Chapter 16 Preliminary Design of FS Projects

16.1 Roads and Bridges

Design of roads and bridges for FS projects are conducted by the following procedures:

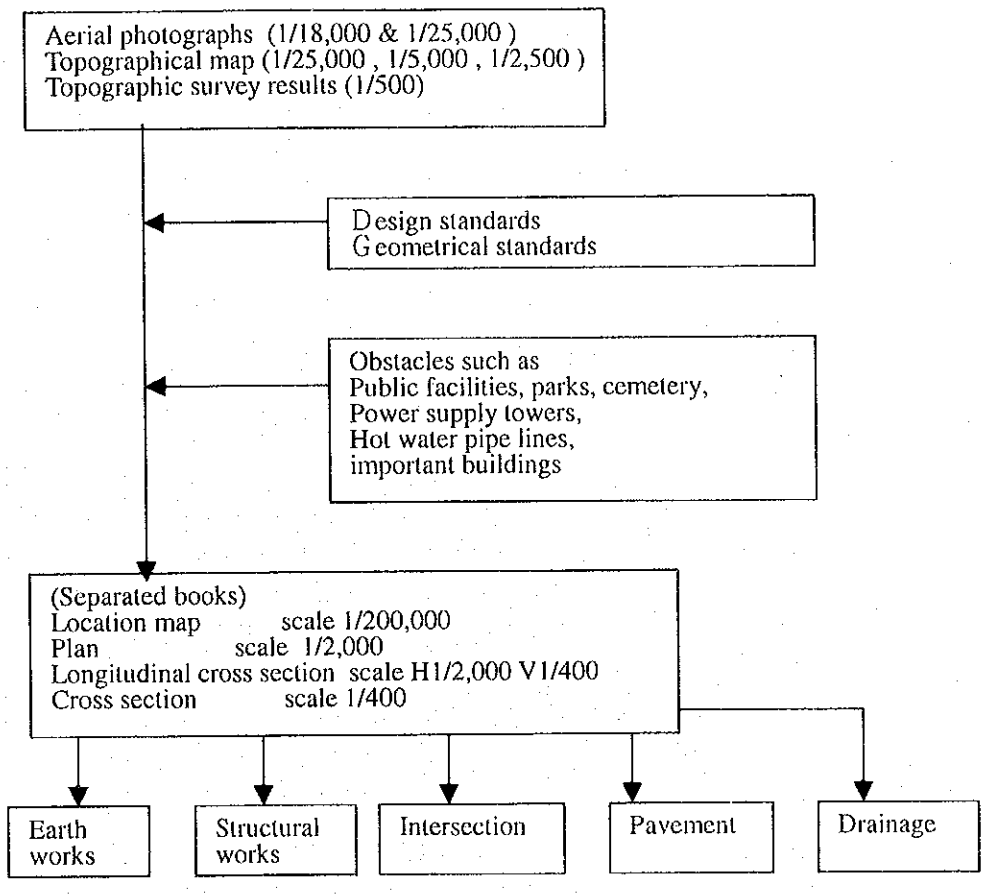


Figure 16.1.1 shows roads alignment for whole F/S projects with lane numbers.

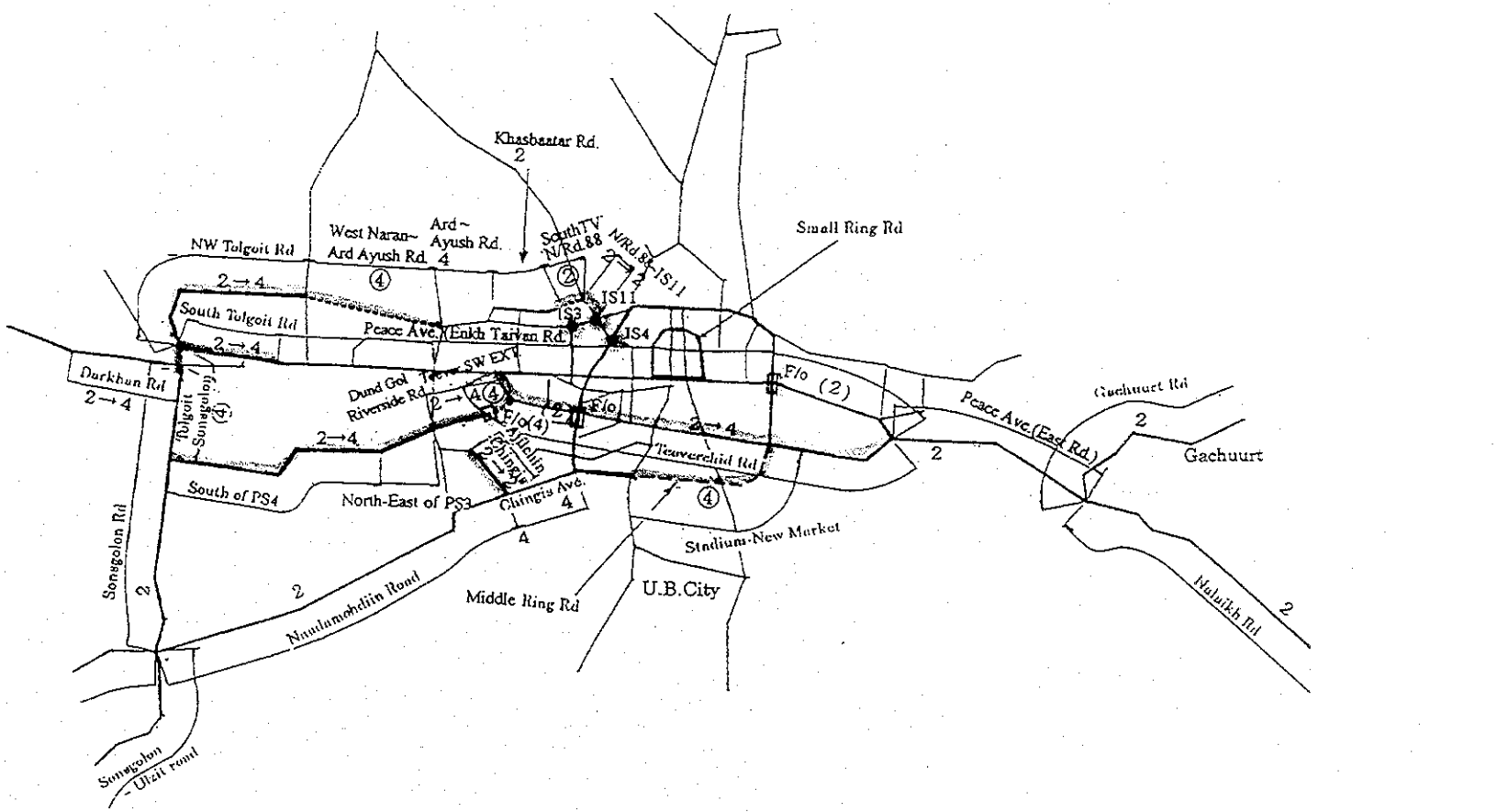


Figure 16.1.1 Traffic Lane Number of Roads for FS Project

16.2 Design Policy for Each Route

16.2.1 South Tolgoit (New road along the existing road Fig. 16.2.1)

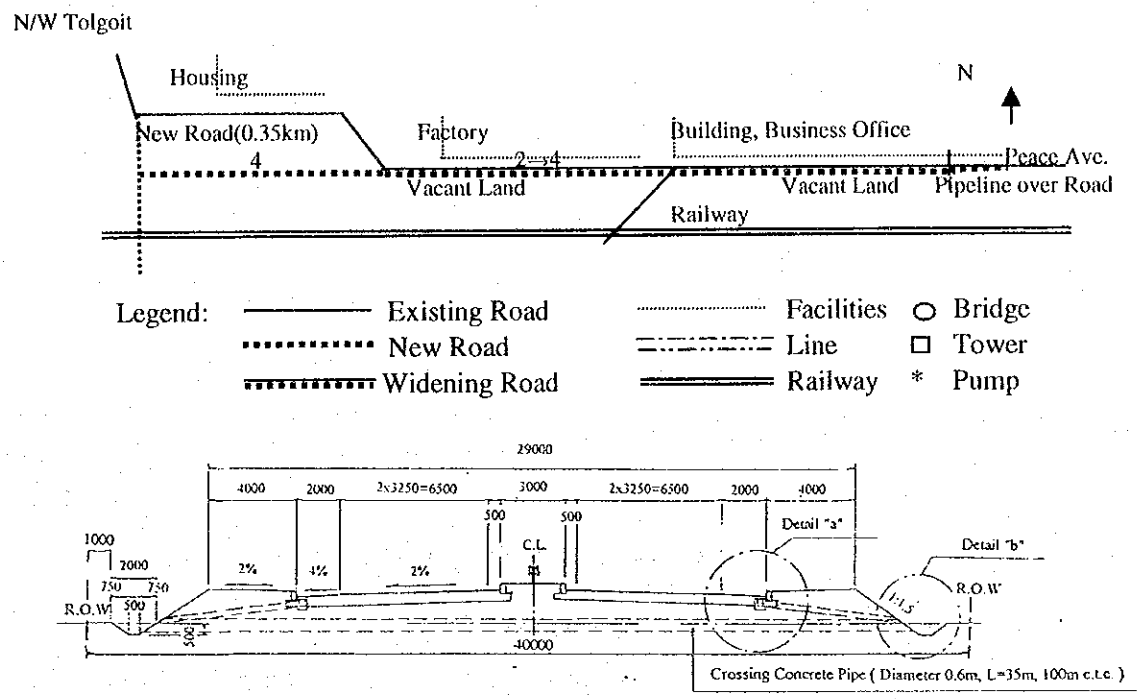


Figure 16.2.1 South Tolgoit

The route is selected to pass the south side of South Tolgoit road considering the existing factory and buildings located at its north side. Pipe lines shall be shifted up to ensure the clearance limit of the road.

16.2.2 Sonsgolon – Tolgoit (New road Fig. 16.2.2) (Cross section is same as 16.2.1.)

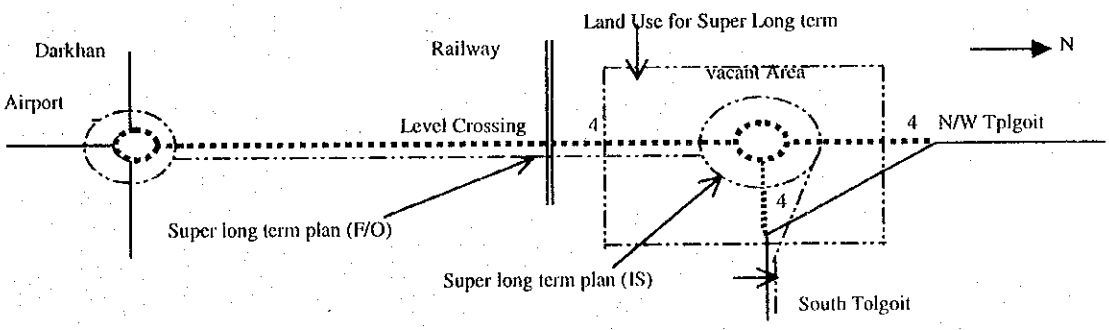


Figure 16.2.2 Sonsgolon~Tolgoit

Sonsgolon road from the air port meeting with Darhan highway will be extended crossing the railway to connect with Tolgoit road. Two large rotaries at both sides of the railway are designed to ensure the smooth traffic at the two intersections. It is expected to ensure large land acquisition in this stage considering the construction of fly-over in future.

16.2.3 North-West Tolgoit Road (Improvement Fig 16.2.3)

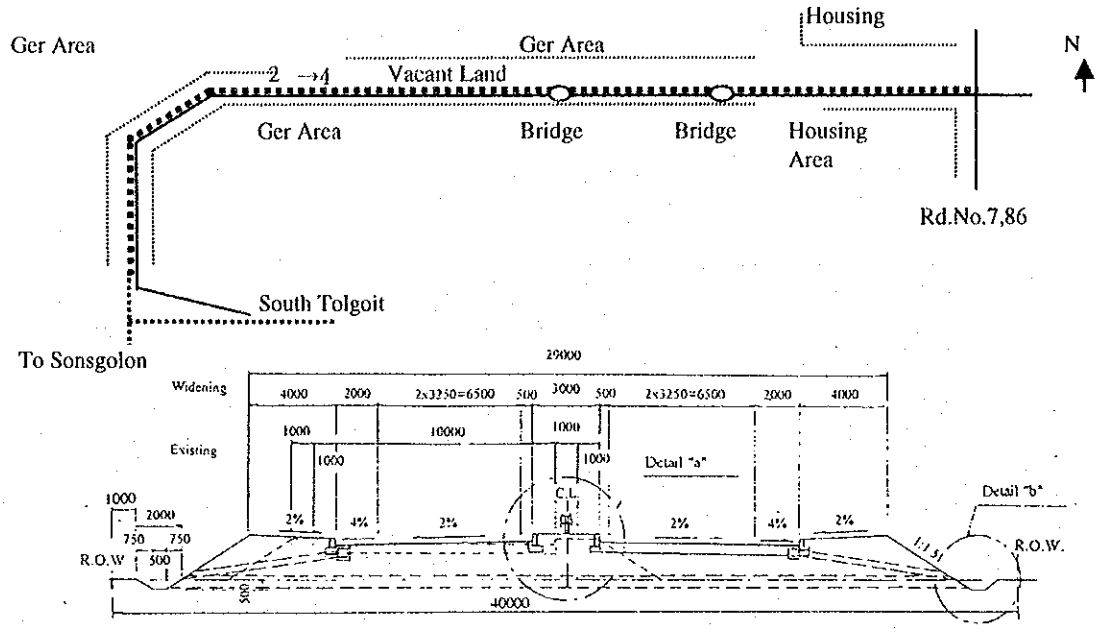


Figure 16.2.3 North-West Tolgoit Road

New widening of the road is planned to the north side of the existing Tolgoit road considering the available spaces and minimum earth work volume. Two new bridges will be constructed parallel with existing one.

16.2.4 West Naran – Ard Ayush (New Road Fig 16.2.4)

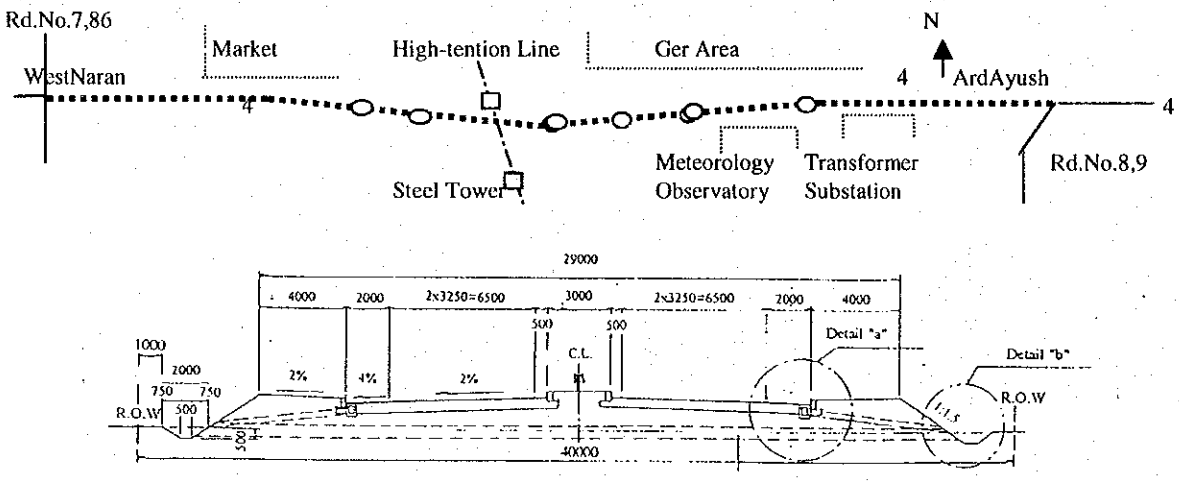


Figure 16.2.4 West Naran~Ard Ayush

This section is composed of hills with south slopes and many valleys. South side low route is selected to reduce the earth work volume by high embankment, large excavation, and the length of bridges. The valleys have traces of flood with height of 1 to 3 m. Slope protection shall be designed for the filling and cutting area. Control points are steel tower for electrical power and meteorological station.

16.2.5 South of TV – N/Roads 88 (New Road Fig 16.2.5)

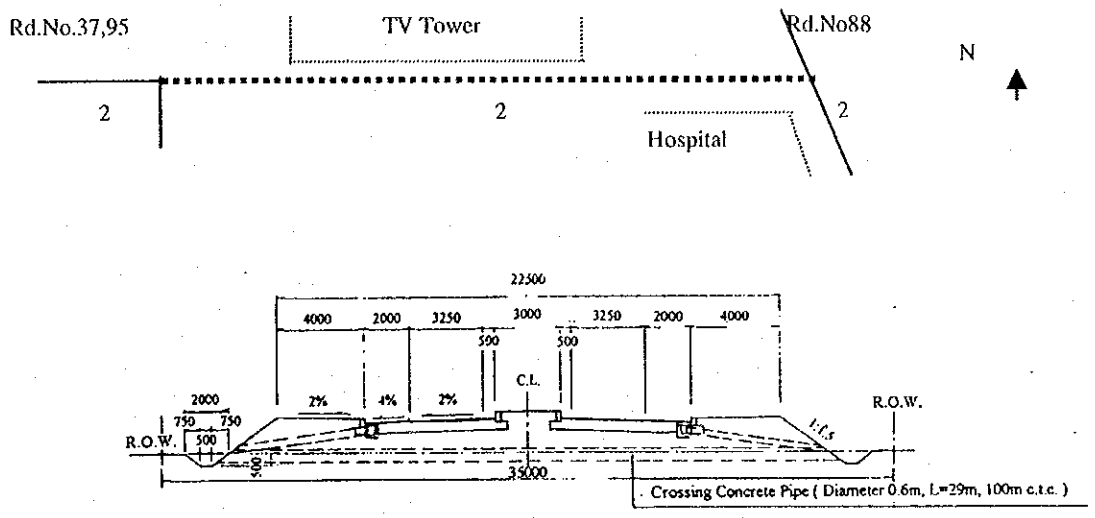


Figure 16.2.5 South of TV~N/Road.88

The height difference between right side and left side is substantial. An embankment of the existing roads at the starting point and ending points is designed to save the cutting at the middle point of the road (at the side of TV tower).

