Chapter 8 Travel Demand Forecast

8.1 General

Traffic forecasts were carried out for year 2020 using the JICA STRADA program. The study area was divided into 52 traffic zones considering the existing and future land use. Results of traffic surveys were used as the basis for making traffic forecast as shown below in Figure 8.1.1. Multiple linear regression models were built for trip generation and attraction by using the year 1998 trip data as dependent variables and 1998 Pop and Emp(W) data as independent variables. The incremental assignment method was used for traffic assignment.

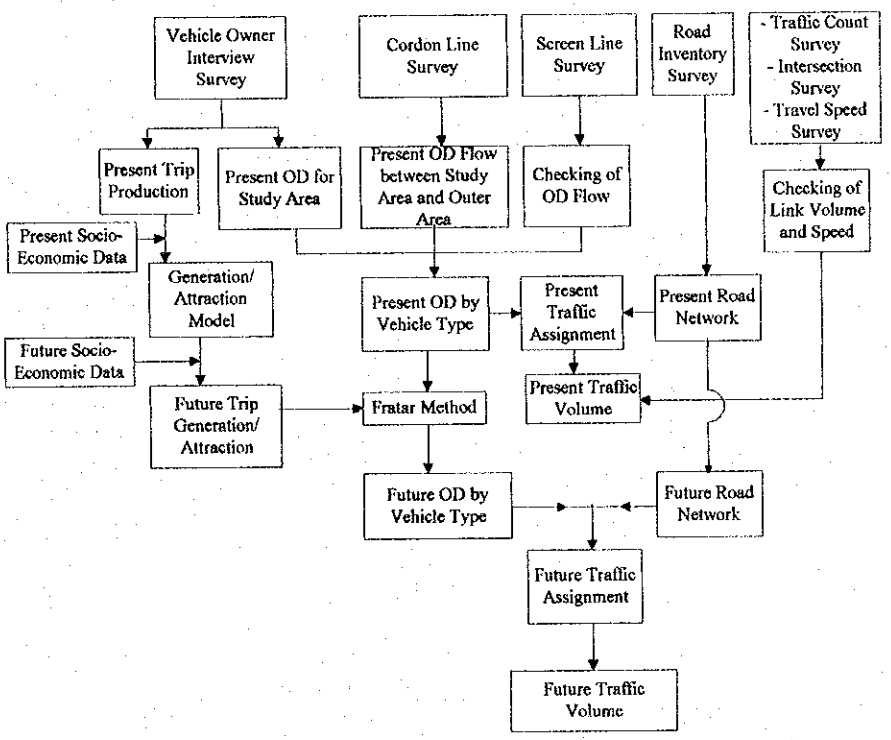


Figure 8.1.1 Flow Chart for Traffic Demand Forecast

8.2 Results

Fig 8.6.1 shows the simulated traffic flow for year 1998. Both, traffic volume and traffic congestion is shown in this figure. Traffic volume (in pcu) is shown by the width of link and traffic congestion by VCR (i.e. Volume Capacity Ratio). As can be seen from this figure that at present no link is congested i.e. VCR is less than 1.00 for all links. This was confirmed during field observation, as no road with traffic congestion was observed. Traffic flow was also forecast for year 1999 i.e. after opening of new central market. It was found that traffic volume on links around the new central market (esp. Teerverchid Street and the Ikh Toyruu Street) increases although no traffic congestion occurs.

Figure 8.6.3 shows traffic flow on the existing road network for year 2020. This can be termed as the "Without Project Case" or "Do Nothing Case". From the figure, it can be seen that traffic congestion will be seen in the western and southern part of the city. This can be explained by the fact that most of the future development is proposed to take place in the western part of the city as per the socio-economic framework for year 2020. Roads in the southern part will become congested because of the development of the satellite town of Ulziit.

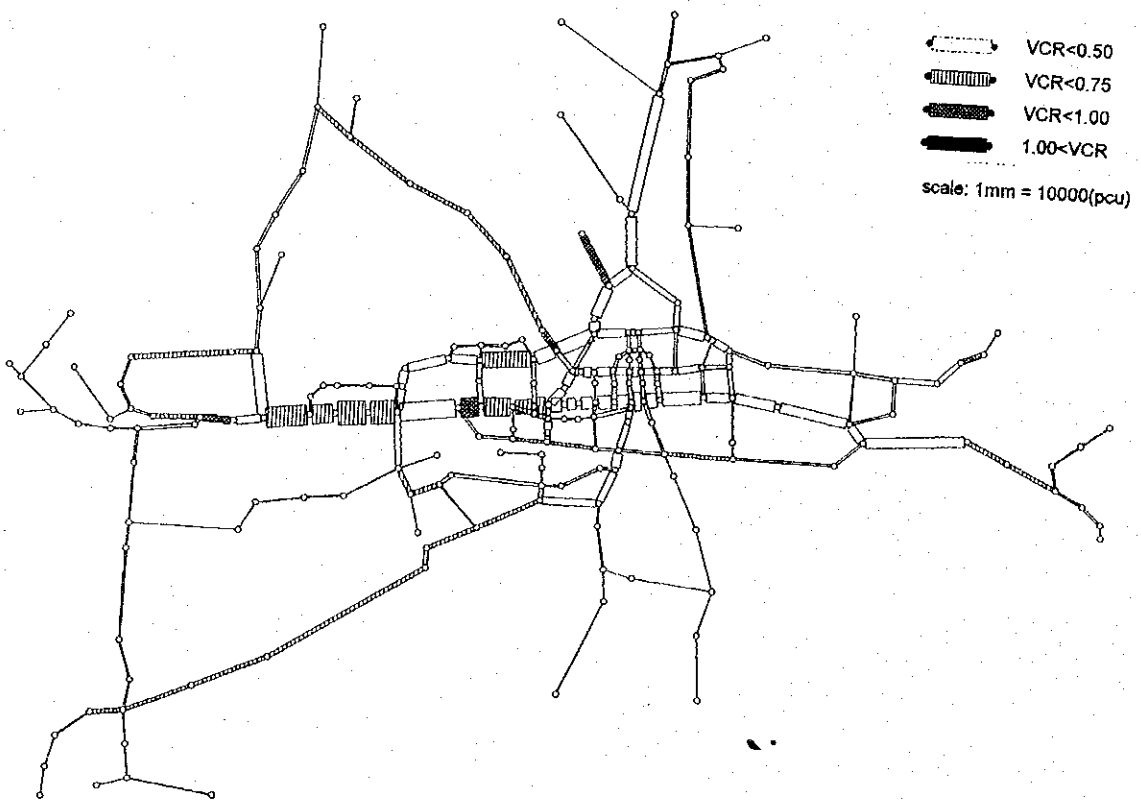


Figure 8.6.1 Traffic Flow for Year 1998

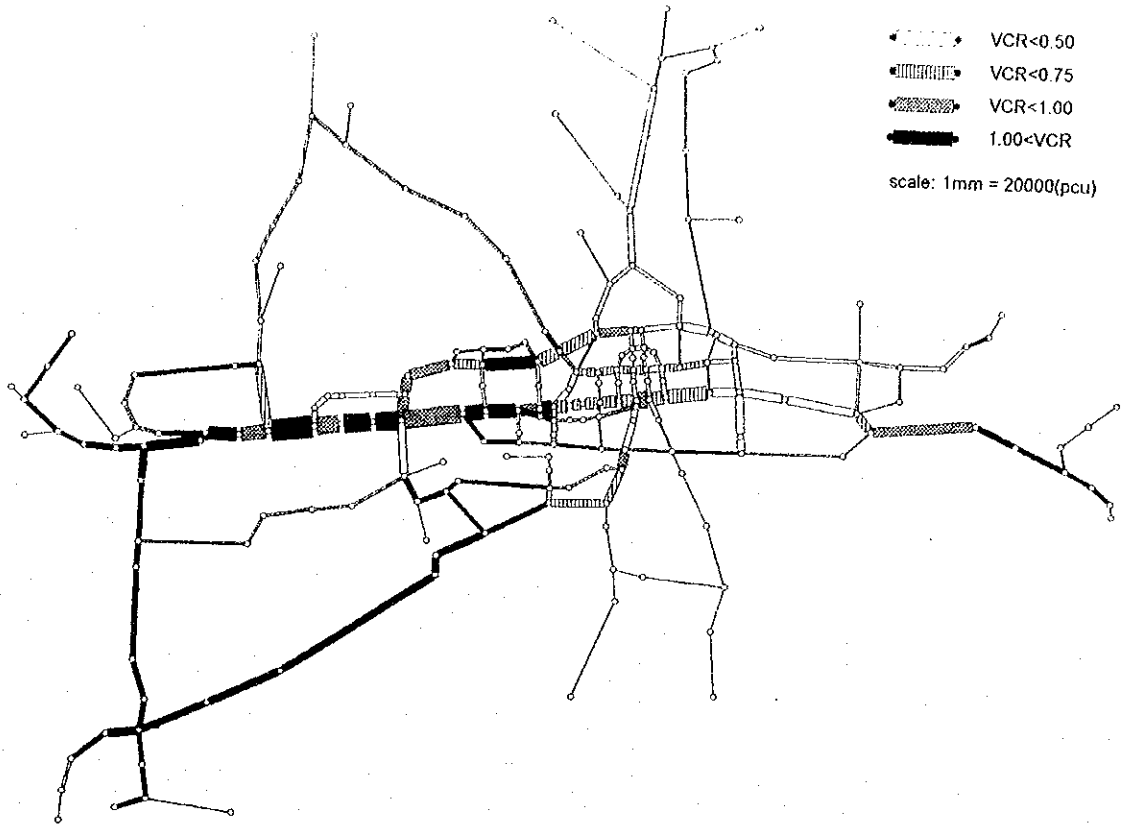


Figure 8.6.3 Traffic Flow for Year 2020 (Without Project)

Chapter 9 Public Transport

9.1 Problems of Public Transport

9.1.1 Replacement of Aged Vehicles

Use years of current vehicles indicate the timing of vehicle inputs fluctuated in the past 10 years due to economic chaos in the early part of 1990s. Particularly, trolleys purchased in the late 1980s became old and less efficient than those newly acquired ones. In order to sustain the public service, a vehicle replacement program in the coming 5 years or so should be determined, with which the companies, UB city and the Government can prepare a funding schedule for the purchase in advance.

9.1.2 Trolleys and Buses

Trolleys are less efficient than buses in annual run km and travel speed. Slow travel speed of trolleys is a cause of conflicts with other vehicles on roads. On road running, trolleys have to run under the over-head power lines. Sometimes they encounter power off, and vehicles have to stop and stay on roads. Overhead power lines were constructed 10 years before, requiring rehabilitation on heavily used sections. Trolleys have been operated on 8 routes in the past 10 years. Considering their inefficient operations on roads, it is considered better to phase out by stage during the years up to mid-2010s. Instead buses should be put in.

9.1.3 Revenue Shortages

Bus and trolley companies have resulted in a total of deficits Tug 1079 million ($1.3 million) in the first half of 1998, caused by various free riders and non-strict tariff collection by conductors. Governmental compensations for authorized free passengers are virtually none. Urgent actions to reduce the amount of deficits are necessary, with efficient enforcement of laws to support actions of conductors.

9.2 Long Term Plan

9.2.1 Demand Forecast

Forecast of the total public transport passengers is conducted by referring to the socio-economic frameworks and other factors in future. The growth ratio of passengers on city buses and trolleys is estimated at 1.54 from 1998 to 2020, i.e. 1.97 % per annum in the period. Figures of forecasts are in Table 9.1.1.

Table 9.1.1 Growth of Overall Person Trips, 1998-2020

Item	1998	1999	2005	2010	2020
- Population 1)	617,500	617,500	725,000	790,000	925,000
- Person trips per capita	1.88	1.88	1.90	1.92	2.06
- Total person trips 2)	1,160,900	1,221,960	1,377,500	1,516,800	1,905,500
- (Share of public users) 2)	(81 %)	(82 %)	(79 %)	(77 %)	(75 %)
- Public transport users 2)	935,330	996,390	1,148,430	1,246,790	1,475,860
City bus passengers 2)	888,570	888,570	1,039,630	1,137,370	1,364,900
(Ratio of increase) 2)	(1.00)	(1.00)	(1.17)	(1.28)	(1.54)
Minibus passengers 2)	40,940	102,000	102,000	102,000	102,000
Satellite bus passengers 2)	5,820	5,820	6,800	7,420	8,960

Notes: 1) Socio-economic frameworks of the study area.
2) The figures in 1998 is the results of the surveys by the study team, and those in future years are forecasts by the team.

9.2.2 Demand on Roads

There are 134 trolleys and 326 buses in regular sizes on city bus routes. They are assigned on route operation. Influence zone of each route are marked, and passengers in future are calculated by using the forecast population in the zone. The overall growth ratio of passengers is adjusted to have a ratio of 1.54 from 1998 to 2020. Forecast passengers of all types of buses are aggregated on road sections for the future years, being shown in Figure 9.2.1. Growth ratios on sections on Enkh Taivan Avenue, for example, are found in the range of 1.4 to 1.8, where larger ratios are on the eastern sections because of the opening of new Central Market.

