9.3.5 Selection and Application of Structural Type for Kherlen Bridge

(1) Selection of Type of Super Structure

a) Comparison Table of Standardized Large Scaled Bridge

For the cost estimation of each bridge types, the comparison table for standardized large scaled types of bridges with characteristics such as construction cost, method, period, availability of materials, maintenance, affects to river and aesthetic, etc. was made as shown in Table 9-3-4 and 9-3-5.

The total length of bridge is approximately 300m, the super structural types of RC, PC and Steel materials are compared considering arrangement of span length and above characteristics.

From the results of overall evaluation in Tables, prestressed concrete (PC) T girder of standardized super structure type was selected, and to be applied for large scaled bridge.

Table 9-3-4 Comparison of Standardized Large Scale Bridge 1/2

Evaluation Point	Good ↔ Bad		
	1	2	3

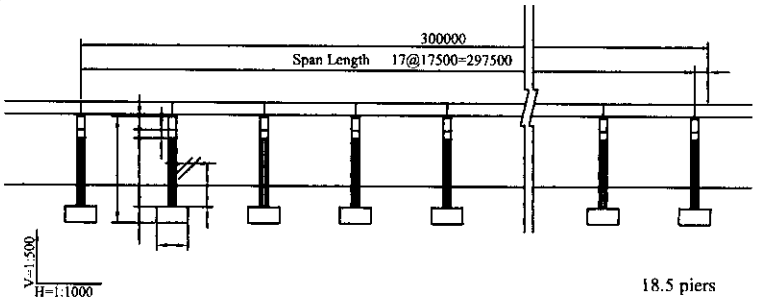
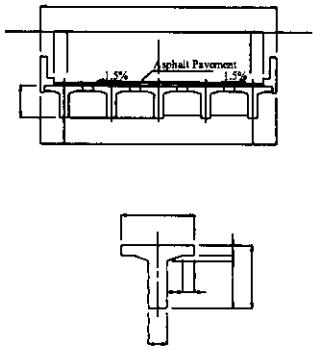
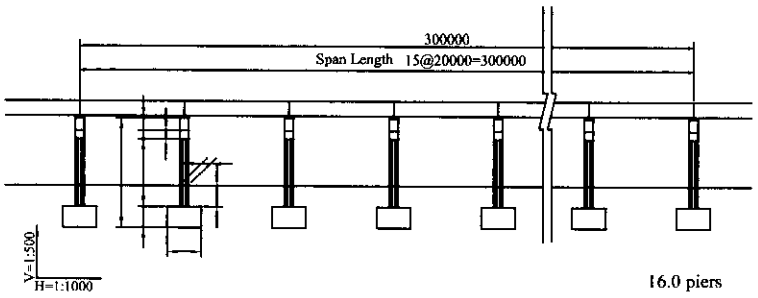
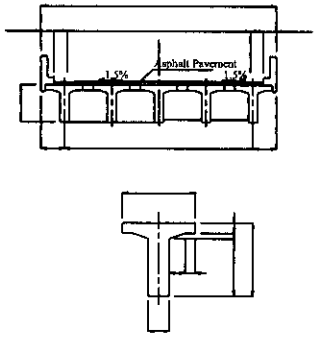
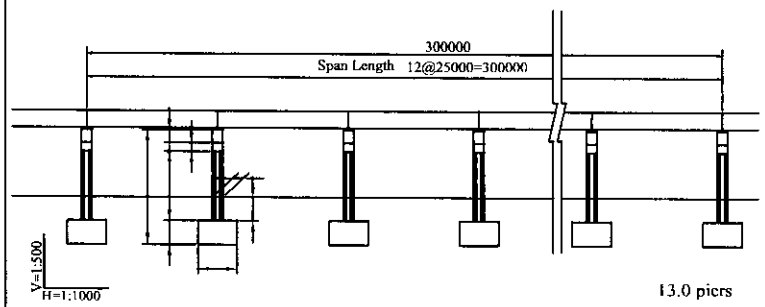
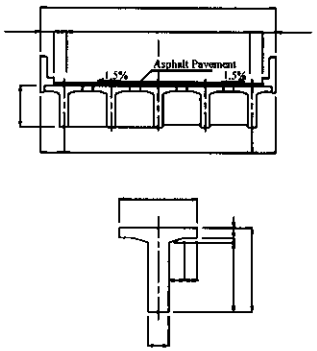
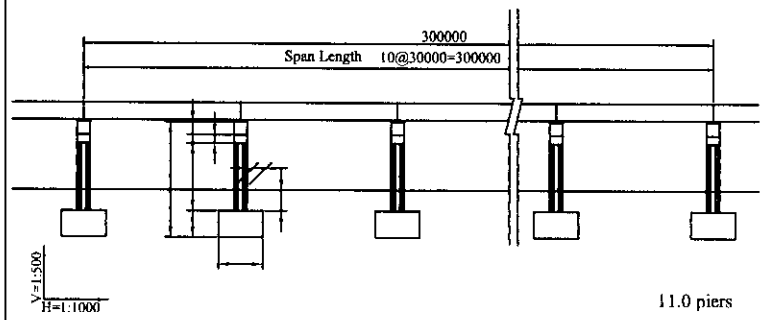
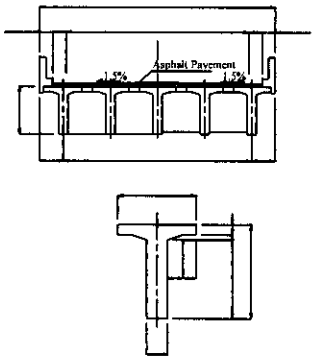
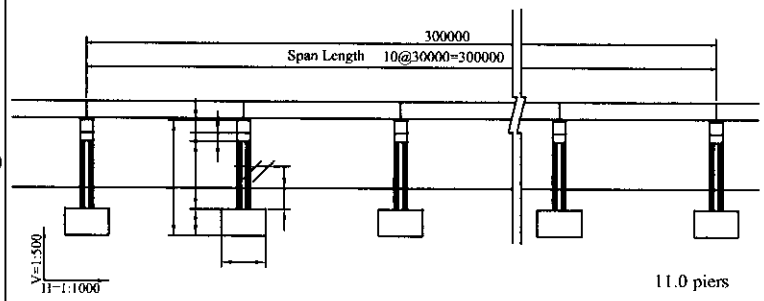
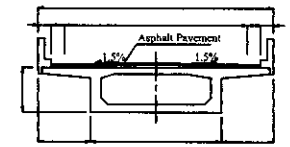
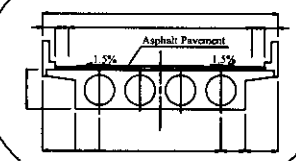
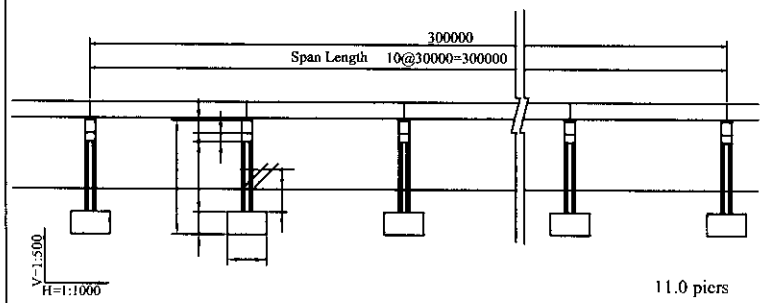
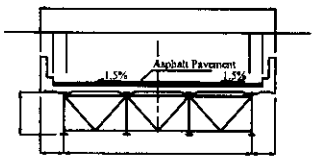
CASE & TYPE	Profile (Unit Length of Bridge 300m)	Bridge Section	Characteristic	Evaluation Point	Adoption
CASE- 1 RC-T @17.5m		 Girder Weight 28.9 ton/no.	1. Construction Cost :US$ 1,905,700 (Cost Index : 1.00) Economical (US$ 710 / m²: bridge surface)	1	
