Chapter 11 Design Criteria for Roads and Bridges

11.1. Application of Design Criteria for Roads and Structures

Mongolian Design Criteria prepared based on the Russian Standards are as follows:

- Construction Norms and Regulations	Road : BNbD 2.05.02.- 97, Road Department, Ulaanbaatar, 1997
- Road Bridge and Pipe Culverts :	BNbD 2.05.03.- 97, Road Department, Ulaanbaatar, 1997
- City Construction, Planning and Building of Urban and Rural Settlements	SniP 2.07.01.- 89, Ulaanbaatar City
- Pavement design	BCH-4683

Study team collected information for the decision of design standard for the study as follows:

From Road Department Mr. Gonchigzeveg, Deputy Director	- Design standards for the project may adopt Japanese or AASHTO, if they are better than Mongolian Standards. - Earthquake class 1~12 in Mongolia, UB City Use class 7~9. Seismic coefficient for design may adopt class 9 (Kh=0.10) - Live load for existing bridges: Russian Standard SNiP 2.05.03.-84
From UB City Mr. Battsooj, Officer of Planning	- Clearance on the road is 4.5m plus overlaid height
From Taffic Police from Regulation Book	- Regulation of Traffic Speed On city roads- 60km/hr On state & regional roads- 80 km Bus, trolley bus carrying passengers on any kind of roads- 50km/hr Tractor, self-propelled machinery and trailing car- 40km/hr
From ADB Project Mr. Gombo, Project Manager of ADB	- Route of Asian Highway ; A3 route, 1,000 vehicle/day planning at present - Asian Highway Network Development United Nations, New York, and Asian Development Bank, 1995

Collected data, report, standards and information are shown in Appendix 6.

Referring to Mongolian design criteria, traffic characteristics and information, Study Team adopted design criteria using Japanese Standards and AASHTO, as following :

- Geometric Design of Highways and Streets [AASHTO 1984]
- Standard Specifications for Highway Bridges [AASHTO 1992]
- Guide for Design of Pavement Structures [AASHTO 1986]
- Highway Capacity Manual (HCM) [Transportation Research Board, 1985]
- Application of Geometric Design Standard [Japan Road Association 1083]
- Traffic Capacity of Roads [Japan Road Association 1984]
- Specifications for Highway Bridges, Part 1: Common specifications

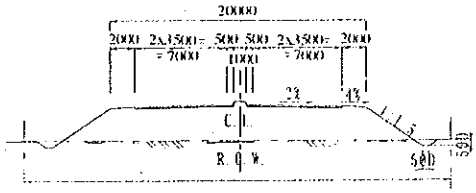
[Japan Road Association 1996] Part 3: Concrete Bridges
Part 4: Substructure

11.2. Geometric Design Standards of Roads

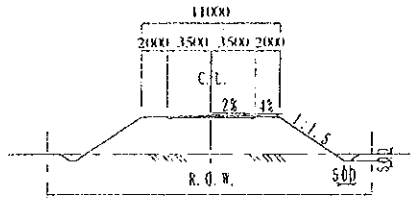
Based on the classification shown in previous chapter Table 10.1.2 of road category and design speed, geometric design standards are proposed for 5 categories of roads from S to D as given in Table 11.2.1. The basis of road width composition is determined considering traffic capacity and requirement as in the following Figure 11.2.1. The limits of horizontal and vertical clearance of roads and railways are illustrated in Figure 11.2.2 and 11.2.3.

Table 11.2.1 Basic Geometric Standard

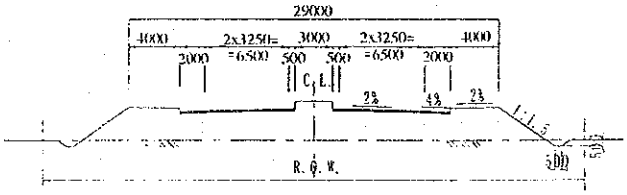
Category		S: Highway	A: Regional Road	B: Primary Road	C: City Road	D: Residential road
Terrain		Flat	flat	Flat	flat	Flat
Design Speed	km/h	120	80	60	60	40
Stop. Sight Distance	m	210	110	75	75	40
Lane Width	m	3.75	3.5	3.25	3.25	3
Number of Lane	no.	4	4,2	4,2	2	2,1
Median Width	m	4 or More	1 or None	3	None	None
Inner Shoulder	m	0.75	0.5	0.5	0.5	None
Outer Shoulder	m	3	2	2	2	None
Cross Slope	%	2	2	2	2	2
Min. Radius	m	700	300	150	150	60
Min. Radius not required Without Transition Curve	m	2100	900	500	500	250
Max. Gradient	%	3	5	5	6	7
Min. Vertical Curve Length	m	100	70	50	50	40
Super Elevation	%	6	6	6	6	6
V. Clearance	m	5	5	5	5	5



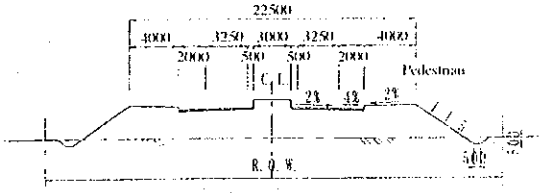
Type A
for category A Regional Road 4 Lanes



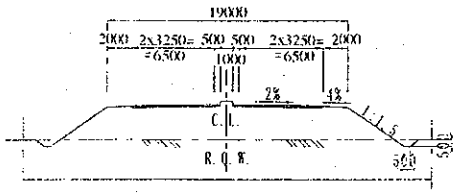
Type A'
for category A Regional Road 2 Lanes



Type B
for category B Primary Road 4 Lanes

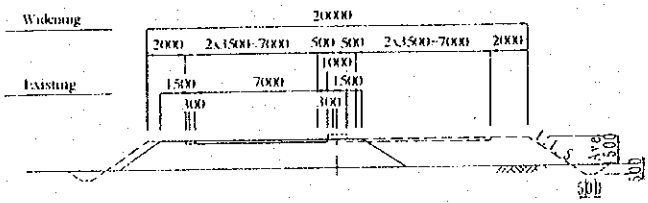


Type B'
for category B Primary Road 2 Lanes

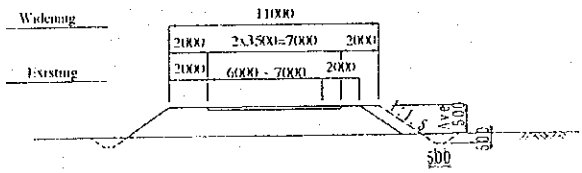


Type C
for category C City Road 4 Lanes

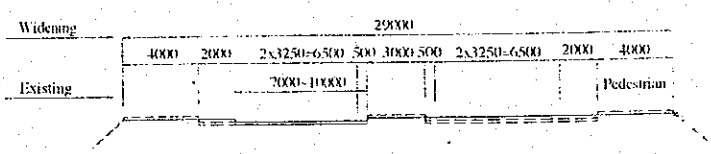
Cross Section for New Road



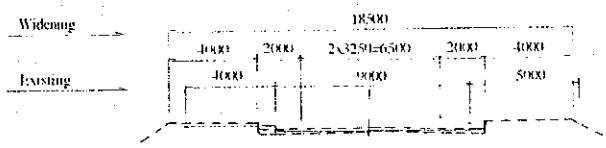
Type D
for category A Regional Road (2 - 4 Lanes)



Type E
for category A Regional Road (2 - 2 Lanes)



Type F
for category B Primary Road (2 - 4 Lanes)



Type G
for category B Primary Road (2 - 2 Lanes)

Cross Section for Improvement / Widening

Figure 11.2.1 Typical Cross Section

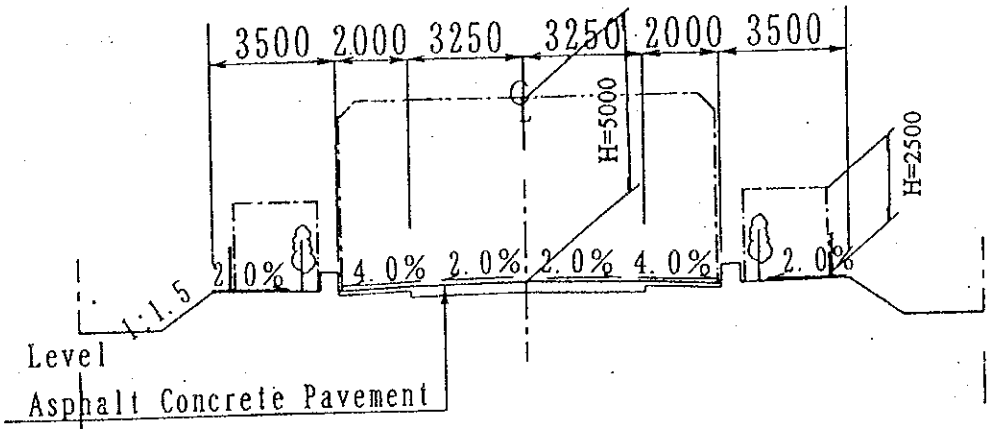


Figure 11.2.2 Clearance for Road and Street

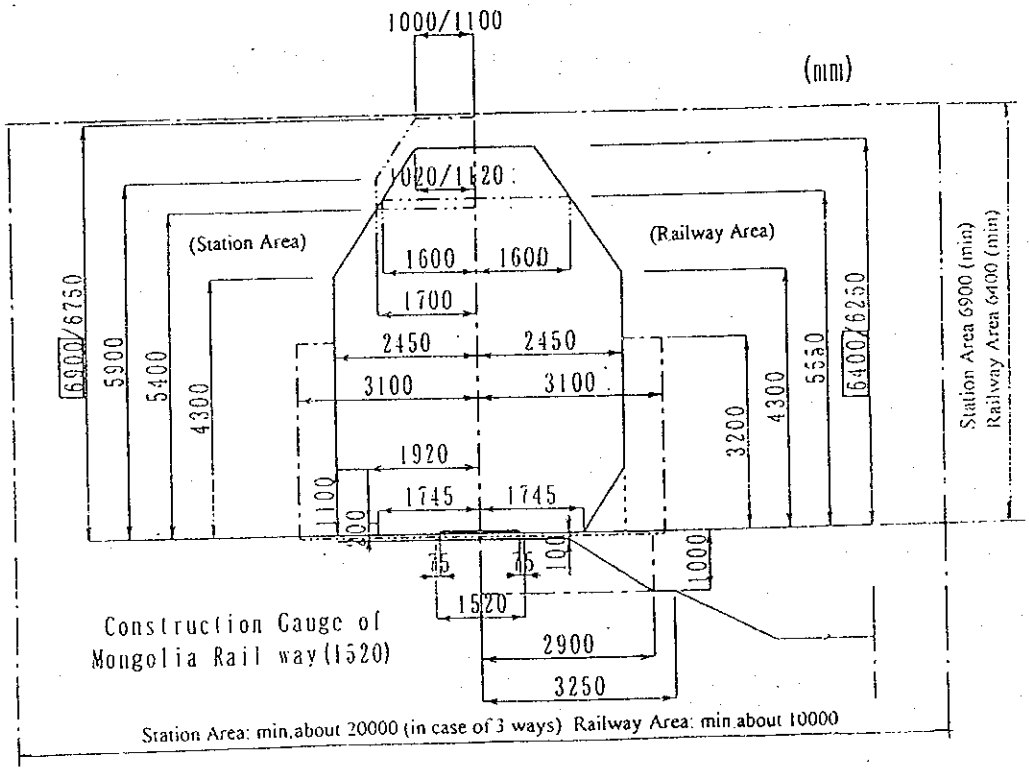


Figure 11.2.3 Clearance for railway

11.3. Traffic Capacity of Roads

The roads for the analysis of the design traffic capacity are classified in 6 types of roads, where analysis covers 2 lane and multi lane capacities. The traffic capacities were computed as shown in Table 11.3.1

Level	Running condition	Applicability
A	Low traffic volume and free driving at high speed	(Not Applicable)
B	Stable traffic flow with speed limited. There remain freedom to some extent in the selection of speed and lane.	Applicable for designing of regional roads
C	In the limits of stable traffic flow, but speed and maneuverability are rather restrained due to high traffic volume.	Standard for city road designing Primary, City Road
D	Unstable traffic flow, but tolerable speed could be kept. There is, almost, no freedom for driver to act.	(Not Applicable)
E	Unstable traffic flow with frequent stops. Running condition of road is similar to its traffic capacity condition.	(Not Applicable)
F	Low speed with restrained running. Long time stops are occurring. Traffic flow exceeds road traffic capacity.	

Table 11.3.1 Analysis of Traffic Capacity (Multilane)

Categories		Highway	Regional Road	Regional Road	Primary-Road	Primary/City Road	Primary/City Road
	Unit	4 lanes	4 lanes	2 lanes	4 lanes	4 lanes	2 lanes
Design speed	Km/hr	120	80	80	60	60	60
Terrain of grade		Flat	Flat	flat	Flat	flat	flat
No. of lane		2+2=4	2+2=4	1+1=2	3+3=6	2+2=4	1+1=2
Width of lane	M	3.75	3.5	3.5	3.25	3.25	3.25
Lateral :Road side	M	3	3	2	2	2	2
Clearance :Median	M	0.75	0.5		0.5	0.5	
Basic capacity	pcu/h/lane	2000	2000	1250	2000	2000	1250
Service level		B	C	C	C	C	C
Coefficient of service level		0.54	0.6	0.43	0.6	0.6	0.43
Max. service flow rate	pcu/h/lane	1080	1200	535	1200	1200	535
Rate of heavy vehicle	%	10	10	10	10	10	10
Coefficient :Width of lane		1	1	1	0.94	0.94	0.93
:Lateral clearance		1	1	1	1	1	1
:Heavy vehicle		0.91	0.91	0.91	0.91	0.91	0.91
:Road class		1	1		1	1	
:Driver population		1	1		1	1	
Directional Distribution Rate				0.94			0.94
Total		0.91	0.91	0.85	0.85	0.85	0.8
Service flow rate	veh/h/lane	980	1090	450	1020	1020	425
Design hour volume ratio	%	8	8	8	8	8	8
Directional distribution	%	60	60		60	60	
Peak hour factor				0.94			0.94
Daily traffic capacity	veh/d/lane	10200	11300	5250	10600	10600	5250
Daily traffic capacity	veh/day	40000	45000	10500	63000	42000	10000
Coefficient No. of Intersection		1	1	1	1	1	1
Applied Daily Traffic Capacity		**40000**	**40000**	**10000**	**56,000**	**37000**	**9000**

The basis of applied figures for the analysis of traffic capacity is mentioned as below.

(1) Service Level:	B= C=	Highway, major regional road City road (research by HCM)
(2) Basic Capacity:	Multilane 2 lanes 3 Lanes	2000 pcu / h / lane 2500 pcu / h / 2 lane 12000 veh./day/ 3 lane Traffic capacity is not prescribed in case of 3 lanes. However, the capacity for 3 lanes is determined considering 2000 veh./day for one lane capacity (width 4~4.7m).
(4) Calculation method and coefficients		In accordance with HCM, (AASHTO), and Geometric Design Standard, Road Capacity Manual (Japan Road Association)

11.4. Pavement Design

There are two kinds of pavement in UUB. One is flexible bituminous pavement, and the others is rigid cement concrete pavement. Rigid pavement was adopted in the 1980s, however it is not used in UUB now. Main reasons come from the problems for initial cost and maintenance as shown in the following Table 11.4.1.

Table 11.4.1 Comparison of Pavements

	Flexible Pavement	Rigid Pavement
Initial cost	Low	High
Conditions for construction	Allowable temperature : Min.5 deg. C	Can not open to traffic during min. 7 day curing period Keep over 0 deg. C during curing period
Performance period	7-10 yeas	20-30 years
Repair	Easy	Difficult
Snow on pavement	Melt soon	Remain longer time

Study team decided in this study to design mainly by flexible pavement for new construction and for overlay works from the point of urgency and total budgetary matters. However the concrete pavement is still expected to be studied in future for its long durability. Especially a study of the prefabricated concrete slab pavement including site experiment is worthy to be studied as a measure for construction in cold season. Examples are found in building wall and airport runways in Mongolia.

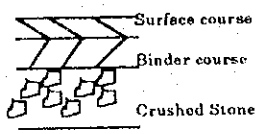
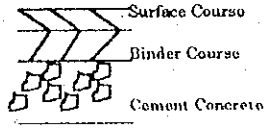
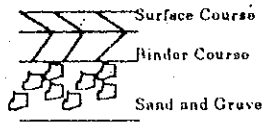
One of the important conditions is the freezing and melting of ground soil to be considered in the pavement design in Mongolia. Pavement will blow up in winter and come down in the hot season. Phenomenon of freezing and melting of the soil is said to be decided by two factors, grading of soil and water contents in the soil. However such places is not so many. UUB is located along the Tuul river. The ground of southern side of UUB near Tuul river is mainly composed of river deposit. It is very permeable and no anxious for freezing. While

the ground of northern mountain side of UUB is composed of rocks and hard stiff clay. They are un-permeable not to keep the water for freezing. These two kinds of soils dominate in UUB.

Permanent freezing layer in UB area is fortunately disappeareing as mentioned in 3.2.4. A large problem occurred on the pavement is un-avoidable shrinkage cracks due to severe cold weather conditions.

Pavement design method in Mongolia , BCH-4683, defines three types of structure as following Table 11.4.2.