9.2.3 Alternate Plans of City Bus Development

Under steady increases in passenger demand, alternate plans to sustain public transport are proposed in which periodic replacement of depleted vehicles is considered. The assumed service years are 9 years for buses and 12 years for trolleys. In reality, the years depend on the annual-km and mechanical conditions in operation of every vehicles.

Case 1. Bus and trolleys

Buses and trolleys should be purchased when they come to the end of service life. The shares of vehicle composition among the companies are supposed same as they are at present. New vehicles will increase the service capability because of larger run km and capacities.

Case 2. Staged phase out of trolleys

Buses will continue their service with vehicle renewal at appropriate timing.Trolleys are less efficient than buses in life travel km and travel speed, while they are generating traffic conflicts with other vehicles on roads. Overhead power lines were installed in 1987-88 and need replacement on heavily used portions. It is proposed trolleys should be terminated gradually by stages. Instead, buses should be put in. The phase out is:

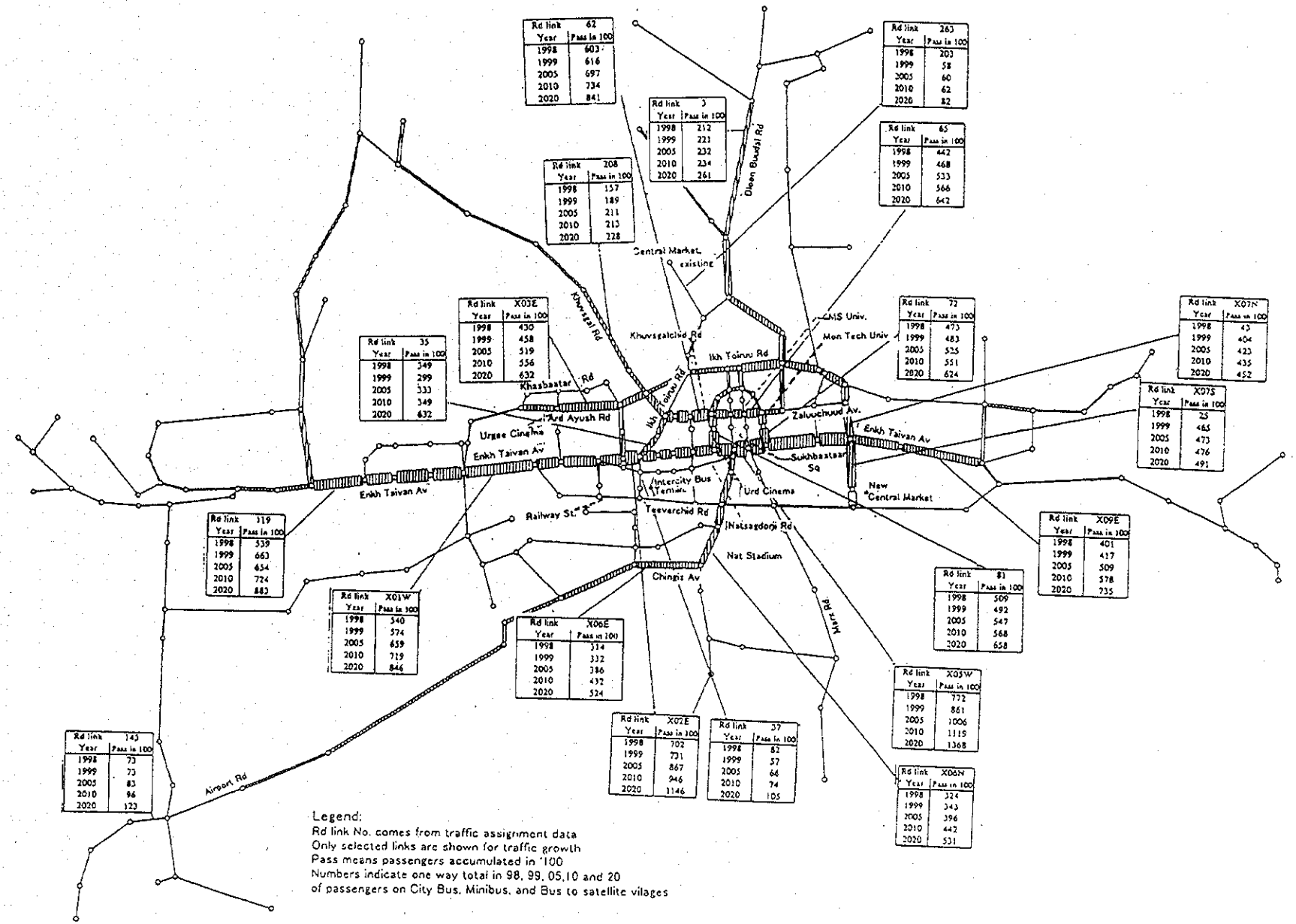


Figure 9.2.1 Accumulated Public Transport Passengers on Roads

1st	2002	Routes No. 3 and No. 6
2nd	2006	Routes No. 1, 4 and 5
3rd	2014	Routes No. 2, 7 and 8

Some trolleys are necessary to be purchased for use because after 2002 the remaining routes continue the operation by the mid-2010s. Vehicle purchase plans are summarized in 3 phases as Table 9.3.3 (1) and (2).

Table 9.3.3 (1) Vehicle Purchase Plan (Case 1)

	Co. 1	Co. 2	Co.3	Trolley	-	Priv.	Total	Trolley	City Bus
1999-05		71	69	81	-	50	271	81	140
2006-10	100	57	29	53	-	18	257	53	186
2011-20	100	128	124	122	-	68	542	122	352
Total	200	256	222	256	-	136	1070	256	678

Table 9.3.3 (2) Vehicle Purchase Plan (Case 2)

	Co. 1	Co. 2	Co.3	Trolley	Buses forTrol	Priv.	Total	Trolley	City Bus
1999-05		71	69	65	15	50	270	65	155
2006-10	100	57	29		36	18	240		222
2010-20	100	128	124		97	68	517		449
Total	200	256	222	65	148	136	1027	65	826

9.2.4 Economic Evaluation

Economic evaluation of Case 1 and Case 2 is conducted to find the economic viability in the internal rate of return (EIRR). The cost is composed of vehicle purchase cost and daily vehicle operation cost on routes for years 1999-2020 in terms of prices in mid-1998.

There will be overflowed passengers if new vehicles are not purchased. Number of vehicles will decrease gradually and much more passengers will overflow from the bus and trolley service in the case of no renewal. Those overflowed passengers are supposed to travel by using private cars, where the cost of using cars represents an economic cost to the country. If new vehicles are put in, overflowed passengers can be reduced, resulting in the savings in the economic cost (i.e. the economic benefits). The cost and benefits are estimated for the years 1999-2020 and the following economic internal rate of return (EIRR) is calculated:

Case 1	Economic Cost $ 114.6 million,	EIRR	32 %
Case 2	Economic Cost $ 104.6 million,	EIRR	34 %

Case 2 of the staged phase out plan of trolleys shows a larger return to the economy of Mongolia. The investment cost on vehicle purchase is less in Case 2. If slow moving trolleys are reduced, other vehicles can move smoothly and the road capacity can be used more efficiently. Consequently Case 2 is recommended for the long term planning.

9.3 Short Term Vehicle Replacement Plan

9.3.1 Updated Vehicle Retirement Program

TCD and bus/ trolley companies prepared in November 1998 an updated annual vehicle retirement plan from 1999 to 2002, based on their assessment of engine and physical conditions in addition to the use years in the past. The above new data are used for the vehicle replacement program of short term period (the phase 1, 1999-05). Influence of the new data was examined for the long term plan of Case 2, and found little change in the estimate of EIRR.

9.3.2 Vehicle Replacement

The replacement program has a total of 248 as under.

Year	Co 1	Co 2	Co 3	Bus for Trolley	**City Bus Total**	**Trolley**	Private	G Total
2002	0	70	65	15	**150**	**53**	45	248

Of those purchases, private vehicles are included in the feasibility study of Phase 1. Their renewal program is based on their judgment on market opportunity, having no relation with the city budget. After estimating the EIRR including private ones, the cost by the public bus/trolley companies without private buses are discussed next.

9.3.3 Economic Evaluation

(1) Conditions

1) The evaluation period

The period of analysis in cost and benefit streams for the Phase 1 is set from 1999 to 2014, since all trolleys will terminate the service in that year.

2) Benefits and cost

Methods of passenger demand and benefit estimates in this period are same as the forecast in the long term master plan from 1999 to 2020. Cost of replacement vehicles in Phase 1 is revised by using the updated retirement data.

(2) EIRR

Economic rate of return (EIRR) of Phase 1, in which two trolley routes are changed to bus operation, is calculated. The result presents close values to Case 2 of the master plan.

Phase 1 (1999-05) EIRR 32%, B/C ratio (at 10 % rate) 1.39

9.3.4 Conclusion and Recommendation

The high economic return means the public transport system is vital to the development of economy and community of Ulaanbaatar. It is worthy to be sustained with appropriate vehicle replacement plan. The economic cost of vehicle replacement in Phase 1 is

Buses of City	150 vehicles	$15,000,000
Trolleys of City	53 trolleys	$6,890,000
Power lines of trolleys on roads of 18 km		$1,427,000
	Total economic cost	$23,317,000

It is an urgent necessity to determine funding sources for this amount. It is recommended bus companies, City and TCD, and Government of Mongolia should work jointly to solve this funding matter immediately.

9.4 Other Recommendations

9.4.1 Restructure of Organizations

Existing four public corporations were separated from the UB city, without no private fund participation. The all assets provided by the city in 1996 were as under:

Total Assets in 1996

(Tug million in prices of mid-1996)

Company 1	5029
Company 2	2295
Company 3	262
Trolley	865
Total	8451

Although their assets have increased in the past few years, restructure and merger of those companies will be necessary along with the gradual phase out of trolleys.

9.4.2 Bus Qualities

Different sizes of bus, such as use of mini and medium buses should be considered on selected routes. Low floor buses, which will be beneficial particularly for aged persons for on and off, is worthy to examine for using although the cost is higher by 30-40%.

9.4.3 Changes in Service

- Express/Shuttle Buses

Currently no shuttle bus service is provided. But, Route No 13 and No.10 are operated with many frequencies in central area of the city. When demand increases much more in the future, other shuttle service need be supplied in other roads. Express service should be considered also.

- **Monthly pass and discount tickets**

The monthly pass system should be extended to daily commuters if they use public bus/trolley daily. If a passenger changes to another route he has to pay another Tug 100 on the second route. It is considered better to study the application of multi-ride ticket system.

9.4.4 Financial Restructure

The deficit in the first half of 1998 was Tug 1078 million ($0.78 million) in the total of four corporations. Loan agencies of World Bank and others would not supply funds to sustain city bus corporations, if there are no immediate actions by the city and the government to reduce deficits in financial terms. The following points should be reminded in increasing revenues.

(1) Revenue Generation

1) Conductors

Number of conductors on the bus should be increased to collect the fare at every door side. It is said non-qualified free riders including children are 20% or more of daily passengers. Conductors should be empowered legislatively to delete those non-qualified passengers.

There are pocketing a part of the collected revenue by conductors. They should be inspected frequently to recover lost revenues.

2) Aged and handicapped persons

There are aged, handicapped persons and others who would be covered by the welfare policy of the city for free rides. They carry ID card issued by TCD in using the bus. They are around 10% of daily uses. Bus companies should be compensated by the city for those qualified free passengers.

3) Campaigns through news media

News media of TV, radio, newspaper, etc. should be utilized to know the bus fare should be paid when people use the bus. A market system that users must pay the tariff whenever they receive a transportation service should be known thoroughly.

(2) Tariff Revision

Bus fares should be increased periodically. An example plan is to increase the fare Tug 100 to Tug 150 in 2000, and again to Tug 200 in 2006. This revision together with other actions for revenue generation will improve the financial position of the companies. (22.1.3 in Chapter 22)

Chapter 10 Future Road Network Plan

10.1 Road Classification

The future road network is formulated based on comprehensive evaluation of the present condition of roads, forecast of future traffic volume and forecast of number of passengers using public transport.

At first, the roads were classified into 5 categories with consideration of their role and design standards.