			2. Construction and/or Erection (Easy/Difficult) Construction Yard / Crane	1	
			3. Construction Period (Short/Long) Long	3	
			4. Girder Concrete Casting & Strength σ28 (Easy/Difficult) Simple Form Work, Easy Casting Concrete, σ28=240kg/cm²	1	
			5. Width of pires / River section ratio 18.5 Piers in the River	3	
			6. Others (Landscape,Approach Height) Landscape : Not good, Approach Height : Lower	3	Point 12
CASE- 2 RC-T @20.0m		 Girder Weight 39.5 ton/no.	1. Construction Cost :US$ 2,001,000 (Cost Index : 1.05) Economical (US$ 740 / m²: bridge surface)	1	
			2. Construction and/or Erection (Easy/Difficult) Construction Yard / Crane or Launching by Temporary Girder	2	
			3. Construction Period (Short/Long) Long	3	
			4. Girder Concrete Casting & Strength σ28 (Easy/Difficult) Simple Form Work, Easy Casting Concrete, σ28=240kg/cm²	1	
			5. Width of pires / River section ratio 16.0 Piers in the River	3	
			6. Others (Landscape,Approach Height) Landscape : Fair, Approach Height : Lower	3	Point 13
CASE- 3 PC-T @25.0m		 Girder Weight 55.6 ton/no.	1. Construction Cost :US$ 2,401,200 (Cost Index : 1.26) Not Economical (US$ 890 / m²: bridge surface)	2	
			2. Construction and/or Erection (Easy/Difficult) Cast in Place / Launching by Temporary Girder	3	
			3. Construction Period (Short/Long) Shorter than Case 1, 2	2	
			4. Girder Concrete Casting & Strength σ28 (Easy/Difficult) Simple Form Work, Easy Casting, σ28>400kg/cm² (Required Quality Control)	2	
			5. Width of pires / River section ratio 13.0 Piers in the River	2	
			6. Others (Landscape,Approach Height) Landscape : Fair, Approach Height : Higher	2	Point 13

