

Table 2-15 Design Water Level and Structural Type at Major River Crossing Points

River	Design Riverbed Gradient	Design River Width (m)	Calculated Water Depth (m)	Flow Capacity (m^3/s)	Water Level (m)	Design Discharge (m^3/s)	Remarks
Makuyuni 1	0.008	3.0	1.1	2.8	0.5	-	Reshaping of river width and riverbed gradient
Makuyuni 2	0.007	8.0	1.2	50	-	-	Box culvert
Mto wa Mbu	0.002	8.0	1.6	43	1.6	-	Height below box girder bridge over actual flood water level provides clearance
Mto wa Simba	0.004	7.0	1.7	54	1.7	-	
Kirurumo	0.035	-	-	-	-	32.5	50% discharge level is used as it is a small river and as crossing point is located at inner side of curved section
						65.0	Bridge is planned as debris flow control measure as crossing point is located at outer side of curved section
Marera	0.005	6.0	1.5	42	-	-	Present level of flow capacity is maintained

7) Scale and Location of Road Drainage Facilities

The principles of the drainage plan for each watershed, excepting major river crossing points, are described below.

- As the road banking height is determined based on past flood records (road submergence records), there will be no disruption to road traffic due to road submergence unless rainfall exceeding the past records occurs. Areas along the route mainly consist of natural flood plains or cultivated land except at those sections running through urbanised areas at Mto wa Mbu and Karatu and, therefore, it is unlikely that standing water on the road surface will cause any major problem to local life.

- As side ditches (earth ditches) will be constructed at cut sections on both the upstream and downstream sides of the road, standing rainwater on the road surface is not anticipated.

- Based on the above, any plan to immediately drain the calculated discharge to the downstream side of the road will constitute excessive investment. The drainage plan for the Project will, therefore, be based on the past drainage performance.

Based on the above principles, the drainage facilities in each watershed will basically be located at the following sites.

- Valley sections of road profile
- Sites where drainage facilities currently exist
- Flat sections, such as swamp sections, where the vertical gradient is almost 0%
- Urbanised sections at Mto wa Mbu and Karatu for immediate drainage

(7) Speed Control Facilities

Installation of hump, drift and sign are planed at Esralei and town area. The drift shall be installed at the sagged (lowest) point of the project road in the vertical plan. The drift is expected to control the vehicle speed at the sagged point, that will protect wild life crossing this point from traffic accident. In addition, speed control by police officers is expected.

(8) Design Principles for Special Sections

The target road shows many changes in terms of the topography and conditions of areas along the route over its distance of 77 km and application of the standard cross-section to the entire route will cause many problems. Accordingly, the following design principles are adopted for urbanised sections and cliff sections based on the field survey findings.

1) Urbanised Areas at Mto wa Mbu and Karatu

- Site ditches will be constructed on both the upstream and downstream sides and an existing river will be used for discharge.
- Pavements will be introduced to ensure the safety of pedestrians.
- Existing tall trees and trees where white storks build their nests will be used to form a control zone.

A: traffic control tree zone:2 - 3 m
B: Water channel space:1 - 2 m
C: Pavement space: 3 - 5 m
D: Utility space: 5 - 10 m

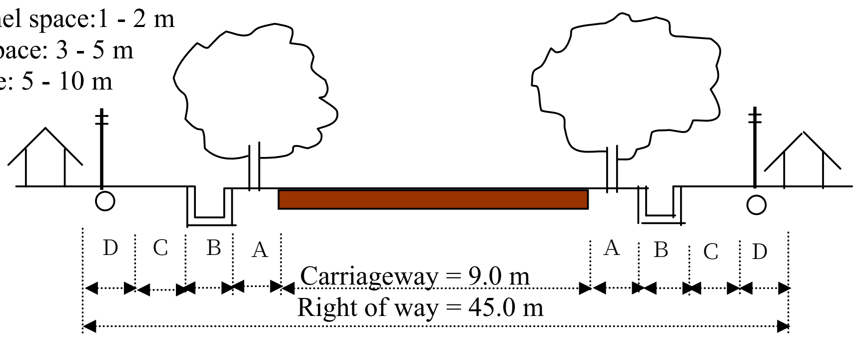

Fig. 2-4 Expected Outlook of Completed Road in Urbanised Area (Example of Arusha)

2) Cliff Sections

- In principle, side ditches will be constructed on the upstream side while free drainage will be permitted on the downstream side.
- The drainage speed will be reduced through the introduction of falling works and others.
- A minimum shoulder width of 0.5 m will be permitted.
- The intrusion of the drainage facilities to the shoulder or carriageway will be permitted.
- Cutting will be given priority in sections adjacent to a national park, taking the boundary into consideration. Intrusion of up to 1 - 2 m into a national park area will be permitted.
- A turnout is adopted in Cliff section of the width shortage .

A: Shoulder :0.5 m
B: Carriageway :6.0 m

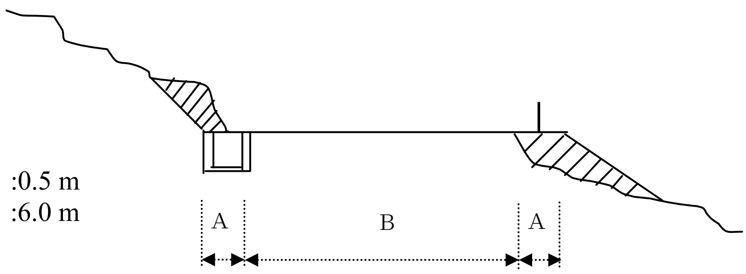

Fig. 2-5 Standard Cross-Section at Cliff Section

(9) Public Facilities and Private Houses Relocation Plan

With the improvement of the Makuyuni-Ngoro Ngoro Road, the relocation of the following public facilities and private houses will be necessary. The selection criteria for the subject buildings are described below.