Table 10.1.1 Comparison of Road Classification by Design Standards

Proposed Standards			
Category of Road	Design Speed	No. of Lane	Width
S: Asian highway (Inter state highway)	120	4,6,8	3.75
A: Regional road	80	2.4	3.5
B: Primary road (City Trunk road)	60	2.4	3.25
C: City road (major network road)	60	2.4	3.25
D: Residential road (Minor network road)	40	2.1	3

Mongolian Standards			
Category of Road	Design Speed	No. of Lane	Width
Trunk roads:			
- for high speed	120	4~8	3.75
- with regulated speed	80	2~6	3.5
Trunk streets:			
- of city importance	100, 80	4~8	3.75, 3.6
- of regional import	70, 50	2~4	3.5,(4.1)
Street & roads of local importance:			
- in residence area	40, 30	2~3	3
- in industrial area	50, 40	2~4	3.5
- Park road	40	2	3
Access roads:			
- main	40	2	2.75
- Secondary	30	1	3.5

Conceptually it will look as follows:

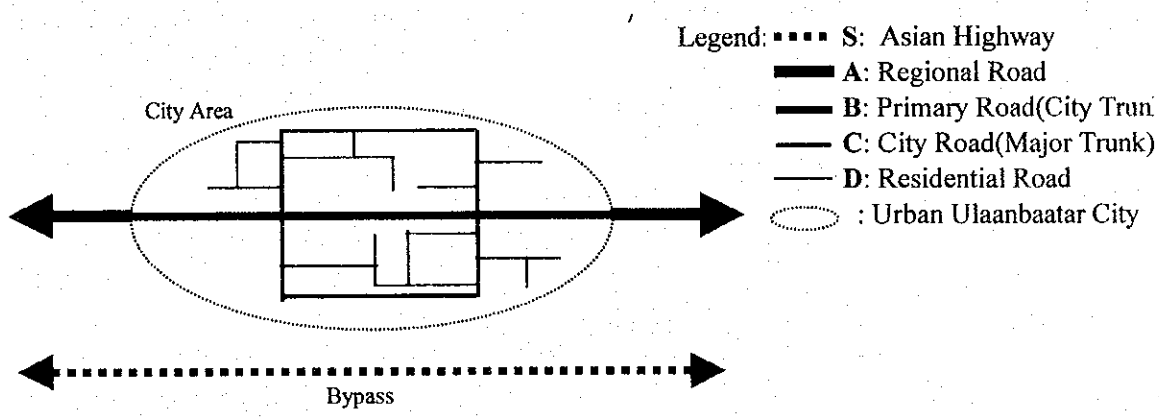


Figure 10.1.1 Definition of Roads and Streets

The above-mentioned categories A, B and C were included and S and D were not included in the long-term road network.

Basic policy taken for the definition of the long-term road network:

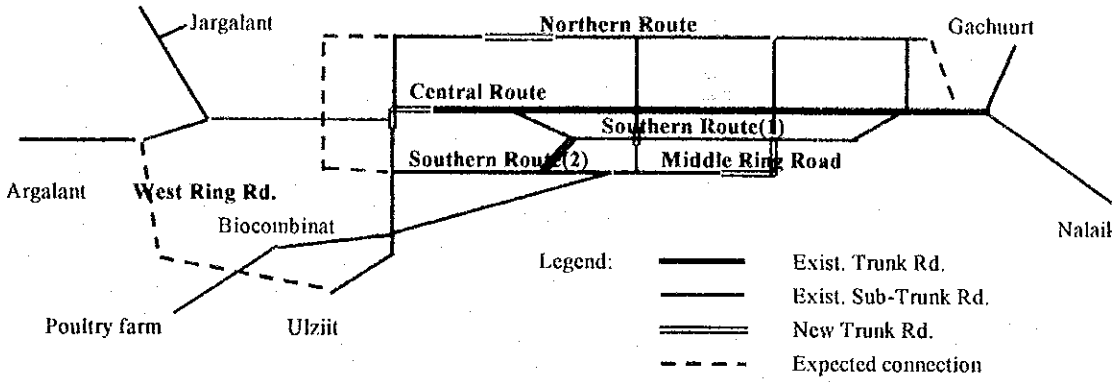
GUB (Greater Ulaanbaatar)	• A super long-term road network (coded as R1) was established with consideration of roads connecting 6 satellite towns. At that time these roads are not dead end roads but as ring roads. • 4 ring roads out of 5 were excluded from the long-term road network plan as premature ones. These 4 ring roads should be studied separately for the establishment of a plan after 2020.
UUB (Urbanized Ulaanbaatar)	• Maximum utilization of the existing roads is considered with following study results: - Existing condition of roads and bridges - Traffic survey and future traffic volume • Destruction to environment is to be minimized. • Appearance of the city and harmony of the construction and maintenance costs shall be considered.

10.2 Network Plans

Actual concepts to reduce the future traffic congestion in urban area road network are as follows.

Places where congestion is expected	Measures for solution	Necessary works
Enkh Taivan Avenue	Cross point with railway and the road at West part shall be improved. (Central route)	Improvement- expansion at the west end of Enkh Taivan Avenue in connection with regional roads.
Road parallel to Enkh Taivan Avenue	It shall be improved as a bypass. (called Northern route)	New construction / improvement at the west side of Enkh Taivan Avenue to the third district of Northern route extention
Road to the northern ger settlement	The restriction of farther development prevents the negative environmental effect. (Maintenance of the existing roads should be continued.)	
Road to airport	The widening of the existing bridge on Tuul river is difficult from cost. Alternative route shold be considered.	
Enkh Taivan Bridge	By withdraw of trolley bus, traffic flow is more smooth.	
Teeverchid road due to opening new central market	It is expected to be widened. Connect to the south side of railway through a new fly-over.	New construction / improvement of missing sections of Southern route and widening of the existing road
City center area	Middle ring road is required for dispersing traffic from the city center area.	New construction of missing sections of Ring route and two fly-overs

Conceptional expression of the above mentioned is shown in the figure below.



Based on the above concept, six alternative long-term road networks for year 2020 (coded as R2 to R7) were formulated by changing lane number and selection of route. Traffic forecasts were carried out for all these networks. Figure 10.4.2 shows traffic flow for year 2020 for the future road network (R7). This can be termed as "With Project Case". It can be seen from this figure that the construction of new routes will contribute to the reduction of the traffic congestion, especially in the western part of Peace avenue.

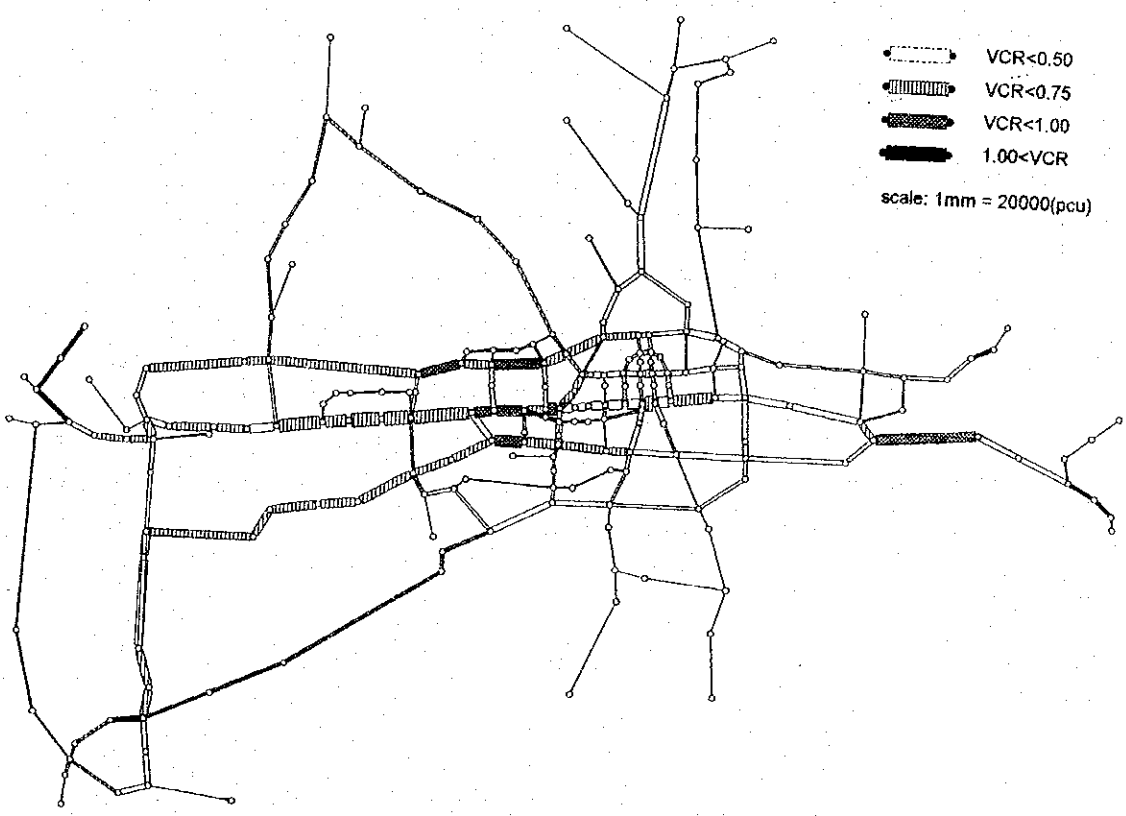


Figure 10.4.2 Traffic Flow for Year 2020 (With Project – R7)

The following table is the summary of comparison of 6 alternatives called as R2 to R7.

	Outline	Environmental affect and Resettlement	Financial cost (MUS$)	Benefit-Cost Ratio B/C
R2	Principal road network plan for long term period by 2020 All main roads are expanded to be 4 lanes	D	D 246	D 1.311
R3	Reduced the northern route as 2 lanes. New road at the south side of TV stations. Improvement of Rd No 88 about 0.4 km	B	B 228	B 1.396
R4	Reduced the southern route as 2 lanes.	A	B 229	B 1.402
R5	Reduced the Naadamchidiin road as 2 lanes	C	C 231	D 1.336
R6	Reduced the Naadamchidiin road as 2 lanes Northern route will connect from west Naran to Ardayush by 4 lanes. Expand Teeverchid street to Peace avenue at the west end. The roads of South of PS4 and PS3 are 2 lanes	C	D 237	C 1.374
R7	Modification of R6 Khasbaatar road shall be 2 lanes	B	A 225	A 1.423

Notes: Rank , A; Good, B; Fair, C; Poor, D; Bad

In terms of traffic flow (i.e. average speed and VCR), no substantial difference was found among the 6 alternatives of R2 to R7, so the criteria of traffic flow was not considered for evaluation. From the above, R7 is selected as the best alternative, because of the least cost and the largest B/C ratio, and Fig.10.4.1 shows its routes.

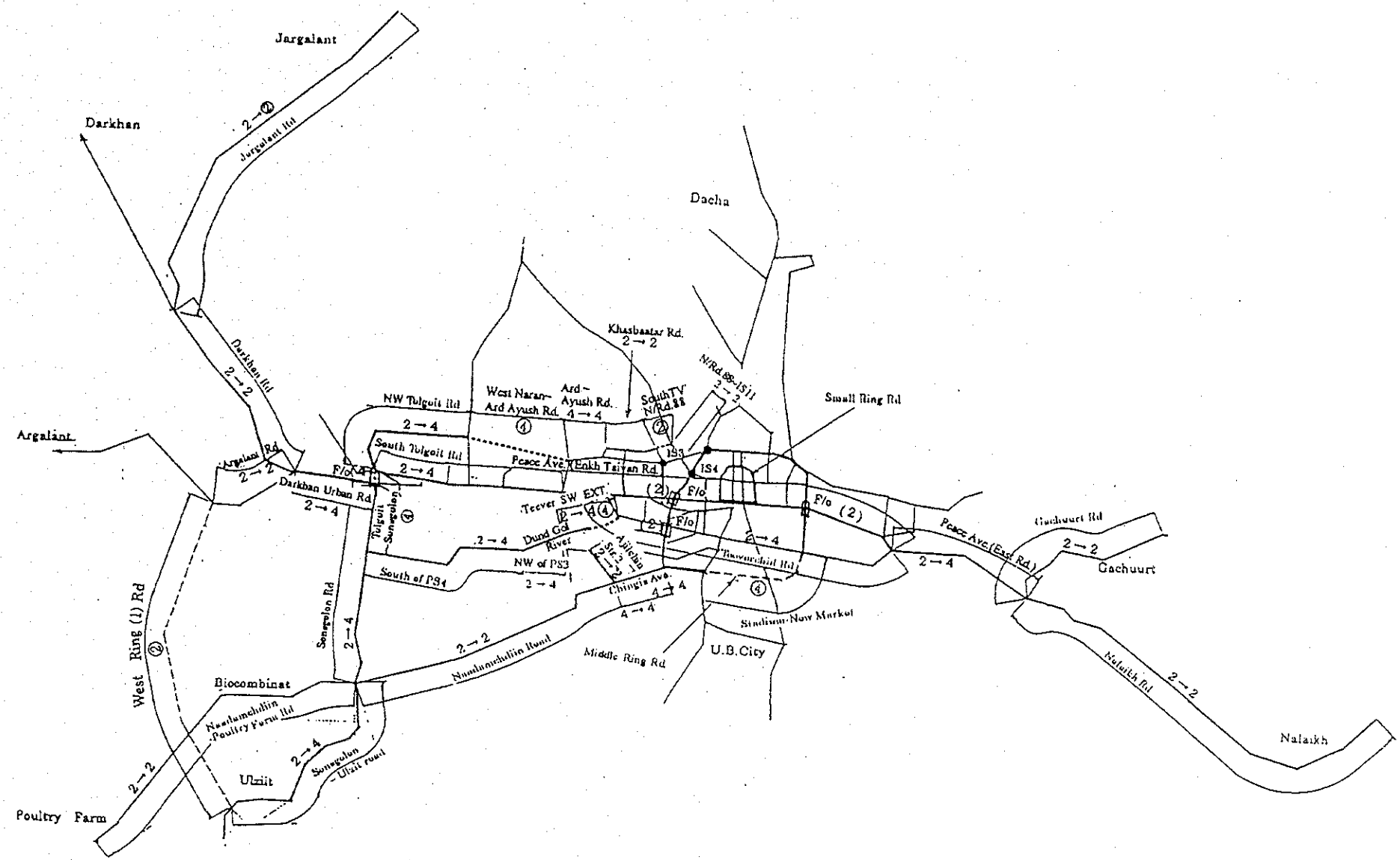


Figure 10.4.1 Required Traffic Lane for Best Alternative R7 of Future Road Network in 2020