16.2.6 N/Rd.88 – Intersection 11 (Improvement Fig. 16.2.6)

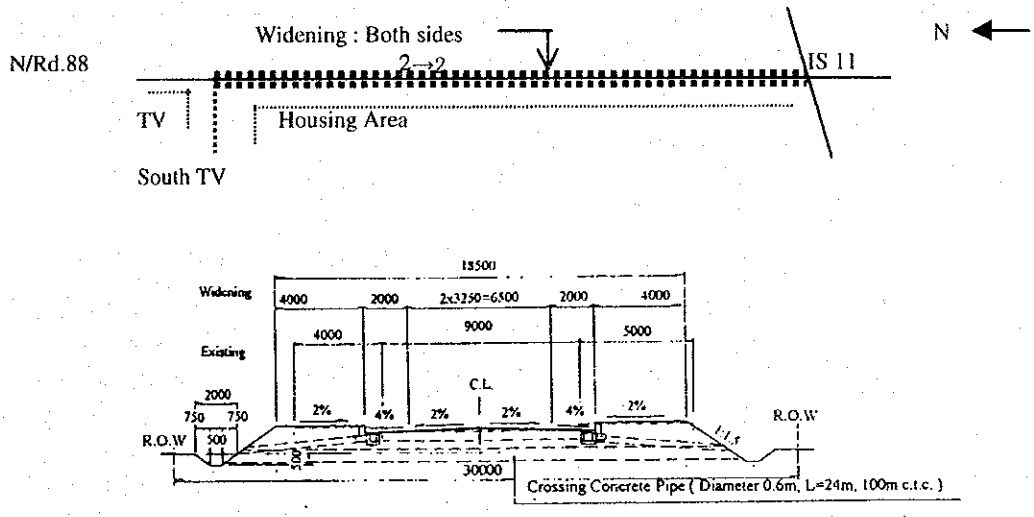


Figure 16.2.6 N/Rd.88~ Intersection 11

Road will be expanded to both sides by 0.75m. Pedestrian sidewalk will be installed by cutting the existing cliff partially.

16.2.7 National Stadium – New Central Market (New road Fig 16.2.7)

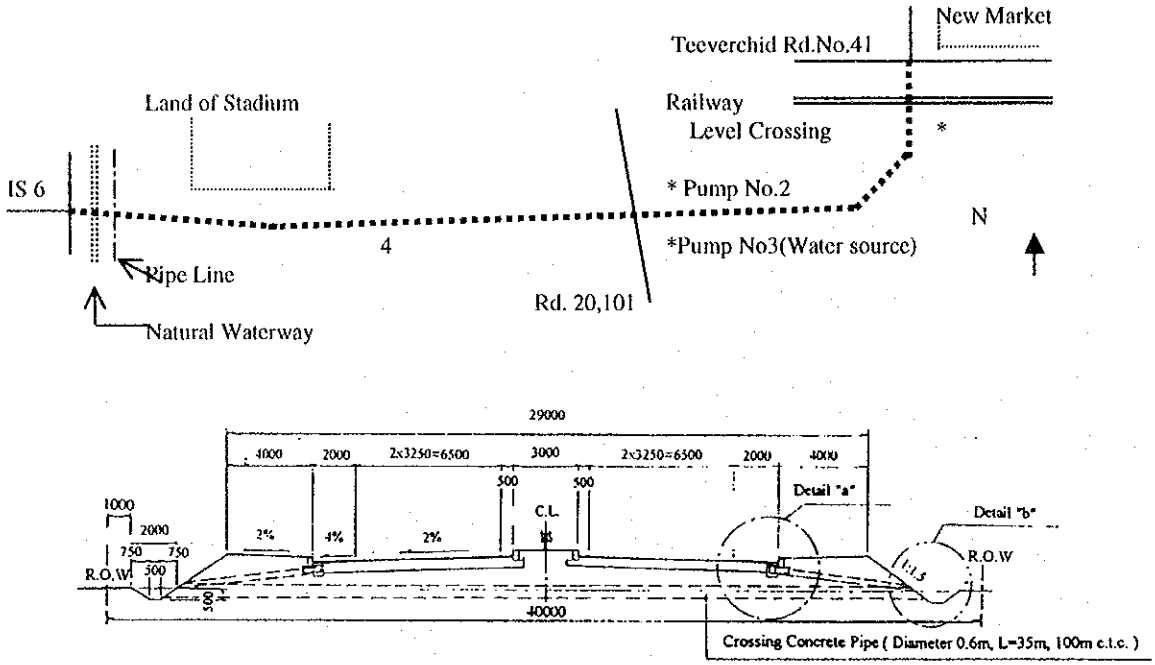


Figure 16.2.7 National Stadium~New Central Market

Starting point is the intersection of memorial battle tank. The road will cross the road (No. 20) to the president house at grade and pass the water resource flat area to cross the railway and connect with New Market road at grade. Both end intersections shall be improved. Longitudinal slope shall be minimum for road surface drainage. Treatment of water drainage and pipeline along the Tingis Avenue shall be taken into account.

16.2.8 Teeverchid Street (Improvement Fig 16.2.8)

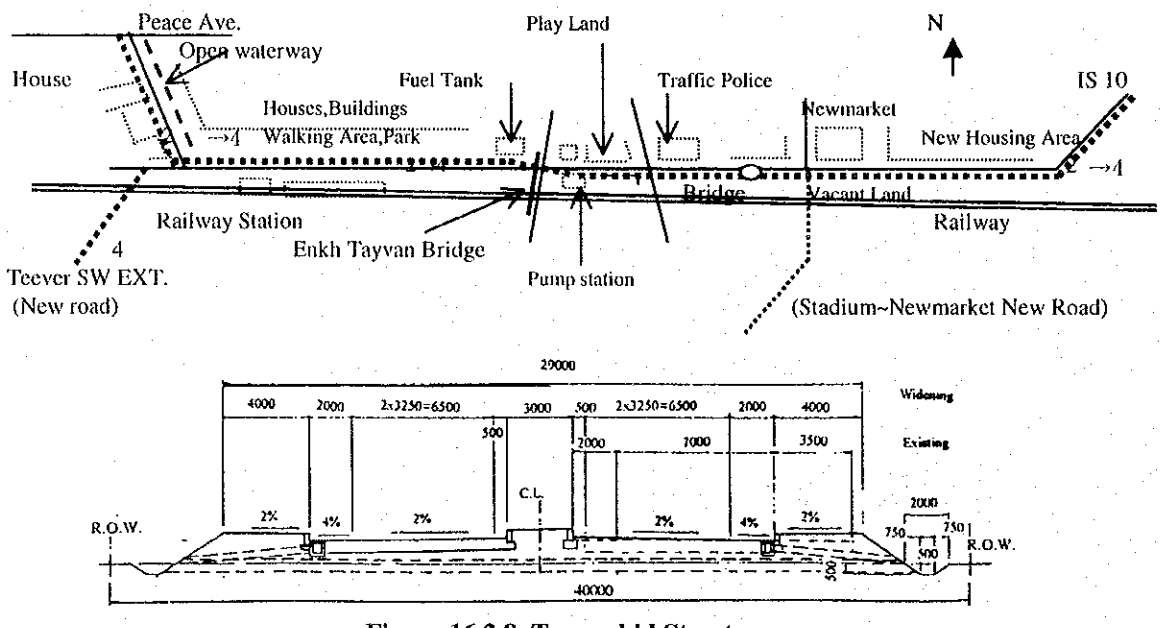


Figure 16.2.8 Teeverchid Street

The alignment is set to the north side of the existing Teeverchid road at the west side from Enkh Tayvan bridge, while to the south side at the east side of the bridge due to the available spaces. Existing road shall be utilized as much as possible and a new 2 lane road shall be constructed parallel with them. Control points are a pier of the bridge, pipeline and its pump station, 2 fuel stations, etc. Existing storm drainage near new central market has been constricted by the construction of new market. Therefore new bridge will not be constructed.

16.2.9 Teeverchid Street Extension (New flyover Fig 16.2.9)

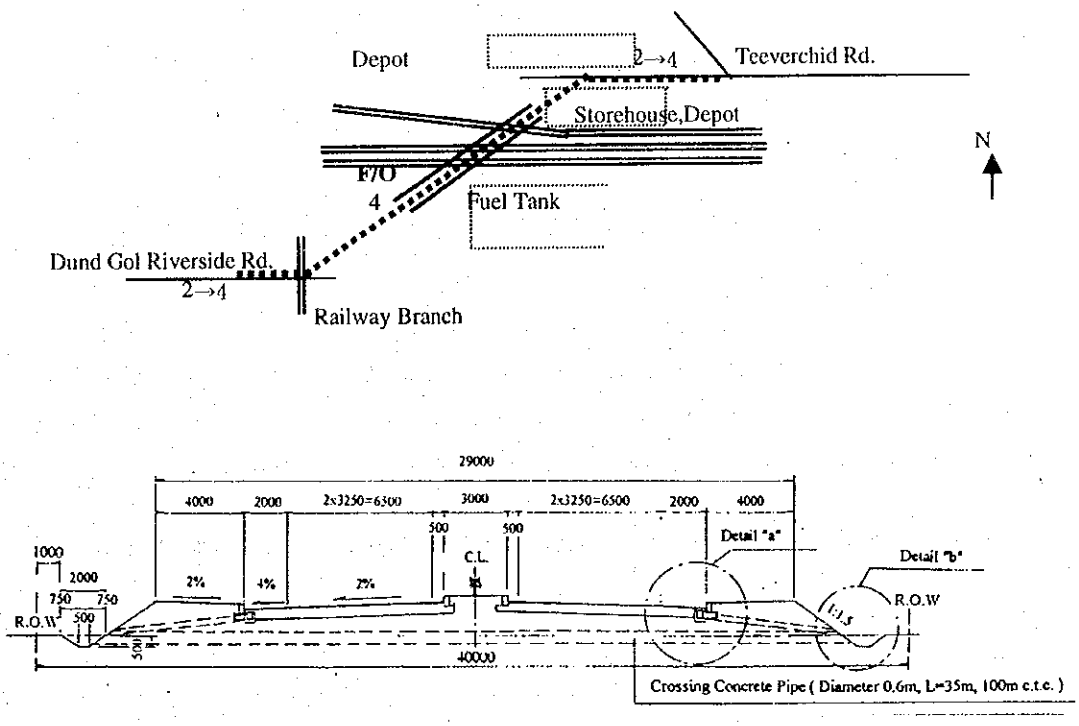


Figure 16.2.9 Teeverchid Street Extention

Now Teeverchid street connects at the west end to Peace Avenue. However the Peace Avenue will become over capacity at the west side in future. New fly-over is planned to connect from Teeverchid street to south side of railway (Dund gol river side road). This area is sorting yard of UB station and there are many obstacles, such as store house, fuel tanks, etc. The route is selected to minimize the relocation of existing facilities.

16.2.10 Dund gol River Side Road (Improvement Fig 16.2.10)

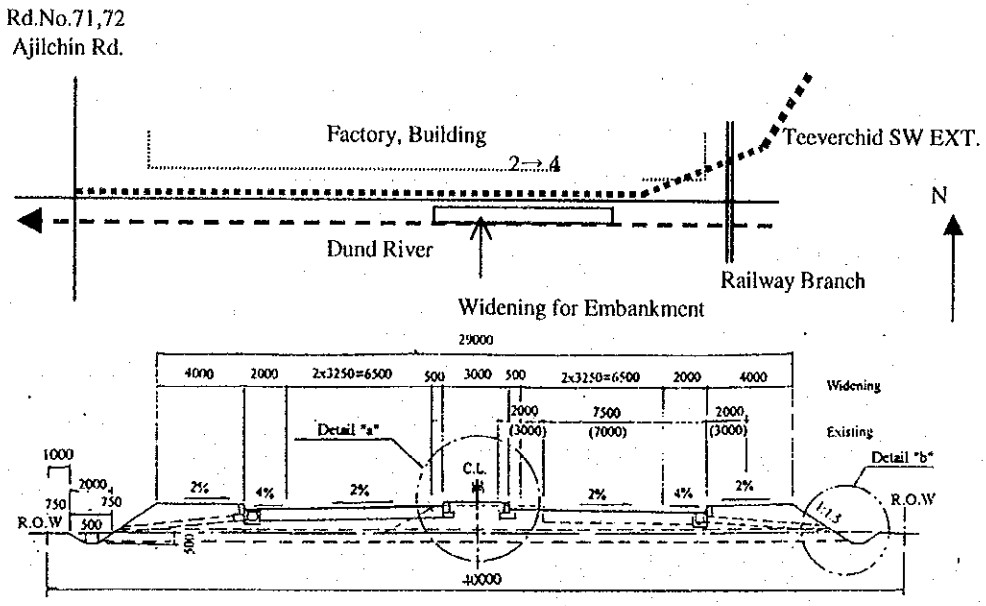


Figure 16.2.10 Dund Gol River Side Road

This road is connection road to Teeverchid extension:. There are factories in north side and Dond gol river in the south side. The dike is 1.5 m higher than the road level. The road will be expanded to the north side since a pedestrian sidewalk of south side will be set on the dike.

16.2.11 South of Power Station 4 – Ajilchin Road IS (Improvement Fig 16.2.11)

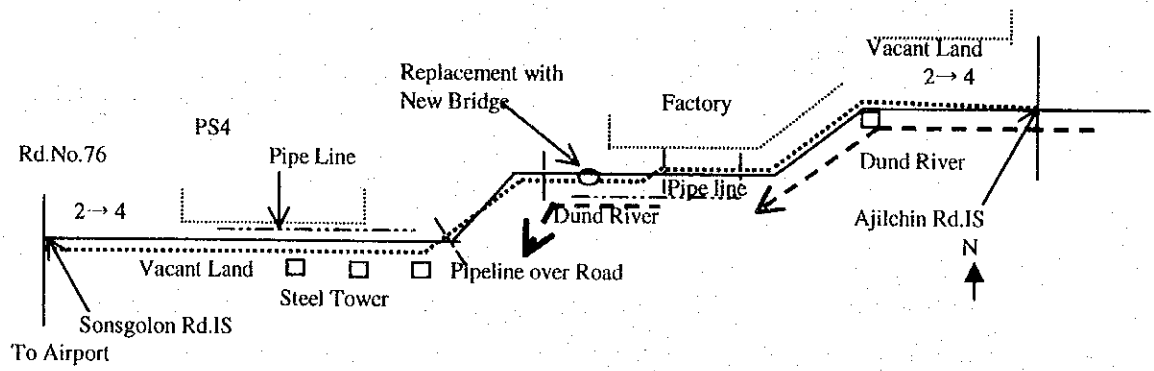


Figure 16.2.11 South of Power Station 5~Ajilchin Road IS

There are large size pipeline and steel transmission tower of power line along the road from Sonslgolon roads IS to PS 4. New route is planned to pass the south side of the existing road.

There is a large size multi-box culvert between PS4 and IS with Ajilchin road. New bridge is planned instead of the damaged culvert. From this culvert, the road alignment will be moved to the north side of the existing road to avoid the large power transmission towers and to reduce the volume of earth work.

16.2.12 Ajilchin – Chingis Avenue (Repair Fig 16.2.12)

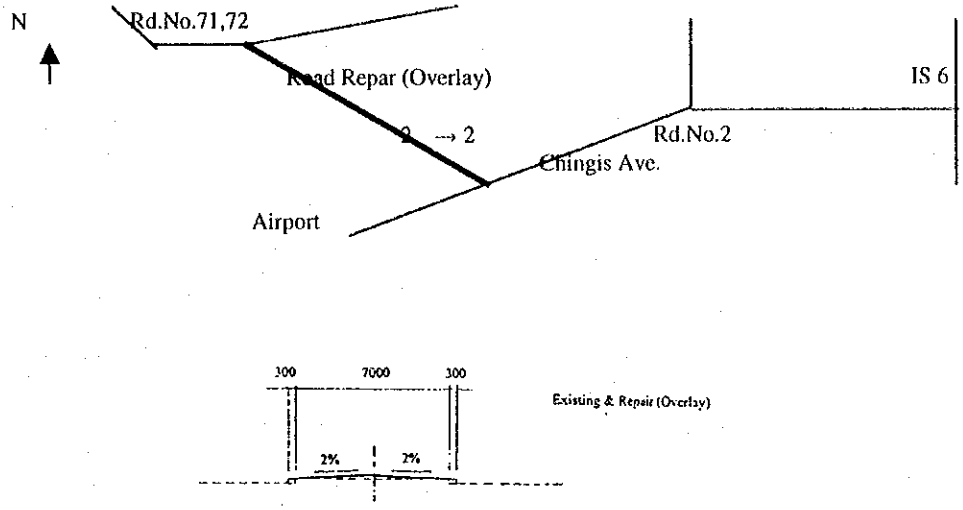


Figure 16.2.12 Ajilchin~Chingis Avenue

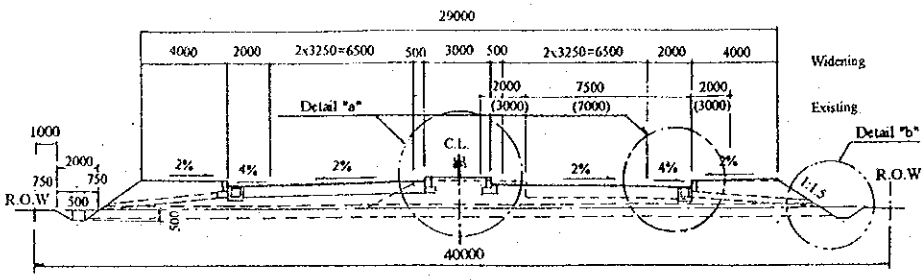
This road was selected as a pilot project for repair. Mainly overlay will be applied.

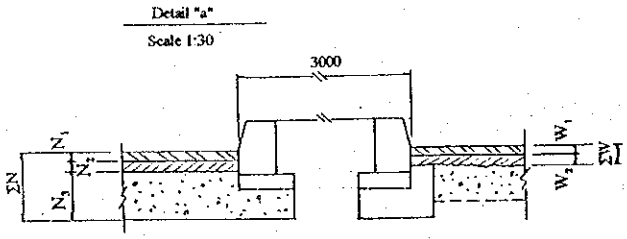
16.3 Drainage

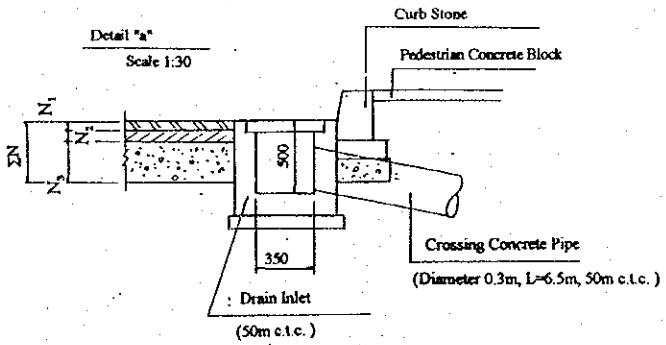
The typical cross section of drainage for the road surface water is shown Figure 16.3.1.