Table 11.4.2 Pavement Structural Type by BCH-4683

	Normal structure	Lean Concrete Base	Low cost base
Sketch			
General description	Load on the surface will be dispersed gradually	Load will be born by the layer of lean concrete (50-150kg/cm2)	Utilize local available materials
Advantage	Common	Good for the soft ground area	Price is low
Disadvantage		Cost is high	Durability is low

Minimum thickness	Surface course	4 cm
	Binder course	6 cm
	Base course	Not define
	Sub base course	ditto

Through the discussion with Road Department, ASSHTO was selected for the design and DNPS-86 was used as an analysis software.

Basic design criteria for the flexible pavement design are as follows:

Table 11.4.3 Basic Design Criteria

Analysis period	20 years
Performance period of the first pavement	10 years
Terminal serviceabilty	2.5
Converted axle loads	18 kips (8.2 ton)
Layer coefficient	
Surface course	0.42 / inch
Base course (Crushed stone)	0.14 / inch
Subbase course (gravel)	0.08 / inch
Subgrade (Roadbed)	Modulus 30,000 psi (CBR 25)

11.5. Structure Design

In the beginning of Mongolian development, design standards applied came from various countries, and existing structures have various loading capacities.

11.5.1. Dead Load

The following unit weights of materials in the Table 11.5.1 were used in computing of the dead load.

Table 11.5.1 Unit Weight of Materials

Type of Dead Load	Unit Weight (kgf/m3)	Type of Dead Load	Unit Weight (kgf/m3)
Steel or cast steel	7850	Asphalt pavement	2300
Cast iron	7250	Bituminous	1100
Aluminum alloys	2800	Compacted sand/earth/gravel	1900
Concrete(plain)	2350	Loose sand/earth/gravel	1800
Concrete(reinforced/pc)	2500	Underground water	1000
Cement mortar	2150	Timber	800

11.5.2. Live Load

The various loading capacity is expected to increase along with future development of economy. In consideration of Mongolian development up-to the year 2020, more heavy design load is recommended.

The Japanese live loading system, TL-25 (B-Live Load) is a more heavy load and has larger external force compared with AASHTO American standard, and Mongolian standard as shown in Figure 11.5.1. In conclusion, the Japanese live loading system in accordance with Specifications for Bridges (Japan Road Association, 1996) is recommended to be applied in this study, as illustrated in Figure 11.5.2 and Table 11.5.2.

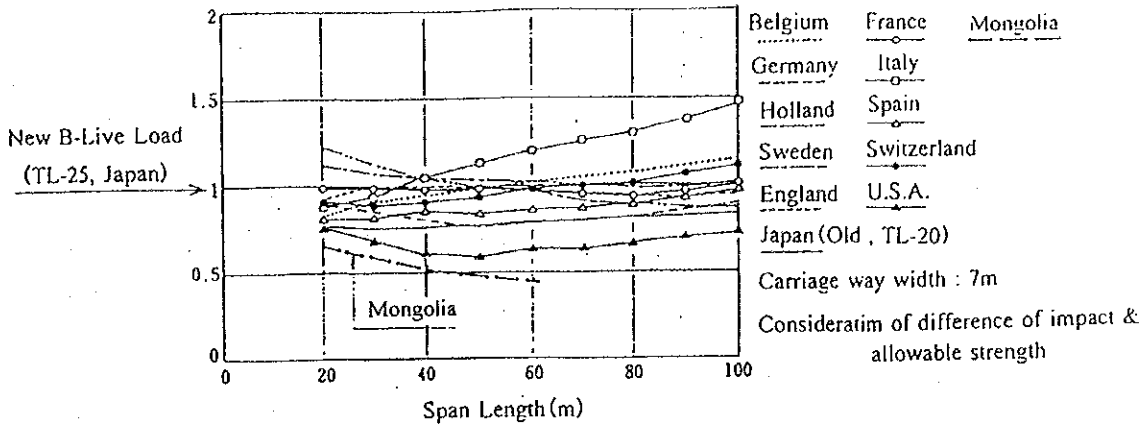


Figure 11.5.1 Comparison of Bending Moment for Live Loading in the World

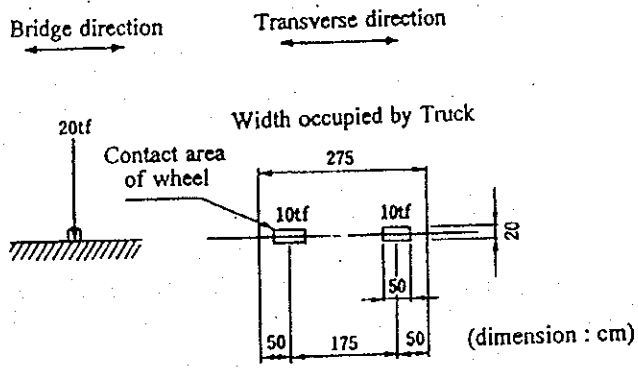


Figure 11.5.2 (1) T-Loading

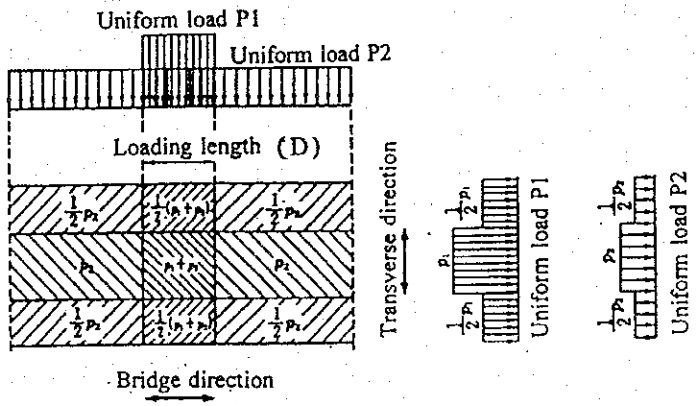


Figure 11.5.2.(2) L-Loading

Table 11.5.2 L-Loading (B-Live Load)

Main loads (wide 5.5m)						
Uniform loads P1			Uniform loads P2			Sub loads
loading length D(m)	load (kgf/m²)		load (kgf/m²)			
	for Bending moment	for Shearing force	L≦80	80<L≦130	L>130.	
10	1,000	1,200	350	430-L	300	50% of main loads

L: Span length

11.5.3. Earthquake

Earthquake motions shall be considered for the seismic response of the soils at the site in accordance with Mongolian Specification. Earthquakes in Mongolia are divided in class 1 to 12, and class 7 to 9 of earthquakes are defined for structures in UB City. In this study, 0.10g of Kh, class 9 is adopted as the acceleration coefficient for seismic load through the discussions with Road Department.

11.5.4. Other Loads

The other loads and the loading combinations for the design such as earth pressure, hydraulic pressure, breaking force, impact, etc are proposed to be in accordance with Japanese Specifications.

11.6 Bridges

11.6.1 Super Structure

Applicable type of super structure in relation to the typical type and bridge length is illustrated in Table 11.6.1.

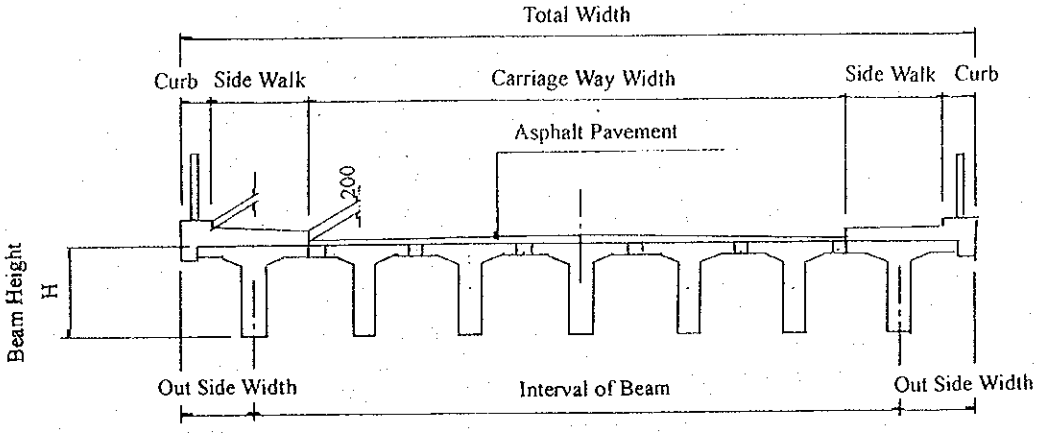
Table 11.6.1 Application of Superstructure Type

Span Length / Typical Type		10	20	30	40	50 (m)	(Simple Beam) Height of beam/Span
Reinforced concrete	Slab	▬					1 / 15~17
	Hollow-slab		▬				1 / 20
	T-beam		▬	▬			1 / !6~18
Prestressed Concrete	Precast I-beam	▬	▬				1 / 23
	Precast T-beam		▬	▬			1 / 18
	Cast in situ T-beam			▬	▬	▬	1 / 18~20
	Cast in situ Hollow-slab			▬	▬		1 / 20
	Cast in situ Box-beam				▬	▬	1 / 18~20

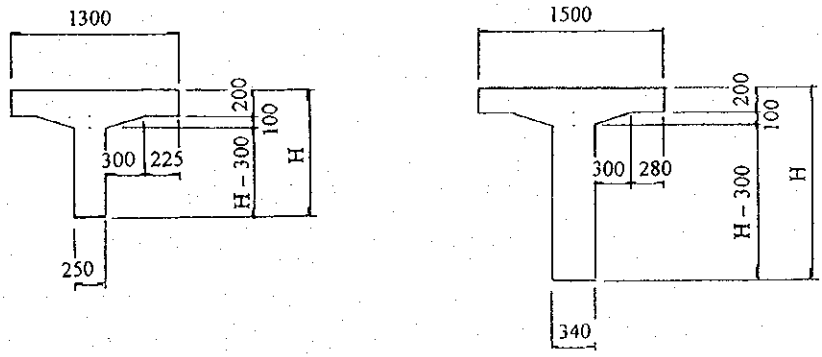
Note: ▬ Adopted Superstructure type in the Study

There are no steel bridges in Ulaanbaatar due to importing of materials, worsening of the quality in the extremely cold environment and no fabrication systems. Therefore, Study Team decided to adopt PC and/or RC bridges referring the past constructed records.

Simple section shape of T-shape beam are recommended considering some problems in Mongolia such as complicated curb form work, slenderized web and limited cover between reinforcing bar and surface for placing concrete as shown in Figure 11.6.1.



Cross Section



Beam Length(m)	Beam Height(Hm)
15	0.8
17.5	0.95
20	1.1

Reinforced Concrete Beam

Beam length(m)	Beam Height(Hm)
22.5	1.45
25	1.6
30	1.8

Prestressed Concrete Beam

Figure 11.6.1 Typical Cross Section of Super Structure

11.6.2 Sub Structure and Foundation

Structure		Height	Type
Sub Structure Type	Abutment	H=3~5m	● Gravity
		H=5~12m	● Reinforced Reversed T- Shape
		H>12m	● Reinforced Buttressed, Box
	Pier		● Reinforced Wall,
			● Rigid Column,
			● Pile
Foundation Type			● Spread Footing
			● Pile Foundation
			● Caisson, etc.

11.7 Grade Separation

There are two kinds of grade separation with fly-over bridges in this project.

On Intersection	Heavy traffic in future traffic flow of right/left turn lanes frontage road on level crossing part
On Railway	Coordination with traffic flow of both side of railway

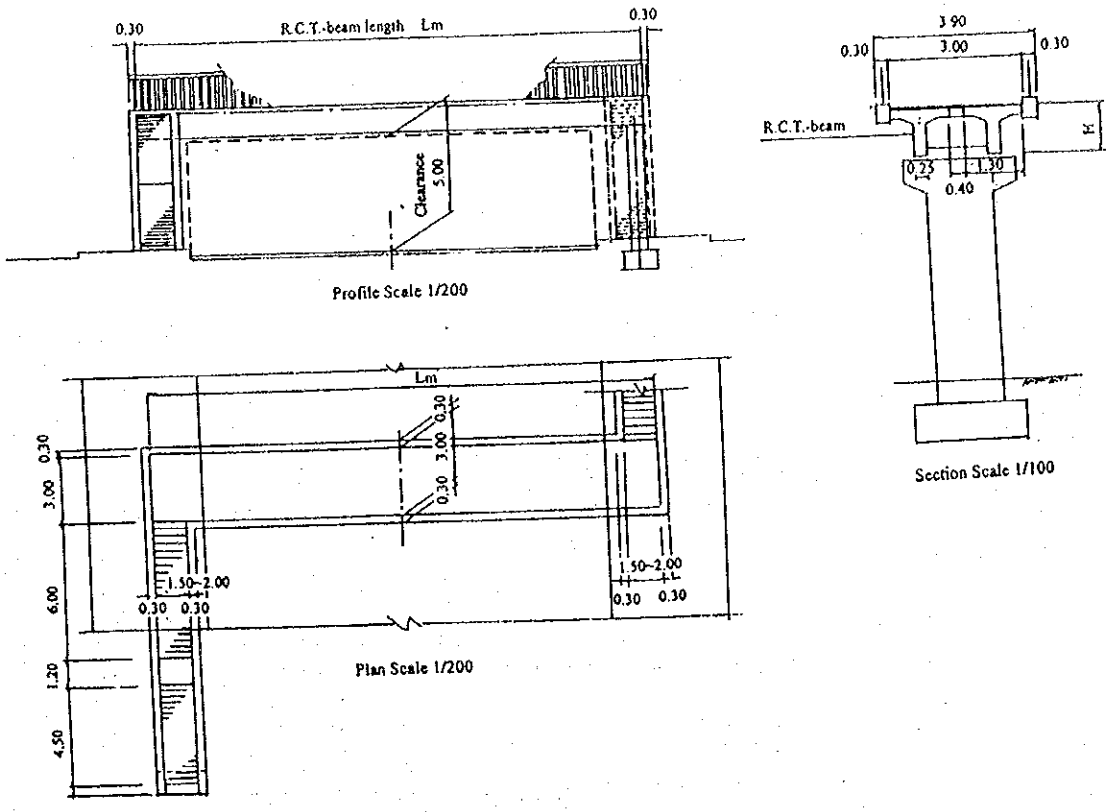
11.8 Road Crossing Facility

Study team selected a few candidate locations for pedestrian over/under passes where a lot of pedestrians are crossing. They generate obstruction to traffic flow based on the results of road as shown in Figure 5..3.1. Considering the possibility to obtain the materials, easier construction and maintenance, the recommendable type of overpass is concrete structure. They are illustrated in Figure 11.8.1.

UUB has only two crossing facilities. One is the overpass in front of Haraholin Zaha on the Peace Avenue. Here almost people cross the street under the pedestrian bridge.

Another one is the underpass near central department store on Peace Avenue. Width of subway is about 8 m with 8 kiosk (small shop). It seems as a shopping arcade and few people use this subway.

Pedestrian underpass is difficult to construct because of many underground facilities, such as power cables, telephone lines, water/hot water pipe and drainage/sewerage pipe, etc. While pedestrian overpass is not recommendable from the point of severe climate conditions in winter.



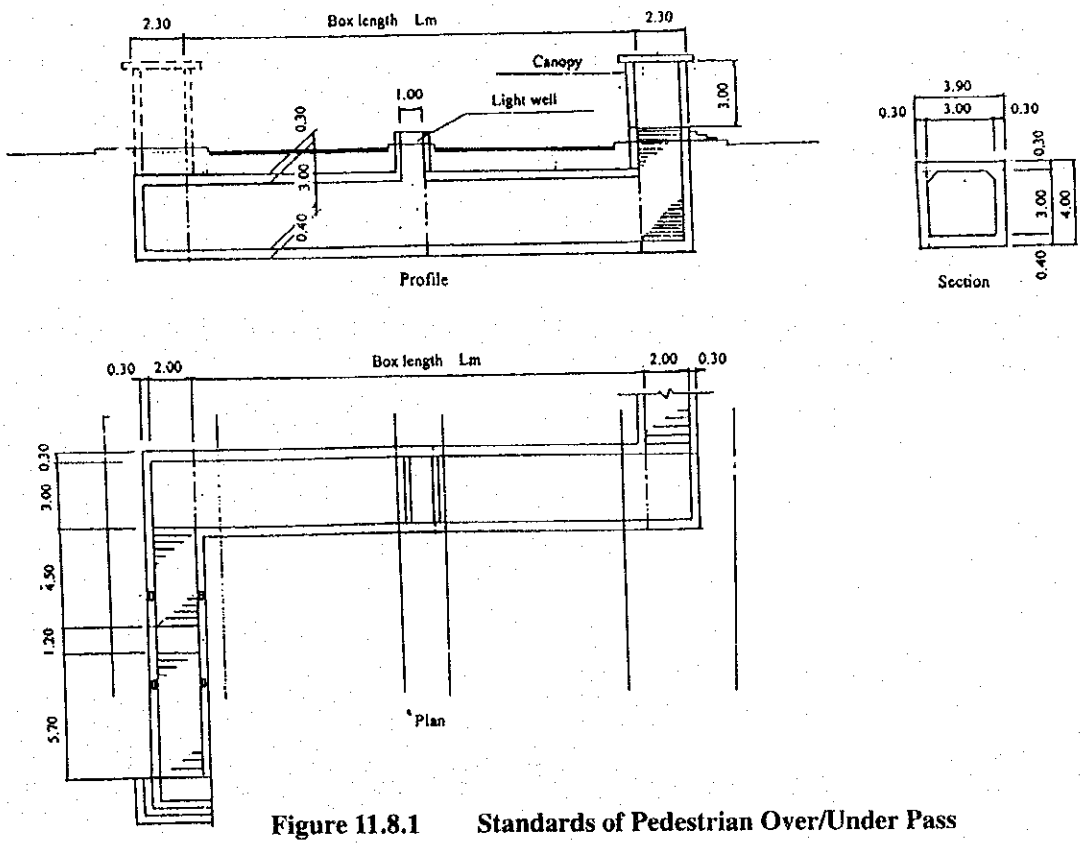


Figure 11.8.1 Standards of Pedestrian Over/Under Pass

Considering the moral of the UB people and the traffic volume, pedestrian over/under passes seem to be too early to be developped. Mongolian side also requested to develop other high priority infrastructures first because of limited resources.