Chapter 11 Study of Design Standards for Road and Bridges

11.1 Applicable Design Standards

The Mongolian standards are developed on the basis of Russian ones. Upon discussions with the Mongolian side it was agreed to follow AASHTO and JIS standards mentioned below:

- 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 1983]
- Traffic Capacity of Roads [Japan Road Association 1984]
- Specifications for Highway Bridges, [Japan Road Association 1996]
  - Part 1: Common specifications
  - Part 3: Concrete Bridges
  - Part 4: Substructure

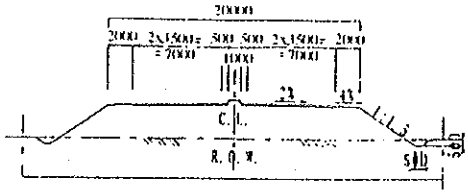
11.2 Examination of Road Geometric Design Standard

The roads were classified into 5 types and a basic geometric standard for each type of road was established as shown in Table 11.2.1

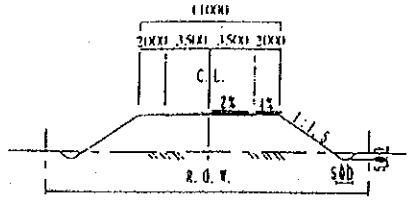
Table 11.2.1 Basic Geometric Design Standard

Category	Unit	S: Highway	A: Regional Road	B: Primary Road	C: City Road	D: Residential
Terrain		flat	flat	flat	flat	flat
Design Speed	km/h	120	80	60	60	40
Stop. Sight Distance	m	210	110	110	75	40
Lane Width	m	3.75	3.5	3.25	3.25	3
Number of Lane	no.	4	4,2	4,2	4,2	2,1
Median Width	m	4 or more	1 or more	3	-	-
Inner Shoulder	m	0.75	0.5	0.5	0.5	-
Outer Shoulder	m	3	3	2	2	-
Cross Slope	%	2	2	2	2	2
Min. Radius	m	700	300	150	150	60
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

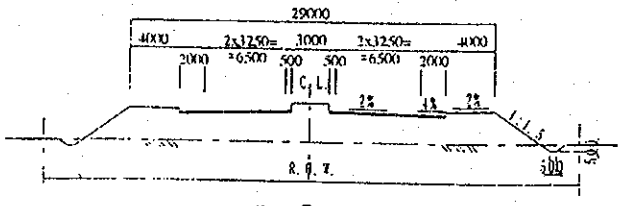
Standard cross-section of each road is shown in Figure 11.2.1.



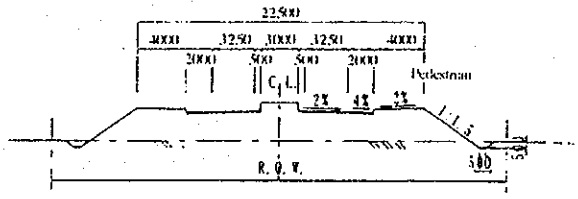
Type A
for category A Regional Road 4 Lanes



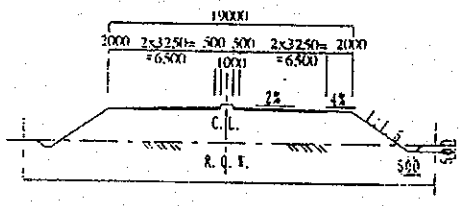
Type A′
for category A Regional Road 2 Lanes



Type B
for category B Primary Road 4 Lanes

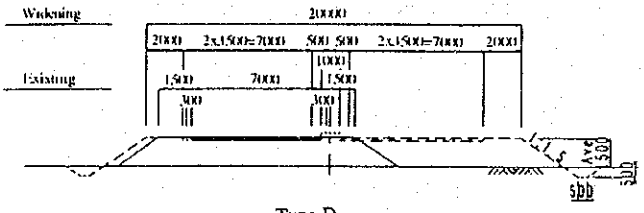


Type B′
for category B Primary Road 2 Lanes

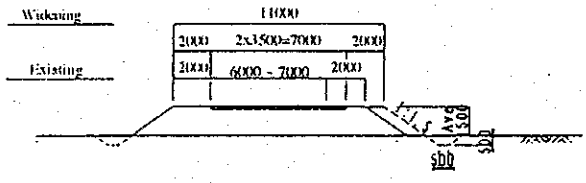


Type C
for category C City Road 4 Lanes

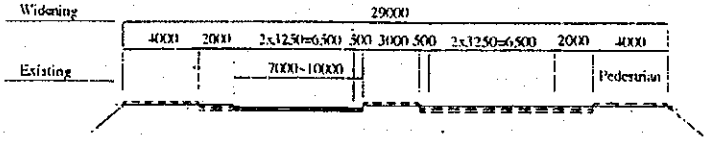
Cross Section for New Road



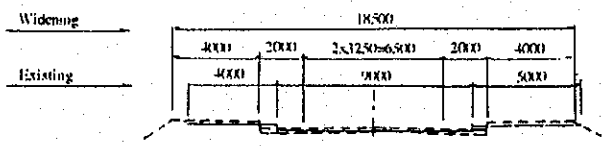
Type D
for category A Regional Road (2 - 4 Lanes)



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

11.3 Examination of Road Traffic Capacities

Road traffic capacities were calculated on the basis of the American HCM (Highway capacity manual), AASHTO and Japanese standards (Road Association: Road Traffic Capacity).

The results are shown below.

Analysis of Traffic Capacity (Multi-lane)

Description /Road	Highway	Regional Road	Regional Road	City Road	City Road	City Road	City Road
Lane Number Applied	4	4	2	6	4	3	2
Daily traffic capacity	40000	40000	10000	56000	37000	12000	9000

Here the service level B for Highway, Regional roads and C for City roads is adopted in the column of applicability in the table below.

Level	Running condition	Applicability
A	Low traffic volume and free driving at high speed	(Not Applicable)
B	Stable traffic flow with speed limited. Passing freedom is left for selection of speed and lane.	Applicable for designing of regional road Highway, Regional
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. Short or even long time stops are occurring. Traffic flow exceeds road traffic capacity.	

11.4 Pavement Design

Cement concrete pavement was used in UB city in the past, but, because such type of pavement requires large investments in the beginning and its maintenance is not simple, asphalt pavement became the main type of pavement during the recent past years.

However, taking into consideration the durability of the cement concrete pavement, it is recommendable to investigate its execution method in the extremely cold environment and consider, especially, the utilization of prefab method extensively used in construction of buildings and airport runways.

Almost, there is no permafrost in UUB. There is a fear of appearance of pavement damages due to freezing and thawing process. However, the southern part of UUB is formed from sand and gravel with high perviousness and its northern part from impervious soil both difficult to be

subjected to freezing and melting. Therefore, the consideration of this phenomenon was excluded from the study.

In the case of Mongolia, the main problem related to the pavement is the appearance of shrinkage cracks during the cold period and, still, there is no method for proper handling of this matter.

Therefore, it has decided to design the pavement with an analytical period of 20 years and utilization period of 10 years in accordance with the DNPS-86 program based on AASHTO.

11.5 Structural Design

Taking into account the trend towards increase of weight of vehicles, design load for bridges was taken, after comparison of AASHTO, JIS, Mongolian standards, etc., in accordance with the Japanese B-live load (TL-25).

The earthquake load was taken as the grade of 9 according to the Mongolian 12-mark grading system (coefficient of a horizontal load is 0.1 g). For the other kind of loads (earth pressure, water pressure, shear force, impact load, etc.), the Japanese standards were used.

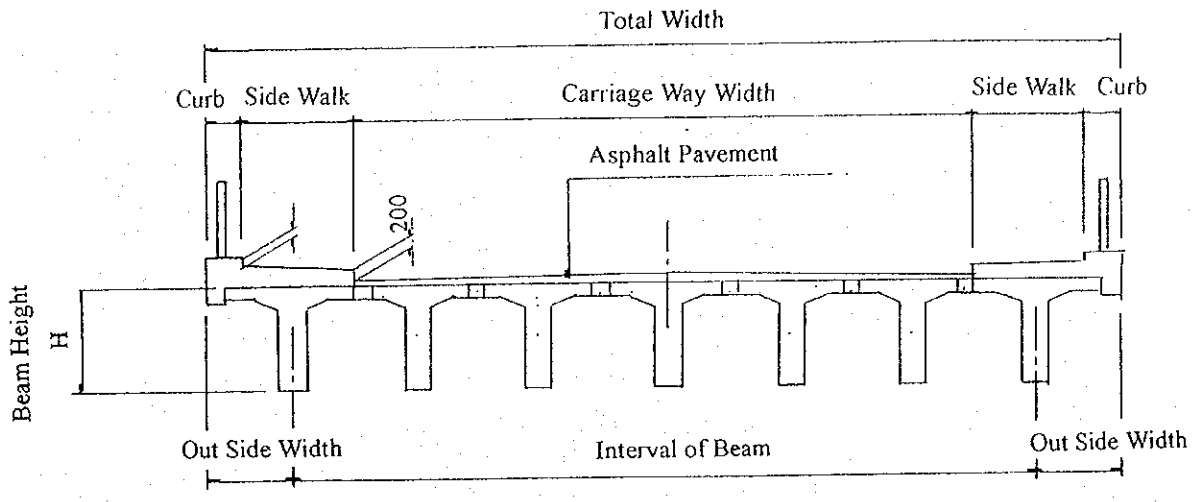
Super Structure

There are no steel bridges in Ulaanbaatar due to difficulty of importing of materials, worsening of the quality in the extremely cold environment and no fabrication system. Therefore, the bridges were decided to be of RC and PC types, and from the execution point of view, unified simple T-type ones are used. It was assumed that 15-20 m standard spans will be used for RCT-type bridges and 20-30 m spans for PCT-type ones.

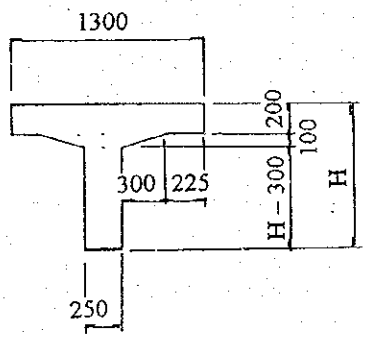
Increase of weight of vehicles and traffic turn in the both left and right directions were taken into account during the designing of the fly-overs in 2 places. Their general view and standard cross-section are shown on Figure .11.6.1

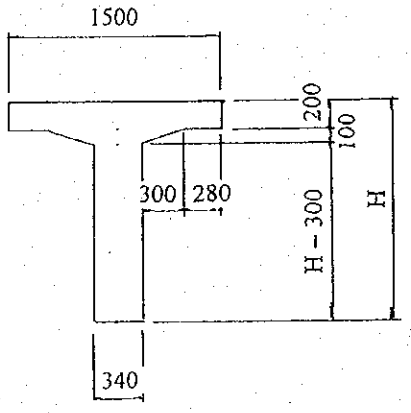
Pedestrian bridges

After the investigation of the places with a large number of traffic accidents, it was assumed that the construction of pedestrian bridges are mostly needed at the 3 locations and different options for solving the problem were considered. The construction of underpasses is difficult due to the existence of many underground facilities. It was, also concluded that pedestrian bridges without roof structures do not suit for usage in cold period. However, after the consideration of the utilization condition of the existing 2 pedestrian bridges, in manner of citizens and their priority in regards to construction of the other infrastructure facilities, it was agreed with the Mongolian side not to subject the pedestrian bridges to FS.



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 Car Parking Facilities

Car parking facilities are becoming a problem. At first, it is connected with traffic jams appearing due to parking of cars on the road side near business and commercial centers. The Study Team investigated the number of cars parked at typical places shown on Figure 11.9.1 where congestion is seen and considered necessary to have parking spaces. The necessity will be intensive because of the increase of number of cars in future.

Secondary, it is connected with car parking spaces inside the apartment blocks. It is impossible to keep a car in the open in a country where the temperatures reach (-) 40°C in the winter. There are some concrete garages with heating systems. But, following the increase in the number of cars, the garages are in short supply and there is a strong tendency now to locate container garages in empty spaces without obtaining any approval for their usage. It is becoming a matter of concern that Ulaanbaatar will be filled up with containers used as garages.

It was decided to exclude the car parking problem from being covered by the FS. However, the following 2 points are better to be taken into account for the future:

1) While taking a policy for liquidation of containers located in empty places inside the apartment blocks, a law making the construction of garages underground or first floor obligatory should be adopted.

2) A law to ensure preservation of necessary lands for parking in commercial areas etc. for the future and control the construction of new buildings should be adopted.

11.7 Safety Facilities

Many traffic signals in the city do not operate because of breakage and shortage of spare parts and the traffic control function is instead fulfilled by policemen. Although the city main roads are equipped with lighting poles, in many places they are not supplied electric power due to the cost of electricity or breakage.

Road signs and road surface signs are lagging behind the traffic growth. Paint markings used for road surface signs is of short durability and signs disappear quickly. Clear painting of surface signs may significantly change the image of the roads in Ulaanbaatar.