16.4 Quantities

The quantities of roads and subsidiary utilities and pipe culverts along the roads are listed in Appendix Table 16-1.







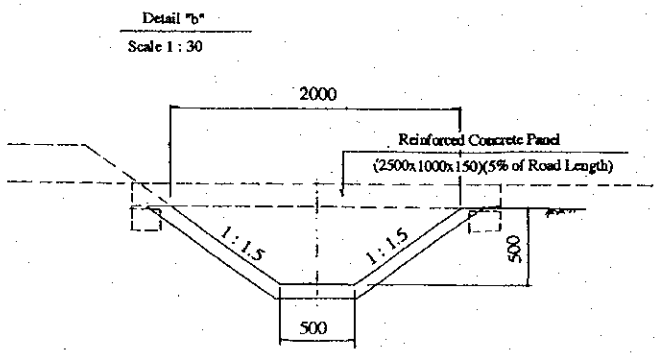


Figure 16.3.1 Typical Cross Section of Drainage

16.5 Design of Bridge and Crossing Structures

16.5.1 Road Bridge

Existing bridge will be utilized as the 2 lane bridge of a new 4 lane road. New bridge for the widening of road will be constructed along the existing one and the old bridge shall be reconstructed in future. The centerline of the bridge was set at the same alignment of the road, although countermeasures shall be considered in future against "closed by construction".

The foundation level was decided to be 1 to 3 meters depth (Gravel sand or solid clay layer) are found in almost all areas of UUB at which the N value will exceed more than 50.

The typical general view and quantities for the road bridges were drawn in Figure 11.6.1.

There are 4 existing bridges in Table 16.5.1 below, and their bridges have following damages:

Table 16.5.1 Existing Conditions of Bridges

Route	Bridge No.	Damages
N/W Tolgoit	No.28, No.29	Scoured on front of abutments
Teeverchid	No.17	Pedestrian slab has minor damages
South of PS4	No.50	Big deformed, cracks at walls

16.5.2 Flyover

Three flyovers below in Table 16.5.2 are designed as described of respective structural type :

Table 16.5.2 Structural Type of Each Flyover

a) East Cross Roads Bridge has 2 lanes.	Span length was decided to be 30 m with PC beam. considering clearance limit and existing underground facilities. Retaining wall will be installed on both sides of approach section for ensuring the space for side road.
b) Teeverchid west end over railway bridge Width is 4 lanes	Span was decided 30 m with PC at main span, and 20 m by RC beam at side span considering many branch rail,. Clearance limit for railway is 6.9 m. 3 column rigid frame. Approach section is embankment with retaining wall.
c) Over railway bridge from Bus terminal to Engel Street. Width is 2 lanes	Main span is 25 m by PC beam. Side span is 17.5 m by RC beams. Approach section is embankment with retaining wall.

a) East cross Roads

Conventional diamond type is recommended from the following points:

- It is a simple structure with one grade separation
- Land acquisition will be minimized. Current road width is 49 m at north side and 16 m at south side. More 15m width of land shall be acquired in the south side.
- Construction cost is low

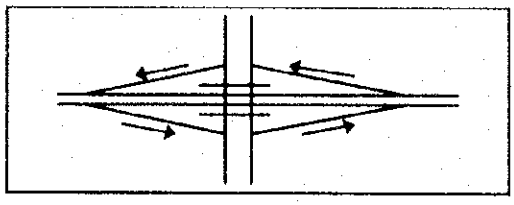
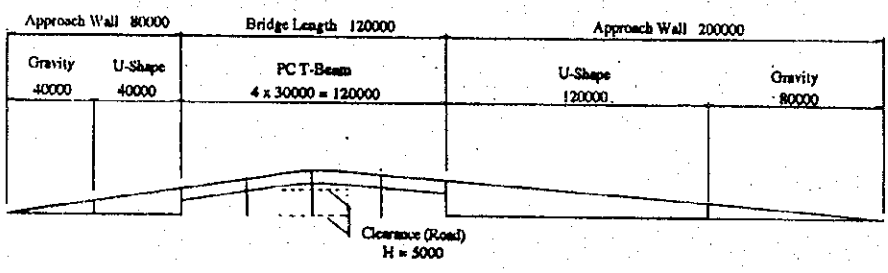
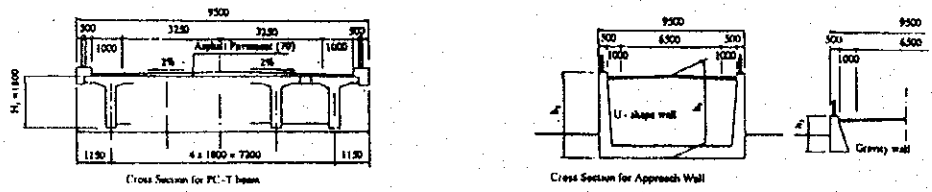


Figure 16.5.1 Illustration of Conventional Diamond Type

Profile and typical cross section are shown in Figure 16.5.2 below.



Profile



Cross Section

Figure 16.5.2 Typical Cross Section and Profile for East Cross Section

b) Teeverchid west end over railway bridge

This flyover is S-shape crossover bridge on the marshalling yard.

Profile and typical cross section are shown in Figure 16.5.3 below.

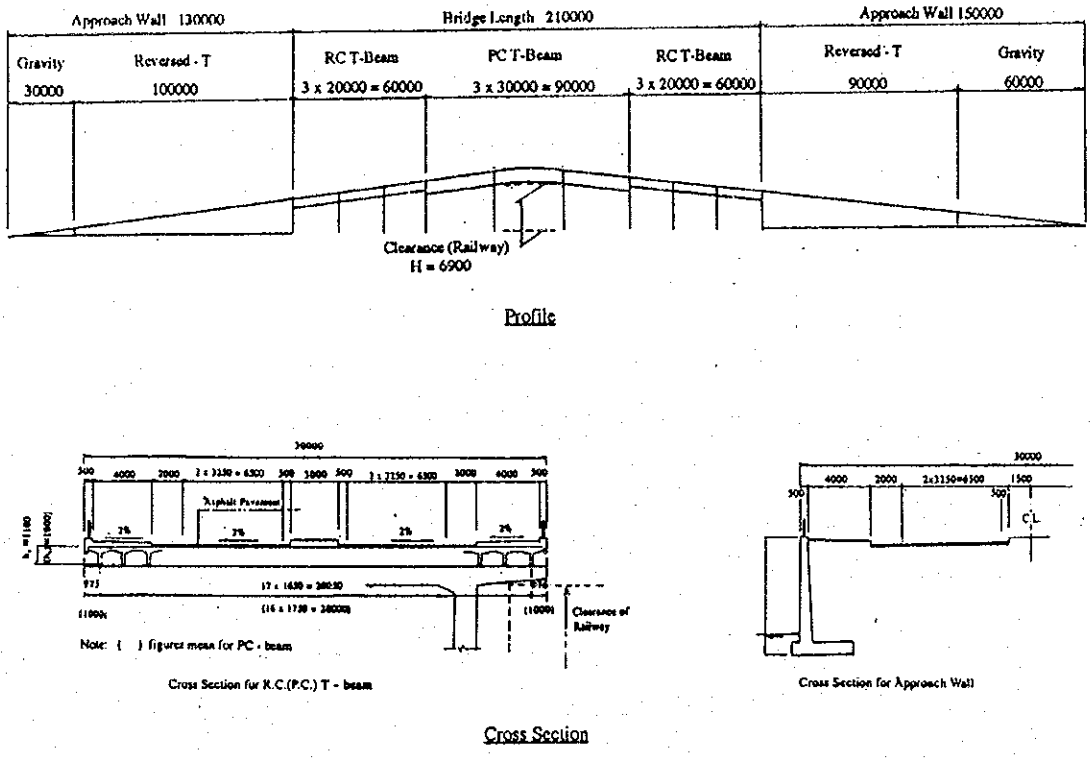


Figure 16.5.3 Typical Cross Section and Profile for Teeverchid SW Ext. F/O

c) A bridge over the railway from Bus terminal to Engel street

This bridge shall cross over not only UB station area but also Teeverchid street. Connection ramp with Teeverchid street shall be taken into account. However there are many control points as shown in Figure 16.5.4.

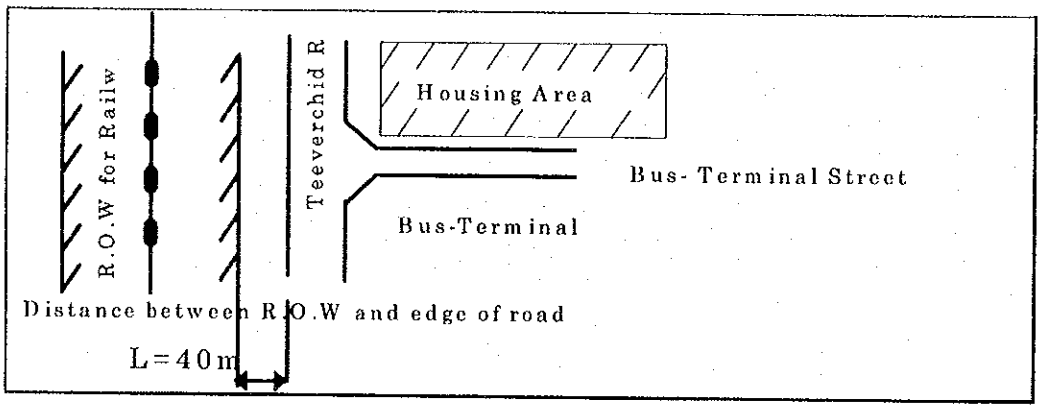


Figure 16.5.4 Control Points of Bus Terminal F/O

Existing bus terminal area has a possibility to be utilized as a quadrant for the grade separated intersection. Two alternatives as shown in Figure 16.5.5 will be considered.

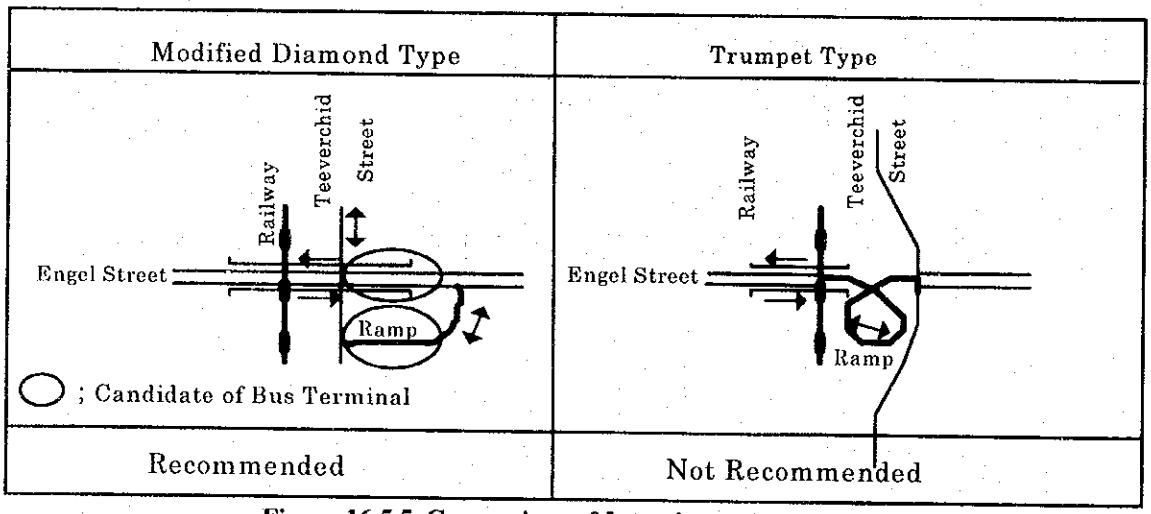


Figure 16.5.5 Comparison of Interchange Type

In case of trumpet type, the diameter of ramp shall be min. 80 m and the Teeverchid street needs to be moved to the north side by about 40 m. This seems difficult from the land acquisition point, and a modified diamond type was recommended. Main span is 25 m by PC beam. Side span is 17.5 m by RC beams. Width is 2 lanes. Approach section is embankment with retaining wall.

Profile and typical cross sections are shown below Fig. 16.5.6.

Profile and typical cross section are shown below Figure 16.5.6.

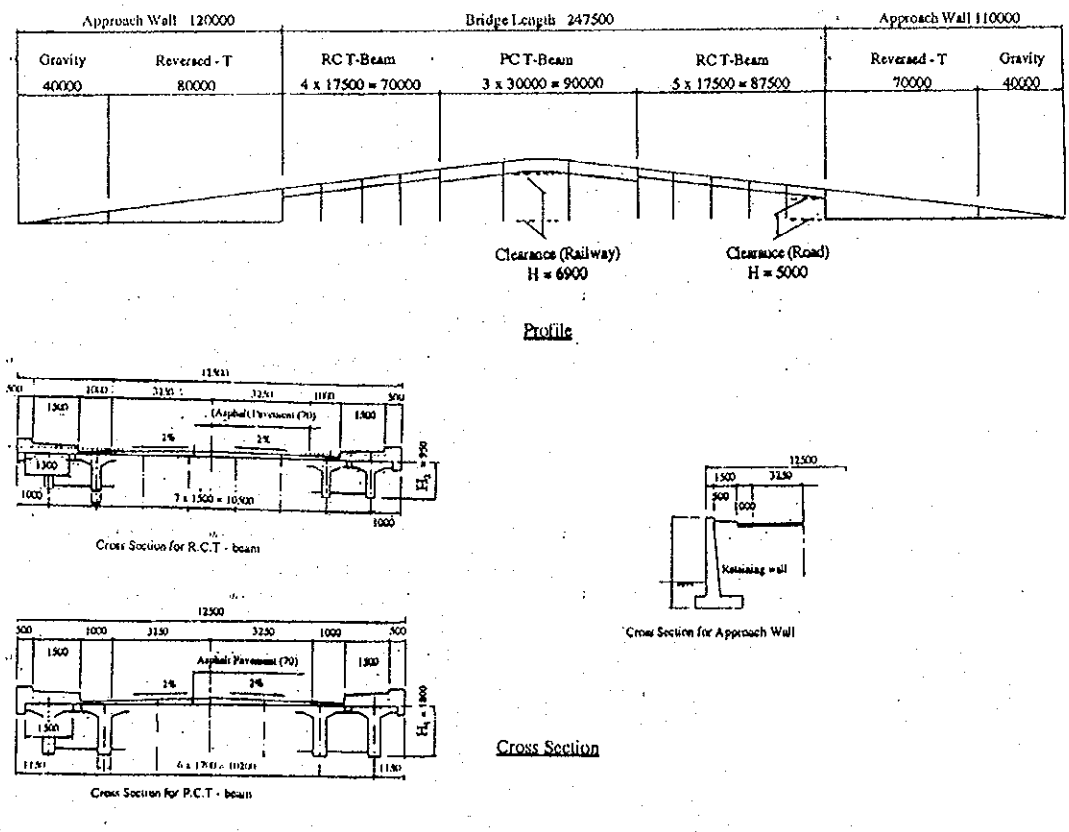


Figure 16.5.6 Typical Cross Section and Profile for Bus Terminal F/O

16.5.4 Intersection

Following 2 intersections are expected to be improved to reduce traffic congestion and accidents as mentioned in Chapter 4.

1 IS 3 Shortage of transional length from B to D.

Cross point of Ard Ayush & Amarsannaa Street

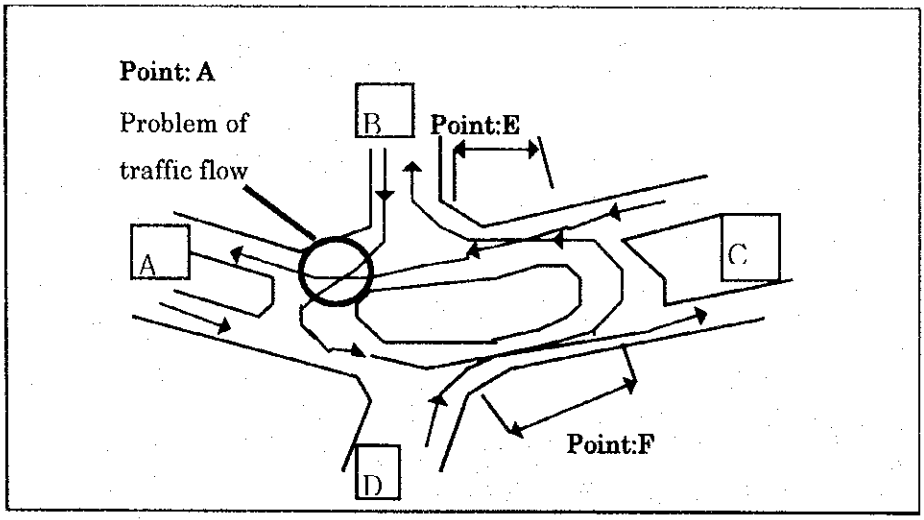


Figure 16.5.7 Layout of IS 3

2 IS 4 Conflict between the two traffic flows, D1 to B and C1

In front of Geser temple

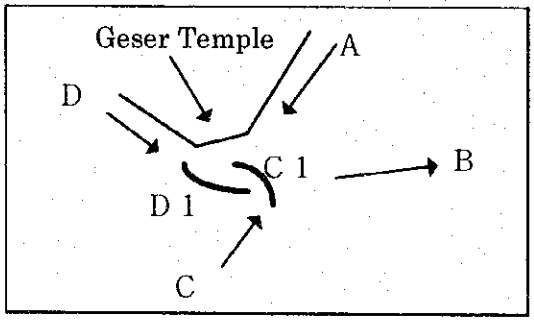


Figure 16.5.8 Layout of IS 4

Traffic capacity of the above two intersections are analyzed based on HCM 1985 for the confirmation of the improvement. Work flow is shown in Figure 16.5.9. Here, ideal saturation flow rate is shown in Table 16.5.3. and a value of 0.9 was adopted as the critical v/c ratio.