11.9 Public Car Parking and Bus Stops

11.9.1 Car Parking

Normal traffic flow is obstructed by illegal parking of vehicles on the roads, such as commercial street and market areas. The typical locations of traffic congestion are as shown in Fig. 11.9.1.

From the results of counted parking car numbers for the above locations, the required car numbers and parking spaces are calculated in year 2020 as shown below Table 11.9.1. (9 m2/vehicle)

Table 11.9.1 Required Area for Parking Space

Place	Existing Car No. at place	Area (x9m2)	Grouth ratio of traffic volume	Future car No. at place	Area required (x 9m2)
a. No.8, 9	116	1044	1.4	170	1600
b. No.26	82	738	1.2	100	900
c. No.19	31	279	1.3	50	500
d. No.41	102	918	1.4	150	1500

Besides, there are many shabby car sheds in the residential area and roadsides. They are giving a bad aesthetic impression. Irregular car sheds shall be removed, and regulation shall be established at an early chance for the people to construct their car parking spaces in their new building or apartment in the construction of them.

These existing locations are shown in photographs.

The standard parking lots for cars and trucks is proposed to avoid traffic congestion as illustrated in Figure 11.9.2.

Required Area for Parking Space

Place	Existing number of cars at place	Area (X 9m2)	Growth ratio of traffic volume	Future number of cars at place	Area (X 9m2)
a. No.8,9	116	1044	1.4	170	1600
b. No.26	82	738	1.2	100	900
c. No.19	31	279	1.3	50	500
d. No.41	102	918	1.4	150	1500

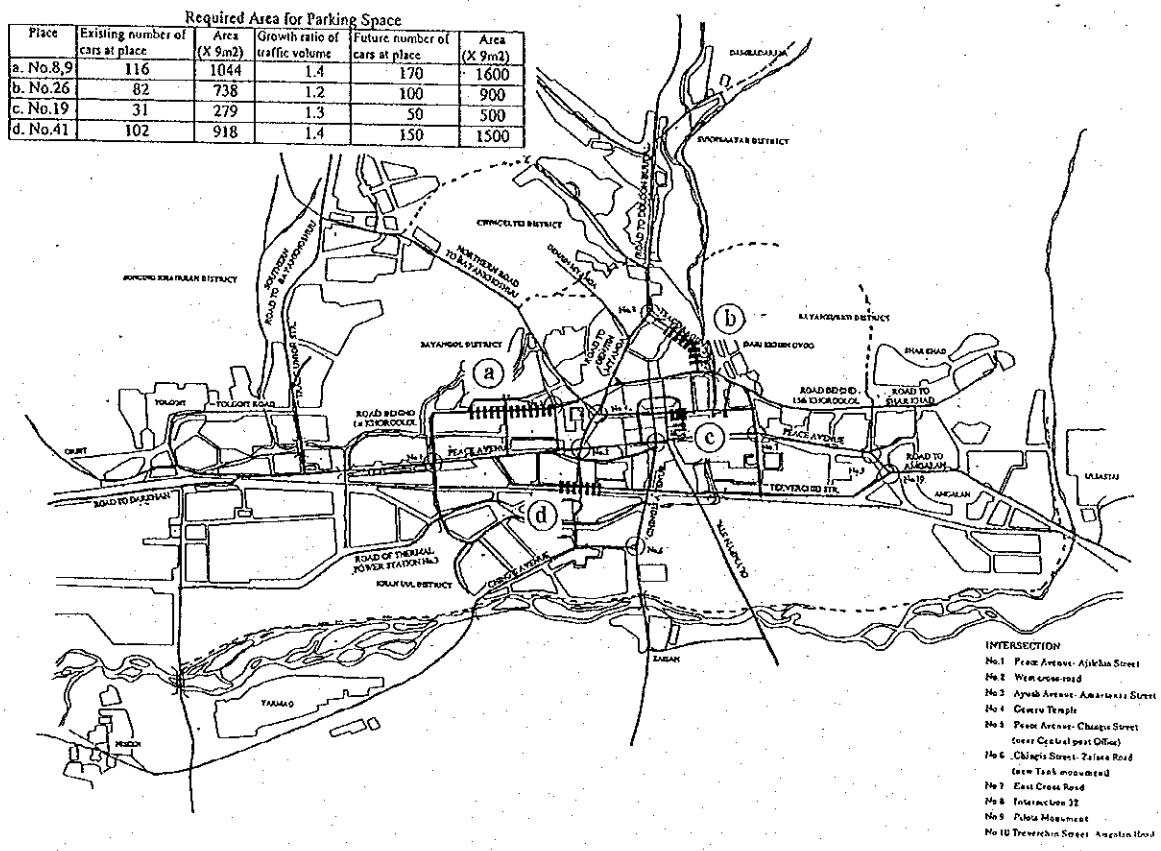
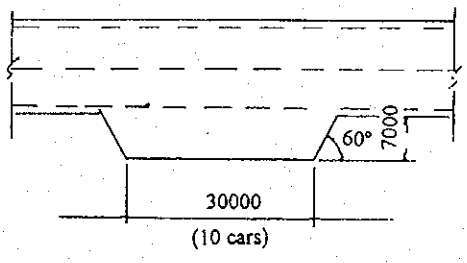
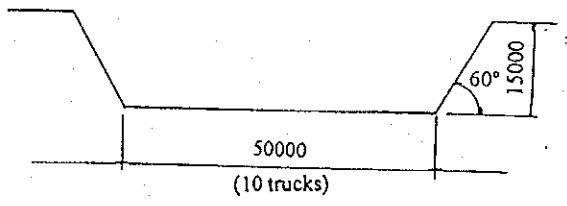


Figure 11.9.1 Typical Locations of Traffic Congestion



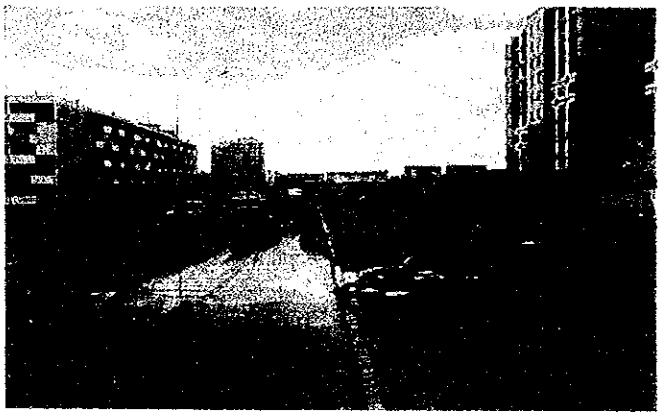
For Car (Ex. Khasbaatar Str.)



For Truck (Ex. Teeverchid Rd.)

Figure 11.9.2 Proposed Plan for Parking Lot

Road No.26 (Material Market)
Car parking on the road



Road No.37, 95 (Residence area)
Car shed along the road

Road No. 8, 9 (Shopping area)
Car parking on the road

11.9.2 Bus Stop

The existing bus stop areas in UB City does not permit smooth flow with trolly and city buses.

Therefore, the length of Bus bay is to be widened according to traffic volume expected as shown in Figure 11.9.3.

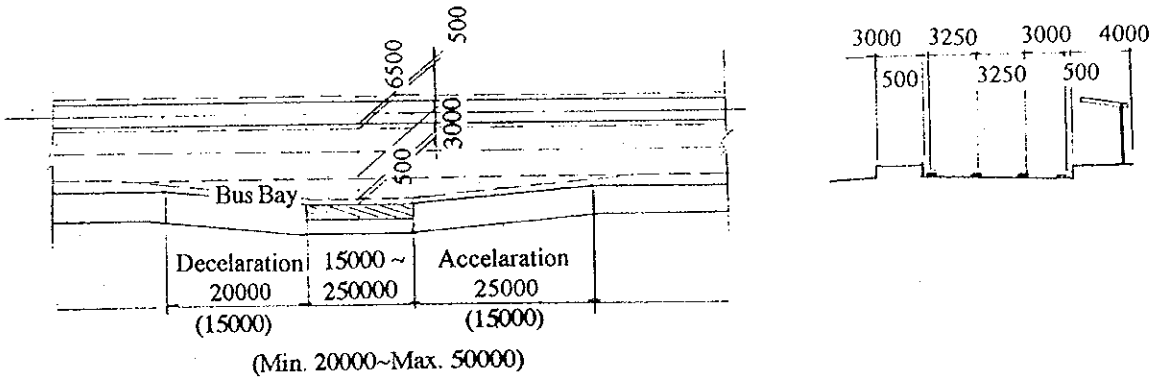


Figure 11.9.3 Expected Plan for Bus Stop Area

11.10 Safety Facilities

Many traffic signals in UUB are out of order due to electrical troubles and lack of spare parts. Their low positions are giving bad visibility. Manual controlling by policeman is still predominant. Road lighting facilities are developed well at almost all major streets. However almost of them are out of order for saving energy or due to electrical troubles.

Few road signs are installed due to lack of budget. Very few road markings are applied. Their paints are normal paint for architectural work and durability is very low. The installation of white line is recommended as it gives a good impression to the road users in UUB. Traffic police is requesting strongly development of safety facilities at an early opportunity.

Chapter 12 Cost Estimation of Future Road Networks

12.1 Basic condition

Cost estimation was done under the following conditions

1	Material Cost	● Local material =Standard price of Road Department, local construction and design companies. ● Fuel and oil for equipment = standard price of local market ● Import materials = 90% of standard unit price of data book of Japan +(plus) transportation cost, insurance fee and import tax (a 10 % addition)
2	Labor cost	● Standard price of Road Department, local construction and design companies
3	Equipment Cost	● Depreciation rate by Japanese standard +(plus) transportation cost, insurance fee and import tax (a 10 % addition) ● Equipment cost excludes labor fee of operator, fuel and oil. (Consumption rate for fuel and oil are based on the standards of Japan)
4	Direct Cost	● Sum of Material cost, labor cost & Equipment cost ● Efficiency of local labor = 40% of Japanese labor (except foreman) ● Equipment work efficiency = standards of Japan.
5	Indirect Cost	● Direct cost x 35 %
6	Consulting Cost	● (Direct Cost +(plus) Indirect Cost x 10%
7	Contingency	● 10 % of above total

The indirect cost includes the cost of head office, site office, temporary work, demolition and resettlement, safety measures and quality control.

The land acquisition cost was not estimated because all of land are still belonging to national government and there were no record of the payment in ensuring the land for public works.

In this Study, cost was split into two portion i.e. "local currency portion" and "foreign currency portion". The cost to be incurred in local currency (i.e. Tugrug) is termed as local currency portion. Similarly, the cost to be incurred in foreign currency is termed as foreign currency portion.

In estimating the foreign and local portion of cost, the following assumptions were made:

	Foreign portion	Local portion
Labor cost		○
Imported materials (fuel and oil, asphalt bitumen	○	
Local materials(gravel, crushed stone)		○
Equipment costs	○	
Indirect Cost	△*	△*
Consulting Cost	△*	△*
Contingency	△*	△*

*Notes: Divided according to the ratio of foreign and local portion of 4.Direct cost.

Table 12.1.1 Unit Material Costs

	Item	Main spec.	Unit	Cost ($)	Reference
1	Diesel		lit.	0.27	225Tg
2	Petrol		lit.	0.28	233Tg
3	Portland cement		ton	51.20	42,900Tg
4	Admixture	Silica cement	kg	2.13	
5	Reinforcement bar		ton	328.00	275,000Tg
6	Timber		m3	34.80	29,200Tg
7	Plywood	t=12mm	m2	11.60	
8	Straight asphalt	80/100	ton	188.00	
9	Cut back asphalt	for Prime Coat	lit.	0.34	
10	Crusher run	Sub-base course	m3	4.86	4,080Tg
11	Crushed stone	Base course	m3	4.86	4,080Tg
12	Sand	Base	m3	5.51	4,620Tg
13	Crusher run	Course aggregate	m3	4.86	4,080Tg
14	Sand	Fine aggregate	m3	5.51	4,620Tg
15	Paint	JIS K 5665	kg	4.21	3,530Tg
16	Bead	JIS R 3301	kg	1.25	
17	Traffic signal	8 each	nos	152,000	
18	Concrete Pipe	Φ600	m	52.00	43,600Tg
19	Concrete Pipe	Φ1000	m	57.20	48,000Tg
20	Concrete Pipe	Φ1200	m	70.30	59,000Tg
21	Steel		ton	313.00	
22	Road lighting		nos	3,640	
23	Cubicle (road lighting		nos	13,600	
24	Traffic signboard	With poll	set	150.00	126,000Tg
25	Reflecting stud		nos	50.90	
26	Rubber bearing	10x2	m2	1,210	
27	Guard fence	Concrete base	m	62.50	
28	Main girder	H-588x300x12x20	ton	313.00	
29	Hand rail	L-50x50x6	ton	274.00	
30	PC Cable	SWPR7B 12.7mm	kg	1.76	
31	PC Cable	IT-19.3mm	kg	4.46	

Note: Reference shows the current local price for reference purpose only; 1US$ = 838.46Tg

Table 12.1.2 Unit Labor Costs

		Cost (in Tg/day)
Engineer	Civil engineer	6,760
	Survey engineer	6,200
Labor	Foreman	5,630
	Skilled labor	4,510
	Labor	2,820
Operator	Plant	9,010
	Equipment	8,450
	Driver	7,320
Administration	Administrator	8,450
	Secretary	5,630
	Clerk	7,040

Table 12.1.3 Equipment Cost

Unit: US$(=838.46Tg)/hour or daily

	Item	Main spec.	Unit	Cost (in $)	Reference
1	Bulldozer	21 t	hr.	95.60	68,700Tg
2	Tractor shovel	2.1m3 (wheel)	hr.	48.20	41,600Tg
3	Back hoe	0.6m3	hr.	80.70	48,000Tg
4	Dump truck	11 t	hr.	23.70	27,600Tg
5	Dump truck	2 t	hr.	5.71	14,400Tg
6	Cargo truck	4 t	hr.	12.10	20,100Tg
7	Truck with crane	4 t、2.9 t	hr.	15.90	27,600Tg
8	Macadam roller	10 t	hr.	24.50	26,700Tg
9	Tire roller	8 t	hr.	28.60	26,700Tg
10	Vibratory roller	4 t, combined	hr.	20.20	29,100Tg
11	Vibratory roller	0.5t, Hand guide	hr.	5.02	8,710Tg
12	Motor grader	3.1 m	hr.	40.90	42,000Tg
13	Asphalt finisher	3.5m, crawler	hr.	125.00	49,300Tg
14	Concrete plant	30m3/h,7.5kW	hr.	39.30	
15	Asphalt plant	30t/h, 110kW	hr.	165.00	186,000Tg
16	Generator	200kVA	day	114.00	
17	Generator	60kVA	day	44.50	14,200Tg
18	Truck crane	25 t	hr.	61.00	44,200Tg
19	Water tanker	6000 l	hr.	17.70	22,900Tg
20	Road sweeper	2～3.1m3	hr.	75.10	
21	Line marker	15cm, hand guide	hr.	2.79	
22	Pile pulling machine	80t	day	759.00	
23	Crawler crane	50t	hr	93.90	

Note: Reference shows the rental charge of "Erdene Zam" construction company

Direct unit cost of major work items are shown in Table 12.1.4

Table 12.1.4 Direct Unit Cost of Work Items

Unit: US$

	Work Items	Spec	Unit	Estimated costs (Financial)	Reference: Local construction companies quotation		
					A	B	C
1	Pavement (Surface)	Asphalt concrete 5cm	m2	8.65	4.95	5.50	5.05
2	Base course	22cm crushed stone	m2	8.29	1.71	1.41	3.08
3	Subgrade	104cm borrow materials	m2	18.66	3.28	2.99	7.00
4	Concrete work		m3	97.93	35.78	48.63	47.46

Costs of road repair works were estimated according to the classification of 4 kinds of current road conditions as mentioned in Chapter 4, shown in Table 12.1.5.

Table 12.1.5 Cost Estimation Method of Repair of Damaged Roads

Categories	Work item	Cost estimation methods
Pavement Repair A (Good sections)	Installation of missing cover of manhole, improvement of pavement gap, repair of pot holes	Estimated cost for overlay (5cm) for 10 % of total surface area and cutting/patching of 15 % of overlay area.
Pavement Repair B (Some amount of repair)	Adding above, partial overlay is necessary for the improvement of pavement conditions	Estimated cost for overlay (5cm) for 50 % of total surface area
Pavement Repair C (Large-scale repair)	Repair works are required from base course to surface from the current condition of damage.	Estimated cost for base course (39 cm) and surface (7 cm) for the total area. Replacing cost shall be included.
Pavement Repair D (Full repair)	Adding above, 50 % of subgrade is expected to be replaced.	Adding above "poor" category, estimated cost for replacing of 50 % of subgrade (104cm)

Figure 12.1.1 shows the flow chart and table number of the cost estimation. Unit costs by items are summarized in Table 12.1.6.