Although the Traffic Police made a strong request for improvement of safety facilities, it was excluded from the F/S because of limited time for the study. It is necessary for the traffic signal facilities to have a unified linked system and soft programs in the scale of the whole city. Therefore, the Study Team has made a general calculation of expenditures required just for intersection lighting, road signs and road surface signs and a detailed designing of the entire signal system has not been carried out.

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

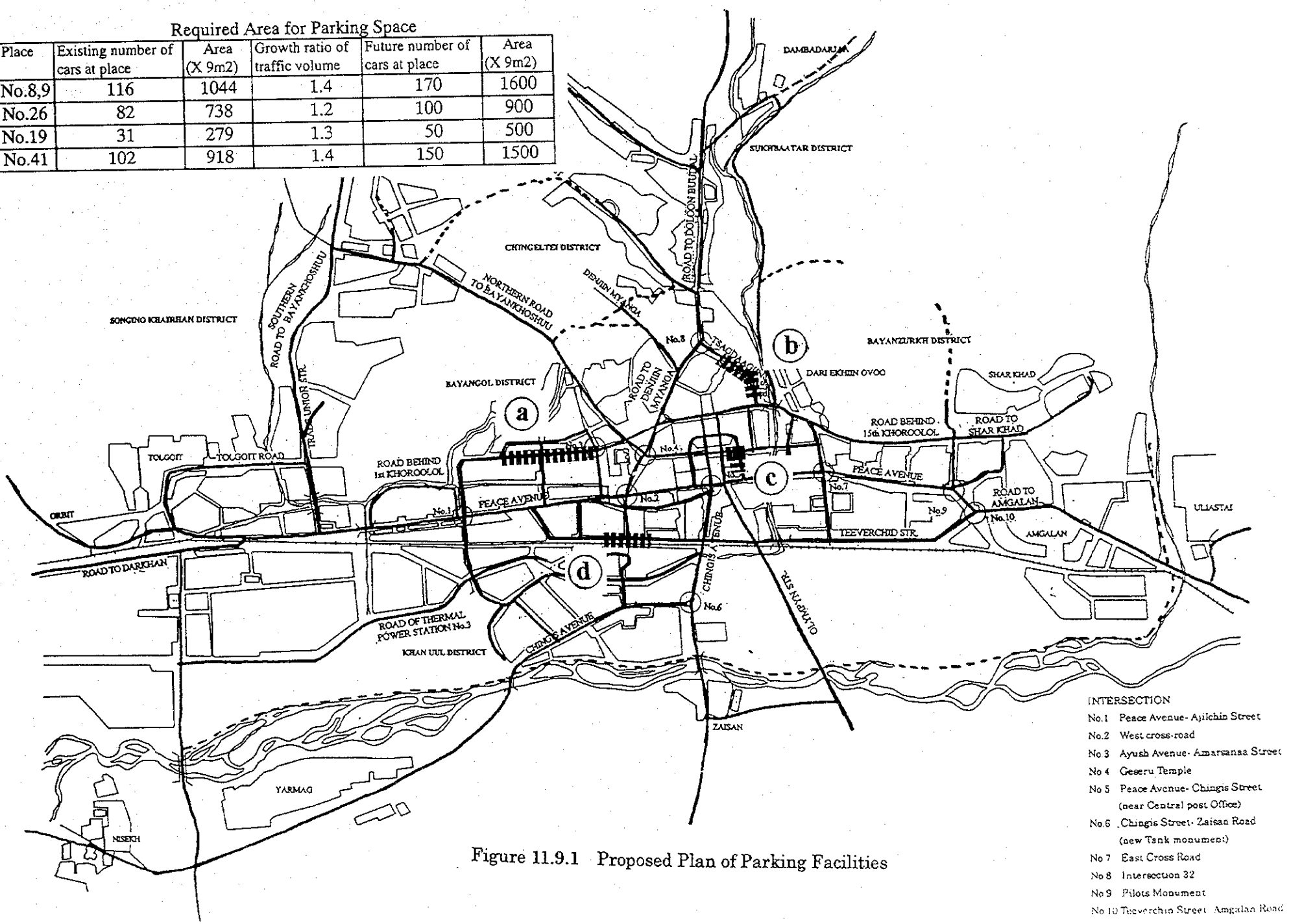


Figure 11.9.1 Proposed Plan of Parking Facilities

11.8 Drainage Facilities

UUB main roads equipped with open ditches are the Enkhtaivan and Chingis avenues. The others are not equipped with such ditches. The reasons are:

1) Because the areas near UB are almost bare with no vegetation, the outflow ratio is high. When a little heavy rain have occurs in the summer, the discharged waters from the northern mountains quickly turns into floods and in a short time comes charing down to the roads inside the city. The necessary cross section of the ditch for handling this water should be of very large capacity.

2) On the other hand, annual precipitation is small, less than 300 mm, and, moreover, most parts of it falls during the summer. Therefore, drainage facilities are not designed because the period for which they are required is short. Budget has not been enough to cover the costs.

3) Even where drainage facilities are constructed, there is, usually, no water flowing in them. They are blocked with garbage and, at the crucial moment, they do not function properly.

As a result, when it rains, south-north direction roads turn into ditches and the rushing streams flow down to the low places. Damages are, especially, heavy on the eastern edge of Tolgoit road and require the necessity of installing drainage facilities with a large cross section.

Although the importance to have better drainage systems in the entire city is recognized, we have studied only the drainage facilities for road surface water flows in the Feasibility Study.

Chapter 12 Cost Estimation of Future Road Network

12.1 Basic Conditions

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 the 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.

12.2 Unit Cost of Work Items

Based on the above conditions, unit cost of each work item is summarized in Table 12.2.1

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

Work items		Unit	Local Currency	Foreign Currency	Total Cost
Pavement Repair A	See Remarks	m^2	1.60	13.74	15.34
Pavement Repair B	See Remarks	m^2	1.66	13.80	15.46
Pavement Repair C	See Remarks	m^2	4.44	31.31	35.75
Pavement Repair D	See Remarks	m^2	7.15	44.71	51.86
New Pavement	Embank	m^2	4.85	43.93	48.78
New Shoulder	H=1.040m	m^2	2.81	30.25	33.06
Block pavement of Sidewalk		m^2	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	Ø600, 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.
Bus Stop	Rehabilitation	Place	7,146.	4,6956.	11,842.
Bus Stop	New	Place	7,207.50	6,589.53	13,797.
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.
Embankment	Borrow	m^3	0.56	17.42	17.98
Base Course	t=220mm	m^2	2.05	6.91	8.96
Approach Road	Bridge No.10	Place	900.	5,900.	6,800.
Approach Road	Bridge No.13	Place	1,800.	11,800.	13,600.
Approach Road	Bridge No.14	Place	1,300.	8,400.	9,700.
Approach Road	Bridge No.24	Place	1,300.	8,400.	9,700.
Approach Road	Bridge No.27	Place	3,.000.	19,700.	22,700.
Abutment	Bridge No.12	Place	900.	6,700.	7,600.
Abutment	Bridge No.28	Place	13,400.	36,200.	49,600.
Abutment	Bridge No.29	Place	19,300.	47,700.	67,000.
Abutment	Bridge No.32	Place	700.	10,500.	11,200.
Abutment	Bridge No.40	Place	1,300.	12,700.	14,000.
Piers	Bridge No.10	Place	12,800.	32,700.	45,500.
Piers	Bridge No.21	Place	8,900.	26,200.	35,100.
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.

Remarks: Costs of road repair works were estimated according to the classification of 4 kinds of current road conditions in the following table:

Categories	Repair work item	Cost estimation subjects/methods
Pavement Repair A (Good sections)	Installation of missing manhole cover, improvement of pavement gap, repair of pot holes	Estimate cost for overlay (5cm) against 10 % of total surface area
Pavement Repair B (Some amount of repair)	Adding above, partial overlay is necessary for the improvement of pavement conditions	Estimate cost for overlay against 50 % of total surface area
Pavement Repair C (Large-scale repair)	Repair works are required from base course to surface judging from the current condition of damage.	Estimate cost for base course (39 cm) and surface (5 cm) for the total area. Replacing cost shall be included for such work. No replacement of subgrade.
Pavement Repair D (Full repair)	Adding above, 50 % of subgrade is expected to be replaced.	Adding above, estimate cost for replacing of 50 % of subgrade (104cm)

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 US$ 226 million, which is close to the Mongolian national budget of US$ 267million (1997). Out of the total cost of about US$226 million for alternative R7, the share of local currency is about US$ 62 million (27%) and that of foreign currency is US$ 164 million (74%).

Total cost of each work in case of R7 is shown in Table 12.3.1. High cost will be required for Bridge (13%) Pipe Culvert (18%), New Pavement (17%) and rehabilitation of pavement (18%). Cross drainage pipe culvert is designed at every 50 m intervals to improve the storm drain conditions in UUB.

Table 12.3.1 Financial Costs of Each Work Items (R7)

(Unit: 1,000 US$)

Work items	Quantities	Unit	Direct Cost	Total Cost	Ratio (%)	Foreign	Local
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
(Ø600, 360 deg.)	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)	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	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	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
		Grand Total		225,924		61,993	163,931

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 economic efficiency. The economic evaluation is carried out by estimating and comparing the benefit-cost ratio (B/C) for each alternative road network. The economic benefits derived from road improvement projects consist mainly of savings in Vehicle Operating Costs (VOC) and travel time.

13.2 Estimation of VOC

The HDM-VOC computer program was used to estimate VOC. This 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 in discussions with Road Department, and is shown in Table 13.5.1. VOC vary considerably depending on the type of vehicle and road surface condition. The three vehicle types and their representative models used for estimation of VOC is shown in Table 13.3.1.

Table 13.3.1 Vehicle Type and their Representative Model

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

The five categories of road surface condition 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 <= 4)
(2) Fair (4 < IRI < 7)
(3) Poor (7 <= IRI < 9)
(4) Very Poor (IRI >= 9)
(5) Very Poor -Unpaved (IRI >= 12)

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 estimated 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

13.3 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 benefits 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

Economic benefits are estimated as the savings in the total VOC cost for a year. The ratio B/C is tabulated by comparing the benefits of the year and the annualized investment cost.

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 Current Budget

The central government prepares the budget for roads from the state budget and Road Fund.

In 1997, revenue of the State Budget was 214 billion tugrugs (about US$ 267 million) and expenditure was 291 billion tugrugs (about US$ 366 million). From that, 4 billion tugrugs (about US$ 5 million) were allocated as the road budget for 1997, 10% of which or 400 million tugrugs (about US$ 0.5 million) were received by UB city.

A Master Plan for Improvement of Roads in Mongolia was worked out in 1995 under the assistance of the ADB. It ensures that the road users should pay for the total cost of roads. If this total cost will be paid from vehicle tax, foreign vehicle transit fee and fuel tax (about 14%), then the economic benefit should exceed the road maintenance cost. The plan estimates the necessary cost for road maintenance for the whole of Mongolia as US$ 13.8 million.

The UB Fund and the Capital City Road Fund are different funds.

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). Since February 1997, a fee of 200 tugrugs is collected for the UB Fund from each car entering UB from the west and east edges and it is estimated to total 110 million tugrugs in a year. At present, the UB city administration is considering to transfer this source of revenue to the Capital City Road Fund established in 1998.

At present, Mongolia has received a loan of US$ 53 million in total from the Kuwait Fund, WB and ADB for road construction and its amortization should start from 2001.

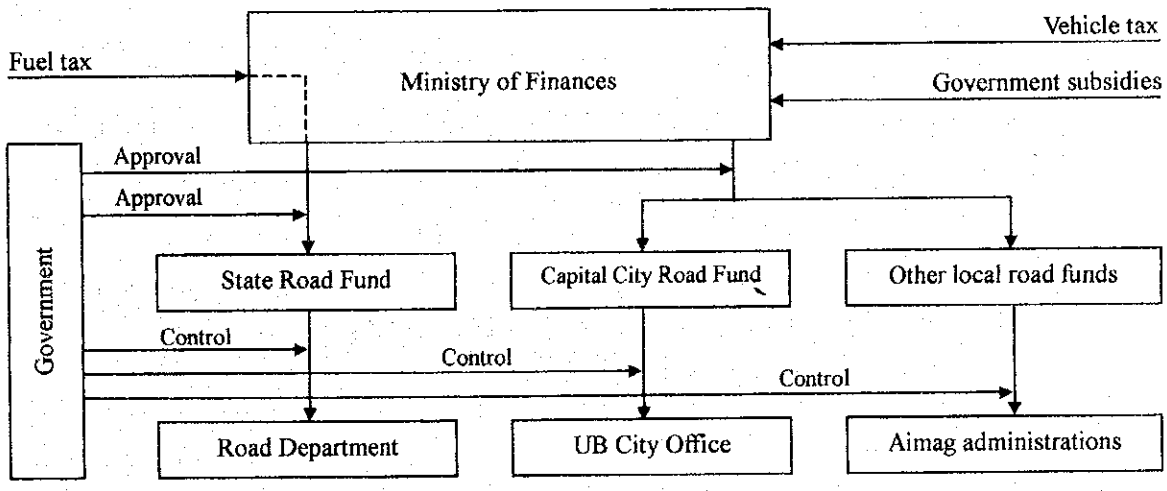


Figure 14.1.1 Formation of Road Funds

14.2 Funds in Future

An estimation of the possible road budget for Mongolia was made on the following assumptions:

1) The annual growth rate of the national budget was assumed as 3.0-3.6 % based on its growth rate of 3.6% / year in the past and forecast of GDP.