Table 16.5.3 Ideal Saturation Flow Rate

Traffic Flow Direction	Ideal Saturation Flow Rate per Lane (PCU/green hour)
Through traffic	1800
Right-turn traffic	1200
Left-turn traffic	1200

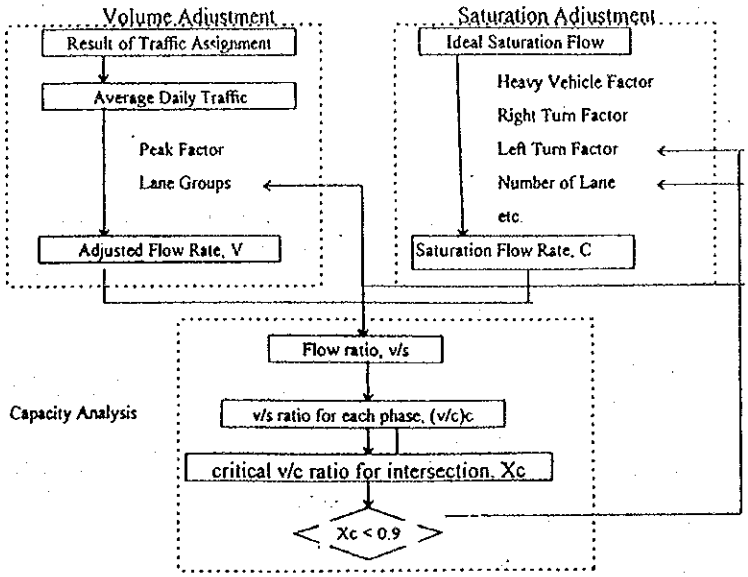


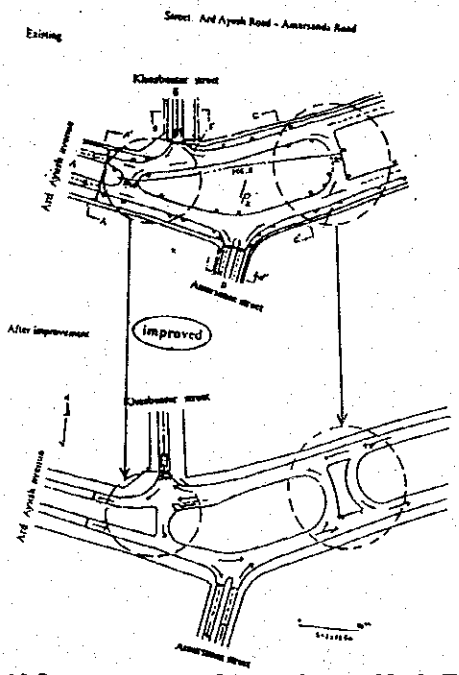
Figure 16.5.9 Flowchart of Capacity Analysis for Intersection

The result of critical v/c ratio in present and in 2020 is shown in Table 16.5.4.

Table 16.5.4 V/C Ratio In 1998 and 2020

	1998	2020
IS 3	0.58	0.59
IS 4	0.52	0.90
	At peak hour	At peak hour

Improvement methods of above intersections are shown in Figure 16.5.9 and Figure 16.5.10.



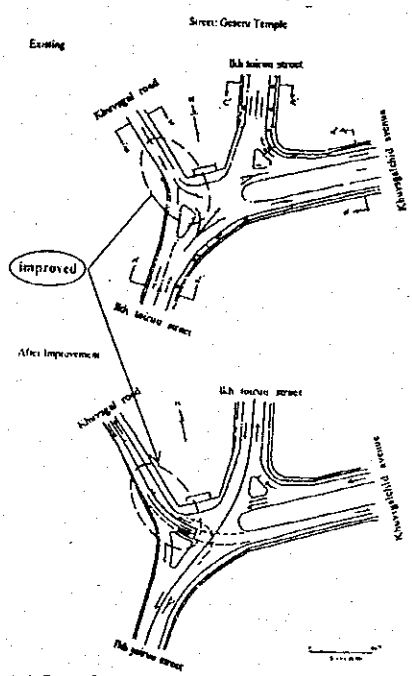


Figure 16.5.10 Improvement of Interchange No.3 Figure 16.5.11 Improvement of Interchange No.4

16.5.5 Drainage and Hydrological Study

The location of existing underground drainage pipes are shown in Figure 4.4.2 in Chapter 4.

The discharge capacity of the above pipes are shown as below: (average velocity is 1-2 m/s)

Diameter	60	70	80	100	150
Water depth (m)	0.50	0.60	0.70	85	130
Area of pipe (m2)	0.26	0.35	0.46	0.52	1.21
Q (m3/sec)	0.2-0.5	0.3-0.7	0.4-0.9	0.5-1.0	1.0-2.4

It is easy to know that these capacities are not adequate for the treatment of all rain on the roads. However on the new design for the roads, the same size of crossing pipe culvert were used for the convenient connection with existing ones.

While in case of drainage along the road, the study team could recommend to use open ditch instead of pipe culvert from two points:

1) Can ensure much more capacity even in case of over capacity

2) Maintenance (sweeping) cost becomes low and easy

UUB receive floods by rainfall in the summer season and roads are placed under water at some locations causing traffic congestion. As mentioned in the chapter 11, the design of adequate capacity of road drainage for these water flows are too expensive and unreasonable.

As one solution, we may propose the following idea. There are many empty lands in UUB area. Some of them belong to public and others to private. These empty areas will be used as an emergency retention pool of the rain water under the establishment of new regulation. Storm water ditches and pipes from the roads shall be connected to these lands and the flood water could be stored tentatively in these places, and it shall be drawn out gradually down stream.

Following is an analysis of the water flow as total UUB and another recommendations for solutions. Rivers inside of UUB will be divided into following 6 areas and the calculated discharge volumes of each area are shown below:

Zone	A	B	E	C	F	D
River name	Bayangol river	Tolgoit river	Urbanized area	Selbe river	Urbanized area	Uliastai river
Catchment area (km2)	86.7	110.8	7.9	295.4	19.6	316.3
Discharge volume (m3/sec)	77.2	95.9	18.3	173.6	35.2	185.9
Necessary Cross section (m2)	7m x 15m	10m x 15m	4m x 6m	13m x 20 m	4 m x 12m	13 m x 20m

(In accordance with the specification of " Hydrology of Roads and Bridges published in Moscow ")

These large volumes of water will flow out through the river. Waterways are shown in Figure 4.4.1 in Chapter 4. However the water will be obstructed to flow out to Tuul river by many obstacles, such as Teeverchid street embankment and railway embankment.

There are 4 existing main ditches and 2 pipe culverts at crossing of the railways in UUB as shown in Fig16.5.12. Among these outlets through the embankment of railways, improvement of E area and new installation at F area should be performed.

Besides, some river sections at crossing of railways shall be improved to deepen and widen for safety of bridges.

16.6 Design of Pavement

Performance period in the design was assumed to be 10 years as mentioned in Chapter 11. It means the middle year of the performance period from 2000 to 2010 is 2005. Future traffic volume (ADT) for the design of pavement in 2005 are assumed based on the traffic forecast results in 2020. They are divided into 2 categories in 4 lane roads and 2 lane roads as shown in Table 16.6.1.. Heavy traffic volume is assumed to be 20 % of ADT.

Table 16.6.1 Heavy Traffic Volume in 2005 and 2020

Categories	2020 ADT	2005 ADT	2005 Heavy Traffic	Eqivalent 18 kip single axle loads number
4 lane road A	18,400	15,000	3,000	492,000
4 lane road B	25.200	20,000	4,000	656,000
2 lane road A	2,600	2,400	480	78,000
2 lane road B	11,700	9,000	1,800	295,000

The results of calculations necessary for the thickness of the pavements are shown in Figure 16.6.1, and Figure 16.6.2 for F/S routes.

This analysis was done by using DNPS-86 program based on the AASHTO guide.

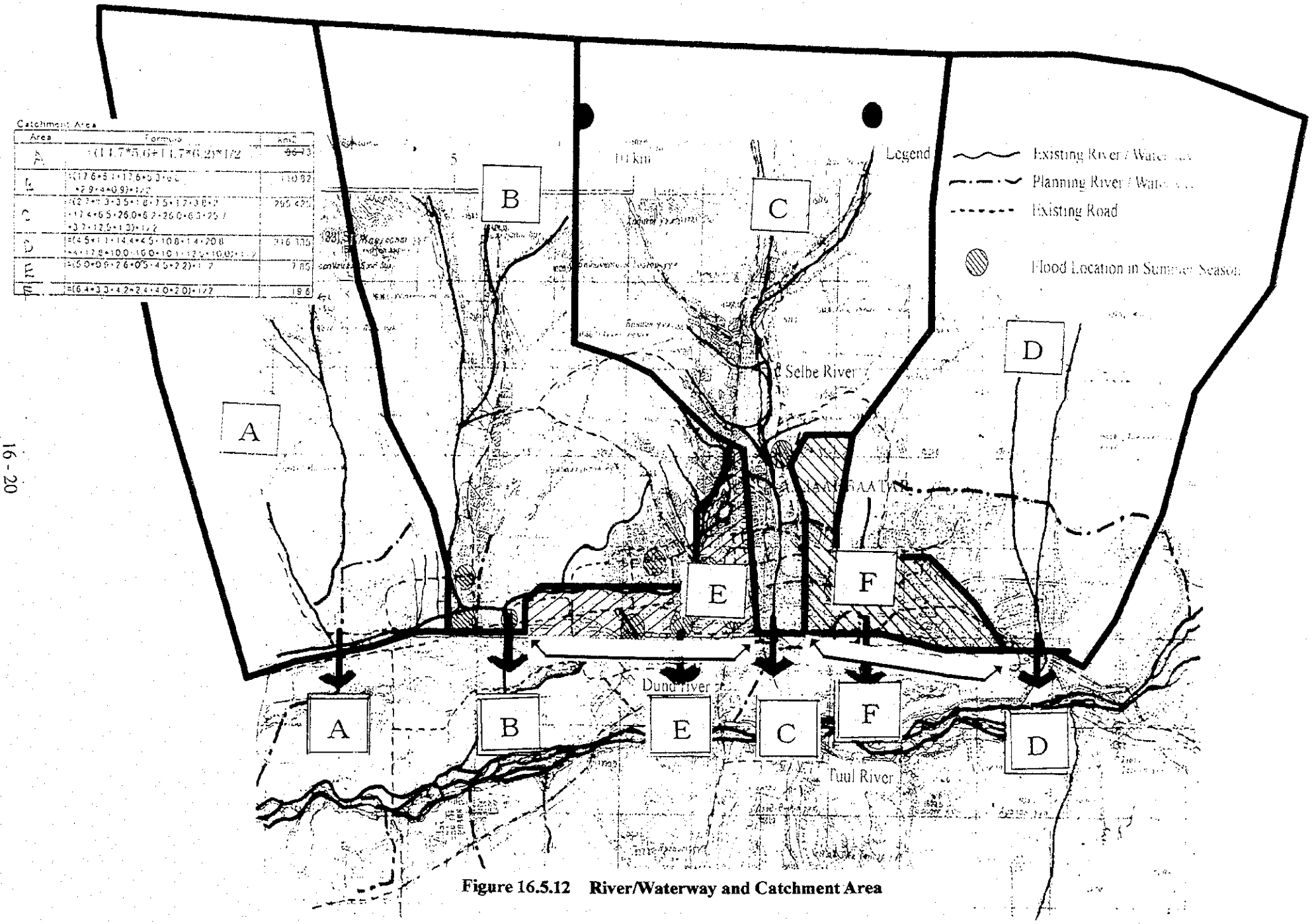
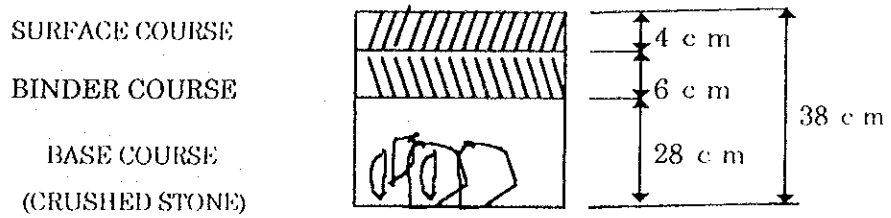
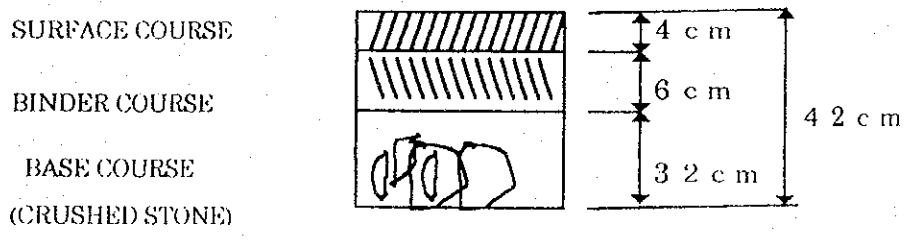


Figure 16.5.12 River/Waterway and Catchment Area

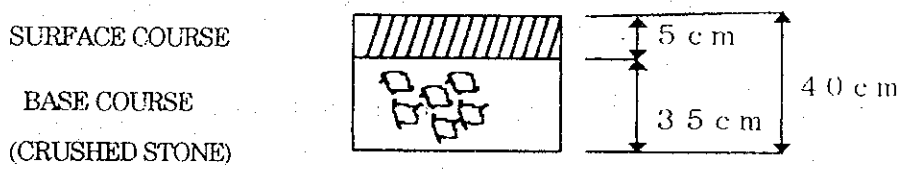
a) 4-Lane Road
Traffic Volume is 18,400 (Veh. /day) in 2020



b) 4-Lane Road
Traffic Volume is 25,200(Veh. /day) in 2020



c) 2 -Lane Road
Traffic Volume is 2,600 (Veh. /day) in 2020



d) 4-Lane and 2 -Lane Road
Traffic Volume is 2170 (Veh. /day) in 2020

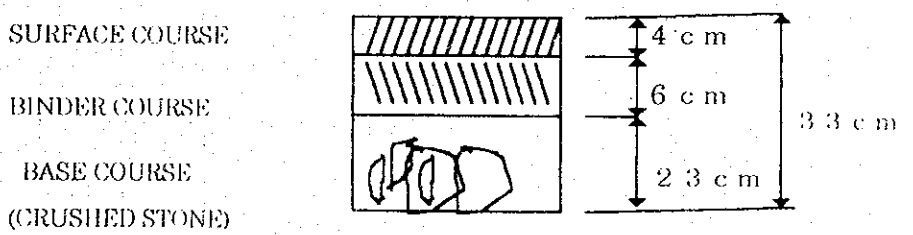


Figure 16.6.1 Necessary Thickness of Pavement for FS Projects

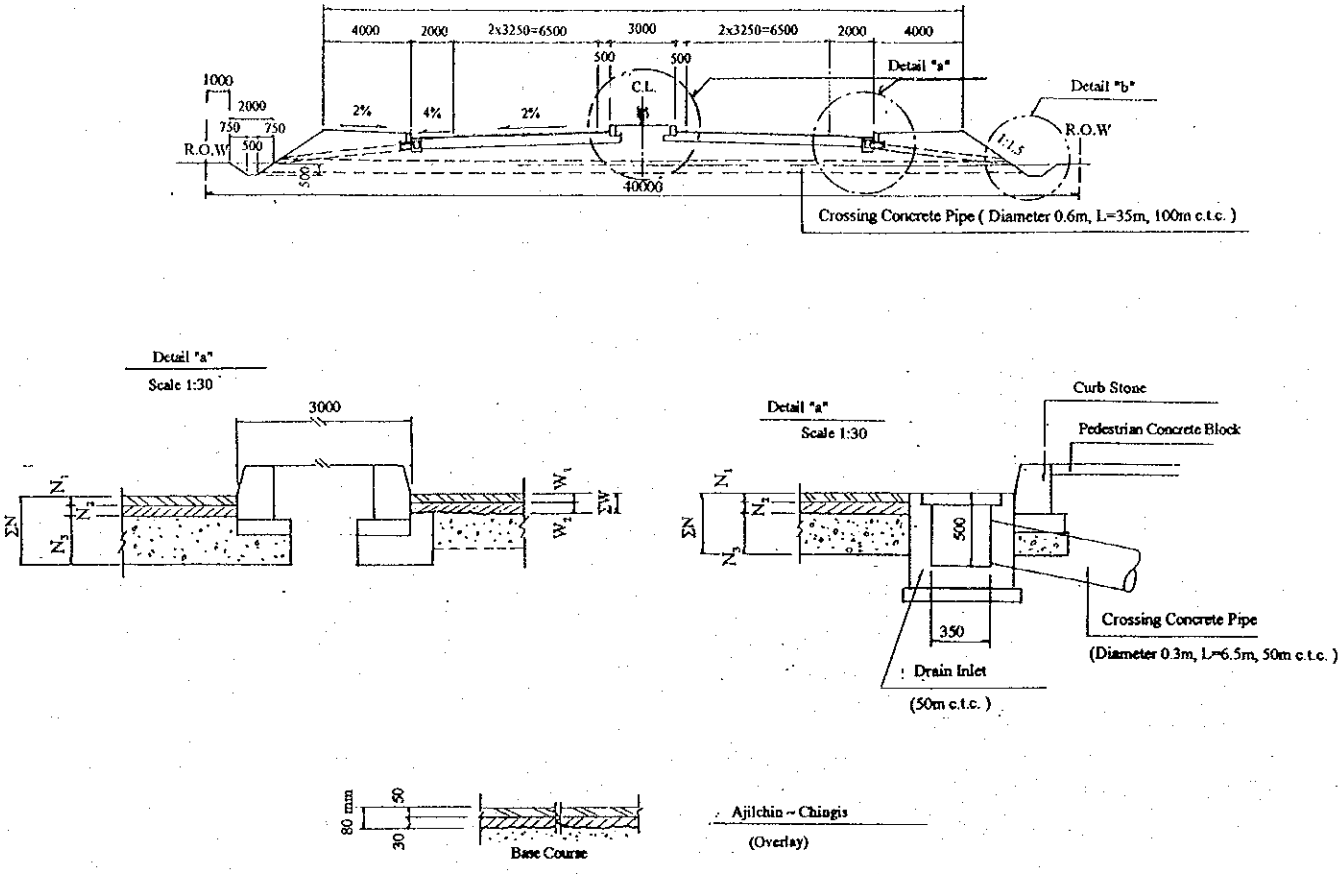


Figure 16.6.2 Thickness of Pavement for the FS Routes

Table 16.6.2 Thickness of Pavement for the F/S Routes (cm)

No.	Route	ΣN	N1	N2	N3	ΣW	W1	W2
①	Tolgoit~Sonsgolon	42	4	6	32			
②	West Naran~Ard Ayush	42	4	6	32			
③	Stadium~New Market	33	4	6	23			
④	Teeverchid SW EXT.	38	4	6	28			
⑤	South Tolgoit(West)	42	4	6	32			
⑥	South TV~N/Rd.88	40	5		35			
⑦	N/W Tolgoit	42	4	6	32	8	5	3
⑧	N/Rd.88~IS 11	40	5		35	8	5	3
⑨	South Tolgoit(East)	42	4	6	32	8	5	3
⑩	Teeverchid Rd.	38	4	6	28	8	5	3
⑪	Dund Gol Riverside Rd.	38	4	6	28	8	5	3
⑫	South of PS 4 (PS 3)	38	4	6	28	8	5	3
⑬	Ajilchin Str.2					8	5	3

Note: ΣN:Total Pavement Thickness (New Road)
N1:Surface Course
N2:Binder Course
N3:Base Course

ΣW:Total Pavement Thickness (Exist Road)
W1:Surface Course
W2:Binder Course

16.7 Improvement of Bus Stops

The following are the suggestions needed to sustain the service of public transport in proper condition.