Table9-3-5 Comparison of Large Scale Bridge (Kherlen Bridge) 2/2

Evaluation Point	Good ↔ Bad		
	1	2	3

CASE & TYPE	Profile (Unit Length of Bridge 300m)	Bridge Section	Characteristic	Evaluation Point	Adoption
CASE- 4 PC-T @30.0m		 Girder Weight 72.8 ton/no.	1. Construction Cost :US$ $2,515,500 (Cost Index : 1.32) Not Economical (US$ 930 / m²: bridge surface)	2	Acceptable
			2. Construction and/or Erection (Easy/Difficult) Cast in Place / Launching by Temporary Girder	3	
			3. Construction Period (Short/Long) Shortest	2	
			4. Girder Concrete Casting & Strength σ28 (Easy/Difficult) Simple Form Work, Easy Casting, σ28>400kg/cm² (Required Quality Control)	2	
			5. Width of pires / River section ratio 11.0 Piers in the River	1	
			6. Others (Landscape,Approach Height) Landscape : Fair, Approach Height : Higher	1	Point 10
CASE- 5 PC-BOX (PC-Hollow) @30.0m		 Girder Weight 378.6 ton / Span  Girder Weight 473.3 ton / Span	1. Construction Cost :US$ 2,801,400 (Cost Index : 1.47) : PC-Box Not Economical (US$ 1,040 / m² : bridge surface)	3	
			2. Construction and/or Erection (Easy/Difficult) Cast in Place / Launching or All Staging Support	3	
			3. Construction Period (Short/Long) Shorter than Case 1, 2	2	
			4. Girder Concrete Casting & Strength σ28 (Easy/Difficult) σ 28>400 kg/cm²(Required Quality Control in Site)	3	
			5. Width of pires / River section ratio 11.0 Piers in the River	1	
			6. Others (Landscape,Approach Height) Landscape : Good, Approach Height : higher	1	Point 13
CASE- 6 STEEL-I @30.0m		 Girder Weight 299.6 ton/Span	1. Construction Cost :US$ $4,783,300 (Cost Index : 2.51) Not Economical (US$ 1,770 / m² : bridge surface)	3	
			2. Construction and/or Erection (Easy/Difficult) Slab : Cast in Place (complicated form work)/ Crane and Partly Staging Girder : Splicing with Bolts in Site	3	
			3. Construction Period (Short/Long) Shorter than Case 1, 2	2	
			4. Slab Concrete Casting & Strength σ28 (Easy/Difficult) Complicated Form Work and Casting, 28>240kg/cm²	3	
			5. Width of pires / River section ratio 11.0 Piers in the River	1	
			6. Others (Landscape,Approach Height) Landscape : Fair, Approach Height : Higher	2	Point 14

b) Application of Type of Super Structure for Kherlen Bridge

The total length of new proposed Kherlen Bridge is 268.8m for the Project stage, considering 360m long of bridge in future stage.

Referring to comparison table of type for standardized large scale bridge, types of super structure for Kherlen Bridge are considered with characteristics for evaluation as shown below Table 9-3-6.

Though the type of steel girder is higher cost due to import materials, required skilled technology for fabrication and maintenance for re-painting, it shall also to be compared for Kherlen Bridge.

Table 9-3-6 Characteristics of Proposed Super Structure Type for Kherlen Bridge

Case Type	Bridge Length	Characteristic for Evaluation
- RC T Girder	268.8m(16@ 16.8m span)	1. Construction Cost: Economy or not 2. Erection: Easier or Heavier 3. Construction Period: Short or Long 4. Materials: Available in Mongolia or not 5. River: Obstacle/influence or not 6. Maintenance: Need or not 7. Aesthetic: Good or not 8. Others
- PC T Girder	268.8m(8@ 33.6m span)	
- PC Box Girder	268.8m(8@ 33.6m span)	
- Steel I Girder	268.8m(8@ 33.6m span)	

c) Recommendation of Type of super Structure for Kherlen Bridge

The detailed comparison of type for Kherlen Bridge is shown in Table 9-3-7.

In viewpoints of comparison table and mentioned below reasons, the type super structure for Kherlen Bridge is applied **PC T shape Girder scaled 268.8m length (8@ 33.6m span length)**.

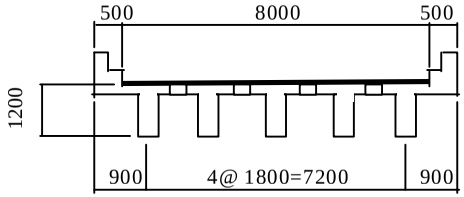
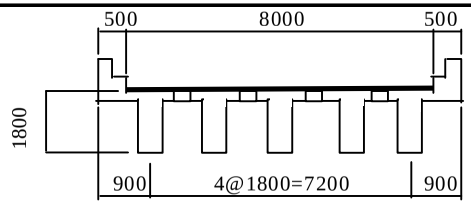
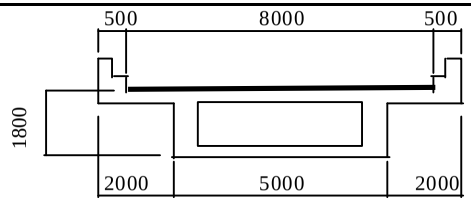
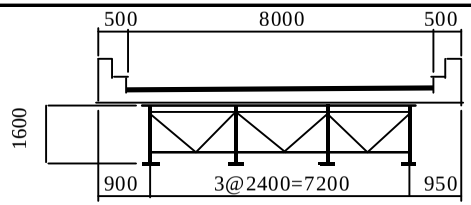
Applied Reasons:

- Construction Cost: Fair (second economy)
- Erection of girder: Heavier crane or launching with temporary steel beam, portal frame
- Construction period: Short
- Materials: Import of PC wires, tension equipment etc
- River: Not obstacle because of long span (width of pier/river ratio: less than 5%)
- Maintenance/ Structure: Massive concrete (high strength), No maintenance
- Aesthetic: Fair
- Others: Technical transfer for prestressing method, and heavier erection method

These girders shall be fabricated in casting yard, and transported to the bridge location. Beside, fabrication such as pouring concrete and form/ reinforcing steel bar works shall avoid at the site as much as possible, due to short season for works (6-7 month per year) in Mongolian natural conditions.

Though the type of steel girder is higher cost due to import materials, it shall also to be compared for Kherlen Bridge.

Table 9-3-7 Comparison of Girder Type for Kherlen Bridge

Type	View of Girder	Characteristics	Point	Evaluation
		Point: Good **1** → Bad **3**		
Reinforced Concrete T Shape Girder 16@16.8m=268.8m		1. Construction Cost: Economy $770/m2 (Cost Index 1.00) 2. Girder Erection Method: Easy by Crane 3. Construction Period: Long (Girder no.64, Sub-str. no.17) 4. Materials: Available in Mongolia 5. Affect to River: Obstacle of Piers 6. Maintenance/ Structure: Free, Strength σ 28=240kg/cm2 7.Aesthetic: No good 8. Others: Total Point	1 1 3 1 3 2 3 14	
Prestressed Concrete T Shape Girder 8@33.6m=268.8m		1. Construction Cost: Fair $870/m2 (Index 1.10) 2. Girder Erection Method: Heavier Crane or Launching 3. Construction Period: Short (Girder no.32, Sub-str. no.9) 4. Materials: Not Available (Import of PC wire, equipment) 5. Affect to River: Not Obstacle of piers 6. Maintenance/ Structure: Free, Strength σ 28=400kg/cm2 7.Aesthetic: Fair 8. Others: Technical Transfer for PC Bridge Total Point	2 2 1 2 1 1 2 11	**Acceptable**
Prestressed Concrete Box Shape Girder 8@33.6m=268.8m		1. Construction Cost: Not Economy $960/m2 (Index 1.24) 2. Girder Erection Method: Staging Support or Launching 3. Construction Period: Longer 4. Materials: Not Available (Imprt of PC wire, eqquipment) 5. Affect to River: Not Obstacle of piers 6. Maintenance/ Structure: Free, Strength σ 28=400kg/cm2 7.Aesthetic: Fair 8. Others: Technical Transfer for PC Bridge Total point	2 3 2 2 1 1 2 13	
Steel I Shape Girder 8@33.6m=268.8m		1. Construction Cost: Not Economy $1610/m2 (Index 2.09) 2. Girder Erection Method: Easier by Crane, and Part Staging 3. Construction Period: Shorter (Girders made in Overseas) 4. Materials: Not Available (Import of Steel) 5. Affect to River: Not Obstacle of piers 6. Maintenance/ Structure: Required for painting etc. 7.Aesthetic: Good 8. Others: Technical Transfer for Steel Bridge Total Point	3 2 2 3 1 3 1 15	

(2) Recommendation of Type for Sub Structure

According to the results of geological survey for the Kherlen Bridge, bearing stratum can be seen 3 to 4m from existing river bed. Therefore, the foundation shall be embedded into bearing layer, up to approximately depth of 4 to 5m from existing river bed, with spread footing type.

The type of piers shall adopt RC wall shaped elliptical column and beams from comparison table of Clause 9.4, economical cost, construction period, river flow aspects.

9.4 Selection and Application of Structural Type for the Project

9.4.1 Scale and Location of Planned Bridges for the Project

(1) Loading Capacity of Existing Bridges on the Project Route

In case of selection of North Route, there are two existing bridges (No.1 crossing Khujirt River and No.2 crossing Khutsaa River) between starting point of Baganuur and existing Kherlen River.

As mentioned in Chapter 4, the stability for bridges of RC slab/girder type for No.1 and No.3 applying International Loading system is not sufficient (over strength). The temporary wooden bridges of No.2, No.4 and No.5 are surely replaced to permanent concrete bridges.

The existing RC slab bridge of No.1 (Khujirt River) constructed in year 1970s shall be replaced with new RC T girder bridge or large scaled RC box culvert depending on the requirement of design river section (broken approach wall by past floods), overage of existing RC slab, and insufficient load capacity for Millennium Arterial Road.