2) Taking into account the Government policy giving much importance to road infrastructure, it was assumed that the increasing ratio of the budget for branches other than roads will be kept at a level of 3.0% per annum. Assuming that the difference between the national budget and the budget mentioned above will be allocated as a road budget, then its increasing ratio will look as shown in Figure 14.4.1.

3) The increasing ratio of expenses for road construction and improvement from the road budget was assumed as 4% per annum taking those expenses for 1997 as a base.

4) According to the ADB report, the budget required for road maintenance in 1997 was to be US$ 13.8 million, but, in reality, it was just Tg. 1.1 billion (US$ 1.36 million). Therefore, its increasing ratio was taken as 1.0% to ensure its steady growth up to 2020.

5) Amortization for the present loans which should start from 2001 is shown in Table 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
4. Kuwait	1996	18.2	2.5	20	5	6	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

6) The balance between 2) and 3) - 5) is an acceptable amortization for future loans (Figure 14.4.2) , and having that balance, the amortization will become possible for the first time beyond 2010.

7) If the grace period is 10 years, then it will be possible to get new loans starting from 2000, and as Table 14.4.6 shows, their total amount will be US$34 million in 2000 and may increase up to US$66 million if starting from 2005.

Table 14.4.6 Acceptable Amount of Loan

			1997	2000	2005	2010	2015	2020
15	Budget for Roads	(M$)	5.45	11.1	19.6	26.7	31.3	35.9
16	for Improvements	(M$)	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 Loans	(M$)	-	-	-	1.7	3.3	5.6
21	Cumulative Acceptable Loans ($million)	Situ.-1	-	34	66	152		
		Situ.-2		17	33	76		

In 1998, the Road Department made a request to OECF for a loan of ¥3 billion (US$25 million) for the projects for construction of roads under its jurisdiction. This loan is not yet approved. If the implementation of the projects will start in 2000, then the amount of Cumulative Acceptable Loans will be significantly decreased and it will be necessary to look for other sources for the improvement of UUB road network.

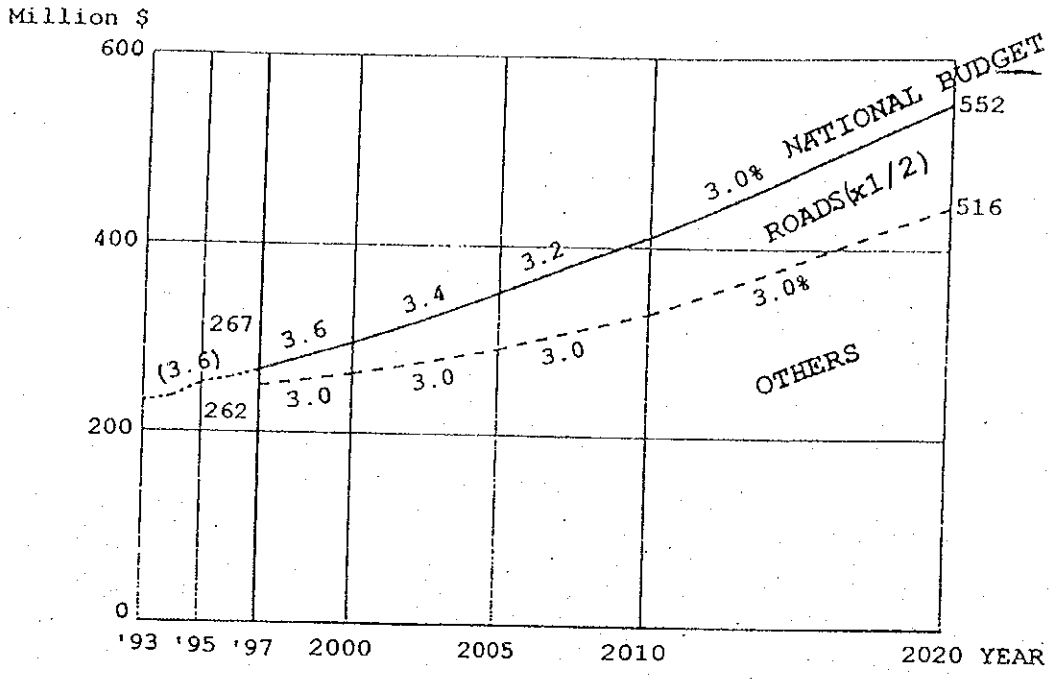


Figure 14.4.1 National Budget Forecast

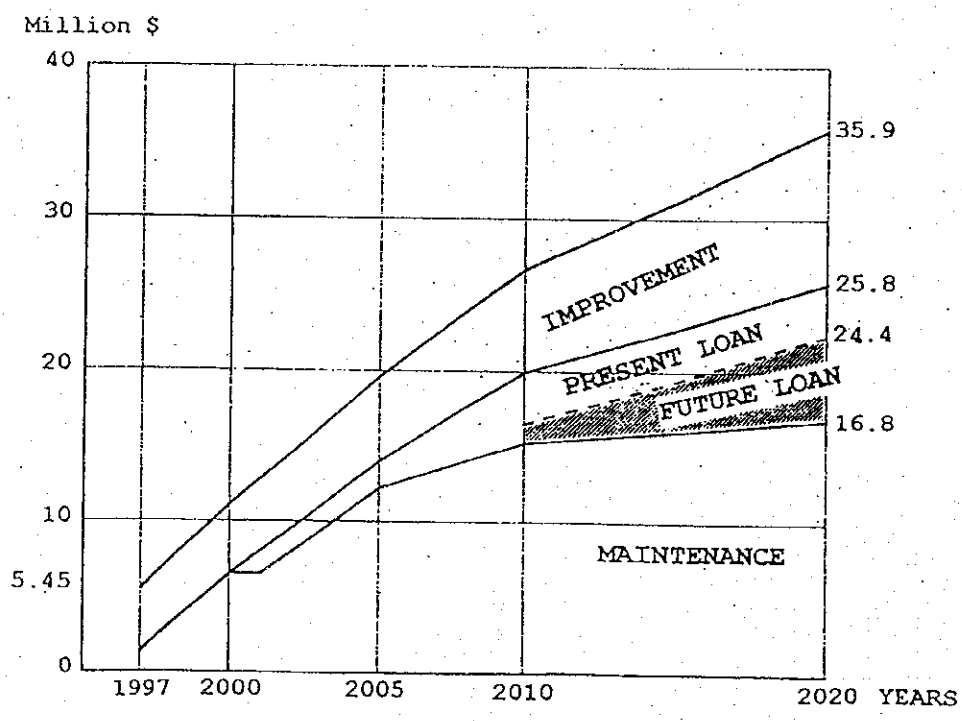


Figure 14.4.2 Road Budget

Chapter 15 Selection of Projects for Feasibility Study

15.1 Outline of the Selection

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.

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	**South-South**

	street to Chingis avenue in order to handle the existing traffic.	
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, ease 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

15.2 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".

Figure15.1.1 shows the locations of the projects from 1 to 4 of above table.

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

Route Name	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**
		Bridge No.28,No.29		**2**	**Protect ion of Abutment**	
	New	**Bridge No. NB-28',NB-29'**		**-**	**Yes**	**2**
	New	**West Naran ~ Ard Ayush**	**3.006**	**-**	**Yes**	**4 4**
	New	**Bridge.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	**Nouth Road 88 ~ Intersection 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 Road	1.85	2	-	-
	39	**South of Power Station 4**	**5.942**	**2**	**Yes**	**4**
	New	**Bridge.No.SB-50'**		**2 (Broken)**	**Yes**	**4**
	117	**Dund Gol River Side Rd**	**1.00**	**2**	**Yes**	**4**
	New	**Teeverchid South West Exttention**	**0.71**	**-**	**Yes**	**4**
	New	**Teeverchid Extention Flyover**	**Bridge 0.21 Approach 0.28**		**Yes**	**4**
	41	**Teeverhid Road**	**8.368**	**2**	**Yes**	**4**
	New	**Bridge No.CB-17'**		**2**	**Yes**	**4**
	1	*Peace Ave. (East)*	*4.5*	*4/2*	-	-
	71	Ajilchin Str. 1	1.3	2	-	-
	72	**Ajilchin Street 2**	**1.096**	**2**	**Yes**	**2**
Middle Ring Route	2	Chingis Avenue	2.6	4	-	-
	34	Engels Str				
	New	**Terminal~Engel Road Flyover**	**Bridge 0.248 Approach 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 Road Flyover**	**Bridge 0.12 Approach 0.28**		**Yes**	**2**
	97	13/14 kholoo rd				
	New	**Stadium~New Market**	**3.12**	**-**	**Yes**	**4**
(Improve /New)	IS 4	**Geser Temple** Intersection			**yes**	**Yes**
	IS 3	**Ayush-Amarsanaa** Intersection			**yes**	**Yes**
		Other 16 IS in FS Route			**yes**	**Yes**