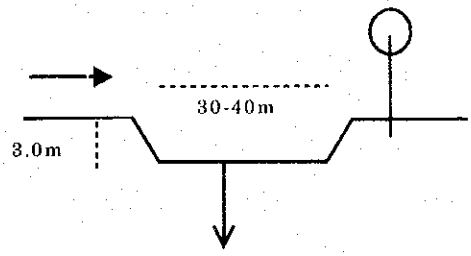
16.7.1 Improvement of Bus Stops

1) Improvement by Dividing the Stop Area

The bus stops and bays used by several routes should be extended in longer lengths. Stopping area should be divided into 2 groups, each having a standing information board indicating the designated routes and relevant information of the group. If there is a stop zone without a bus bay, same works with pavement markings painting should be performed.

Bus and trolleys should be instructed to use the designated stop area with the information board. In cases there are bus bays constructed, the bay area should be made longer to have a division in 2 blocks of stopping.

In order to mitigate confusion of stops with many passengers, improvements should be made on both sides of Enkh Taivan Avenue and in the eastward direction of the Ard Ayush Road as the stops are often used in mixture of bus, trolley and minibuses. The westward direction of Ard Ayush is used by trolleys alone while buses run the northern side on Khasbaatar Road.

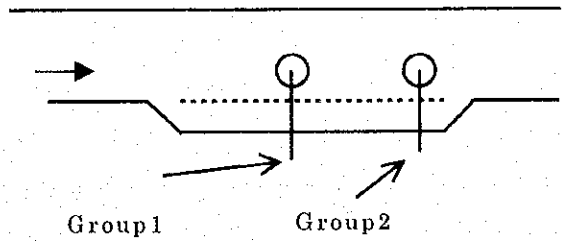


Existing bus bay

Occasionally a bus route information board with the route No. is mounted on the wall of the kiosk or on the pole.. No grouping of routes are indicated.

Improvements

Extend the area to a length of 40-50m. Divide the area into 2 groups, each with a standing bus route information board with a light for night. The board must show the route No. start destination, operation hours, etc.



2) Selected stops

Number of stops on those roads are classified as shown under:

	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

3) Cost

Bay: improvement work and cost in Tugruk are

-1 Expand the stop area by 10m for a total of 50m long Tug 700,000

-2 Two bus route information boards with a small light 400,000*2= Tug 800,000

-3 Total Tug 1,500,000

Road-side stop: work and cost are

- Two bus route boards with a small light and pavement markings on the ground

450,000*2= Tug 900,000

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

(Data by TCD, November,1998. $1.00 = Tug 838.46. It was Tug 2 million when a stop at "Workers Cultural Palace on Chengis Avenue was constructed in October 1998. The expansion is estimated at 1/3 of this standard bay area at Tug 700,000)

16.7.2 Relocation of Bus Stops

(1) Existing situation

It is found that some bus stops are located too close to the intersection causing non-disciplined traffic flows to enter the intersection and cause accidents. In addition some passengers cross the road disregarding the signal of the intersection or painted pedestrian crossing at a risk of traffic accidents. It is a matter of concern that the existing stops would increase these accidents.

(2) Relocation

Those bus stops should be relocated to a certain distance away from the junctions. At the same time rules and devices to maintain safety for passengers should be installed and enforced through traffic police, painted marks, median devices, etc. An example is the stop site beside the Pedagogical University and in front of Hotel Ulaanbaatar. The bus stop site should be moved

50m toward the north from the Hotel. According to TCD, a bus stop at the far east end of Ard Ayush Road has been planned to be moved a certain distance away to the west. But it has not been moved yet because the City has not implemented the plan yet. They should be moved at the earliest possible time.

16.7.3 Bus Roads and Bus Lanes

(1) Bus roads

Monopolistic bus road may be necessary to give priority to public transport by buses in crowded areas. Bus roads can be determined on certain streets, for certain hours in one direction or in both directions, where all other cars and trucks are excluded for use. Consequently, there must be adjacent streets for those excluded vehicles. Candidate streets for bus roads are Ard Ayush Road and Khuvsgarchid Road.

(2) Bus lanes

Bus lanes ca be determined on some road sections where cars and trucks are required to run in other alternate lanes. The section must have 3 lanes or more in one direction. In the case of 2 lane carriage way in one direction, it is likely difficult to maintain one lane for bus and another for other vehicles since vehicles run at different speeds requiring another lane for overtaking. It should be noted that vehicles turning in/out through other crossing streets would interrupt the flow of buses in the lane.

Beside the two sections mentioned in 1) above, another candidate street of the bus lane is Ikh Toyruu street in front of inter-city bus terminal. On which one direction to the north should be a bus lane for bus and trolley, while 2 lanes in another direction are for the mix of all vehicles. No trolleys are running in the southward direction. Some western sections on Enkh Taivan Avenue is worthy for consideration for bus lanes as they have enough width for lanes to be used by other vehicles.

(3) Bus priority lanes

The bus priority lanes are defined that the lane is principally for bus use but other vehicles may join in the lane but not be allowed to pass the buses by using the inner lane. Other vehicles in the lane should follow the bus ahead. The rule is less strict than the 2) bus lane above. The above examples of sections can be the bus priority lane also.

(4) Timing and rules

It is considered that there is no need to enforce immediately the rules of giving priority on bus transport, since traffic congestion is not so heavy as can be seen in other cities. Discussions with other agencies including traffic police are necessary. Also social consensus of respecting traffic rules should be strengthened by various means.

16.7.4 Road facilities

Pavement marks on roadways, pedestrian sidewalks, crossing ways, traffic guidance at intersections and so on should be clearly painted and renewed regularly. Lane separation, bus stop areas, no parking zones, etc. should be painted. Median fences preventing free crossing by pedestrians are also necessary on some congested streets and roads in school areas.

There are traffic signals on main junctions in the city, but they are not functioning constantly, which causes traffic jam and accidents at those junctions. Visibility is not good, some are not clear because of overgrown tree leaves, some are not high enough to be recognized by drivers. Those signals should be improved.

Chapter 17 Construction Method for F/S Projects

17.1 Key Points for Construction for F/S Projects

Following shall be taken into consideration for the construction of roads and bridges in UUB :

- Construction period is limited from May to October due to the prevailing severe weather conditions.
- Asphalt pavement construction period is from June to September, if pavement works are carried out on days of more than plus 5 degrees.
- On hauling hot asphalt mixture from mixing plant to site, covering cloths and insulators are necessary for trucks to maintain the temperature of the mixture.
- Early compaction is necessary after laying of hot mixture.
- Sufficient application of tack coat for the construction joints is necessary to avoid cracks later on.
- Rock excavations are expected in most areas of UUB. And normal soil is frozen in autumn to spring. Therefore large size excavator with hydraulic breaker is required.
- There is a possibility to drive sheet piles into frozen soil or hard stratum where the N value is more than 50. Auger or breaker is necessary to perform this work.
- Large size truck crane is unavailable in UUB. However large size rail crane of Mongolian Railway could be used for construction of the cross-over-bridge on railways.

17.2 Key Points on Each Route

Roads for the Feasibility Study are grouped into 4 routes. Major points to be taken into consideration are summarized as follows:

Central route	• Measures for the embankment on soft ground stratum • Safety measures at several railway crossing.
Northern route	• West section: Measures for residential people • Middle section: Slope protection on many embankment and excavation areas. • Eastern section: Traffic control in city busy area.
Southern route	• Eastern section: Traffic control in busy street. • Flyover section: Safety mesures for railway works. • Middle section: Available land is narrow. Safety controls must be provided for vehicles. • Western section: No special items required.
Middle ring route	• Water resource section: Mesures for the water from the construction works. Safety control for train operation required. • Flyover at East Cross: Traffic control required. • Flyover at Bus terminal: Safety control for train. Traffic control required.

17.3 Construction Method

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.
Super structures:	Two kinds of methods will be proposed, 1) by truck crane 2) by portal crane (as shown in Fig 17. 3. 7(2)). Large size truck crane shall be imported, although Their cost is expensive compared with portal cranes. However truck crane is recommended because of their possibility for various works at the site where minimum number of equipment can be mobilized..
East cross intersection	It has high traffic volume which is expected to increase more after opening of the new central market near the intersection. Discussion with traffic police is essential prior to design and construction. Right of way is not sufficient in southern side (19m). Empty land of south-east area may be utilized as temporary fabrication yard.
Cross over bridge near bus terminal & Teeverchid street	The work can be done by usual construction methods except for the work conditions on railway works. Discussion with railway authority shall be done before construction is started.

Major construction methods for F/S projects are shown as follows.

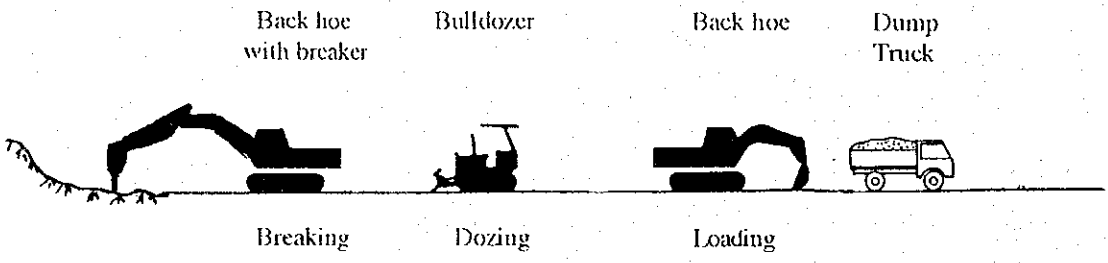


Figure 17.3.1 Hard Soil or Rock Cutting

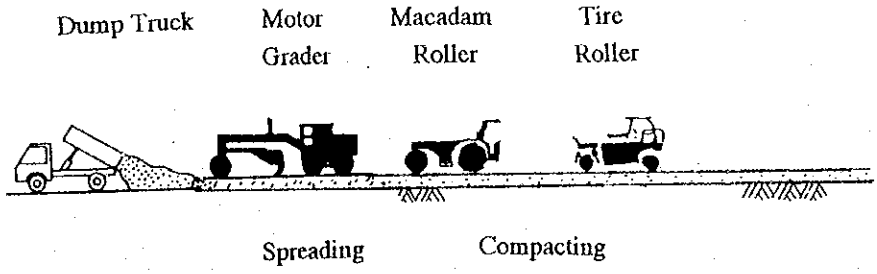


Figure 17.3.2 Subgrade

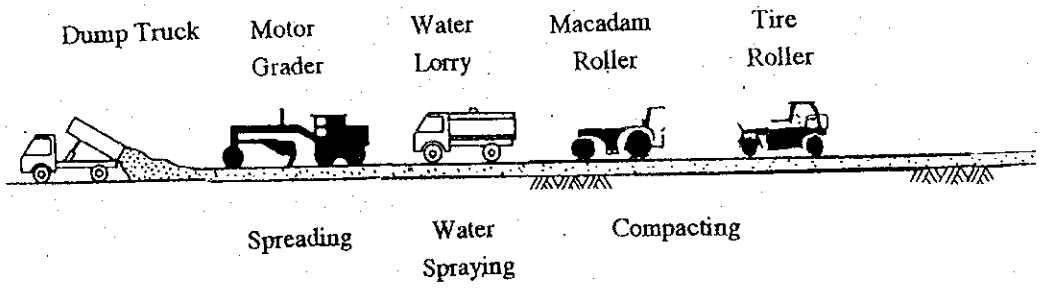


Figure 17.3.3 Base Course

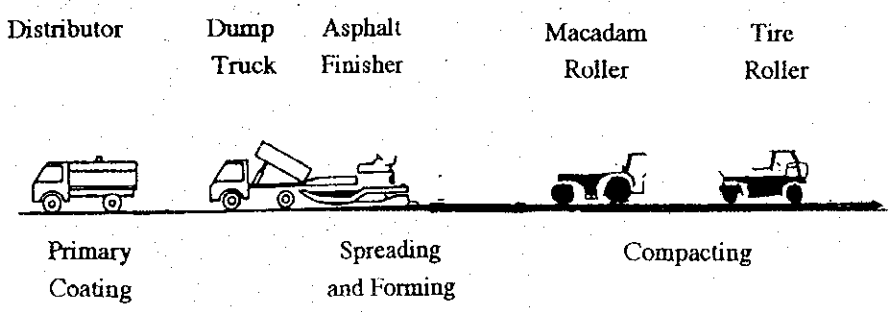


Figure 17.3.4 Asphalt Pavement

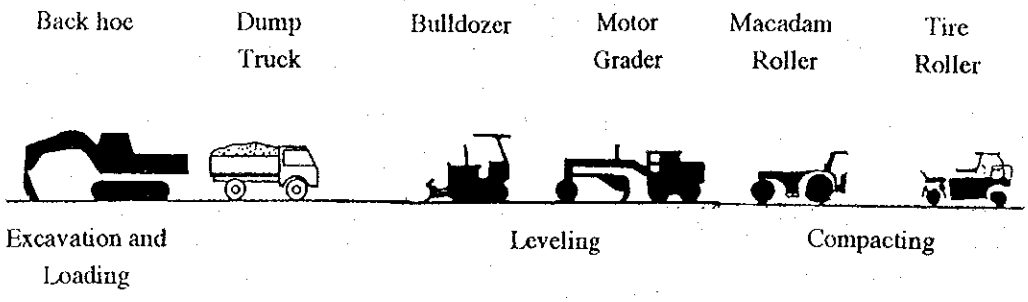


Figure 17.3.5 Breaking of Existing Pavement

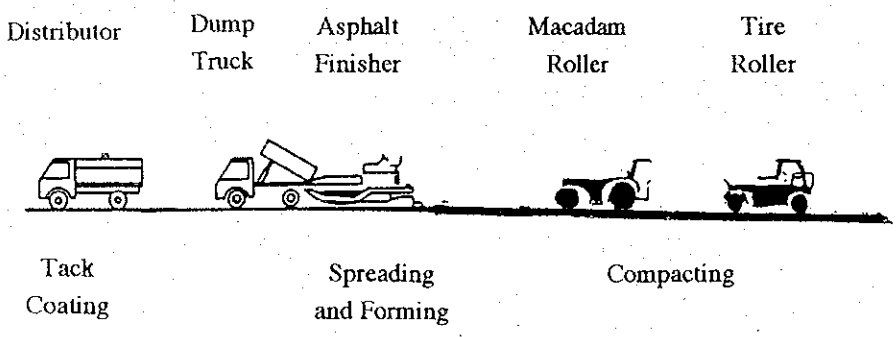
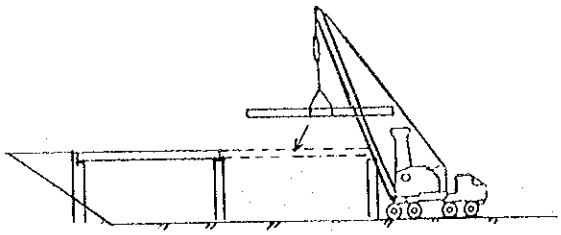
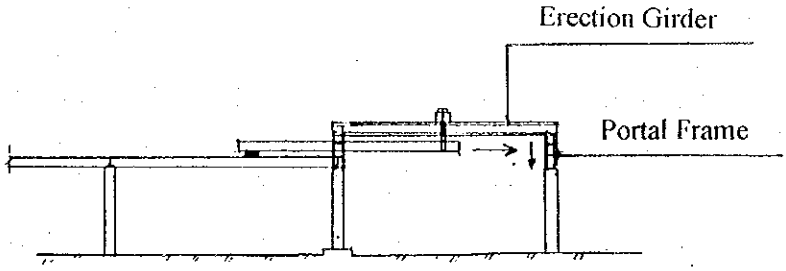


Figure 17.3.6 Overlay



Erection Method : Truck Crane



Erection Method : Launching

For East Cross Road F/o & Over Railway F/o

(Note : Erection for Over Railway shall use rolling stock crane)

Figure 17.3.7 (1) Construction Method of Road Bridges

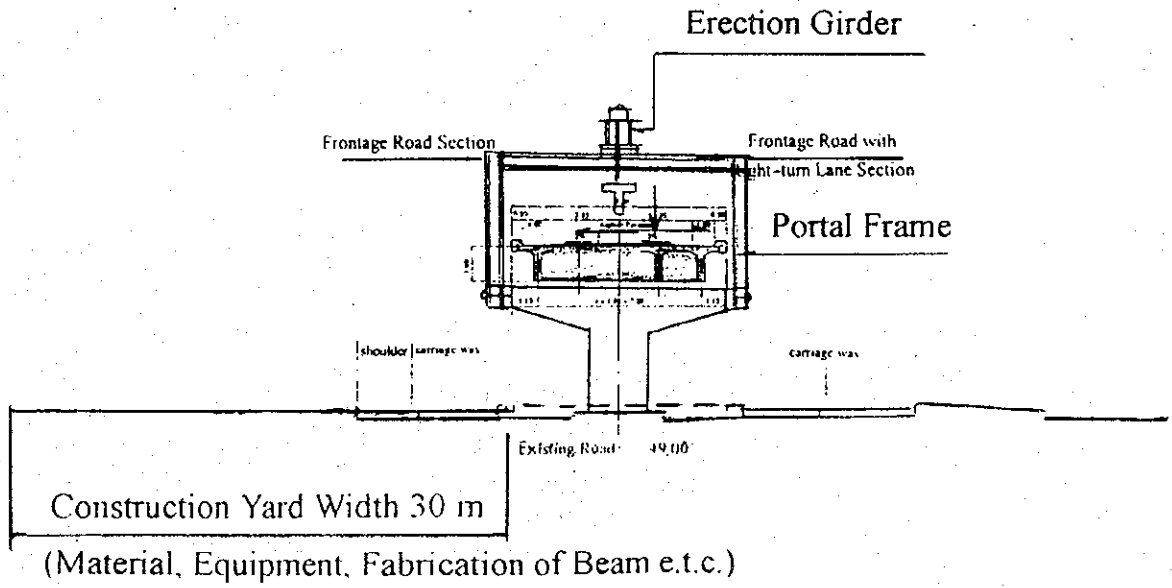
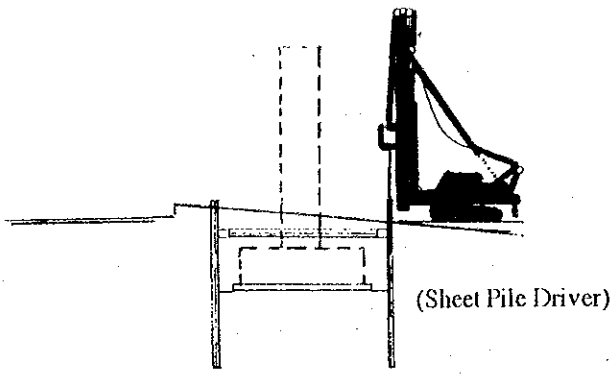
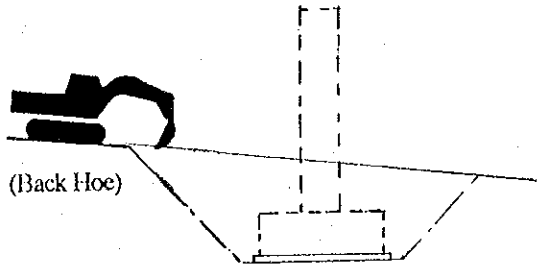