In Clause 9.3, the existing Kherlen Bridge (No.3) shall be utilized for light vehicles of trucks, livestock and pedestrian as loading limitation. New bridge crossing Kherlen River shall be constructed at downstream side of existing bridge for a part of Millennium Arterial Road.

(2) Scale of Bridges

Including the above locations of bridges, the whole hydrological analysis in the Project area was examined as report.

From the results of hydrological analysis, the scale of designated river section at each river and water way were determined for existing bridges and proposed route, as shown below Figure 9-4-1 and Table 9-4-1.

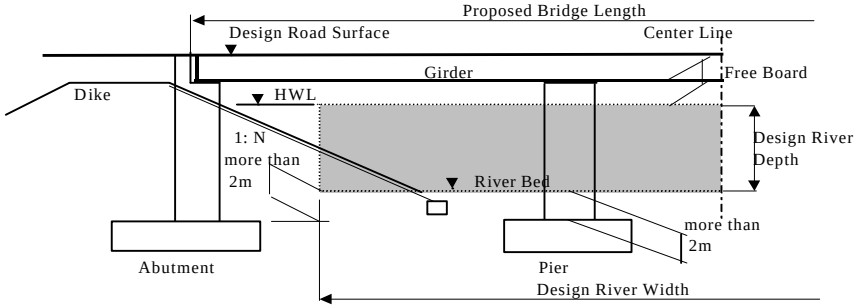


Figure 9-4-1 Determination of Proposed Bridge Length

Table 9-4-1 Existing Conditions and Design River Section

- For Existing Bridges

Name of Bridge		BrNo1(Khujirt)	BrNo.2(Khutsaa)	BrNo.3(Kherlen)	BrNo.4(Tsenkher)	BrNo.5(Murun)
Item		Existing	Existing	Existing	Existing	Existing
Existing Conditions	River Width	8m(9m)	15m(14.7m)	270m(268.8m)	30m(30.7m)	20m(19.6m)
	Road Surface Level	EL 1360.0m	1330.6m	1303.1m	1370.9m	1057.0m
	Girder Bottom Level	EL 1358.2m	1329.6m	1301.8m	1370.2m	1056.3m
	Lowest River Bed Level	EL 1356.5m	1326.8m	1297.6m	1369.0m	1055.0m
	River Bed Width	4.6m	5m	67.2m	25.0m	15.6m
	Girder Bottom-River Bed	1356.5m	1326.8m	1297.6m	1369.0m	1055.0m
	HighWater level	EL				
	Water Level (April, May)	0.2m	0.2m	0.9m	0.3m	0.3m

- For Proposed Route

Name of Bridge		B1	B2	B3	B4	B5	B6
Item	Name of river	Khujirt	Khutsaa, Nariin	Kherlen	Tsenkher	Urt Val.	Murun
Proposed Dimension	Discharge (Q m3/s)	111	128	1100	300	85	350
	River Width (Bridge Length)	15.0m	17.5m	268.8m	52.5m	15.0m	52.5m
	High Water level	2.0m	1.8m	2.0m	1.8m	1.7m	1.9m
	River Bed Width	9.0m	11.5m	260.8m	46.5m	9.0m	46.5m
	River Bed Level	1352.0m	1327.5m	1297.6m	1366.3m	1383.2m	1090.3m
	Embankment Height	2.6m	2.6m	3.0m	2.6m	2.6m	2.6m
	Freeboard	0.6m	0.6m	1.0m	0.6m	0.6m	0.6m
	Height of Girder + Pavement	1.1m	1.3m	1.9m	1.3m	1.1m	1.3m
	Road Surface Level(Min)	1356.2m	1331.7m	1303.0m	1370.5m	1387.1m	1094.6m
	Slope of Protection (1:N)	1:1.5	1:1.5	1:2.0	1:1.5	1:1.5	1:1.5

Freeboard of bridges is defined in accordance with Mongolian Standard BNbD 2.05.03-97, as 0.5m for 1m depth of water, 0.75m for river with ice and 1.00m for heavy flow with sand, respectively. Japanese standards are shown in Table 9-4-2 for clearance below girder bottom (Design Guidelines for River Facilities in Japan). These have a greater level of detail and shall be adopted in design.

Table 9-4-2 Free Board of Bridges- Japanese Guideline

Design Discharge Q (m3/s)	Free Board ΔH (m)
Q < 200	0.6
200 < Q < 500	0.8
500 < Q < 2,000	1.0
2,000 < Q < 5,000	1.2
5,000 < Q < 10,000	1.5
10,000 < Q	2.0

The width of Project bridges is defined 4.5m for one lane, 6.5m and 8m for two lanes. Applied width of carriage way is 8.0m for all Project bridges as Millennium Arterial Road in below Figure 9-4-2.