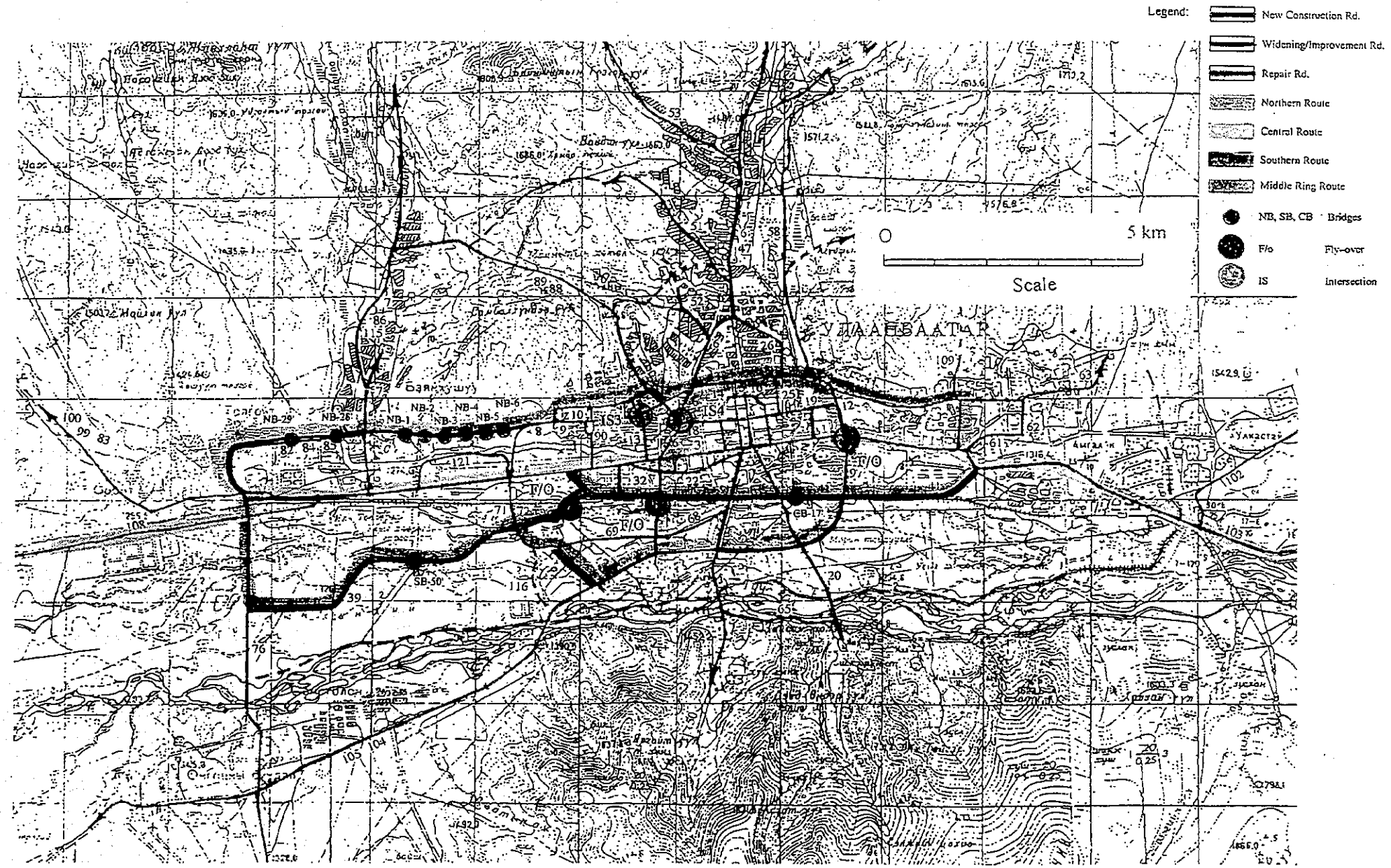


Figure 15.1.1 Location Map for F/S Project

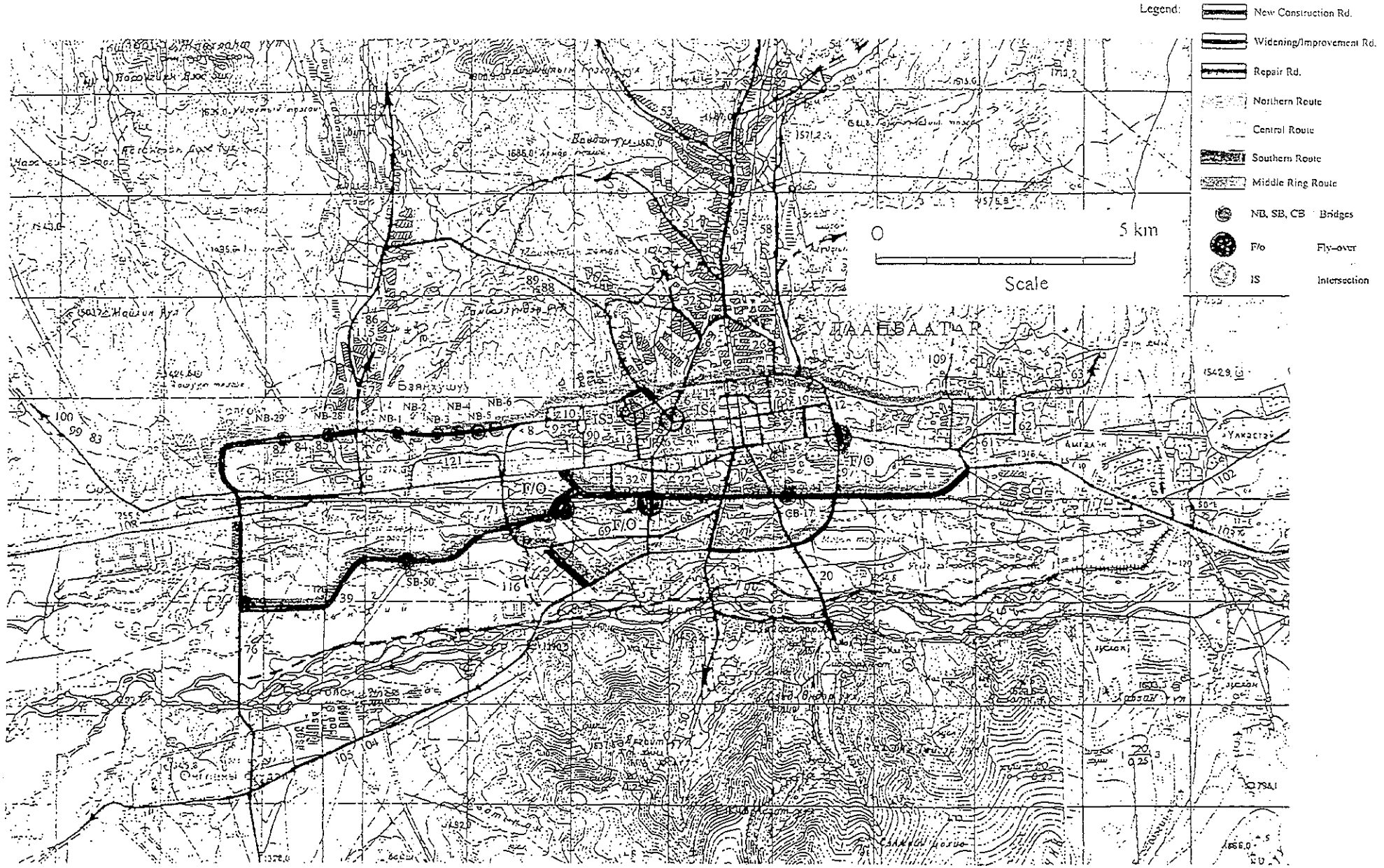


Figure 15.1.1 Location Map for F/S Project

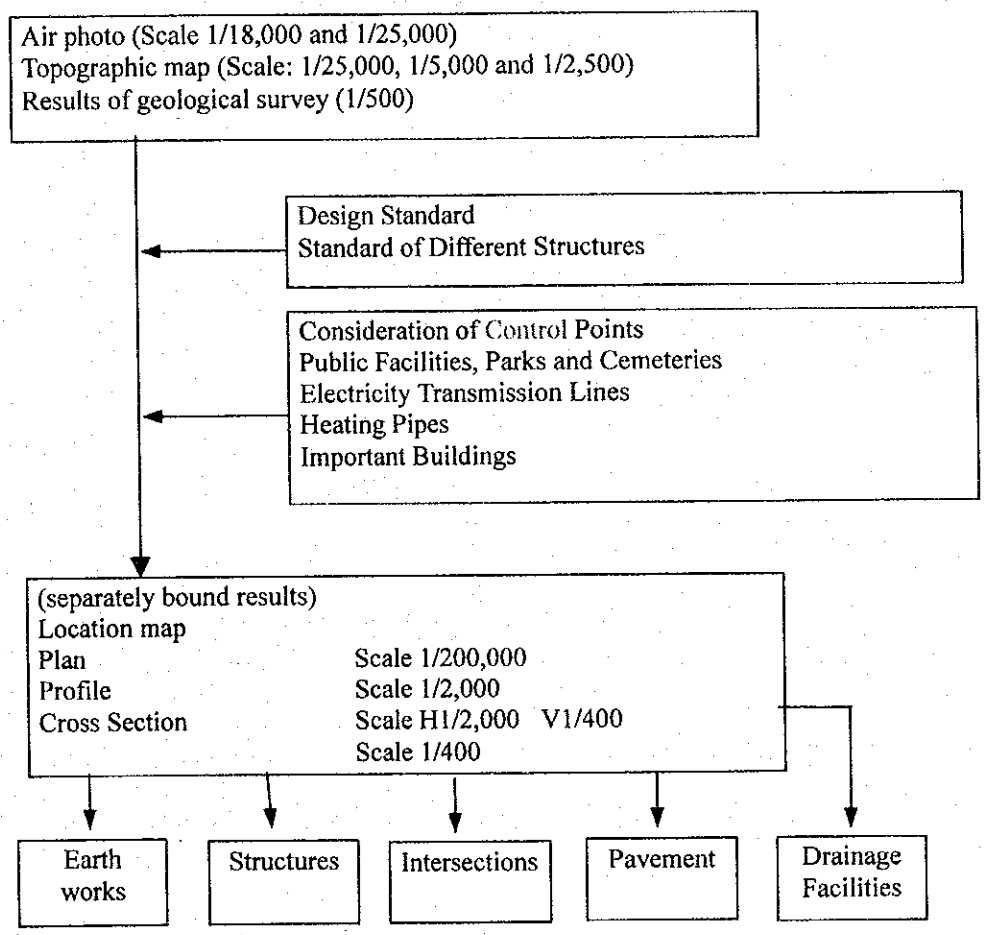
Part 2

Feasibility Study of Selected Projects

Chapter 16 Preliminary Design of F/S Projects

16.1 Design Procedures

Design was executed in the following way.



16.2 Road Bridges

If all existing bridges in 2-lanes on North-West and South-East roads are to be widened, the existing 2 lanes will be continued for use. The new bridge to be constructed in parallel will be designed with 2 lanes. In case of construction of a new bridge, it is recommended to align basically the center of the road with the center of the bridge, although there remains difficult problems in the construction stage. Among the existing bridges, 4 bridges require improvements.

16.3 Drainage facilities

At present, pipes and open ditches were installed partially as road drainage facilities inside urban areas of the city. However, their capacity is not enough. Their capacity is decreased further because of inadequate maintenance. There is a standard for roads in the city to be equipped with pipes, but upon discussions with the city authorities, it was agreed to design open ditches in sub-urban areas of the city because of their easiness to clean.

A more critical problem than the handling of the road surface water is the rushing streams coming from the northern mountainous side during rains. UB city government installed large emergency water-ways in city area for the treatment of the rushing streams. However those capacities are still not enough and sometimes the road itself become a large water-way from the northern mountain area to southern Tuul river. In these cases, the roads traffic are obliged to be interrupted for the time being at some areas. One of the reasons of these troubles come from the interruption of water flow by the embankment of railway and roads which are stretching from east to west as a dike. The Study Team proposed to improve especially two openings for water flow where the capacity is in short.

16.4 Pavement Design

The pavement design is summarized in Chapter 11 describing the methods. The traffic volume was evaluated as shown below on 4 kinds of roads. With the prediction of the heavy vehicle traffic volume for 10 years starting from 2000, the following estimation for the design capacity of the pavement was performed.

Table 16.6.1 Heavy Traffic Volume in 2005 and 2020

Categories	2020 ADT	2005 ADT	2005 Heavy Traffic	Equivalent 18 kip single axle loads number	Design Thickness (cm)		
					Base Course	Binder	Surface
4 lane road A	18,400	15,000	3,000	492,000	28	6	4
4 lane road B	25,200	20,000	4,000	656,000	32	6	4
2 lane road A	2,600	2,400	480	78,000	35	-	5
2 lane road B	11,700	9,000	1,800	295,000	23	6	4

16.5 Improvement of Bus Stops

16.5.1 Division of the Bus Stop Area

At present all buses come to the stop area (bus bay and road side) and people move back and forth to catch a bus. In order to reduce the confusion at the crowded bus stops, the stop area should be extended by 10m to have two separate groups each having its own designated routes. At the side of each group there must be a bus information board showing routes, frequency and other pertinent information. Bus drivers should stop at one designated group area. The following busy bus bays are selected for improvement.

	Enkh Taivan Ave. (East Cross Rd)– (Ajilchin Circle)	Ard Ayush Road (Trolley end point in Dist 3/4) – (Ard/Amarasana J)
Stop without bay	6	1
Stop with bus bay	15	3
Total	21	4

The total cost on the above 2 sections are:

7 stops * 0.9million =Tug 6.3 million = $7,500

18 bays* 1.5 million = Tug 22.5 million = $26,800

Total $34,300

16.5.2 Bus Lanes and Bus Priority Lanes

It is considered no need to enforce immediately rules of giving priority on bus transport since traffic congestion is not so heavy. Need may arise after several years. Accordingly, in the coming years, discussions with other agencies including traffic police should be held to prepare the implementation.

Chapter 17 Construction Method for F/S Projects

17.1 Key points for construction of F/S projects

In general, the followings should be taken into consideration in the construction of roads and bridges in UUB :

1. Construction period is limited from May to October due to severe weather conditions.
2. Asphalt pavement construction period is from June to September, if pavement works are carried out on days of more than plus 5 degrees C.
3. On hauling hot asphalt mixture from mixing plant to site, covering cloths and insulator is necessary for trucks to keep the temperature of the mixture.
4. Early compaction is necessary after laying of hot mixture.
5. Sufficient application of tack coat for the construction joints is necessary.
6. Rocks can be expected during excavation in most areas of UUB. And, normal soil is frozen in early spring and late autumn. As a preparation for excavation of frozen soil, a large size excavator is required.
7. There is a possibility to drive sheet piles into frozen soil or hard stratum where N value is more than 50. Therefore, auger or breaker is necessary.
8. Temperature keeping facility is required to avoid freezing during the preparation of cement-concrete mixture.
9. Large size truck crane is unavailable in UUB. However, large size rail cranes of Mongolian Railway could be used for construction of fly-over on railways.

17.2 Key points on each route

Roads for the Feasibility Study were divided into 4 routes.

Major points to be taken into consideration on each route are summarized as follows:

Central route	• Measures for the embankment on soft ground stratum • Safety measures at several railway crossings.
Northern route	• West section: Measures for residential people because the route will past through the residential area • Middle section: Slope protection measures against rushing streams during raining on many embankment and excavation areas. • Eastern section: Traffic control facilities are necessary because surrounding areas of the section will transfer to be the city business area.
Southern route	• Eastern section: Safety measures due to heavy traffic volumes • Fly-over section: Safety measures for railways • Middle section: Available land is narrow. Safety control required for vehicles. • Western section: No special items
Middle Ring	• Water resource section: Measures for the water supplied for the construction works. Safety control for trains.

Route	• Fly-over at East Cross: Traffic control • Fly-over at Bus terminal: Safety control for train. Traffic control.

17.3 Construction method based on above conditions

Road earth works and pavement:	No special problems except work efficiency considering above conditions.
Foundation works of bridge:	Usage of sheet piles shall be decided by prior checking of soils at site about their freezing status and their hardness.
Fly-overs:	Two kinds of methods will be proposed, 1) by truck crane 2) by portal crane Taking into account the current condition of equipment (especially of large size truck crane, etc. locally available, it seems necessary to consider the import of equipment. However, truck crane is recommended because of its possibility for various works in the site where minimum number of equipment be prepared, although its operation cost is high.
East cross intersection	It has high traffic volume. Serious discussion with traffic police is essential for designing of temporary facilities and traffic management. Right of way is not enough on the southern side. Open land on the south-east side, despite of its unevenness, may be utilized as temporary fabrication yard.
Fly-over	Discussions with the railway authorities are essential for designing and construction of fly-overs near the bus terminal and western end of Teeverchid road.