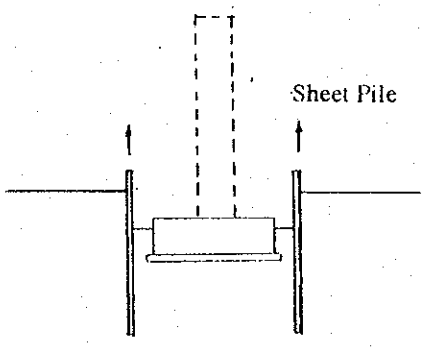
Figure 17.3.7(2) Construction Method of Flyover



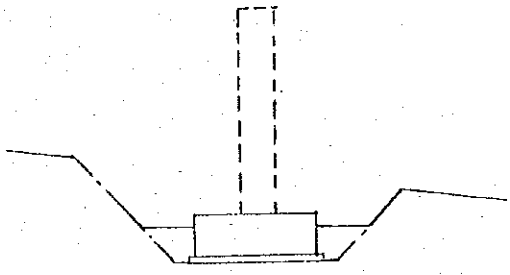
Setting Sheet Pile and Excavation
(Closed Railway, Roadway)



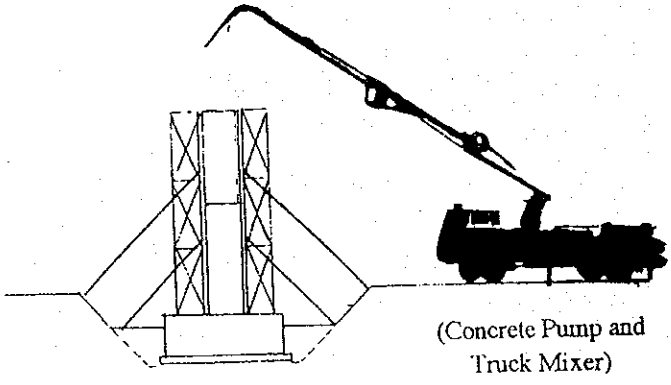
Open Excavation and Leveling Concrete



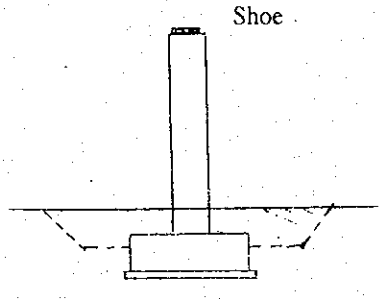
Pour Concreting for Footing, Removal of Sheet Pile and Backfill



Pour Concreting for Footing and Backfill



Pour Concreting for Wall



Backfill and Shoe Setting

Figure 17.3.8 Construction Method of Substructure

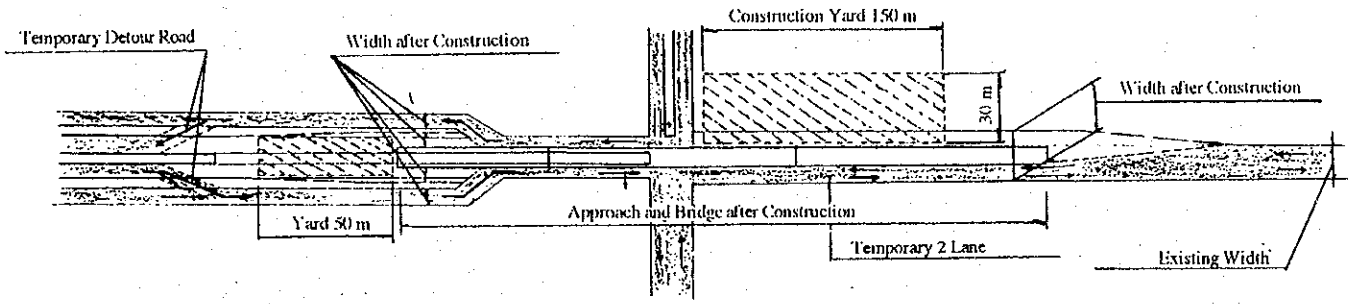


Figure 17.3.9 Plan of Temporary Traffic Diversion (East Cross Rd.)

17.4 Construction Period

17.4.1 Working Days

Considering the temperature and rainfall in Ulaanbaatar City, mentioned in Chapter 3, working days are estimated, and shown in Table 17.4.1.

Table 17.4.1 Working Days of Each Month in Ulaanbaatar City

Month	1	2	3	4	5	6	7	8	9	10	11	12
Earth work					25	25	20*	20*	25	25		
Pavement and concrete work					20*	25	20*	20*	20*			

Notes: 20day in July and August for rainfall, and 20 days in May and September for pavement and concrete works for low temperature condition prevailing.

17.4.2 Construction Periods for Major Work Items

Construction periods are assumed considering the above working conditions.

The examples of construction schedules are shown in Table 17.4.2 for widening of existing Teeverchid road and in Table 17.4.3 for the flyover.

Table 17.4.2 Widening of Existing Road (Teeverchid Road; 8km)

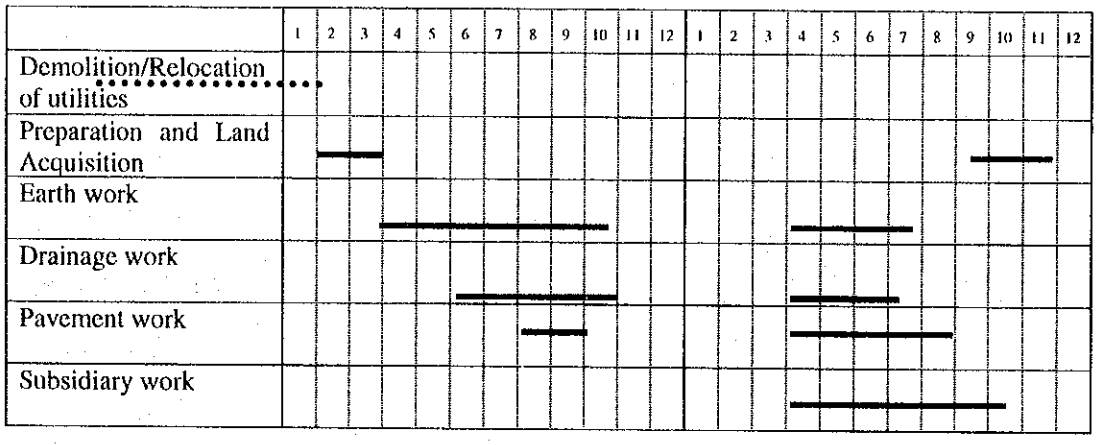
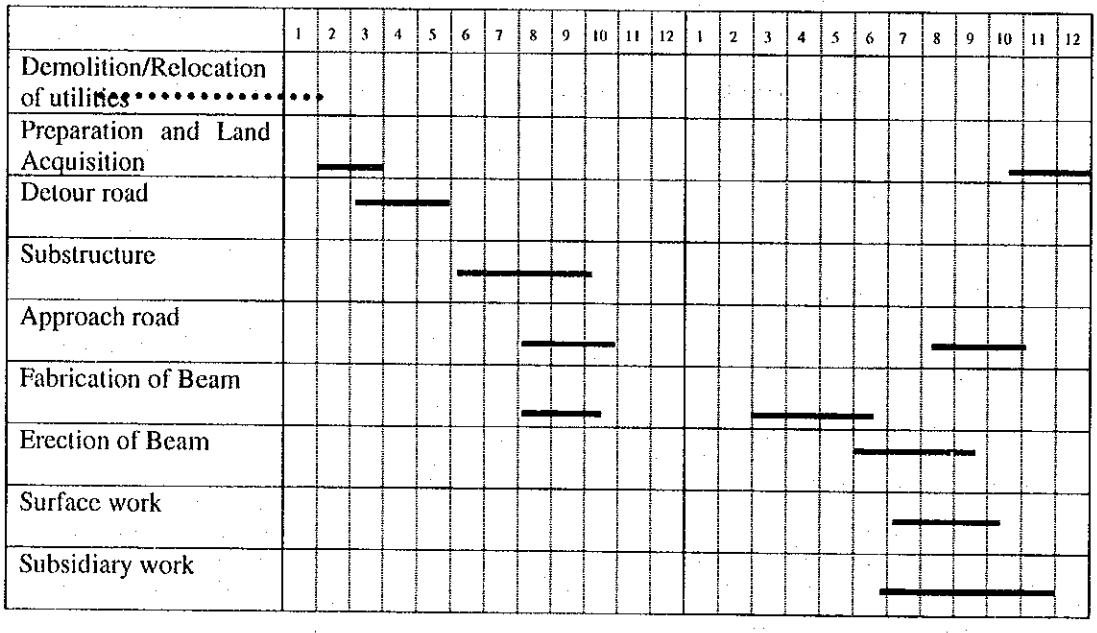


Table 17.4.3 Construction Schedule for Flyover/Bridge



17.4.2 Construction Schedule for Each Route

Construction period for each route is assumed as follows:

Total construction period.	Central route	2 years
(excluding design period)	Northern route	4 years
	Southern route	6 years
	Ring Road & 2 Flyover	3 years

Breakdown of construction schedules for each route are shown in Table 17.4.4.-17.4.7.

Table 17.4.4 Construction Schedule for Central Route

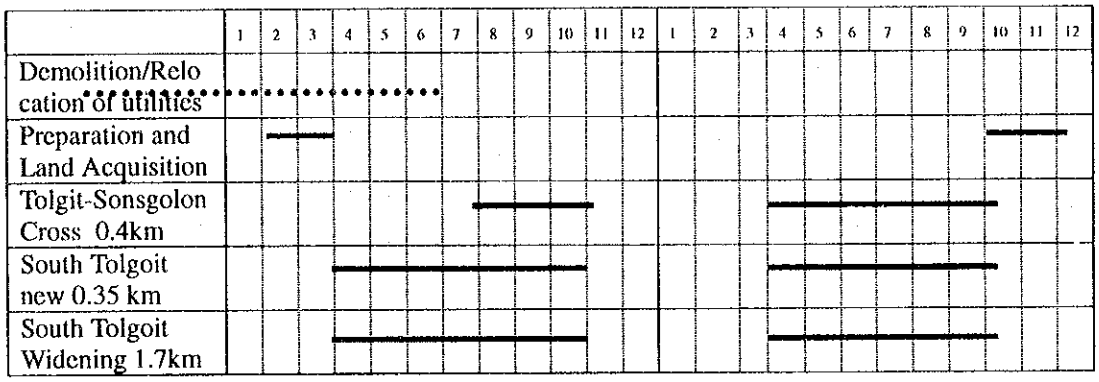


Table 17.4.5 Construction Schedule for Northern Route

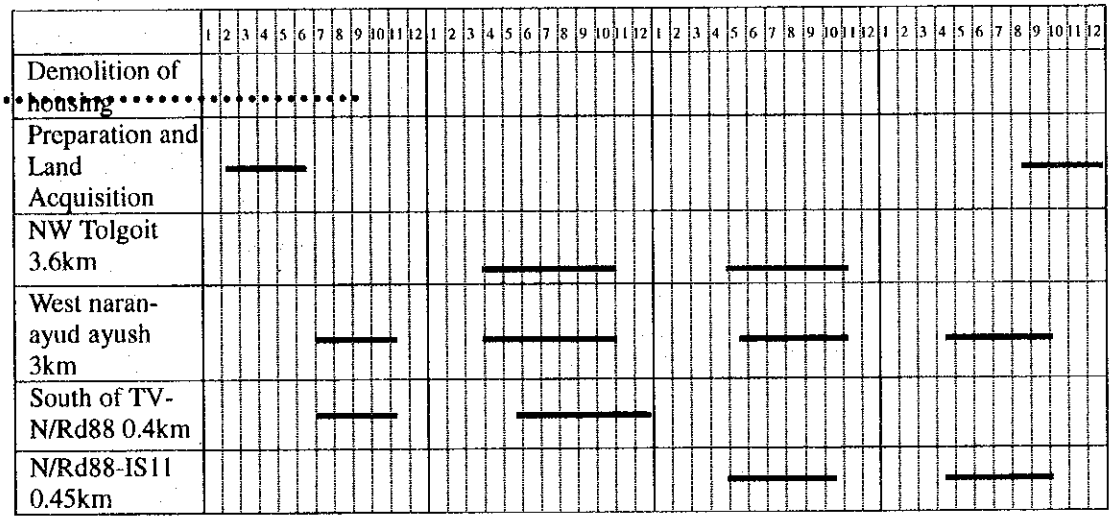


Table 17.4.6 Construction Schedule for Southern Route

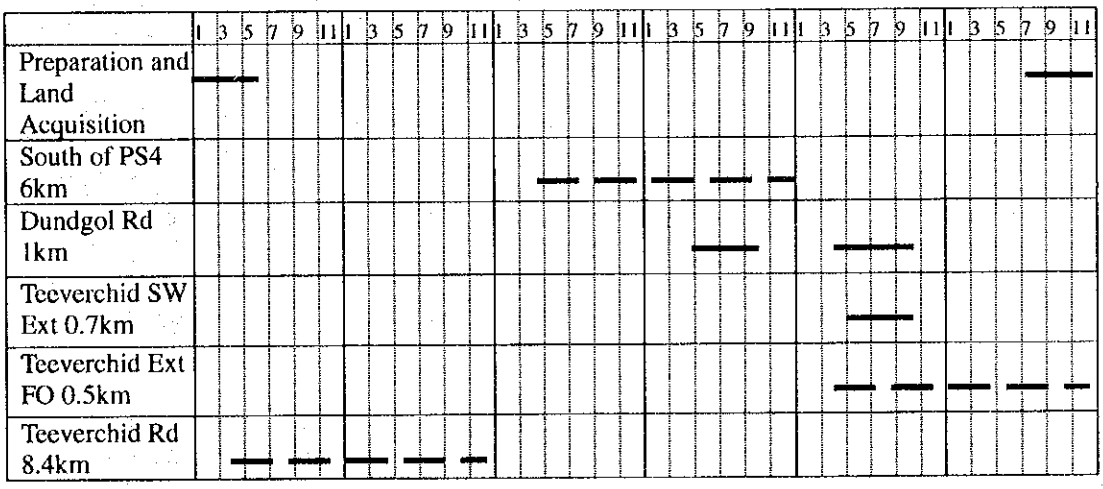


Table 17.4.7 Construction Schedule for Middle Ring Route

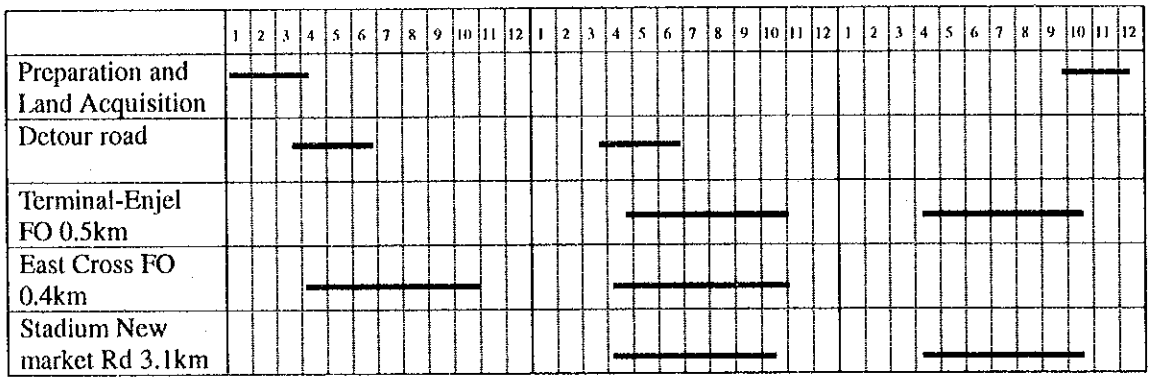


Table 17.4.8 Construction Schedule for All Projects

	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 Construction Equipment

17.5.1 Equipment Owned by Construction Companies in Mongolia

There are more than 30 construction companies concerned with road development works in Mongolia. They have about 760 units of construction equipment.

Almost all of the equipment are Russian made, and were purchased in 1990 or before. Their availability is less than 20-40%, and their performance level are less than 50 %, even if they can work. It means that theoretically available numbers of the equipment is existing number x (0.2-0.4) x 0.5) as shown in Table 17.5.1.

The numbers of available units are few. They are located not only in UB but also out of UB.

Table 17.5.1 Main Construction Equipment of Mongolian Construction Companies

Model	Existing Units	Available units
Asphalt finisher	13	1-2
Macadam roller	46	4-8
Tire roller	18	2-4
Motor grader	70	7-14
Bulldozer	65	6-12
Back hoe	43	4-8
Dump truck	270	30-60

Source: *: Road Department

17.5.2 Current Condition of Equipment Supplied by Previous Japanese Grant Projects

Totally about 40 models and 100 units of the equipment were supplied by Japanese grant aid projects "The Project for Road Construction Utilizing Rock Asphalt in Mongolia". The list of the equipment supplied is shown in Appendix AP17.1. It consists mainly of construction equipment and some laboratory equipment.

All of the above equipment are under the management of the state company "Erdene zam". They are keeping working data of the equipment every month. They are now using about 60 units of construction equipment for roads improvement works at the project of the World Bank, "Road maintenance and Improvement of Unpaved road (Kharhorin – Tariat : Total length is 24km). The project started from July and ended in November 1998.

17.5.3 Necessary Numbers of Equipment Required in F/S Projects

FS projects have been divided into 4 groups, Central route, Northern route, Southern route, Ring Road & 2 Flyovers. It is assumed that these 4 route projects shall be implemented step by step considering all the available resources. Among the projects, Teeverchid Rd. widening and Teeverchid Ext.F/O Bridge construction are considered to be in large scale. The equipment for the above two projects can be also utilized for other projects by scheduling the construction periods.