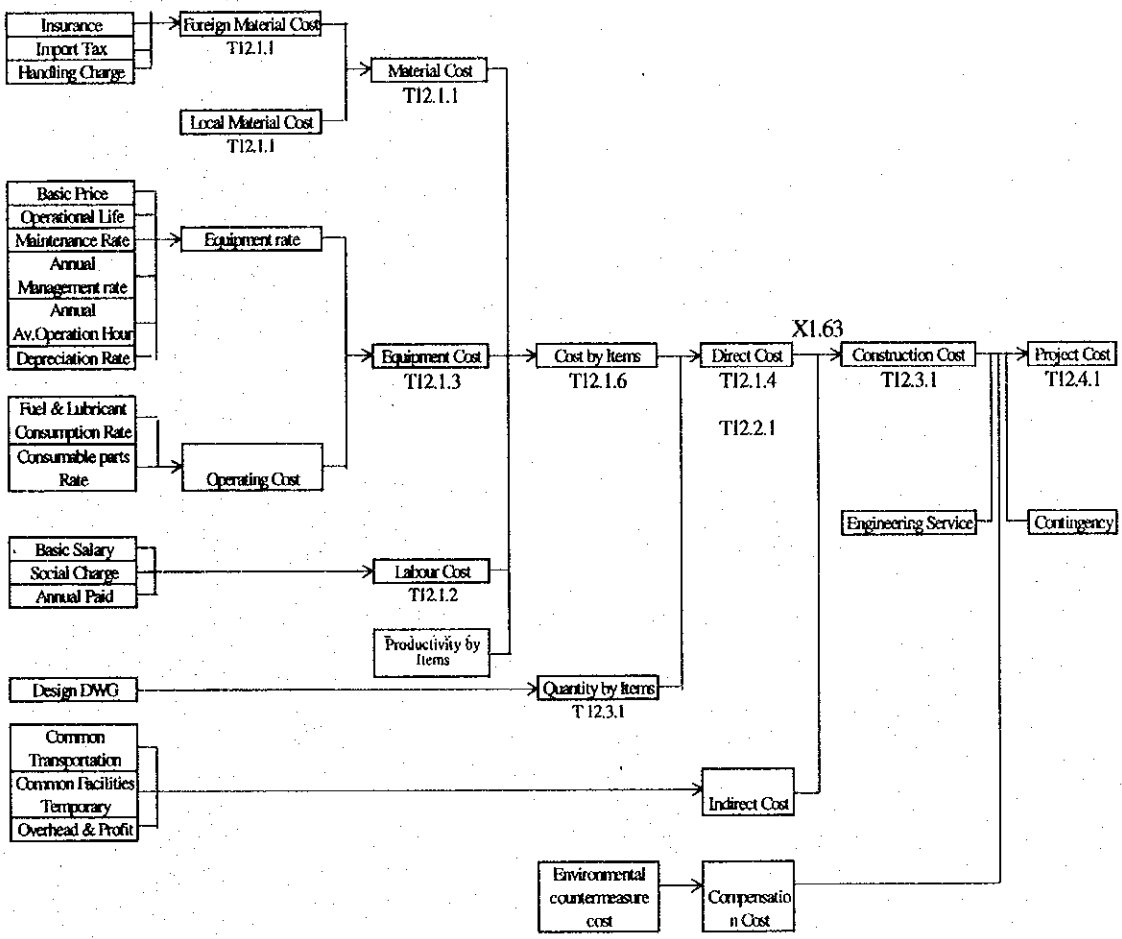


Figure 12.1.1 Flow Chart of Costs Estimation

Table 12.1.6 Summary of Unit Cost by Work Items

Work Item		Unit	Cost (US$) Local	Foreign	Total
Excavating and loading by Back hoe		m3	0.03	2.93	2.96
Dozing by Bulldozer		m3	0.04	2.38	2.42
Loading by Back hoe		m3	0.03	2.84	2.87
Rock loading By Back hoe		m3	0.04	3.37	3.41
Spreading	t=20cm	m3	0.04	1.56	1.60
Spreading	t=30cm	m3	0.02	1.20	1.22
Compacting	t=20cm	m3	0.01	0.54	0.55
Compacting	t=30cm	m3	0.	0.26	0.26
Back filling		m3	0.78	4.26	5.04
Surplus soil hauling	L=5km	m3	0.23	7.11	7.34
Waste hauling	L=5km	m3	0.30	9.30	9.60
Borrowing soil	L=20km	m3	0.54	15.97	16.51
Concrete work	Reinforced concrete	m3	36.45	83.65	120.10
Concrete work	Small structure	m3	37.99	72.89	110.88
Concrete work	Plain concrete	m3	34.23	63.70	97.93
Concrete work	Levelling using concrete	m3	33.77	59.58	93.35
Reinforcing-bar placing		ton	390	0	390
Forming		m2	4.10	3.65	7.75
Forming	For precast concrete	m2	3.95	0.25	4.20
Graveling for base		m3	6.95	28.73	35.68
Pavement breaking	Direct breaking	m3	0.53	7.12	7.65
Pavement cutting	t=5cm	m	0.09	0.44	0.53
Structure breaking	Plain concrete	m3	6.68	14.55	21.23
Pipe laying	Dia. 300mm	m	2.25	29.28	31.53
Pipe laying	Dia. 600mm	m	55.13	10.04	65.17
Pipe laying	Dia. 1000mm	m	62.01	14.05	76.06
Pipe laying	Dia. 1200mm	m	76.04	18.08	94.12
Concrete block masonry		m2	1.32	0.	1.32
Slope finishing	Embankment area	m2	0.11	2.23	2.34
Slope finishing	Cutting area	m2	0.25	2.74	2.99
Banking for subgrade	borrow soil t=20cm	m3	0.59	18.07	18.66
Banking for subgrade	soil in site t=20cm	m3	0.14	6.74	6.88
Banking for subgrade	borrow soil t=30cm	m3	0.56	17.42	17.98
Banking for subgrade	soil in site t=30cm	m3	0.11	6.09	6.20
Sloping work	Cutting area	m2	0.44	6.56	7.00
Sloping work	Embankment area	m2	0.30	6.05	6.35
Pavement removing		m3	1.07	17.61	18.68
Leveling		m2	0.04	0.85	0.89
Subbase course work	t=240mm	m2	1.75	7.27	9.02
Subbase course work	t=240mm	m2	1.76	7.78	9.54
Base course work	t=150mm	m2	1.12	5.32	6.44
Base course work	t=150mm	m2	1.10	4.68	5.78
Base course work	t=220mm	m2	2.05	6.91	8.96
Base course work	t=220mm	m2	2.02	6.27	8.29
Paving	t=40mm	m2	0.74	6.64	7.38
Paving	t=30mm	m2	0.60	5.18	5.78
Paving	t=50mm	m2	0.96	7.69	8.65
Road cutting		m2	0.30	20.54	20.84
Overlay	t=50mm	m2	1.66	13.81	15.47
Concrete plate placing		m2	5.81	0.	5.81
Side walk Base course	t=100mm	m2	1.29	5.54	6.83
Gutter placing		place	259.	357.	616.

12.2 Unit Cost of Necessary Work Items

Based on the above conditions, unit cost of work items are summarized in Table 12.2.1

Table 12.2.1 Unit Direct Cost of Each Work Items (Unit: US$)

Work items		Unit	Cost (US$) Local	Foreign	Total
Pavement Repair A		m2	1.60	13.74	15.34
Pavement Repair B		m2	1.66	13.80	15.46
Pavement Repair C		m2	4.44	31.31	35.75
Pavement Repair D		m2	7.15	44.71	51.86
New Pavement	Embank H=1.040m	m2	4.85	43.93	48.78
Improvement of Shoulder	Spading D=0.22m	m2	2.15	10.47	12.62
New Shoulder		m2	2.81	30.25	33.06
Block pavement of Sidewalk	Concrete Plate Block	m2	7.14	6.39	13.53
Curb stone		m	10.24	8.52	18.76
Boundary Block		m	8.63	7.55	16.18
Pipe Culvert	ϕ 600、360°	m	112.15	166.05	278.20
Open Ditch	500 / 2000 x 500	m	29.66	27.84	57.50
Road Line	W=15cm	m	2.66	0.28	2.94
Road Sign		place	167.54	43.00	210.54
Traffic Signal (New)	New	IS	929.	176,900.	177,829.
Reflecting Chatter Bar		Place	0.21	50.91	51.12
Road Lighting	New	IS	232.	33,400.	33,632.
Rehabilitation of Bus Stop	excluding Curb stone	Place	7,146.	4,6956.	11,842.
New Bus Stop	excluding Curb stone	Place	7,207.50	6,589.53	13,797.
Rehabili of Bus Terminal	Rehabilitation	Place	853,200.	939,200.	1,792,400.
Rehabili of Car Parking lot		Place	44,400.	313,100.	357,500.
Pedestrian Bridge		Place	45,900.	52,600.	98,500.
Pedestrian Under Pass		Place	27,100.	154,100.	181,200.
Prime Coat at Shoulders	Prime Coat	m2	0.	0.34	0.34
Embankment	Borrow Materials	m3	0.56	17.42	17.98
Grass on slope	Grass	m2	0.19	3.82	4.01
Base Course	t=220mm	m2	2.05	6.91	8.96
Bridge Approach Road	Bridge No.10	Place	900.	5,900.	6,800.
Bridge Approach Road	Bridge No.13	Place	1,800.	11,800.	13,600.
Bridge Approach Road	Bridge No.14	Place	1,300.	8,400.	9,700.
Bridge Approach Road	Bridge No.24	Place	1,300.	8,400.	9,700.
Bridge Approach Road	Bridge No.27	Place	3,.000.	19,700.	22,700.
Bridge Abutment	Bridge No.12	Place	900.	6,700.	7,600.
Bridge Abutment	Bridge No.28	Place	13,400.	36,200.	49,600.
Bridge Abutment	Bridge No.29	Place	19,300.	47,700.	67,000.
Bridge Abutment	Bridge No.32	Place	700.	10,500.	11,200.
Bridge Abutment	Bridge No.40	Place	1,300.	12,700.	14,000.
Bridge Piers	Bridge No.10	Place	12,800.	32,700.	45,500.
Bridge Piers	Bridge No.21	Place	8,900.	26,200.	35,100.
Bridge Piers	Bridge No.39	Place	1,800.	5,200.	7,000.
Flyover for Road	W=9.5m	Place	313,500.	826,100.	1,139,600.
Flyover for Railway	W=19.0m	Place	792,500.	2,304,400.	3,096,900.
Flyover for Railway	W=12.5m	Place	538,500.	1,558,400.	2,096,900.
Bridge for River	W=9.5m	Place	80,100.	335,400.	415,500.
Bridge for River	W=12.5m	Place	96,500.	373,400.	469,900.
Bridge for River	W=19.0m	Place	160,200.	670,800.	831,000.

12.3 Estimated Costs of Future Road Network

Alternative long-term road networks (codes of R1 to R7) were formulated in Chapter10. Total quantities in case of R7 and their cost is shown in Table 12.3.1. High cost will be required for rehabilitation of pavement (18%), pipe culvert (18 %), New Pavement (17%) and Bridge (13 %) . Cross drainage pipe culvert is designed at every 50 m interval to improve the current drain conditions.

Table 12.3.1 Financial Costs of Each Work Items (R7)

(Unit: 1,000 US$)

Work items	Cost Estimation	Quantities	Unit	Direct Cost	Total Cost	Ratio (%)	Total Cost Local	Foreign
Pavement Repair A		412,452	m2	633	1,034	0.46%	108	926
Pavement Repair B		693,868	m2	5,363	8,761	3.89%	941	7,820
Pavement Repair C		496,121	m2	17,735	28,969	12.86%	3,598	25,371
Pavement Repair D		47,779	m2	2,478	4,048	1.80%	558	3,490
New Pavement	Embankment H= 1.040m	478,228	m2	23,328	38,106	16.92%	3,789	34,318
New Construction of Shoulder		215,746	m2	7,133	11,652	5.17%	990	10,662
Block pavement of Sidewalk	Concrete Plate Block	185,058	m2	2,505	4,091	1.82%	2,158	1,933
Curb stone		160,895	m	3,018	4,929	2.19%	2,691	2,238
Boundary Block		254,571	m	4,120	6,730	2.99%	3,589	3,141
Pipe Culvert	ϕ 600、360°	91,655	m	25,499	41,652	18.49%	16,791	24,861
Open Ditch	500 / 2000 x 500	224,466	m	12,907	21,083	9.36%	10,875	10,208
Road Line	W=15cm	847,108	m	2,489	4,065	1.80%	3,681	384
Road Sign		4,093	place	862	1,408	0.62%	1,120	287
Traffic Signal (New)	New	3	IS	534	872	0.39%	5	867
Reflecting Chatter Bar		600	Place	31	50	0.02%	0	50
Road Lighting	New	3	IS	101	165	0.07%	1	164
Rehabilitation of Bus Stop	Rehabilitation excluding Curb stone	142	Place	1,682	2,747	1.22%	1,658	1,089
New Construction of Bus Stop	New construction excluding Curb stone	68	Place	938	1,533	0.68%	801	732
Rehabilitation of Bus Terminal	Rehabilitation	1	Place	1,792	2,928	1.30%	1,394	1,534
Construction of Pedestrian Bridge		1	Place	99	161	0.07%	75	86
Construction of Pedestrian Under Pass		1	Place	181	296	0.13%	44	252
Prime Coat at Shoulders	Prime Coat	719,326	m2	246	402	0.18%	0	402
Embankment	Borrow Materials	240,054	m3	4,317	7,051	3.13%	220	6,832
Grass on slope	Grass	457,334	m2	1,845	3,014	1.33%	143	2,871
Base Course	t=220mm	68,000	m2	609	995	0.44%	228	767
Bridge Construction			L.S.	17,447	28,500	12.65%	6,349	22,151
				G.Total	225,924		61,993	163,931

Source: JICA Study Team

Table 12.3.2 shows the quantities for future road networks of R7.

Table 12.3.2 Quantity of Future Roads Network (R7)

Route	Road Length	Existing Lane	Existing Width	Planned Lane	Improve/Widening/New Road Type, Contents	Repair Condition, Contents
Darkhan Urban Rd.	3.5km	2	2+9+2	4	F: As.7.0m wide, Sh.2.0m wide	3: 9.0m width
NW Tolgoit Rd.	3.6km	2	2+10+2	4	F: As.9.0m wide, Wa.8.0m wide	3: 10.0m width
Tolgoit~Sonsgolon	0.8km			4	B: New	
Khasbaatar Rd.	2.0 km	2	7	2		4: 7.0m width
West Naran~ Ard Ayush Rd.	3.1km			4	B: New	
SouthTV`N/Rd.88	0.4km			2	B': New	
N/Rd.88~IS4	0.4km	2	4+9+4	2	G: New	3: 9.0m width
Sonsgolon Rd.	5.5km	2	2.5+7+2.5	4	F: As.7.0m wide, Wa.8.0m wide	3: 7.0m width
South of PS4	5.1km	2	3+7+3	4	F:	1: 7.0m width
North West of PS3	0.9km	2	3+7+3	4	F:	1: 7.0m width
Ajilchin Str.2	1.1km	2	3+7+3	2		2: 7.0m width
Chingis Ave.	1.4km	4	2+14+2	4		3: 14m width
Stadium~New Market	3.3km			4	B: New	
Naadamchdiin Rd.	7.6km	2	2+7.5+2	2		4: 7.5m width
South Tolgoit Rd.	2.0km	2	2+9+2	4	F: As.9.0m wide, Wa.8.0m wide	3: 9.0m width
Peace Ave. (Enkh Taivan Rd.)	13.0km	6/4/2		6/4		3: 5.5km*10m 4: 7.5km*20m
Peace Ave.(East Rd.)	4.5km	2	2+12+2	4	F: As.3.0m wide, Sh.2.0m wide	3: 12.0m width
Teeverchid Rd.	8.5km	2	2+7+2	4	F: As.11.0m wide, Wa.8.0m wide	3: 7.0m width
Teever.SW Ext.	0.6km			4	B: New	
Dund Gol Riverside	1.1km	2	2+7.5+2	4	F: As.9.0m wide, Wa.8.0m wide	2: 7.5m width
Middle Ring Rd.	13.0km	4		4/2		
Small Ring Rd.	3.5km	4		4		
Geser Temple	IS					
Ayush~Amarsanaa	IS					
East Cross Rd.	0.3km			(2)	Bridge	
West Cross Rd.	0.3km			(2)	Bridge	
Bus terminal~Engels Str. over railway	0.5km			(2)	Bridge	
Tolgoit~Sonsgolon over railway	0.5km			(4)	Bridge	
Nalaikh Rd.	28km	2	2+7+2	2	E:	4: 7.0m width
Naadamchdiin~ Poultry Farm Rd.	24km	2	2+6+2	2	E: As.1.0m wide	3: 6.0m width
Sonsgolon~Ulziit Rd	15km	2	1.8+7+1.8	4	D: As.7.5m wide Sh.3.0m wide	2: 7.0m width
Darkhan Rd.	20km	2	3+7+3	2	E:	3: 7.0m width
Jargalant Rd	17km	2	2+7+2	2	A': New (except subgrade)	
Gachuurt Rd.	11km	2	1.8+6+1.8	2	E: As.1.0m wide	3: 6.0m width
Dacha Rd						
North Ring Rd.						
West Ring Rd.(1)	18.km			2	A': New	
Argalant	4.5km	2	2+7+2	2	E:	3: 7.0m width
Ulziit/Zuunmod/ Nalaikh Ring Rd.						
Gachuurt/Nalaikh Ring Rd.						
Asian Highway						

Note: A,B,C,D,E and F indicate the type of new construction or improvement as shown in Chapter 17.