17.4 Construction Periods

Construction period for each project is assumed as follows (excluding period for preparation of design and tender documents):

Central route	2 years
Northern route	4 years
Southern route	6 years
Middle Ring Route	3 years

Table 17. 4 . 8 Construction Schedule for All Projects

	Cost	Ratio	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year
Central Route	5.6	5.3%	10.0%	35.0%	55.0%					
			0.5%	1.9%	2.9%					
North Route	35.3	33.3%				10.0%	10.0%	30.0%	30.0%	20.0%
						3.3%	3.3%	10.0%	10.0%	6.7%
South Route	46.7	44.1%		5.0%	10.0%	20.0%	20.0%	20.0%	15.0%	10.0%
				2.2%	4.4%	8.8%	8.8%	8.8%	6.6%	4.4%
Ring Road	18.4	17.4%			10.0%	5.0%	35.0%	50.0%		
					1.7%	0.9%	6.1%	8.7%		
Total	106.1 (MUS$)	100.0%	0.5%	4.1%	9.1%	13.0%	18.2%	27.5%	16.6%	11.1%

Notes ——— Design ——— construction

17.5 Necessary Equipment and Utilization of Equipment Already Supplied

Table 17.5.2 shows main equipment necessary for the execution of F/S projects and equipment supplied by the previous grant aid projects. Almost all of the equipment supplied are able to be used at F/S project. However, additional equipment such as equipment for concrete works and cranes are required.

Table 17.5.2 Comparison of necessary main equipment and supplied by the grant aid project

Model	Required numbers in FS project	Supplied numbers in Grant project
Asphalt finisher	1	1
Back hoe	2	7
Bulldozer	1	3
Motor grader	1	2
Tire roller	2	2
Macadam roller	1	2
Dump truck	26	29
Large hydraulic breaker*	1	1
Concrete mixer	5	
Concrete pump	1	
Truck crane (60 ton)	2	
Asphalt plant (60 ton)	1	

Note: * For excavating rock and frozen soil

Chapter 18 Cost Estimation for F/S Project

18.1 Conditions

Cost estimation for F/S project is done, basically, by using the same unit price (for materials, equipment and labor) and methods as mentioned in Chapter 12 "Cost Estimation for Future Road Network".

However, the following conditions are added due to changes in conditions in the course of F/S:

Item	Estimation in this Chapter	Estimation in Chapter 12
New pavement	Total 10 cm (2 layers) according to pavement design	Assumed and estimated as 7 cm (2 layers) in total
Embankment of roads	According to the results of the survey, the height of embankment varies between 1.0 m-3.8 m. It was divided into and estimated in 3 groups: a) 1.5m, b) 2.1m and c) 3.8m	All embankments were assumed to be of 1.5m
Cutting work	Cuttings at 2 places on the new construction sections were taken into consideration	Not considered
Underground pipe	From the results of current condition survey it was decided to lay at every 100 m	Assumed to lay D60 cm pipe at every 50 m
Extension of existing underground pipe	Designing of 4 kinds of pipe (D1.0 m-D3.0 m) in accordance with the expansion of road width	Not considered
Slope protection for cutting area	Mortar lining	Not considered
Widening of river dike	It should be considered because the road widening in some places affect the river dike	Not considered
Gutter	It was designed for all roads in accordance with the Mongolian standard except repairing sections	Not considered

18.2 Summary of Cost

The cost by work items is shown in Table 18.3.1 and by route (group) is summarised in Table 18.3.4. The total cost of all F/S projects is about US$116 million as shown in Table 18.3.5.

The indirect cost includes the cost of head office, site office, temporary work, demolition and resettlement, safety measures and quality control. The cost of resettlement and demolition is about US$1.23 million and US$ 66,800 respectively, and are included in the indirect cost. The cost of land acquisition was not considered in this Study because the land of existing and planned projects is owned by the government of Mongolia.

The cost of new 16 bridges shows the largest amount and makes up 30% of the total cost. Then comes new pavement of 270,000 m^2 at 20%, embankment of 420,000 m^3 at 10%, followed by drainage facilities.

Table 18.3.1 Each Work Item Cost (F/S Project)

Work items	Specification	Quantities	Unit	Financial cost (Unit: 1,000 US$) Direct Cost	Total Cost	Ratio (%)
Pavement Repair A	(Good sections)	103,882	m2	803	1,312	1.13%
Pavement Repair B	(Some amount of repair)	41,684	m2	1,490	2,434	2.10%
Pavement Repair C	(Large-scale repair)	53,163	m2	2,757	4,504	3.88%
Pavement Repair D-1	(Full repair Asphalt 100 mm)	43,140	m2	1,725	2,818	2.43%
Pavement Repair D-2	(Full repair Asphalt 50 mm)	2,481	m2	78	128	0.11%
New Pavement 1-1	With embankment H=1.040m Asphalt 100 mm	270,352	m2	14,334.	23,415	20.17%
Sidewalk	Concrete Plate Block	224,824	m2	3,043	4,970	4.28%
Curb stone		89,160	m	1,672	2,732	2.35%
Boundary Block		43,484	m	704	1,150	0.99%
Pipe Culvert	Ø600	10,140	m	2,821	4,608	3.97%
Pipe Culvert	Ø1000	265	m	189	308	0.27%
Pipe Culvert	Ø1500	161	m	198	323	0.28%
Pipe Culvert	Ø2000	87	m	190	310	0.27%
Pipe Culvert	Ø3000	34	m	696	1,137	0.98%
Open Ditch	500 / 2000 x 500	56,206	m	3,232	5,279	4.55%
Gutter		1,124	m	510	833	0.72%
Road Line	W=15 cm	173,240	m	509	831	0.72%
Road Sign		602	place	127	207	0.18%
Traffic Signal (New)	New	12	IS	2,696	4,403	3.79%
Rehabilitation of Bus Stop	Rehabilitation excluding Curb stone	13	Place	154	251	0.22%
New Construction of Bus Stop	New construction excluding Curb stone	19	Place	262	428	0.37%
Embankment	Borrow Materials	416,233	m3	7,161	11,698	10.07%
Embankment	Borrow Materials	10,335	m3	186	304	0.26%
Mortar lining		23,500	m2	291	475	0.41%
Excavation		27,451	m3	196	320	0.28%
Excavation and Disposal		217,150	m3	2,743	4,481	3.86%
Bridge Construction		16	LS	21,622	35,319	30.42%
Environmental protection	Grass on slope	170,827	m2	686	1,120	0.96%
	Tree plantation	1	LS		15	0.01%
				Total	116,253	

Table 18.3.4 : Summary of Costs for Each Route

Unit: 1000 US$

		Name of Route				
	Item	Central Route	Northern Route	Southern Route	Middle Ring Route	All Routes
1.	Material Cost	803	6,866	8,001	3,384	19,054
2.	Labor Cost	326	1,696	2,262	859	5,143
3.	Equipment Cost	2,309	13,056	18,367	7,042	40,774
4.	Direct Cost	3,438	21,618	28,630	11,285	64,971
5.	Indirect Cost	1,203	7,566	10,021	3,950	22,740
6.	Consulting Cost	464	2,918	3,865	1,524	8,771
7.	Contingency	506	3,195	4,213	1,664	9,578
	Total Cost	5,611	35,297	46,729	18,423	104,753

Table 18.3.5 : Summary of Costs of F/S Project

Unit: 1000 US$

	F/S Project	Local Currency Portion	Foreign Currency Portion	Total Cost
1	Central Route	1,289	4,322	5,611
2	Northern Route	6,680	28,617	35,297
3	Southern Route	9,123	37,606	46,729
4	Middle Ring Route	3,293	15,130	18,423
	(Sub-Total for All Routes)	20,107	84,646	104,753
5	Repair of Ajilchin Street 2	126	440	566
6	Intersection Improvement	84	4,332	4416
7	New Drainage Facilities	1,858	2,750	4608
8	Const. and rehabilitation of bus stops	376	305	681
9	Environmental Protection	72	1,157	1229
	(Sub-Total)	2,516	8,984	11,500
	Total	22,623	93,630	116,253

Chapter 19 Economic Evaluation of F/S Projects

19.1 General

In the feasibility stage, economic evaluation was carried out to check the economic viability of project investment and determine their priority from the point of economic efficiency. Economic analysis was done using the standard cost-benefit techniques in which costs are compared with benefits over the project life. Three economic indices were estimated i.e. B/C (Benefit-Cost Ratio), IRR (Internal Rate of Return) and NPV (Net Present Value).

19.2 Methodology of Economic Evaluation

(1) Grouping of F/S Projects

The F/S projects were grouped into 4 traffic corridors or routes as given in Chapter 15. Each route was evaluated separately and, also all routes taken together were evaluated.

(2) Estimation of Benefits for Each Route

Construction and improvement of road projects result in following main type of economic benefits to the society.

1) Savings in Vehicle Operating Costs (VOC)
2) Savings in travel time to passengers and freight
3) Increase in road traffic safety
4) Employment generation especially during the construction stage
5) Reduction in environmental pollution
6) Increased opportunities for industrial development

In this study, only the first two types of benefits viz. savings in VOC and savings in travel time were estimated. These two types of benefits constitute the major portion of benefits arising from the road improvement projects. The other types of benefits are difficult to estimate and quantify in monetary terms and thus were not estimated in this study.

To estimate the benefits, the total VOC and the total travel time were calculated for each route in two cases, the "With Project Case" and the "Without Project Case". The difference in total VOC and travel time between these two cases is the total benefit as shown in Figure 19.2.1. Benefits were estimated for year 2010 and year 2020 through traffic assignment and, for other years through interpolation or extrapolation. VOC was estimated by vehicle type and road surface condition

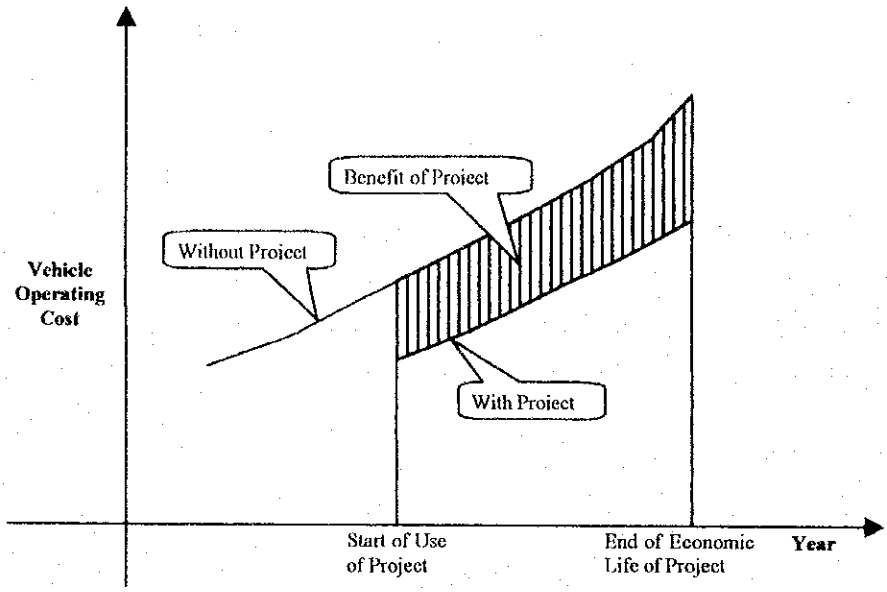


Figure 19.2.1 Sketch Diagram for Project Benefit

(3) Estimation of Construction Cost of Each Route

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.

(4) Economic Analysis

Economic analysis was carried out by comparing the costs and benefits for each year over the project life for each route. Following assumptions were made.

1) A social discount rate of 10% per annum was used. This rate was decided through discussions with the Road Department and, also by referring to similar studies in Mongolia especially by ADB and World Bank.

2) Economic life of 20 years after the completion of construction.

3) Design and construction period of 3 to 7 years depending on route.

Three economic indicators (i.e. B/C, IRR and NPV) were estimated as follows.

1) B/C is the ratio of total discounted benefit and total discounted cost. If it's value is greater than 1 it can be said that the project is economically feasible.

2) NPV is the difference between the total discounted benefit and the total discounted cost. A positive value means that the benefit is greater than the cost and thus the project is feasible.

3) IRR is the economic return generated from an investment, which occurs at regular periods over the project life. IRR is the internal rate of return at which NPV becomes zero. If IRR is greater than the social discount rate (i.e. 10%), the project can be said to be economically feasible.

19.3 Results of Economic Evaluation

The results of economic evaluation are summarized in Table 19.3.1. It can be seen from this table that all the routes (except the Northern Route) are economically feasible. The economic performance of Central Route is highest followed by the Southern Route. The economical performance of Northern Route is low at B/C of 0.71 and IRR of 6.4%. This is because of its high cost. This route passes through mountainous terrain and there are 6 bridges on this route. The economical performance of all routes taken together is only marginally lower at B/C of 0.94 and IRR of 9.3% than the minimum required values of B/C of 1.0 and IRR of 10% to make it economically viable.

Table 19.3.1 Summarized Results of Economic Evaluation

Route	Economic Cost (in US$)	B/C	IRR	NPV
Central Route	4,953,000	1.54	14.7%	2.1
Northern Route	31,574,000	0.71	6.4%	-6.7
Southern Route	41,608,000	1.10	11.3%	2.9
Middle Ring Route	16,451,000	1.03	10.5%	0.4
All Routes	93,429,000	0.94	9.3%	-3.1

B/C : Benefit-Cost Ratio ;IRR : Internal Rate of Return ;
NPV : Net Present Value in million US$