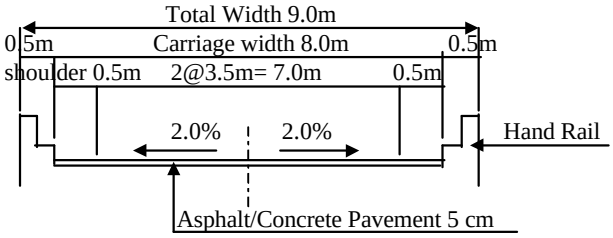


Figure 9-4-2 Width of Project Bridges

(3) Location of Proposed Bridge and Main Box Culvert along the Alternative Routes

Based on the natural conditions of geology, river/waterway, the results of hydrological study from Chapter 5, and the whole studies on alternative routes between Baganuur and Undurkhaan as Clause 9.2, locations of proposed bridges and main large box culverts are shown in Figure 9-4-3.

For the comparison of alternative routes as A, B and C routes, the scale, type and number of structures (bridges and Box culverts) on each route are shown in Table 9-4-3.

These scales and structural types are adopted according to comparison of type from next Clause 9.4.2.

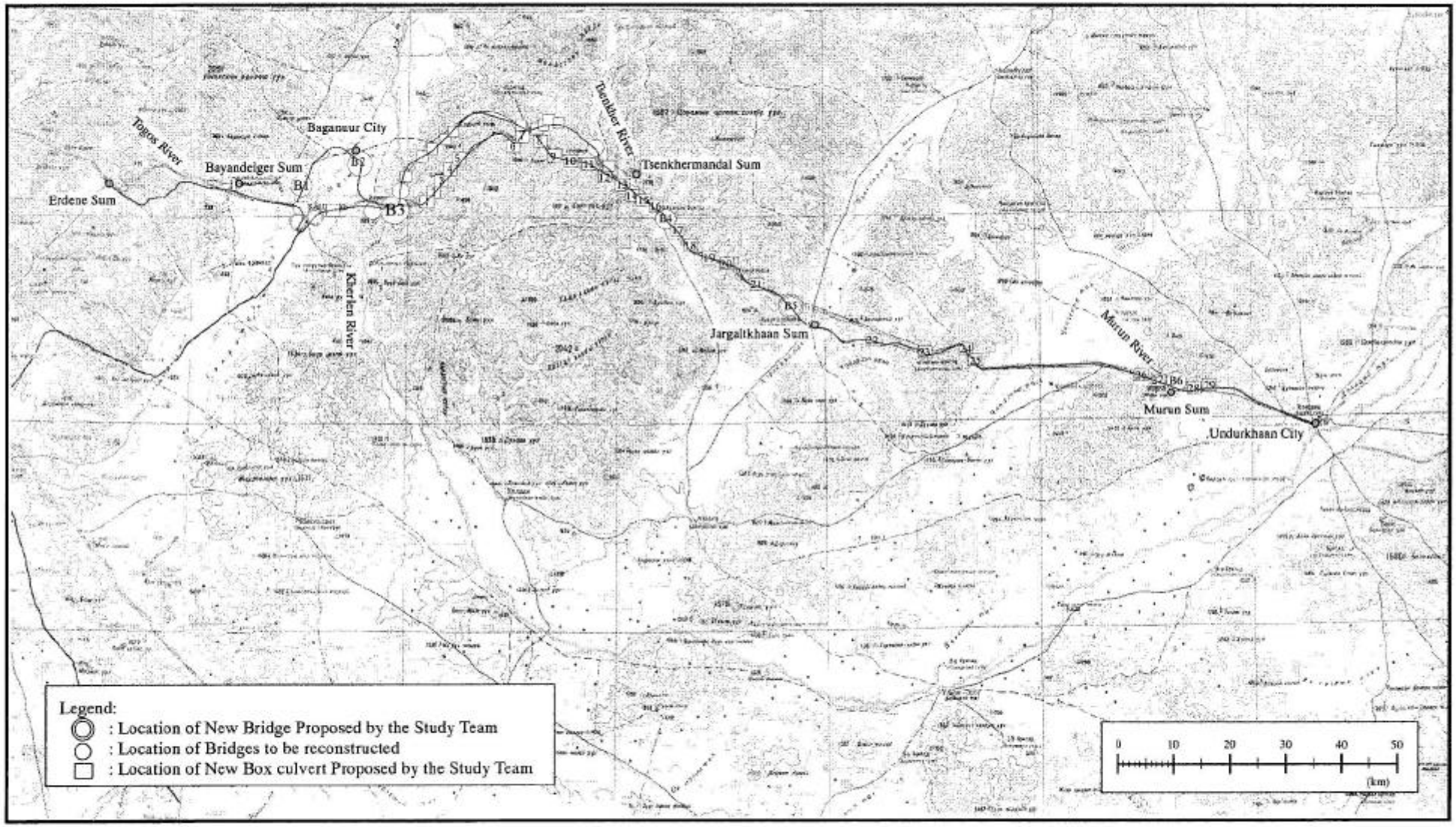


Figure 9-4-3 Location Map of Bridges and Box Culverts for Alternative Routes

Table 9-4-3 List of Bridges and Box Culverts for Alternative Routes

	No.	Structure	Type(*)	Length	Span (m)	Width(m)	Name of River (Vally)	Location
1	BC1	Box	D	2.5	2.5	-	-	↓
2	BC2	Box	D	2.5	2.5	-	-	↓
3	BC3	Box	D	2.5	2.5	-	-	↓
4	A1	RC-T	3	35.0	2@17.5	9.0	Togos	Togos River
5	A2	RC-T	1	15.0	15.0	9.0	(Chandaruu)	↓
6	BC4	Box	E	2.5	2@2.5	-	Delger	↓
7	BC5	Box	E	2.5	2@2.5	-	Rashaant	↓
8	A3	RC-T	1	15.0	15.0	9.0	Khujirt	↓
9	B1	RC-T	2	17.5	17.5	9.0	Khutsaa, Nariin	↓
10	B2	RC-T	6	268.8	8@33.6	7.5	Kherlen	Kherlen River
11	BC6	Box	D	2.5	2.5	-	(Kharzat)	↓
12	BC7	Box	D	2.5	2.5	-	(Yumt)	↓
13	BC8	Box	D	2.5	2.5	-	(Dund Bulag)	↓
14	BC9	Box	E	2.5	2@2.5	-	(Shoboi)	↓
15	BC10	Box	F	7.5	3@2.5	-	(Ust)	↓
16	BC11	Box	D	2.5	2.5	-	-	↓
17	BC12	Box	D	2.5	2.5	-	-	↓
18	BC13	Box	E	2.5	2@2.5	-	-	↓
19	BC14	Box	D	2.5	2.5	-	-	↓
20	BC15	Box	E	2.5	2@2.5	-	-	↓
21	BC16	Box	E	2.5	2@2.5	-	-	↓
22	BC17	Box	E	2.5	2@2.5	-	-	↓
23	BC18	Box	D	2.5	2.5	-	-	Tsenkhermandal
24	BC19	Box	F	7.5	3@2.5	-	(Bogin)	↓
25	BC20	Box	D	2.5	2.5	-	(Toson)	↓
26	BC21	Box	E	2.5	2@2.5	-	(Byatskhan Bulag)	↓
27	B3	RC-T	4	52.5	3@17.5	9.0	Tsenkher	Tsenkher River
28	BC22	Box	F	7.5	3@2.5	-	(Urgun)	↓
29	BC23	Box	E	2.5	2@2.5	-	-	↓
30	BC24	Box	F	7.5	3@2.5	-	(Ar Khadagtai)	↓
31	BC25	Box	E	2.5	2@2.5	-	Uvur Khadagtai	↓