12.4 Comparison of Cost of Alternative Future Road Networks

Table 12.4.1 shows the cost for all alternatives for long-term road network.

Table 12.4.1 Project Costs of R1 - R7 (Unit: 1,000 US$)

		Alternative Road Network						
	Item	R1	R2	R3	R4	R5	R6	R7
1.	Material Cost	75,632	43,182	40,133	40,312	40,704	41,669	40,148
2.	Labor Cost	30,297	15,872	15,035	15,130	14,830	15,122	14,526
3.	Equipment Cost	180,651	91,713	84,646	85,349	86,101	88,776	83,766
4.	Direct Cost	286,580	150,766	139,814	140,791	141,634	145,568	138,440
5.	Indirect Cost	100,303	52,768	48,935	49,277	49,572	50,949	48,454
6.	Consulting Cost	38,688	20,353	18,875	19,007	19,121	19,652	18,689
7.	Contingency	42,095	22,157	20,552	20,694	20,809	21,389	20,341
	Total Cost	467,666	246,044	228,176	229,769	231,136	237,558	225,924

Alternative R7 shows the lowest cost among the 7 alternatives. However, the total cost is about 226 million US dollars, which is close to the Mongolian national budget of 267 million US dollars (1997). Out of the total cost of about 226 million US $ for alternative R7, the share of local currency is about 62 million US$ and that of foreign currency is 164 million US$.

Chapter 13 Economic Evaluation

13.1 General

In the master plan stage of the study, the purpose of economic evaluation is to compare the various alternative long-term road networks and identify the best alternative from the point of cost performance. The formulation of these alternative long-term road networks is discussed in chapter 10. The economic evaluation is carried out by estimating and comparing the benefit-cost ratio (B/C) for each alternative road network in year 2020, which is the target year for the formation of long-term road network plan.

The economic benefits derived from road improvement projects mainly consist of savings in Vehicle Operating Costs (VOC) and travel time. The running of vehicles on road incurs several types of costs to the road user such as cost of fuel, tire, spare parts, maintenance, etc. These costs incurred in running vehicles on road are termed as VOC and, depend on several factors such as surface condition of road, geometric characteristics of road, vehicle characteristics, cost of vehicle and resources consumed in vehicle operation such as fuel, tire, spare parts, etc. The improvement in road network such as road surface improvement or widening generally results in reduction in VOC for that road network. These reductions (or savings) in VOC constitute the major portion of benefits arising from the road improvement projects.

The HDM-VOC model developed by the World Bank was used to compute VOC.

13.2 HDM-VOC Model

The HDM-VOC model is derived from the Highway Design and Maintenance Standards Model (HDM-III) of the World Bank and uses the relationships contained in the original model. The output from the model includes physical quantities of resources consumed, average running speed and unit VOC in any desired currency. Since VOC vary considerably depending on the type of vehicle, this model is designed to estimate VOC for various types of vehicles ranging from small car to an articulated truck. For estimating the different components of VOC, the model requires the following main input data.

a) Roadway characteristics such as roughness (IRI), gradient, curvature etc.

b) Vehicle characteristics and vehicle utilization data such as average annual veh-kms, average life of vehicle, etc.

c) Average consumption rate of resources such as fuel consumption, tire consumption, etc.

d) Unit cost of resources such as cost of new vehicles, cost of fuel, lubricants, tire, maintenance and crew labor rates, interest rate, etc.

13.3 Representative Vehicles and Utilization

(1) Cars

As per the Traffic Police records, there are about 25,000 cars in Ulaanbaatar City. These cars are mainly foreign-made with no clear dominance of any particular type of model or country of origin. The share of Russian-made cars such as LADA, Moskvitch and Volga has decreased drastically in recent years and at present is quite small compared to that of foreign-made cars. The share of second-hand imported cars was high until a few years ago, but is now declining because of new tax laws, which discourage the import of used cars. For estimating VOC for passenger cars, Sonata, a mid-size Korean car is taken as representative for passenger cars.

(2) Bus

There are 3 public bus companies, one trolley bus company and 2 private bus companies in Ulaanbaatar city. By make or country of origin, the buses can be classified as follows.

Russian-made buses (LIAZ) - about 100 buses
Checko-made buses (KAROSA) - about 100 buses
Japanese-made buses (Nissan Diesel and Hino Motors) - 100 buses
Korean and Chinese made buses- about 25 buses
Trolley buses of Russian-make - about 130 buses

Almost all buses run on diesel fuel. The Japanese-made buses are relatively new, which were donated by the Japanese government under the grant aid program in 1996. All the 100 Japanese made buses are owned by the No. 1 Public Bus Company. In addition to these buses, microbuses are also quite prevalent in Ulaanbaatar city. Since the traffic police Dept. do not record these buses separately, it is difficult to confirm their number. For the purpose of estimating VOC, Karosa, a Checko-made bus was used.

(3) Trucks

Almost all trucks in Ulaanbaatar are of Russian-make such as Kamaz, Maz and Zil. For the purpose of estimating VOC, Kamaz 53212, a Russian made truck was used.

The representative models by vehicle type used in this Study for estimation of VOC are shown in Table 13.3.1.

Table 13.3.1 Representative Models of Vehicles Used in Study

Vehicle Type	Representative Models
Passenger car	Sonata, a mid-size Korean car
Bus	Karosa, a Checko-made bus
Truck	Kamaz 53212, a Russian made truck

13.4 Cost of Resources

(1) Cost of Fuel, Lubricant and Tire

Two types of gasoline are sold in Ulaanbaatar city namely A76 type and A93 type. A76 gasoline is a leaded gasoline with Octane Number of 76 and is mostly used by Russian-made cars and some trucks. A93 type is used by foreign made cars. Diesel fuel sold in Ulaanbaatar city has an octane rating of 45 and closely meets the normal international standards. It is supplied in two grades, summer fuel and winter fuel. All gasoline stations sell fuel at same price in Ulaanbaatar city. Fuels are imported mainly from Russia. The fuel and lubricant price and their tax components are shown in Table 13.4.1.

Table 13.4.1 Fuel Prices and Tax Components

Item	Border Import Price	Special tax	Road tax		Value added tax	Transport Cost	Overhead Cost	Financial Cost		Economic Cost
	In US$	In US$	In Tug.	In US$	In US$	In US$	In US$	In US$	In Tug.	In US$
Gasoline A76, 80 per ton	174	31	20,350	24.271	17.449	6.560	76.131	329.902		
per ltr	0.126	0.022		0.017	0.013	0.005	0.055	0.237	199	0.185
Gasoline A-93, 95 per ton	204	36	25,700	30.235	20.402	6.471	89.139	386.268		
per ltr	0.147	0.026		0.022	0.015	0.005	0.064	0.278	233	0.216
Diesel per ton	177	41	2,140	2.518	17.654	10.000	74.312	322.019		
per ltr	0.147	0.034		0.002	0.015	0.008	0.062	0.268	225	0.217
Engine oil										
with Gasoline/ton	983				98.265	20.000	330.276	1,431.195		
per ltr	1.228				0.123	0.025	0.413	1.789	1500	1.666
with diesel/ton	823				82.252	20.000	277.432	1,202.204		
per ltr	1.028				0.103	0.025	0.347	1.503	1260	1.400

Source: NIC (July, 1998)

Notes: 1) Border Import Price is at Sukhbaatar border.
2) Conversion ratio of ton to litre: Gasoline 0.72 or 1.39; diesel 0.83 or 1.2; and oil 1.28/0.8.
3) $1US = Tug 838.46
4) Transport cost is cost of transport from Sukhbaatar to UB by railway.
5) Import prices and overhead costs are estimated by the Study team.

(2) Cost of Crew and Maintenance Labor

The average hourly crew cost was taken as US$ 0.82 for buses and trucks, and 0.21 for cars. This is based on a monthly salary of US$70 for crew members and average working hours of 170hrs per month. It is assumed that 50% of cars are driven by hired drivers and the other 50% by car owners themselves. An average of 2 crewmembers was assumed for trucks and buses.

The average monthly salary of maintenance labor was taken as US$75 and average monthly working hours of 170 hrs. The maintenance overhead of 100% was assumed. The average hourly maintenance labor cost comes to US$ 1.103 for buses and trucks. For passenger cars, this figure is around US$ 0.88.

(3) Interest Rate

The annual interest rate of 10% is assumed in this study. This figure was decided through discussions with the Road Department, and also by referring to similar other studies especially by ADB and World Bank in Mongolia.

13.5 Estimation of VOC

The HDM-VOC computer program predicts the various components of VOC using the input data related to roadway characteristics, vehicle characteristics and unit costs of resources consumed in vehicle operation such as fuel, tire, spare parts, etc.

The input data for HDM-VOC was collected through field and road inventory survey. The price of new vehicles was collected through interviews with car dealers and truck companies. The average vehicle utilization in terms of kms per year, hours per year and age of vehicle was estimated by the study team with discussions with Road Department, and is shown in Table 13.5.1.

Table 13.5.1 Input Data for Estimating VOC

S. No	Item	Car	Truck	Bus
1. Vehicle Characteristics				
1.1	No. of axles	2	3	2
1.2	No. of tires	4	10	6
1.3	Tare weight (kg)	1250	8000	10000
1.4	Load carried (kg)	200	10000	0
2. Vehicle Utilization				
2.1	Annual veh-kms	15,500	29,200	87,000
2.2	Annual veh-hrs	375	910	2,400
2.3	Average service life (yrs)	9	12	9
2.4	Average age (in kms)	65,000	175,000	360,000
2.5	Hourly utilization Ratio	0.6	0.85	0.67
2.6	Average Occupancy	2.54	2.0	35
3. Economic Costs (US$)				
3.1	New vehicle price	7450	21820	100,000
3.2	Fuel price (per lt)	0.216	0.217	0.217
3.3	Lubricant price (per lt)	1.67	1.40	1.40
3.4	Single tire price	50	105	163.00
3.5	Crew time cost (per hr)	0.21	0.82	0.40
3.6	Passenger delay cost (per hr)	0.29	0.15	0.15
3.7	Maintenance labor cost (per hr)	0.88	1.10	0.20
3.8	Annual interest rate (%)	10	10	10

The HDM-VOC model follows the following four steps to compute unit VOC.

1. Computes the average operating speed for the vehicle.
2. Computes the amount of resources (such as fuel, tires) required per 1000 veh-km of vehicle operation for the different components of VOC.
3. Multiplies the amount of resource consumption to the unit cost of resources to compute VOC for each component.
4. Sum up the VOC of each component to compute the total VOC per 1000 veh-km.

The total VOC consists of the following components:

1. Fuel
2. Lubricants
3. Tires
4. Crew
5. Passenger time
6. Maintenance labor
7. Maintenance parts
8. Depreciation
9. Interest

Since VOC vary considerably depending on the type of vehicle and road surface conditions, it was estimated for the following three types of vehicles and five types of road surface conditions.

The three vehicle types considered were;

(1) Passenger Car
(2) Truck
(3) Bus

The five categories of road surface conditions were considered depending on its International Roughness Index (IRI in m/km) value as follows. Road roughness data was obtained from road inventory survey.

(1) Good ($IRI \leq 4$)
(2) Fair ($4 < IRI < 7$)
(3) Poor ($7 \leq IRI \leq 9$)
(4) Very Poor ($IRI \geq 9$)
(5) Very Poor -Unpaved ($IRI > 12$)

For estimating unit VOC, the IRI value of 2, 5, 8, 10 and 15 was used for the road category of Good, Fair, Poor, Very Poor and Very Poor (Unpaved) respectively.

The unit VOC by type of vehicle and road surface condition is shown in Table 13.5.2.

Table 13.5.2 Unit VOC by Vehicle Type in Ulaanbaatar City

(US$ per 1000 veh-km)

Vehicle Type	Road Surface Condition				
	Good	Fair	Poor	Very Poor	Unpaved
Car	118.42	138.75	171.69	215.78	314.33
Truck	225.80	266.61	316.64	374.41	505.62
Bus	675.80	696.00	719.20	736.58	788.08

13.6 Economic Evaluation of Alternative Road Networks

Six alternative long-term road networks for the year 2020 (coded as R2 to R7) were formulated in chapter 10. These alternative road networks are economically evaluated and compared for the purpose of identifying the best alternative from the point of cost performance. The economic evaluation is carried out by estimating and comparing the benefit-cost ratio (B/C) of these alternatives in year 2020, which is the target year for the formation of long-term road network plan.

To estimate the economic benefits, the total VOC for whole of the network for year 2020 is estimated for both "without case" and "with case" for all the alternative road networks. The difference in total VOC for "without case" and "with case" is the VOC savings for year 2020. The savings in travel time have been included in the savings of VOC.

For economic analysis, it is necessary to estimate economic costs. They are the costs incurred by the society and, are estimated by deducting transfer payments such as taxes and social charges from financial cost As of July 1, 1998, the value added tax on material and equipment was 10%. The share of income tax, social insurance and employment insurance was estimated to be about 40% of labor cost So, economic costs were estimated by deducting 10% from material and equipment cost and 40% from labor cost.

From the total economic cost, annual cost (PMT) was estimated by taking the project life to be 20 years and an annual interest rate of 10% per annum as follows.

$$PMT = PV \times r \times [(1 + r)^n] / [(1 + r)^n - 1]$$

Where,

PMT = Annual Cost

PV = Total Economic Cost of Road Network Improvement

r = Rate of Interest = 10% per annum

n = Economic Life of Project = 20 years

Ratios in savings in 2020 against the PMT is B/C ratios. The results of economic evaluation are summarized in Table 13.6.1. As can be seen from the table, alternative R7 has the highest B/C ratio at 1.423 and is thus the best alternative in terms of cost performance.

Table 13.6.1 Economic Evaluation of Alternative Road Networks (R2 to R7)

(Costs and Benefits are in US$)

Future Road Network	Total Economic Cost	Annual Economic Cost	Annual Economic Benefit			Benefit-Cost Ratio (B/C)
			VOC Savings	Time Savings	Total Savings	
R2	236,117,000	27,734,214	33,259,146	3,107,590	36,366,736	1.311
R3	218,855,000	25,706,626	32,821,302	3,069,104	35,890,406	1.396
R4	220,378,000	25,885,517	33,211,227	3,084,807	36,296,034	1.402
R5	221,810,000	26,053,719	31,825,811	2,989,687	34,815,499	1.336
R6	227,979,000	26,778,328	33,649,703	3,152,383	36,802,086	1.374
R7	216,796,000	25,464,777	33,136,937	3,089,819	36,226,756	1.423

Chapter 14 Funding Sources for Road Development

14.1 National Budget

National budget of Mongolia since 1991 are shown in Table 14.1.1. Total revenue shows steady increasing year by year. Grants within total budget occupy one part of revenue since 1993. Total expenditure shows the same tendency with the total revenue, on the other hand, foreign amortization shows rapid increase year by year. In 1997 the foreign amortization occupies more than 20% on the total expenditure.

Table 14.1.1 National Budget (million Tugrik)

	1991	1992	1993	1994	1995	1996	1997
Total Revenue	6,497	11,916	54,843	86,131	144,623	162,924	213,651
Grants	432	615	3,027	3,265	5,049	4,409	6,111
Total Expenditure			61,662	101,326	149,350	211,265	291,222
Foreign Amortization			4,435	5,223	17,197	48,887	73,671

Source: in 1998 Draft Budget, Mongolian Statistics 1996, 1997

14.2 Budget for Roads

Central government prepares the budget for roads from state budget and Road Fund. With the coming into force the Road Law in February 1998, the local governments including UB city, became able to form independently their own road funds (Fig. 14.1.1). This will be distributed to districts and cities. Budget of the central government for roads is shown in Table 14.2.1.