Teeverchid Rd. construction needs major equipment as follows:

Main work Volume	Construction period	Main equipment	Work efficiency	Necessary numbers
Pavement				
74,772m2	2 years 150 days	Asphalt finisher	1900m2/day	0.27->1unit
		Macadam roller	1900m2/day	0.27->1 unit
		Tire roller	1900m2/day	0.27->1 unit
		Asphalt plant with hot mixture silo	60t/h	1
		Motor grader		1
		Water sprinkler truck		1
		Dump trucks		5
Sub-grade embankment 162,135m3	2 years 260 days	Bulldozer	770m3/day	0.8->1unit
		Back hoe	300m3/day	2.0->2 units
		Tire roller	580m3/day	1.07->1 unit
		Dump truck	24 m3/day (20km hauling)	26>26 units

Teeverchid Ext.F/O needs major equipment as follows:

Main work Volume	Construction period	Main equipment	Work efficiency	Necessary numbers
Concrete work 11,000 m3	2 years 200 days	Concrete Agitator car	12m2/day	4.58->5unit
		Concrete pump		1 unit
Erection work of super structure		Truck crane (60ton)		2 units

Table 17.5.2 shows main equipment necessary for the execution of F/S projects and equipment supplied by the previous grant project. Most of equipment supplied by the grant project are able

to be used at F/S project. However additional equipment is expected to have for concrete work and erection work of bridge construction.

Table 17.5.2 Comparison of Necessary Main Equipment and Those Supplied by the Grant Project

Model	Required numbers in FS project	Supplied numbers in Grant project
Asphalt finisher	1	1
Back hoe	2	7
Buldozer	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 (60ton)	2	
Asphalt plant (60 ton)	1	

Note: * For excavating rock and frozen soil

Chapter18 Cost Estimation for F/S Projects

18.1 Basic Conditions

Cost estimation for F/S project is done under the conditions mentioned in Chapter 12.

The following additional conditions are assumed, based on the design of F/S projects.

	Item	For F/S project	(for reference) Total network (in Chapter 12)
1.	New pavement	Binder course: 60mm Surface course: 40mm (50mm surface only at Ajilchin – Chingis)	Binder course: 40mm Surface course: 30mm
2.	Embankment of roads	1.5m (1.0-1.9m) 2.1m 3.8m	1.5m
3.	Excavation in earth work	West Naran – Ard Ayush (1.91 km) South of TV – N/Rd.88 (0.28 km)	None
4.	Underground pipe (Dia. 0.6m)	Laying 100m each	Laying 50m each
5.	Extension of existing underground pipe	Dia.1.0, 1.5, 2.0m for concrete pipe, 3.0m for corrugated pipe.	None
6.	Slope protection for cutting area	Mortar lining: West Naran – Ard Ayush:22,300 m2 South of TV – N/Rd.88: 1,200m2	None
7.	Widening of embankment	Dund Gol Riverside Rd.	None
8.	Gutter	Applied for improving all roads except repairing at Ajilchin – Chingis	None

18.2 Unit Price of Necessary Work Item

Based on the above conditions, additional unit cost of work items for the F/S project (which were not included in the Future road network in Chapter 12) are summarized in Table 18.2.1.

Table 18.2.1 Unit Direct Cost of Each Work Items

Unit: US$

Work items	Specification	Unit	Cost		
			Local	Foreign	Total
Pipe Culvert	ϕ 1000	m	287.	425.	712.
Pipe Culvert	ϕ 1500	m	494.58	732.	1,226.58
Pipe Culvert	ϕ 2000	m	879.	1,302.	2,181.
Pipe Culvert	ϕ 3000	m	8,478.	12,000.	20,478.
Gutter		m	74.	380.	454.
Traffic Signal (New)	New	IS	3,900.	220,800.	224,700.
Mortar lining		m2	3.57	8.81	12.38
Cutting		m3	0.09	6.34	6.43
Cutting and Disposal		m3	0.21	11.14	11.35
Flyover for Road	East Cross Road, W=9.5m, L=120m		335,400.	1,091,600.	1,427,000.
Flyover for Railway	Bus Terminal~ EngelsStr, W=12.5m, L=215m		627,900.	2,697,500.	3,325,400.
Flyover for Railway	Teeverchid SW Ext.(1), W=30.0, L=210m		1,138,100.	5,011,900.	6,150,000.
Road Bridge for River	W=14m, 20m x 2 span		98,900	488,300	587,200
Road Bridge for River	W=14m, 20m x 3 span		134,600	634,500	769,100
Road Bridge for River	W=30m, 17.5m x 1 span		175,400	910,000	1,085,400
Road Bridge for River	W=30m, 20m x 1 span		108,200	475,000	583,200
Road Bridge for River	W=30m, 20m x 2span		196,600	948,500	1,145,100
Road Bridge for River	W=30m, 20m x 3 span		283,900	1,402,600	1,686,500

18.3 Estimated Cost of F/S Projects

Table 18.3.1. shows the total quantities and their cost by work items.

Table 18.3.2.shows the quantities of work items for each road of F/S project.

Table 18.3.3 shows the costs for each road by group (route) of F/S project.

Table 18.3.4 shows the summary of total cost and its breakdown for each group (route).

Table 18.3.5 shows the total cost by local and foreign currency portion for all F/S projects.

Table 18.3.6 shows the summary of resettlement and demolition cost for F/S Projects

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

(Unit: 1,000 US$)

Work items	Cost Estimation	Quantities	Unit	Direct Cost	Total Cost	Ratio (%)
Pavement Repair A		103,882	m2	803	1,312	1.13%
Pavement Repair B		41,684	m2	1,490	2,434	2.10%
Pavement Repair C		53,163	m2	2,757	4,504	**3.88%**
Pavement Repair D-1	Asphalt 100mm	43,140	m2	1,725	2,818	**2.43%**
Pavement Repair D-2	Asphalt 50mm	2,481	m2	78	128	0.11%
New Pavement1-1	With embankment H=1.040m As: 100mm	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	ϕ 600	10,140	m	2,821	4,608	**3.97%**
Pipe Culvert	ϕ 1000	265	m	189	308	0.27%
Pipe Culvert	ϕ 1500	161	m	198	323	0.28%
Pipe Culvert	ϕ 2000	87	m	190	310	0.27%
Pipe Culvert	ϕ 3000	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=15cm	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 18.3.2 Quantities of Work Items for Each Road of F/S Projects

Work items	Unit	N/W Tolgoit Rd 3.627 km	Tolgoit~ Sonsgolon cross	West Naran~ Ard Ayush 3.006 km	South of Tv ~ N/Rd .88	N/Rd .88 ~ IS11	South of PS4 5.942 km	Ajilchin Str.2 1.096 km	Stadium ~ New Market 3.12 km	South Torgoit 0.346 km	South Torgoit 1.671 km	Teverchid Rd. 8.368 km	Teverchid Rd. SW 0.71 km	Dundgol Riverside Rd. 1 km	Geser Temple	Ayush ~ Amarsanaa St.	East Cross Rd. F/O	Bus terminal ~ Engel Rd. F/O	Teverechid Ext. F/O
Pavement Repair A	m2	31,743				2,286					11,697	58,156							
Pavement Repair B	m2	7,054						7,672			3,342	16,616		7,000					
Pavement Repair C	m2						53,163												
Pavement Repair D-1	m2			37,908	3,232									2,000					
Pavement Repair D-2	m2					2,481													
New Pavement I-1	m2	31,743	7,434	11,520	1,265		53,163		56,160	6,228	15,039	74,772	3,960	9,000					
New Pavement I-2	m2																		
Block pavement of Sidewalk	m2	28,216	3,304	21,968	3,128	3,632	47,256		24,960	2,768	13,368	66,464	1,760	8,000					
Curb stone	m	14,108	1,652	10,984	1,564			2,192	12,480	1,384	6,684	33,232	880	4,000					
Boundary Block	m	7,054	826	5,492	782				6,240	692	3,342	16,616	440	2,000					
Pipe Culvert	m	980	35	1,846	112	125	2,183		962	35	561	2,871	80	350					
Pipe Culvert	m	51	35						111		34	34							
Pipe Culvert	m	17	70						74										
Pipe Culvert	m	17							0	70									
Pipe Culvert	m	34							0										
Open Ditch	m	7,054	826	5,492	782	908	11,814		6,240	692	3,342	16,616	440	2,000					
Gutter	m	142	18	110	16	18	236		124	14	66	332	8	40					
Road Line	m	21,762	2,478	18,030	1,564	1,362	35,652	1,096	18,720	2,076	10,026	50,208	4,260	6,000					
Road Sign	place	73	8	60	8	9	119	22	62	7	33	167	14	20					
Traffic Signal (New)	IS	1		1		1	1		3			1	1	1	1	1			
Rehabilitation of Bus Stop	place	2					3	2	0		1	4		1					
New Construction of Bus Stop	place	2		4			3		4		1	4		1					
Embankment	m3	21,585	7,862	25,358	2,093		100,189		123,620	6,587	14,151	84,372	22,848	7,568					
Embankment	m3	9,735							0					600					
Mortar Gunniting	m2			22,300	1,200														
Cutting	m3			25,358	2,093														
Cutting and Disposal	m3			206,374	10,126	650													
Bridge Construction	LS	4		6			1					2					1	1	1
Environmental protection																			
Tree plantation																			
Grass on slope	m2	20,316	2,379	5,069	634	2,616	46,784		24,710	1,993	9,624	47,854	3,088	5,760	0	0			

Table 18.3.3 Summary of Costs for Each Group of F/S Projects

Unit: 1,000 US$

Group (Route)	UB Rd. No.	Road Name	Road Length (km)	Cost		
				Local	Foreign	Total
Central Route	108	Darkhan Rd.	3.5			
	New	Tolgoit~Sonsgolon cross	0.413	278	1,029	1,307
	New	South Tolgoit Rd	0.346	273	920	1,193
	82	South Tolgoit Rd	1.671	738	2,373	3,111
	5,4,3	Peace Ave.	15			
	1	Peace Ave. (East)	4.5			
		Sub total				5,611
Northern Route	1	Darkhan Urban Rd.	3.5			
	3	*Tolgoit~Sonsgolon cross*	*0.413*	278	1,029	1,307
	84,85	N/W Tolgoit Br.No.28,No.29	3.627	2,506	7,813	10,319
	New	Br.No.NB-28',NB-29'				
	New	WestNaran~ArdAyush	3.006	3,607	18,873	22,480
	New	Br.No.NB1~NB6				
	8	Ard Ayush	0.75			
	10	Khasbaatar	1.8			
	New	South of TV~N/Rd.88	0.391	173	660	833
	88	N/Rd.88~IS 11	0.454	116	242	358
	11	Ard Ayush~Ovoo				
	12	North of Ring Rd				
	64	Khoroolol	7.82			
	27	Dandar				
	1	Peace Ave.(East)	4.5			
		Sub total				35,297
Southern Route	108	Darkhan Urban Rd.	3.5			
	76	Sonsgolon Rd.	1.85			
	39	South of PS4	5.942	2,805	13,561	16,366
	New	Br.No.SB-50'				
	117	Dund Gol River Side Rd	1	475	1,689	2,164
	New	Teeverchid SW Ext.	0.71	142	1,023	1,165
	New	Teeverchid Ext. F/O	Br. 0.21 App.0.28	1,859	8,187	10,046
	41	Teeverhid Rd.	8.368	3,842	13,146	16,988
	New	Br.No.CB-17'				
	1	Peace Ave. (East)	4.5			
	71	Ajilchin Str. 1	1.3			
	72	Ajilchin Str. 2	1.096			
		Sub total				46,729
Middle Ring Route	2	Chingis Avenue	2.6			
	34	Engels Str				
	New	Terminal~Engel Rd.F/O	Br. 0.248, App.0.23	1,026	4,406	5,432
	32	Bus Terminal-West cross				
	6	West cross – Ovoo	Total 9.88			
	12	North of Ring Rd				
	New	East Cross Rd.F/O	Br. 0.12 App.0.28	547	1,784	2,331
	97	13/14 Kholoo road				
	New	Stadium~New Market	3.12	1,720	8,940	10,660
		Sub total				18,423
		Total				104,753
Repair Inter-section	72	Ajilchin Str. 2	1.096	126	440	566
	IS 4	Geser Temple		7	361	368
	IS 3	Ayush-Amarsanaa		7	361	368
		Other 10 IS in FS Route		70	3,610	3,680
		Pipe Culvert (New Drainage)		1,858	2,750	4,608
		Rehabilitaion of Bus Stop		152	100	252
		New Construction of Bus Stop		224	205	429
Environ-mental Protection		Grass on slope		57	1,157	1,214
		Tree plantation		15		15
		Total (Others)				11,500

Table 18.3.4 Summary of Costs for Each Route

Unit: 1000 US$

	Item	Name of Route				
		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

Table 18.3.6 : Summary of Resettlement and Demolition Cost for F/S Projects

S. No.	Item	Resettlement Cost (in $)	Demolition Cost (in $)
1	23 Households	23*3000 = 69,000	23*100 = 2,300
2	16 Shops	16*3000 = 48,000	16*100 = 1,600
3	52 Kiosks	52*200 = 10,400	52*50 = 2,600
4	1 Restaurant	-	300
5	1 Heating/power sub-station	500,000	20,000
6	1 Private gasoline station	300,000	20,000
7	1 State gasoline station	300,000	20,000
Total		1,227,400	66,800

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 performed 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 type of benefits viz. savings in VOC and savings in travel time was 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 total travel time was 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 and the method is given in Chapter 13.

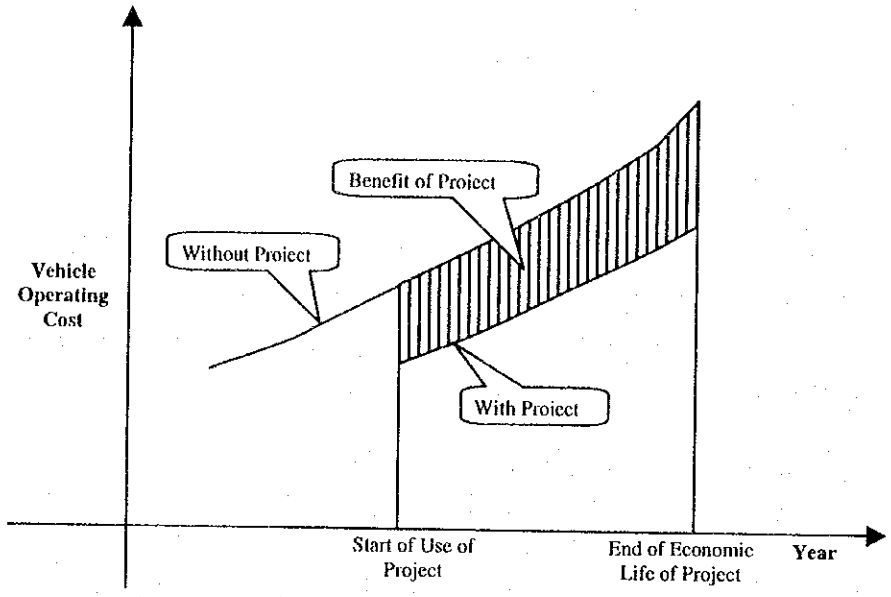


Figure 19.2.1 Sketch Diagram for Project Benefit

(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. 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) The implementation period and cost allocation per year for each route is given in Table 19.2.1.

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 their value is greater than 1 it can be said that the project is economically feasible.

2) IRR is the interest rate received from an investment, which occurs at regular periods over the project life. This investment consists of costs (as payments) and benefits (as income). IRR is the

interest rate 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.

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

Table 19.2.1 Implementation Period and Cost Allocation by Route

Route		Central Route	Northern Route	Southern Route	Middle Ring Route	All Routes
Implementation Period (in yrs)		3	5	7	4	8
Cost Allocation (in % of total cost)	1st Year	10%	10%	5%	10%	1%
	2nd Year	35%	10%	10%	5%	4%
	3rd Year	55%	30%	20%	35%	9%
	4th Year	-	30%	20%	50%	13%
	5th Year	-	20%	20%	-	18%
	6th Year	-	-	15%	-	27%
	7th Year	-	-	10%	-	17%
	8th Year	-	-	-	-	11%
	Total	100%	100%	100%	100%	100%

Implementation Period includes both the design and the construction period

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. The annual cost and benefit streams for each route are shown in Table 19.3.2 to Table 19.3.6.