32	BC26	Box	D	2.5	2.5	-	(Zuulun)	↓
33	B4	RC-T	1	15.0	15.0	9.0	(Urt)	↓
34	BC27	Box	E	2.5	2@2.5	-	(Ulaan Khudag)	Jargaltkhaan
35	BC28	Box	D	2.5	2.5	-	-	↓
36	BC29	Box	F	7.5	3@2.5	-	Duut	↓
37	BC30	Box	E	2.5	2@2.5	-	(Duut)	↓
38	BC31	Box	E	2.5	2@2.5	-	(Tsagaan Morit)	↓
39	BC32	Box	D	2.5	2.5	-	(Del)	↓
40	B5	RC-T	4	52.5	3@17.5	9.0	Murun	Murun
	Total			576.3 m				

(*) Types of structures is showan on next page.

Types of Structure

Structure		Type	Length	Span	Width
Culvert	Box	D	2.5 m	2.5	-
Culvert	Box	E	2.5 m	2@2.5	-
Culvert	Box	F	7.5 m	3@2.5	-
Culvert	Box	G	9.0 m	3@3.0	-
Bridge	RC-T	1	15.0 m	15.0	9.0
Bridge	RC-T	2	17.5 m	17.5	9.0
Bridge	RC-T	3	35.0 m	2@17.5	9.0
Bridge	RC-T	4	52.5 m	3@17.5	9.0
Bridge	RC-T	5	70.0 m	4@17.5	9.0
Bridge	RC-T	6	268.8 m	8@33.6	7.5

9.4.2 Selection and Application of Structural Type for the Project

In the light of present construction/situation of the structures in Mongolia, structure type for the Project shall be proposed and standardized.

Prior to the proposal of design standard, the technical meeting held on May 18th, July 31st, September 20th and December 3rd 2001, joining JICA Study Team and Mongolian Technical Committee in terms of problems, solutions and appropriate design standard for the bridge. These records are shown in Appendix.

(1) Bridge

For the purpose of establishing the "Design Standard" in the Project Road corresponding to the National Highway (Millennium Road), it shall be proposed, and standardized in this Study.

1) Bridge Conditions in Mongolia and Selection of Bridge Type

The types of superstructure of bridge shall be selected taking into account of present conditions based on economical aspect, availability of materials, technical level, construction method and experience, easier construction and maintenance methods.

Moreover, the substructure and foundation shall be determined considering the results of topographic and geological surveys.

a) Selection of Superstructure Type

The type of superstructure is classified into reinforced concrete (RC) bridge, prestressed concrete (PC) bridge and steel bridge.