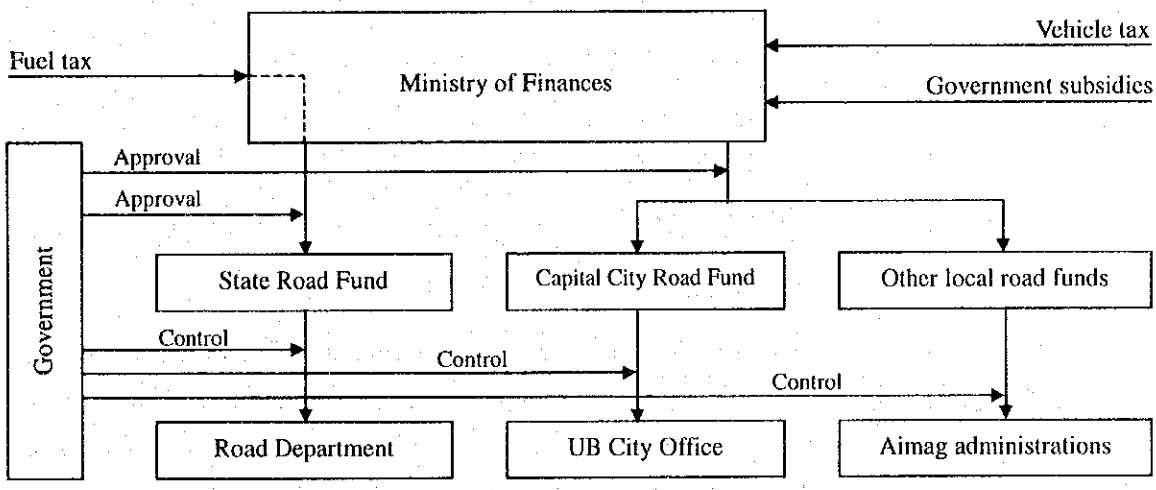


Figure 14.1.1 Formation of Road Funds

Table 14.2.1 **Central Government Budget for Roads** (million Tg)

	1995	1996	1997	1998
Road Construction	1,899.5	2,770.0	3,269.6	6,992.4
Road Maintenance	870.2	1,300.0	911.2	488.6
Equipment Procurement	101.9	30.0	180.1	-
Total	2,871.6	4,100.0	4,360.9	7,481.0

Source : Road Department

Ulaanbaatar city prepares budget from the central government, road fund, city general budget and others. Budget for roads in Ulaanbaatar City is shown in Table 14.2.2.

Table 14.2.2 **Budget for Roads in Ulaanbaatar City** (million Tg)

	1993	1994	1995	1996	1997	1998
Road Budget	162.1	225.7	360.4	349.9	1,131.6	200.0
New Projects	107.9	99.7	160.0	125.3	998.0	200.0
Improvements	-	-	-	117.8	12.0	-
Maintenance	54.2	126.0	200.4	106.8	121.6	-
Routine	54.2	116.5	200.4	106.8	121.6	-
Periodical	-	-	-	-	-	-
Others	-	9.5	-	-	-	-
exchange rate($/Tg)	314.7	404.5	472.5	666.3	793.5	865.8

Source: UB City 93～97: end of the year, 98: end of June

Budget in 1997 was planned as follows:

From General revenue 500MTg.
From Fuel tax revenue 631MTg-----→but decreased to 500MTg

14.3 Movement of Establishing Road System and Resource Fund

Recently, the Mongolian Government made the effort to develop road network and has formulated laws and carried out studies related to road systems since 1995 as follows.

1995: Reform Road Fund, and Fuel Tax Act
1996: Study on Renewal of Resource of Road
1997: Establish Ulaanbaatar Fund
1998: Formulate Road Law, and revise Road Fund into National Road Fund and Local Road Fund
1998: Establish Ulaanbaatar Road Fund

14.3.1 Gasoline and Diesel Fuel Taxation Act (1995,6)

Act described that a proportion of this tax revenue shall be allocated to the road fund, and the amount (percentage) of the tax contributed shall be determined by the government. The tax ratios by this law are shown in Table 14.3.1 and all the taxes are allocated to the Road Fund now. Then, total taxes burdened to fuel and price of fuels are shown in Table 14.3.2.

Table 14.3.1 Excise Duties currently allocated to the Road Fund

Fuels subject to taxation	Tax Ratio (Tg/ton)	Tax to border price
Gasoline under 90 octane	20,350	13.9%
Gasoline over 90 octane	25,700	14.8%
Diesel fuel	2,140	1.4%

Source: Road Department

Table 14.3.2 Price of Fuels and Taxes (July 1998) (US$/ton)

Tax	Border Price	Special Tax	**Gasoline & Diesel** Fuel Tax	Value Added Tax	Tax Total	Transport and Overhead	Total
Tax Ratio		15%+ α	Tab 6-4-5	10%			
Gasoline under 90 octane	174	31	24.271	17.449	72.720	82.691	329.411
Gasoline over 90 octane	204	36	30.235	20.402	86.637	95.610	386.247
Diesel fuel	177	41	2.518	17.654	61.172	84.312	322.484

Source: NIC and Study Team At Sukhbaatar border(Russian) price by railways

14.3.2 Highway Cost Recovery Study (ADB) (1995,12)

The study was carried out under finance of ADB in 1995 in order to establish reasonable road finance system in Mongolia. The report ensures that road users should pay for the total cost of the highway system by means of government taxes and the revenue from the taxes shall be allocated to the road agency. Expenditure by the road agency on maintenance will produce economic benefits to road users more than road maintenance cost. The report recommends establishment and revision of the annual vehicle tax, foreign vehicle transit fees and fuel taxes for road maintenance. In the study, target maintenance cost and user benefits are estimated as shown in Table 14.3.3.

Table 14.3.3 Target Maintenance Cost and User Benefits in 1997 (million US$)

Cost Item	Target maintenance cost	User Benefits
State roads maintenance	7.91	12.72
Local roads maintenance	1.75	2.55
Emergency works	1.00	1.50
Short section improvements	1.33	2.00
State and local bridge construction	1.81	2.17
Totals	13.80	20.94

Source: Highway Cost Recovery Study 1996

14.3.3 Establish Ulaanbaatar Fund (1997,2,6)

Purpose	Sources of the fund
Development of economy	aids and grants
city arrangement	interest of funds
infrastructure	fund derived from other city revenue
public services	profits from operation of the fund

living conditions, welfare of the citizens	fund derived from others.

Revenue in 1997 was 107MTg and will be 433MTg in 1998.

Toll collection at two entrances of the city, east and west of the city, from all vehicles entering to the city will be based on 3) of sources above. At the entrances, 200Tg is collected from each vehicle all day long by a city employee since June last year. Half of the toll revenue will be allocated to the road fund.

Public lottery is issued as one of the tasks to raise funds.

14.3.4 Formulate Road Law, National Road Fund, Local Road Fund (1998,2,2)

These will be practically applied to public in 1999 with registration of details. The list of projects and works to be implemented under the State Road Fund and amount of funds required for their implementation are approved by the Government. The amount of funds of the local road funds and the lost of projects and works to be implemented under these funds are approved by Assemblies of Citizen Representations of aimags and the capital city. The execution of projects and works to be implemented under the State Road Fund is controlled and financed by the Road Department. The execution of projects and works to be implemented under the local road funds is controlled and financed by the governors of aimags and the capital city.

The sources are derived from the followings.

National road fund	Local road fund
fuel tax	
vehicle tax	vehicle tax
toll fee	toll fee
fine for this law	fine for this law
aids and grants	aids and grants
national general budget	national and local general budgets
tax for foreign transit vehicles	
others	

14.3.5 Establish Ulaanbaatar Road Fund (1998,5,7)

According to the road law, Ulaanbaatar city registered the rule of Ulaanbaatar road fund. The source of the fund is derived from the following sources.

1) national road fund
2) vehicle tax (100%)
3) tax for foreign transit vehicles (100%)
4) fine for related laws
   - fine for road law (100%)
   - fine for regulations for citizens (60%)
   - fine for traffic law and traffic safety law (60%)
5) national budget and city budget
6) aids and grants
7) toll fee (100%)

14.3.6 Present Road Loan

Present road loans from foreign countries are shown in Table 14.3.4.

Table 14.3.4 Present Road Loans

(1) Finance Agency	(2) Year of Contract	(3) Amount of Loan (M$)	(4) Local Plus (M$)	(5) =(4)/(3) Local Plus Ratio	(6) Annual Rate of Interest (%)	(7) Redemption Period (years)	(8) Grace Period (years)
IBRD	1992	1.374	-	0	0.75	40	10
IBRD	1995	2.7	1.2	0.4444	0.75	40	10
ADB	1995	25	6.5	0.2600	1	40	10
Kuwait	1996	18.2	6.2	0.3407	2.5	20	5
IBRD	1998	5.7	1.3	0.2281	0.75	40	10
Total		52.974	15.2	0.2869			

Source: Road Department

Amortization for loans will start in 2001 for Kuwait loan, in 2002 for IBRD, in 2005 for IBRD and ADB and in 2008 for IBRD. Now the government requests for 20 million US$ to ADB and 30 million US$ loan for OECF(Japan).

14.4 Fund Resource for Roads in Future

14.4.1 Procedure of Fund Resource Estimation

In order to estimate the road budget in future including acceptable amount of loan from foreign countries, the study team estimated the national road budget based on the following procedures.

1) Total national budget: by past and future economic growth
2) National budget for other than road: by future growth
3) National budget for road: = 1) - 2)
4) Road budget is classified as follows.
   - budget for improvement
   - repayment for present loan projects
   - repayment for future loan projects
   - budget for maintenance
5) Budget for improvement: by future growth
6) Repayment for present loan projects: from present loan situation, estimates amortization for projects
7) Repayment for future loan projects: balance of budget
8) Budget for maintenance: balance of budget before 2010 and target maintenance cost after 2010
9) Acceptable amortization for future loan: none before 2010, balance of budget after 2010: = 7)
10) Amount of cumulative acceptable loan: From acceptable amortization, amount of cumulative acceptable loan until the year 2000,2005 and 2010 will be calculated back under a financial conditions.

14.2.2 Each Step of Procedure

1) Total national budget

Annual increasing ratio for national budget is estimated from an increasing tendency of national GDP from 1993 to 1997 and also the estimation of increasing ratio of GRDP and GRDP/capita in Ulaanbaatar city was conducted by the study team. These are shown in Table 14.4.1.

Table 14.4.1 Estimation of Annual Increasing Ratio for National Budget

National Statistics	1993	1994	1995	1996	1997
GDP in 1993 price (M Tg)	166,219	170,042	180,775	185,048	191,112
growing ratio to 1993	1.0	1.0230	1.0876	1.1133	1.1498
(equal annual ratio = 1.0355)	1.0	1.0355	1.0722	1.1103	1.1497

Progress Report (Study Team)	1997	2000	2005	2010	2020
annual increasing ratio: GRDP in Ulaanbaatar		4.8%	4.6%	4.3%	4.2%
annual increasing ratio: GRDP/ capita in Ulaanbaatar		2.5%	2.5%	2.5%	2.6%
mean ratio		3.65%	3.55%	3.4%	3.3%

Estimated annual increasing ratio for national budget : ①, ② and ③		3.6%	3.4%	3.2%	3.0%

Source: Mongolian Statistics and Study Team

2) National budget for branches other than roads

National budget for branches other than roads will increase similar to the total national budget, but because of road development policy the increasing ratio will be 3.0%, less than for roads. (⑤, ⑥ and ⑦ in Table 14.4.3 and Figure 14.4.1)

3) National budget for roads

National budget for roads = total budget (annual increasing ratio 3.6%～3.0%) –(minus) budget for other than roads (annual increasing ratio 3.0%). (⑧ in Table 14.4.3 and Figure 14.4.1)

4) Constitution of national budget for roads

National budget for roads will be allocated for road improvement, maintenance, amortization for present loans and amortization for future loans. (⑮～⑳ Table 14.4.3 and Figure 14.4.2)

5) Budget for improvement

Annual increasing ratio for road improvement will be estimated as 4%. Amount of budget will be estimated based on the amount in 1997 and annual increasing ratio 4%. (⑬ and ⑭ in Table 14.4.3 and Figure 14.4.2)

6) Target maintenance

In the Highway Cost Recovery Study, the target maintenance cost in 1997 will be 13.8 USM$ including small scale improvement of roads and bridges (Table 6.4.7).

Within the budget for roads, the target maintenance budget shall be prepared upto 2010 to support the road development. The target maintenance budget will increase 0% until 2000 and 1% from 2000 to 2020 annually. (⑨~⑫ in Table 14.4.3)

7) Maintenance

From 2000 to 2005 the maintenance budget is the balance of budget for improvement and amortization for present loans from the budget for roads. From 2010 to 2020 it will be target maintenance cost. (⑰ and ⑱ in Table 14.4.3 and Figure 14.4.2)

8) Repayment for present loans

Amortization for present loans during repayment period, which is [redemption period]-[grace period], will be estimated by present loan conditions as shown in (9) in Table 14.4.10. (⑲ in Table 14.4.3 and Figure 14.4.2)

Table 14.4.2 Amortization of Present Road Loan

Finance Agency (1)	Year of Contract (2)	Amount of Loan (3) M$	Annual Rate of Interest (4) %	Redemption Period (5) yrs	Grace Period (6) yrs	Annual Amortization Ratio (7) %	Annual Amortization Amount (9) =(3)x(7) M$	2000	2001	2002-4	2005-7	2008-15	2016-20
① IBRD	1992	1.374	0.75	40	10	4	0.1			0.1	0.1	0.1	0.1
② IBRD	1995	2.7	0.75	40	10	4	0.1				0.1	0.1	0.1
③ ADB	1995	25	1	40	10	4	1.0				1.0	1.0	1.0
④Kuwait	1996	18.2	2.5	20	5	9	1.6		1.6	1.6	1.6	1.6	
⑤ IBRD	1995	5.7	0.75	40	10	4	0.2					0.2	0.2
Total		52.974					3.0	0	1.6	1.7	2.8	3.0	3.4

Source: Study Team

Amount of amortization for present road loans in each year is shown at the bottom line of the above table.

9) Acceptable amortization for future loan

Acceptable amortization for future loan is the balance of budget for roads as shown below. (⑳ in Table 14.4.3 and Figure 14.4.2)

[Acceptable amortization for future loan]⑳

=[Budget for Roads]⑮

-[Budget for Improvement]⑯

-[Budget for Maintenance]⑰ or

-[Budget for Target Maintenance]⑱

-[Amortization for Present Loan]⑲

According to column ⑳ in Table 14.4.3, there is no allowance to amortize any new loans in 2005, but 1.7 million US$ in 2010 and 7.6 million US$ in 2020 will be allowed to apply amortization for new loans.

Table 14.4.3 Forecast of the National Road Fund and Loans

		1995	1996	1997	2000	2005	2010	2020
①	National Budget Revenue (M Tg)	144,623	162,924	213,651				
②	(M $)			267.06	296.95	350.99	410.86	552.16
③	Annual Increasing Ratio	(68%)	(13%)	(31%)	3.6%	3.4%	3.2%	3.0%
④	Budget for Roads, ~1997 (M Tg)	2,872	4,100	4.361				
⑤	Budget for Others (M Tg)	141,751	158,824	209,290				
⑥	after 1997 (M $)			261.61	285.86	331.40	384.18	516.31
⑦	Annual Incr. Ratio for Others				3.0%	3.0%	3.0%	3.0%
⑧	Budget for Roads, 1997~ (M $)			5.45	11.09	19.59	26.68	35.85
⑨	for Maintenance (M Tg)	972	1,330	1,091				
⑩	(M $)			1.36				
⑪	Target Maintenance (M $)			13.8	13.8	14.5	15.2	16.8
⑫	Target Mainte. Incr. Ratio				0%	1%	1%	1%
⑬	for Improvement (M $)			4.09	4.6	5.6	6.8	10.1
⑭	Annual Increasing Ratio				4%	4%	4%	4%
⑮	Budget for Road (M $)			5.45	11.1	19.6	26.7	35.9
⑯	for Improvement (M $)			4.09	4.6	5.6	6.8	10.1
⑰	for Maintenance (M $)			1.36	6.5	11.2		
⑱	for Target Maintenance (M $)			(13.8)	(13.8)	(14.5)	15.2	16.8
⑲	for Present Loan (M $)			-	-	2.8	3.0	1.4
⑳	for Future Loan (M $)			-	-	-	1.7	7.6

① : National Statistics 1997
② : in 1997 = ①/800
in 2000~2020 (② in 1997) x ③
③ : Study Team
④ : Road Department
⑤ : = ①—④
⑥ : in 1997 = ⑤/800
in 2000~2020 = (⑥ in 1997) x ⑦
⑦ : Study Team = ③ in 2020
⑧ : = ② - ⑥
⑨ : Road Department
⑩ : in 1997 = ⑨/800
⑪ : in 1997 ADB Cost Recovery Study
in 2000~2020 = (⑪ in 1997) x ⑫
⑫ : Study Team
⑬ : in 1997 = ⑧ - ⑩
in 2000~2020 = (⑬ in 1997) x ⑭
⑭ : Study Team
⑮ : = ⑧
⑯ : = ⑬
⑰ : in 1997 = ⑩
in 2000,2005 = ⑮ - ⑯ - ⑲
⑱ : in 1997~2005 = ⑪ ideal
in 2010~2020 = ⑪
⑲ : (9) in Table 14.4.2
⑳ : = ⑮ - (⑯~⑲)