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$

Table 19.3.2 Economic Evaluation of Central Route

Discount Rate = 10% per annum

Design and Construction Period = 3 years (2000 - 2002)

Economic Life = 20 years after construction (i.e. 2003 - 2022)

(Costs and Benefits are in US$)

Year	Yearly Cost	Yearly Benefit	Discounted	
			Cost	Benefit
2000	495,300	0	450,273	0
2001	1,733,550	0	1,432,686	0
2002	2,724,150	0	2,046,694	0
2003	0	444,629	0	303,688
2004	0	488,877	0	303,554
2005	0	537,528	0	303,421
2006	0	591,021	0	303,287
2007	0	649,838	0	303,154
2008	0	714,507	0	303,021
2009	0	785,613	0	302,888
2010	0	863,794	0	302,755
2011	0	949,756	0	302,621
2012	0	1,044,272	0	302,488
2013	0	1,148,194	0	302,355
2014	0	1,262,459	0	302,223
2015	0	1,388,094	0	302,090
2016	0	1,526,233	0	301,957
2017	0	1,678,118	0	301,824
2018	0	1,845,118	0	301,692
2019	0	2,028,738	0	301,559
2020	0	2,230,631	0	301,426
2021	0	2,452,616	0	301,294
2022	0	2,696,691	0	301,162
Total	4,953,000	25,326,728	3,929,653	6,048,459

B/C	**1.539**
IRR	**14.66%**
NPV	**2,118,806**

$$B/C = \frac{\text{Total Discounted Benefit}}{\text{Total Discounted Cost}} = \frac{6,048,459}{3,929,653} = 1.539$$

$$NPV = (\text{Total Discounted Benefit} - \text{Total Discounted Cost}) = 6,048,459 - 3,929,653 = 2,118,806$$

IRR is calculated through hit and trial method as follows:

$$\sum_{j=1}^{n} \frac{(\text{Yearly Benefit} - \text{Yearly Cost})_j}{(1+IRR)^j} = 0; \text{ where } n = \text{Total number of years for economic evaluation}$$

Table 19.3.3 Economic Evaluation of Northern Route

Discount Rate = 10% per annum

Design and Construction Period = 5 years (2000 - 2004)

Economic Life = 20 years after construction (i.e. 2005 - 2024)

(Costs and Benefits are in US$)

Year	Yearly	Yearly	Discounted	
	Cost	Benefit	Cost	Benefit
2000	3,157,400	0	2,870,364	0
2001	3,157,400	0	2,609,421	0
2002	9,472,200	0	7,116,604	0
2003	9,472,200	0	6,469,640	0
2004	6,314,800	2,023,843	3,920,994	1,256,647
2005	0	2,109,724	0	1,190,884
2006	0	2,199,249	0	1,128,562
2007	0	2,292,573	0	1,069,502
2008	0	2,389,858	0	1,013,533
2009	0	2,491,271	0	960,493
2010	0	2,596,987	0	910,228
2011	0	2,707,189	0	862,594
2012	0	2,822,068	0	817,453
2013	0	2,941,821	0	774,674
2014	0	3,066,657	0	734,133
2015	0	3,196,789	0	695,714
2016	0	3,332,444	0	659,306
2017	0	3,473,855	0	624,803
2018	0	3,621,267	0	592,106
2019	0	3,774,934	0	561,120
2020	0	3,935,122	0	531,755
2021	0	4,102,108	0	503,927
2022	0	4,276,179	0	477,556
2023	0	4,457,637	0	452,564
2024	0	4,646,796	0	428,881
Total	31,574,000	66,458,370	22,987,023	16,246,436

B/C	**0.707**
IRR	**6.38%**
NPV	**-6,740,587**

Table 19.3.4 Economic Evaluation of Southern Route

Discount Rate = 10% per annum

Design and Construction Period = 7 years (2000 - 2006)

Economic Life = 20 years after construction (i.e. 2007 - 2026)

(Costs and Benefits are in US$)

Year	Yearly Cost	Yearly Benefit	Discounted	
			Cost	Benefit
2000	2,080,400	0	1,891,273	0
2001	4,160,800	0	3,438,678	0
2002	8,321,600	0	6,252,141	0
2003	8,321,600	3,696,824	5,683,765	2,524,980
2004	8,321,600	3,800,389	5,167,059	2,359,743
2005	6,241,200	3,906,856	3,522,995	2,205,318
2006	4,160,800	4,016,305	2,135,148	2,060,999
2007	0	4,128,820	0	1,926,125
2008	0	4,244,488	0	1,800,077
2009	0	4,363,396	0	1,682,278
2010	0	4,485,635	0	1,572,188
2011	0	4,611,299	0	1,469,302
2012	0	4,740,483	0	1,373,149
2013	0	4,873,286	0	1,283,288
2014	0	5,009,809	0	1,199,308
2015	0	5,150,157	0	1,120,824
2016	0	5,294,437	0	1,047,476
2017	0	5,442,759	0	978,928
2018	0	5,595,236	0	914,866
2019	0	5,751,985	0	854,996
2020	0	5,913,125	0	799,044
2021	0	6,078,779	0	746,754
2022	0	6,249,074	0	697,885
2023	0	6,424,140	0	652,215
2024	0	6,604,110	0	609,533
2025	0	6,789,122	0	569,644
2026	0	6,979,317	0	532,366
Total	41,608,000	124,149,832	28,091,058	30,981,288

B/C	**1.103**
IRR	**11.33%**
NPV	**2,890,229**

Table 19.3.5 Economic Evaluation of Middle Ring Route

Discount Rate = 10% per annum

Design and Construction Period = 4 years (2000 - 2003)

Economic Life = 20 years after construction (i.e. 2004 - 2023)

(Costs and Benefits are in US$)

Year	Yearly	Yearly	Discounted	
	Cost	Benefit	Cost	Benefit
2000	1,645,100	0	1,495,545	0
2001	822,550	0	679,793	0
2002	5,757,850	0	4,325,958	0
2003	8,225,500	0	5,618,127	0
2004	0	2,397,969	0	1,488,950
2005	0	2,357,761	0	1,330,895
2006	0	2,318,227	0	1,189,617
2007	0	2,279,356	0	1,063,336
2008	0	2,241,137	0	950,461
2009	0	2,203,558	0	849,567
2010	0	2,166,610	0	759,384
2011	0	2,130,281	0	678,773
2012	0	2,094,562	0	606,720
2013	0	2,059,441	0	542,315
2014	0	2,024,909	0	484,747
2015	0	1,990,956	0	433,290
2016	0	1,957,573	0	387,295
2017	0	1,924,749	0	346,183
2018	0	1,892,475	0	309,435
2019	0	1,860,743	0	276,588
2020	0	1,829,543	0	247,227
2021	0	1,798,866	0	220,983
2022	0	1,768,703	0	197,526
2023	0	1,739,046	0	176,558
Total	16,451,000	41,036,466	12,119,424	12,539,850

B/C	**1.035**
IRR	**10.48%**
NPV	**420,426**

Table 19.3.6 Economic Evaluation of All Routes

Discount Rate = 10% per annum

Design and Construction Period = 8 years (2000 - 2007)

Economic Life = 20 years after construction (i.e. 2008 - 2027)

(Costs and Benefits are in US$)

Year	Yearly Cost	Yearly Benefit	Discounted	
			Cost	Benefit
2000	934,290	0	849,355	0
2001	3,737,160	0	3,088,562	0
2002	8,408,610	0	6,317,513	0
2003	12,145,770	0	8,295,724	0
2004	16,817,220	6,597,900	10,442,170	4,096,777
2005	25,225,830	6,825,518	14,239,323	3,852,827
2006	15,882,930	7,060,989	8,150,454	3,623,404
2007	10,277,190	7,304,584	4,794,385	3,407,642
2008	0	7,556,582	0	3,204,728
2009	0	7,817,274	0	3,013,897
2010	0	8,086,959	0	2,834,430
2011	0	8,365,948	0	2,665,649
2012	0	8,654,562	0	2,506,918
2013	0	8,953,132	0	2,357,640
2014	0	9,262,003	0	2,217,250
2015	0	9,581,529	0	2,085,220
2016	0	9,912,079	0	1,961,052
2017	0	10,254,032	0	1,844,278
2018	0	10,607,782	0	1,734,457
2019	0	10,973,736	0	1,631,176
2020	0	11,352,315	0	1,534,045
2021	0	11,743,954	0	1,442,697
2022	0	12,149,105	0	1,356,790
2023	0	12,568,232	0	1,275,997
2024	0	13,001,819	0	1,200,016
2025	0	13,450,364	0	1,128,559
2026	0	13,914,383	0	1,061,357
2027	0	14,394,410	0	998,157
Total	93,429,000	240,389,192	56,177,487	53,034,963

B/C	**0.944**
IRR	**9.27%**
NPV	**-3,142,524**

Chapter 20 Environmental Impact Assessment

20.1 Existing Environment and Baseline Survey

20.1.1 Socio-Economic Environment

1) Resettlement

At present, most households traditionally living in ger area do not have such a certificate of residence. Horoo chairmen have more detailed registration of households and residents.

2) Economic Activities

Households in the Tolgoit area and Songino Khairkhan duureg breed livestock and use hilly land for pasture. For instance, 58 households of 2nd horoo have a total of 347 head of cattle and goats. A few households grow some vegetables in a small field inside of their fences. High unemployment exists in this horoo, therefore, approximately only 25% of horoo population are employed. 1867 inhabitants (that is 35% of total horoo population) are registered as very poor people. There are 680 retired people. The condition is similar to those of 3rd and 4th horoo.

3) Cultural Property

Geser temple, protected by the State, is located at the IS4 intersection, which is proposed improving. The temple dates from 1838 and has a managed Buddha school for lama disciples. The Mongolian Law on Special Protected Areas sets the mode of historical and cultural monuments. It states that "Within 0.1-3.0 km of the territory of Natural or Cultural and Historical Monuments, it is prohibited to construct buildings which spoil the view and scenery, to plow or dig land, to use explosives, to explore or mine natural resources, to touch, erode or remove Natural or Cultural and Historical Monuments, or to conduct any other activity which causes damage to them".

20.1.2 Natural Environment

1) Hydrological Situation

Catchment areas of West Naran-Ard Ayush new road branch off from Sambalkhundev Mountain elevated 1525 m above sea level and end at the flood embankment in Unur khoroolol (micro-area). They are dry, but temporarily rain flood occurs. Storms with high intensity or intensive snow melting process produces severe flash flood in dry bed. flash floods in this area is observed, but there is no regular monitoring system of the hydrological situation in these areas. According to the regular hydrological monitoring of the annual runoff distribution in Mongolia shows that most runoff occurs from July to August.

During the EIA survey catchment area parameters were identified, and catchment areas bed with sediment is widening from beginning to end, and the height ranges from 0.3 to 4.0 m.

2) Landscape

Increase in the number of ger on the slope of hills in Tolgoit area contributed to deterioration in the urban landscape and public spaces. Especially, hills surrounding hills are important because of their commanding natural beauty as a feature of Ulaanbaatar.

20.1.3 Environmental Pollution

1) Air Pollution

Air quality monitoring was carried out at 2 stations – Old market and New Market. The location of the monitoring stations is shown in Figure 20.1.1. The details of the analysis of three hourly samples collected at the above mentioned locations are summarized in Table 20.1.1.Concentration of NO_2 (Nitrogen Dioxide) and SPM (Suspended Particulate Matter) is higher than the permissible level of standard (shaded cells).

Table 20.1.1 Ambient Air Quality

Location	Date of Sampling	Avg. 24 hrs Concentration ($\mu g/m^3$)					
		Pb	SPM	SO_2	NO2	NO	CO
Old market (124 Kindergarten)	7-8.10.1998	0,056	345	17,1	86,9	55,0	900
	8-9.10.1998	0,063	318	13,0	60,4	35,8	1700
	9-10.10.1998			15,8	68,0	38,2	2700
New market (Hospital)	7-8.10.1998	0,025	159	7,5	37,6	28,6	1100
	8-9.10.1998	not found	306	7,5	46,7	26,6	1400
	9-10.10.1998	0,045	322	6,7	30,6	14,7	1600
	10-11.10.1998	0,030	338				
Air quality Standard	RESIDENTIAL/ RURAL		150	30	40		3000

2) Noise and Vibration

Noise and vibration monitoring was carried out at 10 sites along the proposed roads. Site location map is shown in Figure 20.1.1. During 10 minutes noise and vibration measured using integral type of noise and vibration level meter. There were registered Leq, L_{50}, Lmax for noise and Leq, L_{10}, Lmax for vibration. The survey was carried out on weekdays, during day and night times. Simultaneous observation of the traffic volume was conducted.

The noise levels are comparatively high due to movement of vehicles. The present noise level, generally ranges from 57dB(A) to 72dB(A), as recorded at all sites. The results of the monitoring are summarized in Table 20.1.2.

Table 20.1.2 Noise and Vibration Level Monitoring
(Daily Average Value)

No	Location	Noise Level (dB)			Vibration Z (dB)			Traffic Volume (10min.)		
		L_{Aeq}	L_{Amax}	L_{A50}	L_{Veq}	L_{Vmax}	L_{10}	S. car	Truck	Bus
1	Old market	67	84	62	40	56	36	68	5	46
2	New market	66	86	59	40	55	38	44	5	6
3	Bars Trade center	68	87	61	48	88	42	48	12	12
4	Tolgoit Apartment bk.	65	83	55	45	64	41	14	4	6
5	Tolgoit Gger area	66	86	52	55	79	48	10	3	4
6	Auto school	64	82	55	55	79	48	8	2	2
7	Brick factory	57	75	49	45	66	37	2	1	0
8	Geser temple	72	90	66	52	74	39	138	11	40
9	TV-Children hospital	61	79	54	42	70	38	3	1	1
10	East Teeverchid road	70	90	58	48	69	41	14	8	6

Power Level of Existing Vehicles in Ulaanbaatar

There is no data available on the investigation of noise made by each type of vehicle in Ulaanbaatar. Accordingly, the noise power levels of an actual passenger car on the dual-lane at-grade road with small traffic volume were investigated briefly. The objective of the study was to investigate existing vehicle noise levels for each type considering the velocity, and on the basis of this to appraise the method of estimating noise levels caused by transportation in the future. The evaluation was based on methods used by the Acoustical Society of Japan (ASJ).

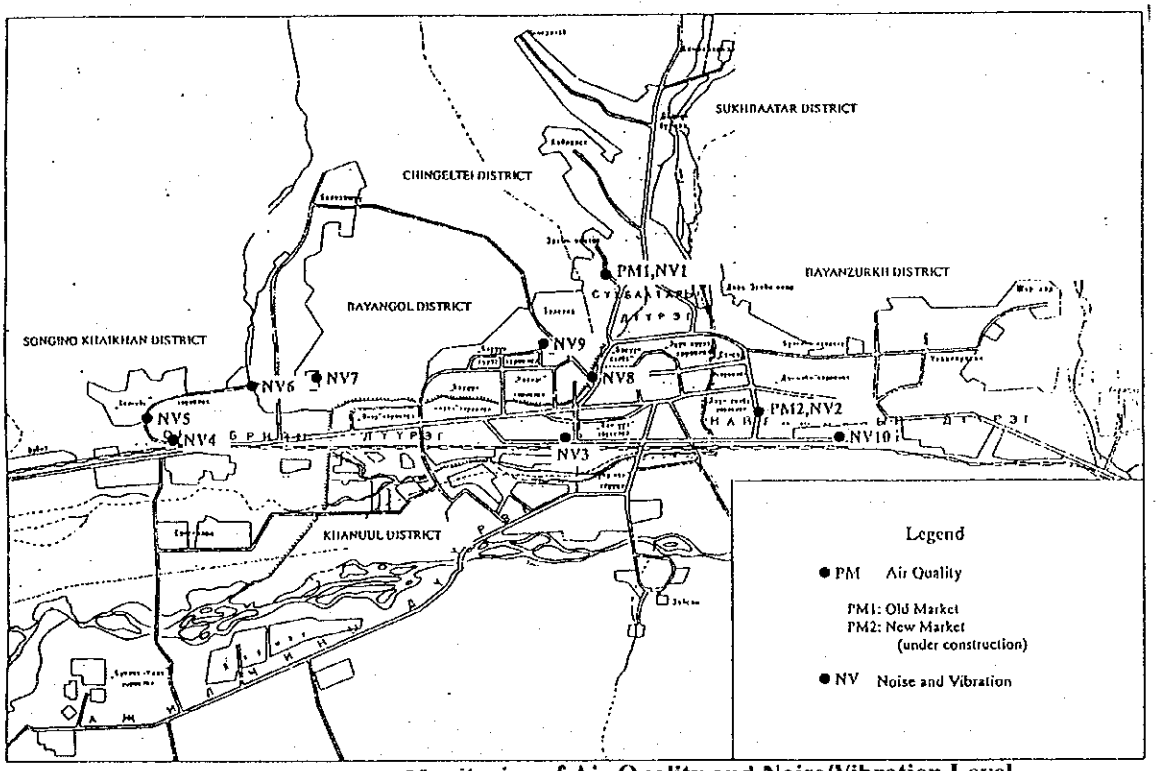


Figure 20.1.1 Location for Monitoring of Air Quality and Noise/Vibration Level

The regression of power level with running vehicle speed was estimated using the measured values. The results with regression formula fixed at 20.0 as the proportion constant, are shown in Table 20.1.3.

Table 20.1.3 Regression of Power Level with Velocity

Type of vehicle	Regression formula	Correlation coefficient	Standard error	Sampling Number
Group of small vehicle	$Lw = 23.8 \log_{10} V + 62.2$ $Lw = 20.0 \log_{10} V + 68.9$	0.56	3.56	50
Group of large vehicle	$Lw = 17.8 \log_{10} V + 78.5$ $Lw = 20.0 \log_{10} V + 74.5$	0.29	4.73	107

Small vehicles: cars, Large vehicles: buses, trucks

Therefore, the average power level in Ulaanbaatar classified by 2 types of vehicles is estimated using the following formula synthesised from the above-mentioned formulae.

$$Lw = 68.9 + 20 \log_{10} V + 10 \log_{10} (a_1 + 3.7 a_2)$$

a_1: Ratio of small vehicle

a_2: Ratio of large vehicle $a_1 + a_2 = 1.0$

20.2 Prediction of Impact and Evaluation

20.2.1 Socio-economic Environment

1) Resettlement

Resettlement will occur due to construction of new roads and flyovers, and the improvement of roads. Land acquisition will be required with regard to NW Tolgoit, Teeverchid roads, etc. Particularly many gers along NW Tolgoit road are located within 2-15 meters from the edge of the existing road. This road passes through the territory of 2, 3 and 4th horoo of the Songino Khairkhan district. EIA estimated that totally 340 households with around 2,700 peoples are living within 50-meter corridor of the existing or planned roads.

The majority of interviewed individuals including horoo officials welcome the road rehabilitation project. They are expecting development and improvement of access roads that will bring improvement of their living conditions. On the other side, inhabitants who are living in the area will be directly affected by the project. They have negative opinion for the project. Some of them recently purchased fences and houses, or started on construction of new houses for the purpose of investment. Some have lived here for a long time, so it seems that relocation to other places may be problematic. Most of them have low income or are unemployed. Most households have no land-possessing certificate; all will require social care and/or compensation.

2) Economic activities

In Tolgoit areas some shops affected by the road widening are more problematic and costly than the kiosks and will require more handout budgets for compensation. 14 shops, service centers and 36 kiosks along NW Tolgoit road need to be removed. In widening area of Teeverchid road,

a restaurant and heating/power sub-station, near to Enkhtaivan bridge, and 6 kiosks, 2 petrol stations (one is under construction in opposite of New market) exist.

West Naran-Ard Ayush new road will pass near to the borrow pit of a brick factory. This may limit some areas of borrow pit exploitation and affect economy of the factory.

3) Traffic and public facilities

Proposed traffic facilities such as flyovers will cause more effective public transportation network against simultaneous increase of traffic volume and encourage decreasing of traffic accidents. Meanwhile, traffic congestion and noise pollution during construction are expected, so construction planning will need prudent environmental consideration. There are hospitals, schools, and kindergartens along the road corridor. Kindergarten No. 56 is located 40 m from the existing road. It is essential to consider the environmental impact on them.

4) Cultural property

The state protected cultural heritage Geser temple is located at the intersection that is proposed for improvement. The temple area will be affected by road construction. As the distance from road edge to the Geser temple is short, special care should be given during the construction phase. Important is the inclusion in the plan for a specific contracting clauses to define responsibilities of constructing companies and workers who will actually do the construction work.

During construction Period

- Increase of SPM due to groundwork and vibration of construction equipment may affect negatively on the monument quality.
- Lama and disciples regularly visit and hold classes at the temple and may be annoyed by the serious impact from construction noise, dust and waste.

5) Waste

The central dumpsite of Ulaanbaatar located at Morin Davaa is considered as the most suitable one for disposal of solid waste from road construction.