- All facilities and buildings inside the right of way (45 m wide) at Mto wa Mbu and Karatu
- Only those facilities and buildings in the construction area for other sections

Table 2-16 Relocation Quantities

Subject Item	Unit	Quantity
Rerouting of Water Supply Lines	m	16,500
Rerouting of Power Lines	m	2,900
Rerouting of Telephone Lines	m	7,110
Relocation of Buildings (D Rank)	m^2	2,400
Relocation of Buildings (E Rank)	m^2	2,100

2.4 Environmental Monitoring Plan

2.4.1 Monitoring Implementation System

It has been confirmed that those environmental items identified by the IEA as likely to cause negative impacts will be dealt with by the project design if possible and that items, including monitoring, which cannot be dealt with by the project design will be dealt with by the Government of Tanzania. The National Environmental Management Council (NEMC) has proposed agreement of the monitoring plan by the related bodies (Environmental Management Team and the Contractor, etc.) prior to the commencement of the work and that meetings should be held from time to time during the work period.

The purposes of the monitoring plan are to minimise the negative impacts of those items which are identified by the EIA as likely to cause negative impacts and to prevent any occurrence of environmental problems.

2.4.2 Screening of Monitoring Items

The monitoring items to be taken up under the Project are basically those negative impact items suggested by the EIA and the following surveys will be conducted.

(1) Social Environment Survey

- Survey on land use
- Survey on noise and air pollution

(2) Water Environment Survey

- Survey on water level of Lake Manyara
- Survey on water quality of Lake Manyara and rivers to be crossed
- Survey on drinking water quality

(3) Ecosystem Survey

- Survey on animal movement
- Survey on animal diversity
- Survey on vegetation

(4) Former Site Utilisation Survey

- Survey on former soil pit and quarry sites

2.4.3 Monitoring Plan

Table 2-17 summarises the monitoring plan. The environmental standards and detailed survey methods during and after the work period will be decided based on the findings of the environmental survey to be conducted at the detailed design stage, taking the unique features of the Project Area into consideration.

At the beginning of the construction work, the Contractor will prepare the environmental plan and submit it to the Environmental Management Team. At the end of the construction work, an environmental engineer(s) working for the Consultant will conduct the final assessment.

Table 2-17-(1) Monitoring Plan During the Work Period (Draft)

Type of Survey	Survey Item	Timing and Frequency of Survey	Scope and Site of Survey	Assessor
Social Environment Survey	Land Use	-	-	-
	Noise and Air Pollution	At the time when the operation of the construction machinery is at its highest level each month during the work period at the survey site(s)	- Corridor for wild animals - Mto wa Mbu and Karatu - Other sites where the movement of wild animals is confirmed	Environmental Management Team
Water Environment Survey	Water Level at Lake Manyara	Monthly observation	- Lake Manyara	Contractor
	Water Quality of Lake Manyara and Rivers	On the day when the cutting work volume is the largest at the cliff section (in the rainy season)	- Lake Manyara and Mto wa Mbu, Mto wa Simba and Kirurumo Rivers	Environmental Management Team
	Drinking Water Quality	-	-	-
Ecosystem Survey	Animal Movement	In each of the four seasons	- Corridors for wild animals - Other sites where the movement of wild animals is confirmed	Environmental Management Team
	Animal Diversity	In each of the four seasons	- Corridors for wild animals - Other sites where the movement of wild animals is confirmed	Environmental Management Team
	Vegetation	In each of the four seasons	- Lake Manyara National Park	Environmental Management Team
Former Site Utilisation Survey	Former Soil Pit and Quarry Sites	At the end of the construction work	- At each soil pit and quarry	Environmental Management Team

Table 2-17-(2) Monitoring Plan After Commencement of Use of Improved Road (Draft)

Type of Survey	Survey Item	Timing and Frequency of Survey	Scope and Site of Survey	Assessor
Social Environment Survey	Land Use	Annually (3 years)	Entire route	Environmental Management Team
	Noise and Air Pollution	In each of the four seasons (3 years)	- Corridor for wild animals - Other sites where the movement of wild animals is confirmed	Environmental Management Team
Water Environment Survey	Water Level at Lake Manyara	Monthly (2 years)	- Lake Manyara	Environmental Management Team
	Water Quality of Lake Manyara and Rivers	In each of the four seasons (2 years)	- Lake Manyara and Mto wa Mbu, Mto wa Simba and Kirurumo Rivers	Environmental Management Team
	Drinking Water Quality	In each of the four seasons (2 years	- Mto wa Mbu and Karatu	Environmental Management Team
Ecosystem Survey	Animal Movement	In each of the four seasons (2 years)	- Corridors for wild animals - Other sites where the movement of wild animals is confirmed	Environmental Management Team
	Animal Diversity	In each of the four seasons (2 years	- Corridors for wild animals - Other sites where the movement of wild animals is confirmed	Environmental Management Team
	Vegetation	In each of the four seasons (2 years)	- Lake Manyara National Park	Environmental Management Team
Former Site Utilisation Survey	Former Soil Pit and Quarry Sites	In each of the four seasons (1 year)	- At each soil pit and quarry	Environmental Management Team