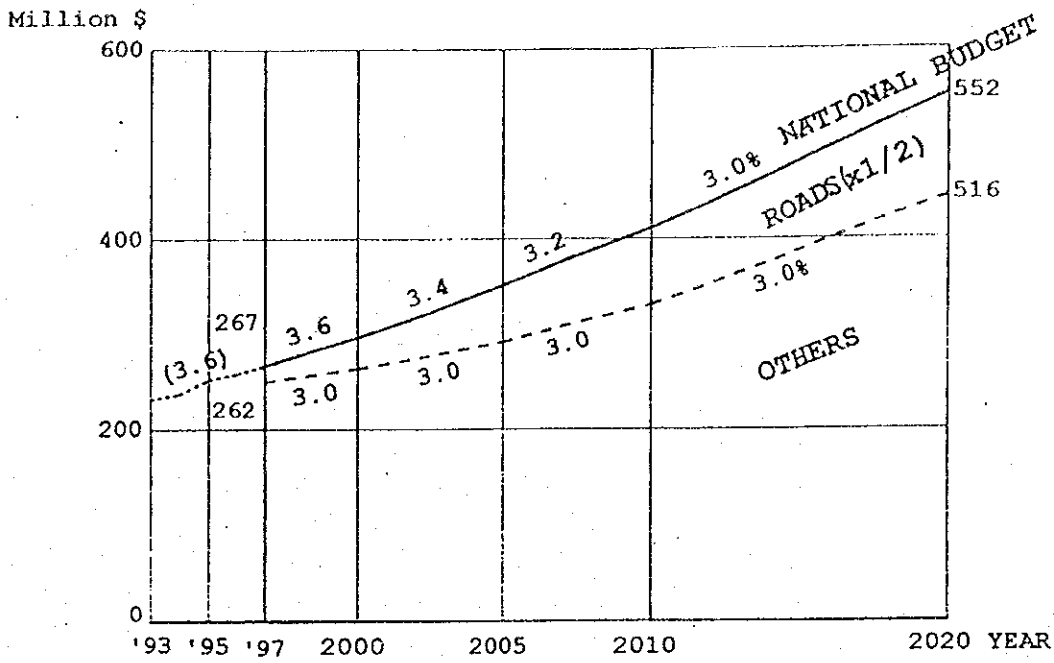


Figure 14.4.1 National Budget Forecast

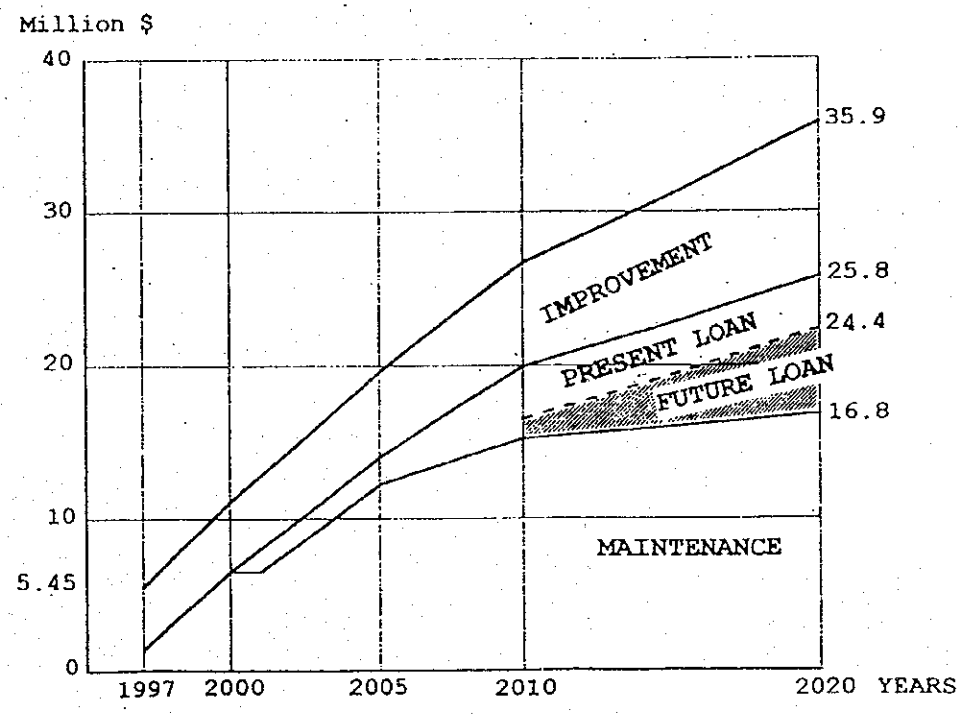


Figure 14.4.2 Road Budget

14.4.3 Acceptable Loans in Future

Based on the acceptable amortization for future loans, the amount of cumulative acceptable loan is calculated under loan conditions. Amortization of present road loans including the foreseen OECF(Japan) loan as reference are shown in Table 14.4.4.

Table 14.4.4 Amortization by Loan Condition

Finance Agency (1)	Year of Contract (2)	Amount of Loan (3) M$	Local Plus (4) (M$)	**Annual Rate of Interest** (5) %	Redemption Period (6) yrs	Grace Period (7) yrs	Annual Amortization Ratio (8) %	Local Ratio adjust (9)=(8)x L.R. %
① IBRD	1992	1.374	-	0.75	40	10	4	4
② IBRD	1995	2.7	1.2	0.75	40	10	4	6
③ ADB	1995	25	6.5	1	40	10	4	5
④ Kuwait	1996	18.2	6.2	2.5	20	5	9	12
⑤ IBRD	1998	5.7	1.3	0.75	40	10	4	5
Total		52.974	15.2					
⑥ OECF				2.3	30	10	8	10

Source: Study Team

For estimation of cumulative acceptable loan in 2000, 2005 and 2010, the study team foreseen annual amortization ratio to loan amount (AARTL) by loan situations as shown in Table 14.4.5.

Table 14.4.5 Annual Amortization Ratio to Loan Amount

Situation	Finance Agency	AARTL	in Table 6-4-12
Situation-1	③ADB, ⑤IBRD	5%	line③,column(9)
Situation-2	⑥OECF	10%	line⑥,column(9)

Acceptable amount of loan in years are estimated in Table 14.4.6.

Table 14.4.6 Acceptable Amount of Loan

			1997	2000	2005	2010	2015	2020
⑮	Budget for Roads	(M $)	5.45	11.1	19.6	26.7	31.3	35.9
⑯	for Improvement	(M $)	4.09	4.6	5.6	6.8	9.0	10.1
⑰	for Maintenance	(M $)	1.36	6.5	11.2			
⑱	for Target Maintenance		(13.8)	(13.8)	(14.5)	15.2	16.0	16.8
⑲	for Present Loan	(M $)	-	-	2.8	3.0	3.0	3.4
⑳	for Future Loan	(M $)	-	-	-	1.7	3.3	5.6
21	Amount of Cumulative	Situ.-1		34	66	152		
	Acceptable Loans(M$)	Situ.-2		17	33	76		

⑮,⑯ and ⑱ in 2015 is mean of 2010 and 2020

According to the estimation of acceptable amortization and cumulative acceptable loans, the study team estimates acceptable amount of loan as shown below under the condition mentioned above.

1998～2000:	17～34 million US$
1998～2005:	33～66 million US$
1998～2010:	76～152 million US$

14.5 Recommendation for Road Resource Fund

As mentioned in each section, Mongolian government is eager to establish a road network system and formulate laws and regulations for road development under the concept that the cost for improvement of road network and road maintenance shall be burdened by road users and road users have the right to obtain benefits from expenditures to improve road networks by the road agencies concerned. Benefit from road user's burden will be more than the burden and it stimulates economic productivity in Mongolia. Table 14.3.3 showed estimates of cost and benefits in an ADB study of 1995, through which B/C ratio is found at 1.50 for the total of maintenance and improvement. In road law, fuel tax and vehicle tax as well as part of general budget and tax for foreign transit vehicles are included in resource of road funds; national road fund and local road fund.

The study team hopes the government continue its efforts to establish management and operation system for road fund and also to retain the necessary budget for roads.

Chapter 15 Selection of F/S Projects

15.1 Scope of Work for Feasibility Study Projects

Projects for the feasibility study is defined by JICA specification to be 4 kinds as shown in following Table 15.1.1.

Table 15.1.1 Kinds of FS Objective Project

	Item	
A	New Construction of Roads and Bridges	Length 15 km
B	Grade Separation of Intersection	2 places
C	Improvement of Roads and Bridges (Widening, Rehabilitation etc.)	Length 10 km
D	Repair of Roads and Bridges (Pavement, Drainage,)	5 km
E	Safety Facilities such as Pedestrian Bridges, Underpass Construction	-

15.2 Key Points to be Realized in Network 2020

Subjects of feasibility study (F/S) are determined from the long term road network by examining future traffic and urban growth in 2020.

The most appropriate option for the long-term road network (R7) was selected among 6 alternatives as mentioned in Chapter 10.

This road network includes the roads connecting with the 6 satellite towns and villages making GUB, and the projects for FS are limited in the area of UUB as agreed by the minutes of meeting on August 29, 1997.

The basic policies are summarized as follows;

1. First priority shall be given to roads connecting the eastern end to western end of the city.
2. Development of roads to northern ger villages shall be suspended for the following reasons:

Environmental Points	Ger village is expected to reduce their development and immigration to the southern area shall be established as a city master plan.
Engineering Points	Road construction in steep slopes is undesirable and becomes costly.

3. Residential roads are expected to be developed at a later due to limited financial resources.
4. Minimum safety facilities shall be developed with the development of city roads.

5. The lane number of roads and bridges shall be decided from the traffic capacity for future estimated volume. (Congestion ratio shall be less than 1.0 in 2020)

For the development of R7 as the most appropriate long-term road plan, following improvements of the existing roads are to be taken into accounts. And all of these improvements are selected as the targets for Feasibility Study.

	Items to be improved and their Conceptions	Route name
1	The Enkhtaivan avenue, as the central road, can perform the function for a while in its present form. But, because the width of the road in its western end suddenly becomes narrow and, also, crosses over the railway diagonally, it was expected to improve this section. New road construction, road widening, new railway crossing construction works will be carried out.	**Central Route**
2	To plan a separate route on the northern side (utilizing as much as possible the existing road to the east of the northern road section of the middle ring road) to ease the congestion expected on the Enkhtaivan avenue and avoid the risk in case of emergency. For that purpose, construction works are required on the following 3 sections:	**North Route**
2.1	To expand the NW Tolgoit Road from its 2-lane width to 4-lane width.	**North-West**
2.2	To construct a new road in the mountainous zone of the central part and connect it with the main road of the 3rd district.	**North-Central**
2.3	Because the 3rd district road is a daily life service road and traffic restraints will be put there, to construct a new section from Khasbaatar road through the empty space beside the TV tower up to the existing road there and, through the improvement of the latter, to the new section with the 3rd district road.	**North-East**
3	To consider the south route based on the existing road and connect the western end of Teeverchid street by fly-over.	**South Route**
3.1	To widen urgently Teeverchid street in order to handle the increased traffic volume following the opening of the new central market.	**South-East**
3.2	The west end of Teeverchid street will be left connected with the Enkhtaivan avenue by the existing route at the first stage.	
	However in order to ease the congestion on Enkhtaivan avenue, an investigation was carried out for the route where the western end of Teeverchid road goes out to the south over the railway.	**South Flyover**
3.3	To widen Dund river road up to Ajilchin street and connect to the fly-over on the western end of Teeverchid street.	**South-Central**
3.4	To improve the existing road from the south of the Power station-4 to the north of the Power station-3.	**South-West**
3.5	To overlay the existing road with damaged pavement from Ajilchin street to Chingis avenue in order to handle the existing traffic.	**South-South**
4	To define the middle ring road in order to restrict the traffic in the center of city in future.	**Middle Ring Route**
4.1	To investigate the construction of a new road on a missed section by passing the central stadium from the new market to the rotary with the tank monument. This road will, also serve as the route connecting 2 central roads with the south route.	**Water Resource Area**

4.2	To investigate the construction of a fly-over over the missing section of the ring road on the intersection of Teeverchid road and the railway (near the bus terminal). With the completion of this fly-over, case of congestion on Chingis avenue is expected.	**Bus Terminal-Flyover**
4.3	Even now on the intersection of the existing ring road with Enkhtaivan avenue is arranged in a irregular way (not allowing traffic movement in a straight way) and the congestion observed even now. Further traffic congestion is sure with the completion of the new central market. Therefore, a fly-over here should be considered.	**East Intersection Flyover**
5	To investigate the improvement of 2 existing intersections in the city where traffic problems are caused.	Intersection
6	To investigate the standard cross-section of road drainage facilities in the city	Drainage facilities
7	To identify locations and approximate cost of construction of parking places to reduce the traffic congestion.	Car parking places
8	To estimate the cost of and pedestrian bridges, pedestrian underground passes, pedestrian crossings, traffic signs, road surface signs and signals as safety measures.	Crossings and safety facilities

15.3 Projects for the Feasibility Study

Table 15.2.1 shows the route name with roads consisting them and **the roads by bold character** show the expected works for Feasibility Study to complete the road network "R7". *Italic character* means the road is included in other groups corridor, also.

Figure15.2.1 shows the locations of the projects from 1 to 4 of above table.

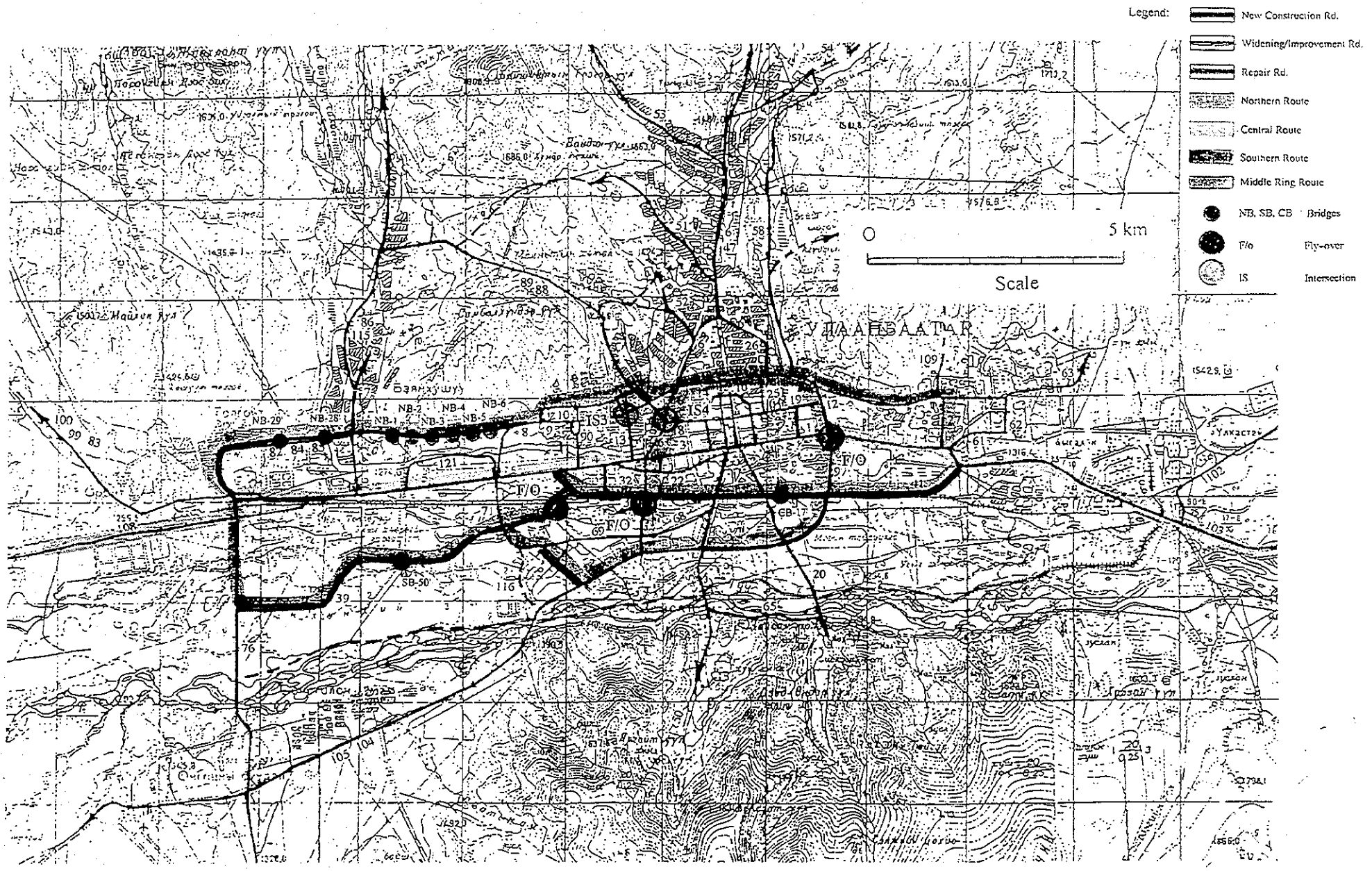


Figure 15.2.1 Location Map for F/S Project

Table 15.2.1 Roads & Bridge Names of Each Group and the Projects for F/S

Group (Route)	UB Rd No.	Road name	Road Length (km)	Existing Roads Lane No.	Necessity for F/S	Lane Number in F/S
Central Route	108	Darkhan Rd.	3.5	2	-	-
	New	**Tolgoit~Sonsgolon cross**	**0.413**	**-**	**Yes**	**4**
	New	**South Tolgoit Rd**	**0.346**	**-**	**Yes**	**4**
	82	**South Tolgoit Rd**	**1.671**	**2**	**Yes**	**4**
	5,4,3	Peace Ave.	15.0	6/4	-	-
	1	Peace Ave. (East)	4.5	4/2	-	
Northern Route	*1*	*Darkhan Urban Rd.*	*3.5*	*2*	-	-
	3	*Tolgoit~Sonsgolon cross*	*0.413*	-	*Yes*	*4*
	84,85	**N/W Tolgoit**	**3.627**	**2**	**Yes**	**4**
		Br.No.28,No.29		**2**	**Protect of**	**Abutment**
	New	**Br.No.NB-28',NB-29'**		**-**	**Yes**	**2**
	New	**WestNaran~ArdAyush**	**3.006**	**-**	**Yes**	**4** **4**
	New	**Br.No.NB1~NB6**		**-**	**Yes**	
	8	Ard Ayush	0.75	4	-	-
	10	Khasbaatar	1.8	2	-	-
	New	**South of TV~N/Rd.88**	**0.391**	**-**	**Yes**	**2**
	88	**N/Rd.88~IS 11**	**0.454**	**2**	**Yes**	**2**
	11 12 64 27	Ard Ayush~Ovoo North of Ring Rd Khoroolol Dandar	7.82	4/2	-	-
	1	*Peace Ave.(East)*	*4.5*	*4/2*	-	-
Southern Route	*108*	*Darkhan Urban Rd.*	*3.5*	*2*	-	-
	76	Sonsgolon Rd.	1.85	2	-	-
	39	**South of PS4**	**5.942**	**2**	**Yes**	**4**
	New	**Br.No.SB-50'**		**2 (broken)**	**Yes**	**4**
	117	**Dund Gol River Side Rd**	**1.00**	**2**	**Yes**	**4**
	New	**Teeverchid SW Ext.**	**0.71**	**-**	**Yes**	**4**
	New	**Teeverchid Ext. F/O**	**Br. 0.21**	**App.0.28**	**Yes**	**4**
	41	**Teeverhid Rd.**	**8.368**	**2**	**Yes**	**4**
	New	**Br.No.CB-17'**		*2*	**Yes**	*4*
	1	*Peace Ave. (East)*	*4.5*	*4/2*	-	-
	71	Ajilchin Str. 1	1.3	2	-	-
	72	**Ajilchin Str. 2**	**1.096**	**2**	**Yes**	**2**
Middle Ring Route	2 34	Chingis Avenue Engels Str	2.6	4	-	-
	New	**Terminal~Engel Rd.F/O**	**Br. 0.248,**	**App.0.23**	**Yes**	**2**
	32 6 12	Bus Terminal-West cross West cross – Ovoo North of Ring Rd	Total 9.88	4		
	New	**East Cross Rd.F/O**	**Br.0.12**	**App.0.28**	**Yes**	**2**
	97	13/14 kholoo rd				
	New	**Stadium~New Market**	**3.12**	**-**	**Yes**	**4**
Intersection (Improve /New)	IS 4	**Geser Temple**			**yes**	**Yes**
	IS 3	**Ayush-Amarsanaa**			**yes**	**Yes**
		Other 16 IS in FS Route			**yes**	**Yes**

Table 15.2.2 shows the total length of each categories, and the subtotal of each categories are adjusted from Figure 15.2.1 to meet with the actual conditions.

Table- 15.2.2 Study Item of F/S Projects

Study Type	Name of Road/Place	Road Length (km)	Traffic Lane	Remark
A: New Construction	Tolgoit~Sonsgolon cross	0.413	4	
	West Naran~Ard Ayush	3.006	4	6-New bridges
	South of TV~N/Rd.88	0.391	2	
	South Tolgoit Rd	0.346	4	
	Stadium~New Market Rd	3.12	4	
	Teeverchid SW Ext.	0.71	4	Br.0.21km
	Total	**7.986**		
B:Grade Separation (Fly-over)	East Cross Rd.	Br.0.12,	2	App.0.28
	Bus Terminal~Engel Str.	Br.0.248,	2	App.0.23
	Teeverchid SW Ext.	Br.0.21,	4	App.0.28
	Total	3 places		
C:Widening/ Improve	N/W Tolgoit	3.627	4	2-New bridges
	N/Rd.~IS11	0.454	2	
	South of PS 4	5.942	4	1-New bridge
	South Tolgoit	1.671	4	
	Teeverchid	8.368	4	1-New bridge
	Dund Gol Riverside Rd.	1.00	4	
	Total	**21.062**		
D-1:Repair of Road	Ajilchin Str 2	1.096	2	
D-2:Repair of Bridge	Br.No.28		Protection of Abutment	
	Br.No.29		Protection of Abutment	
	Br.No.50	New Bridge	Replacement of Bridge	
E: Intersection Improvement	Geser Temple	IS 4		
	Ayush-Amarsanaa	IS 3		
	Each roads	10 Intersections		

Table 15.2.3 shows the topographic survey work volume for FS projects and Table 15.2.4 shows the results of CBR test. Figure 15.2.2 and Figure 15.2.3 show the results of boring for the North and South routes.

Table 15.2.3 Route Length and Actual Surveyed Length for F/S Projects

Projects	Routes length & Places number of F/S Projects				Survey Quantity				Remarks
	Name of route and road. No.	Original Request	Actual Selection	Difference	Length (Km)		Area (Km2)		
					Original	Actual	Original	Actual	
A: New Road Construction	1. Tolgoit ~ Sonsgolon cross	-	0.41		-	0.8 (*)	-	0.083 (*)	*: Route No.1 is include d No.6 & 9.
		-	3.01		-	3.1	-	0.160	
		-	0.39		-	0.4	-	0.020	
	2. West Naran ~ Arda syash	-	3.12		-	1.2	-	0.060	
		-	0.71		-	0.71	-	0.095	
	3. South TV~N/Rd.88	-	0.35		-	- (*)	-	- (*)	
	4. Stadium ~ New Market								*: No.6 is included by No. 1.
	5. Teeverchid SW Ext.								
	6. South Tolgoit Rd.								
	Sub total	15Km	7.99Km	-7.01Km	5Km	6.21Km	0.25Km2	0.418Km2	
B: Grade Separated Intersections	7. East Cross Rd. (F/O)	-	(120m)		200m	300m	0.010	0.015	
		-	(248m)		200m	400m	0.010	0.020	*: No.9 is included by route No.5.
	8. Bus Terminal ~ Engels (F/O)	-	(210m)		-	-	-	- (*)	
	9. Teeverchid SW Ext.								
	Sub total	2 places	3 places	+1 place	400m 2 places	700m 3 places	0.02Km2	0.035Km2	
C: Road Improvemen t Projects	10. N/W Tolgoit Rd.	-	3.63		-	3.6	-	0.175	
		-	0.45		-	0.45	-	0.026	
	11. N/Rd. 88 ~IS 11	-	1.67		-	2.0	-	0.100	
		-	8.37		-	7.8	-	0.565	
	12. South Tolgoit	-	1.00		-	1.1	-	0.067	
	13. Teeverchid Rd.	-	5.94		-	6.0	-	6.0	
	14. Dund Gol Riverside Rd.								
	15. South of PS4								
	Sub total	10Km	21.8Km	+11.8Km	10Km	20.95Km	1.0Km2	1.263Km2	
D: Road Repair Projects	16. Ajilchin Str 2	-	1.1Km		-	0.6	-	0.030	
	Sub total	5Km	1.1Km	-3.9Km	5Km	0.6Km	0.5Km2	0.030Km2	
E: Intersection Improvemen t Project	IS 3, IS4 & Other 10 Intersections in F/S route.	- -			-	9	-	0.015 (*)	*: Khasbaat ar IS
	Sub total	0 place	12 places	+ 12 places	0 place	9 places	0 Km2	0.015km2	IS 3, IS 4 & IS 11are not surveyed.
	GRAND TOTAL	30Km	31.1Km	+1.1Km	20.4Km	28.46Km	1.77Km2	1.761Km2	
		(Except B:intersection)			(+8.06Km)		(-0.09Km2)		

Table 15.2.4 Survey Results of Design CBR and Modified CBR

			Design CBR				Modified CBR	
			Calulation for Design CBR :					
	Route/Place	Road Length	CBR	Rejection judgement	Average Standard Deviation (σ)		CBR	evaluation of material
A: New Construction	Tolgoit~Songolon cross	0.41Km	20.5	-				
	Soth Tolgoit Rd.	0.35Km				20.5		
	WestNaran~ ArdAyush	3.01km	18.7, 28.5, 38.5	Max. =O.K Min.=O.K	Ave.=28.6, σ = 8.1 Design CBR =28.6-8.1=	20.5		
	South TV~N/Rd.88	0.39km	38.5	-		38.5		
	Stadium~New Market	3.12km	20.7, 41.9, 56.1	Max. =O.K Min.=O.K	Ave.=39.6, σ = 14.5 Design CBR =39.6-14.5 =	25.1		
	Teeverchid SW Ext.	0.71km	38.5	-		38.5		
	Khuh Tolgoit Quarry						23, 55	for lower subbase
	Khambiin oboo Quarry						28	for lower subbase
C: Widening /Improve	N/W Tolgoit Rd.	3.63km	3.0, 37.5, 42.6, 44.7	Max.=O.K Min.=Rejection	Ave.=41.6, σ = 3.0 Design CBR =41.6-3.0 =	38.6	21.3, 73.5	
	N/Rd.88 (West part)	0.45km	20.8	-		20.8		
	South Tolgoit Rd.	1.67km	20.7, 25.0	-	Ave.=22.9, σ = 2.2 Design CBR =22.9-2.2=	20.7	18.0	
	Teeverchid Rd.	8.37km	18.4, 19.7, 26.9, 31.1, 32.5, 33.8, 37.7, 59.6	Max.=Rejection Min.=O.K	Ave.=28.6, σ = 6.7 Design CBR =28.6-6.7 =	21.9	3.5, 38, 48	
	Dund Gol Riverside Rd.	1.0km	36.4			36.4		
	South of PS4	5.94km	21.1, 47.6, 48.0, 50.5	Max.=O.K Min.=Rejection	Ave.=48.7, σ = 1.3 Design CBR =48.7-1.3=	47.4	63.5,90, 107	
	Sonsgolon Quarry						12.5, 84	possible for upper
	Songino Quarry						60	subbase course
D: Repair	Ajilchin~Chingis	1.1km	28.7			28.7	42.0	

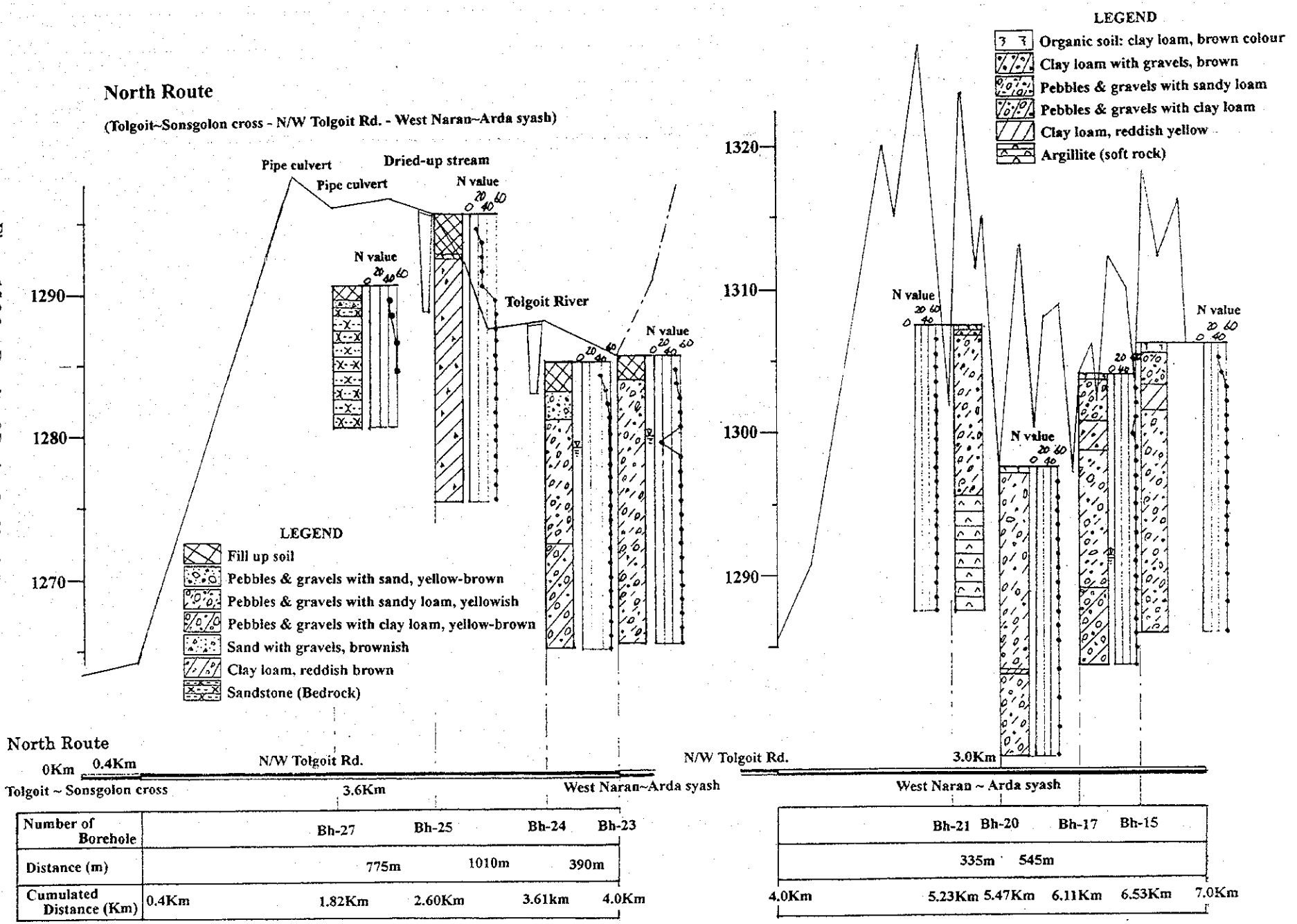


Figure 15.2.2 Results of Boring for North Route

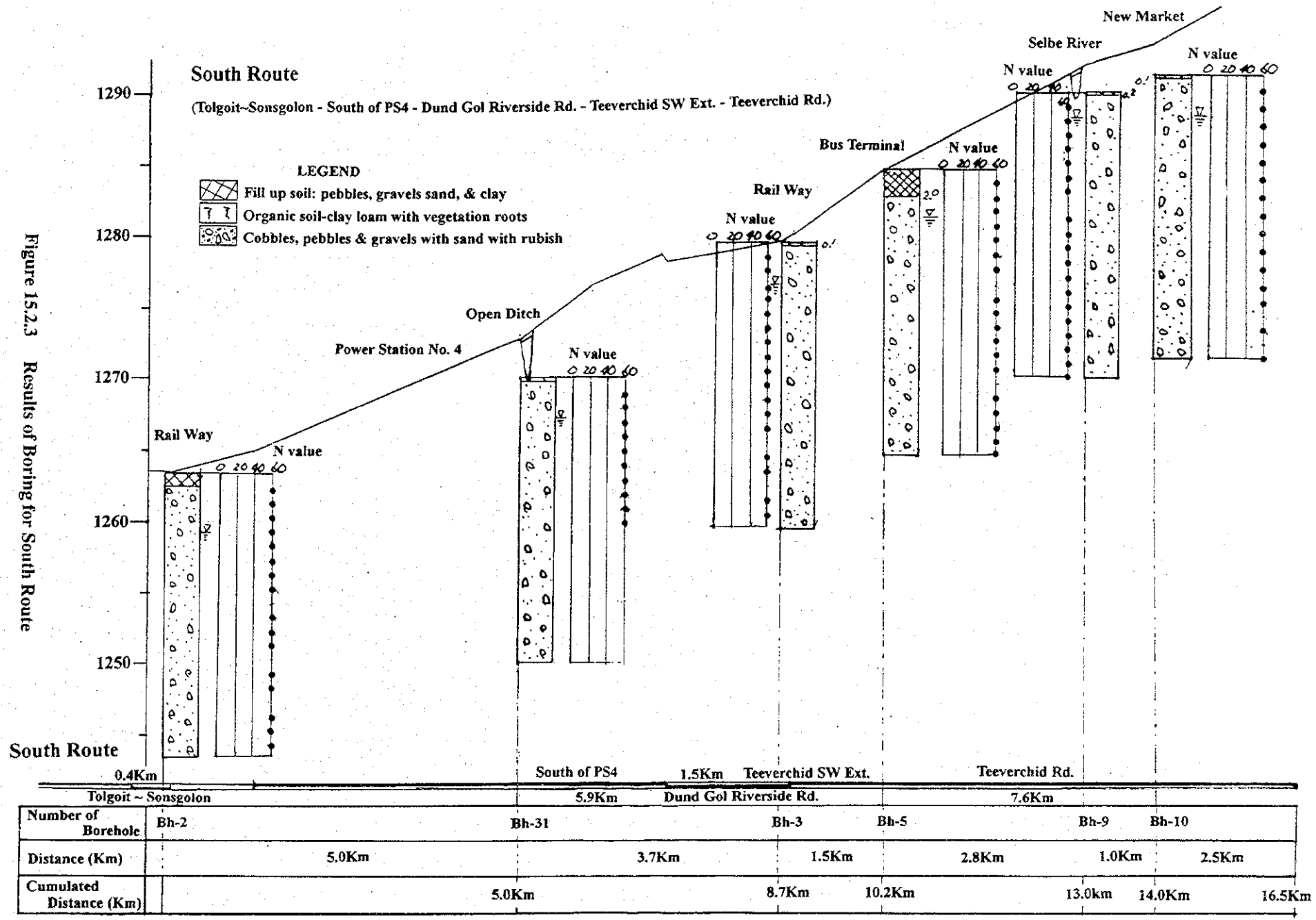


Figure 15.2.3 Results of Boring for South Route

Part 2

Feasibility Study of Selected Projects