The general relation of superstructure type and appropriate span length with ratio of girder height and span length are shown in Table 9-4-4.

Table 9-4-4 Relation between Superstructure Type and Span Length

Type of Bridge		Span Length(m) 20 30 40 50	Girder height/ Length
RC Bridge	Simple Slab		1／13～17
	Simple/continuous Hollow Slab		1／17～20
	Simple T-shape Girder		1／13～17
	Simple Box Girder		1／18
	Continuous Box Girder		1／20
PC Bridge	Simple Slab		1／18
	Simple/continuous Hollow Slab		1／18～22
	Simple T,I-shape Girder		1／15～18
	Simple/continuous Box Girder		1／18～22
Steel Bridge	Simple H-shape Beam		1／22
	Simple I-shape Girder		1／17
	Continuous I-shape Girder		1／18
	Continuous Box Girder		1／18～20

Regarding to the type of superstructure, many RC T shape girder bridges were constructed in the past and at present on account of availability of cement and aggregate in Mongolia.

These types of RC T shape girders are classified into three lengths of standardized girder, 12m, 15m and 18m in accordance with Mongolian Standard referred Russian Standard.

However, these types of T shape girder of Mongolian Standard have some problems in structural and constructional points.

On the other hand, Japanese live loading system (A, B- live load) applying heavy trucks and trailers is established in year 1994 for “International Criteria”. Based on the Japanese live loading method, prestressed/ reinforced concrete T shape girders were standardized to simplify, easy construction and short construction period.

This comparison of characteristic for T- shape girders between Mongolian and Japanese Standard is listed in Table 9-4-5. (Comparison Table Mongolian & Japanese T Girder Section)

Steel bridge has not been constructed for road bridges due to higher construction cost came from import materials, required equipment such as welding/ painting machine, factory for fabrication, and necessity of maintenance.

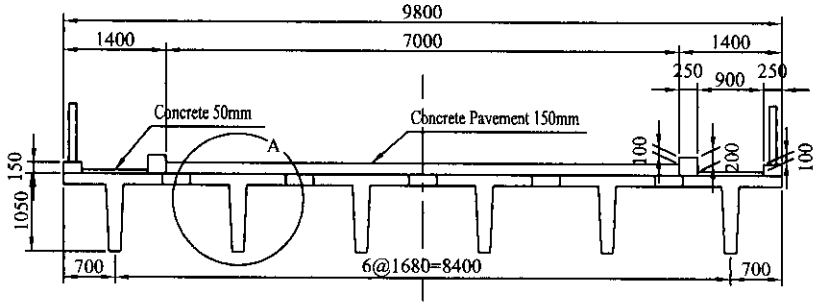
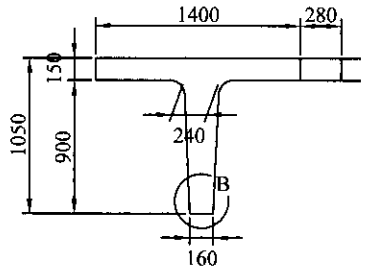
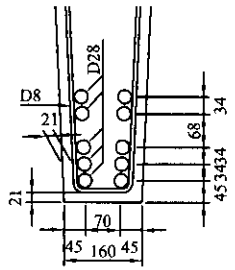
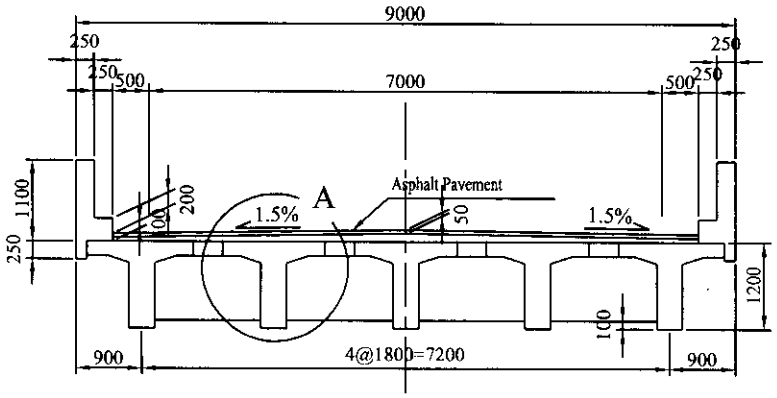
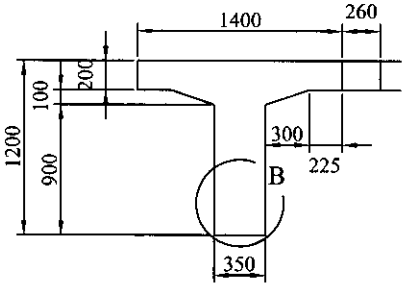
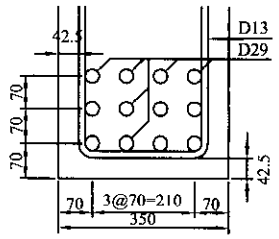
However, the type of steel I shape girder has compared in Clause 9.3.5. From the results of comparison table, the type of steel girder shall not be adopted for the Project.

Therefore, the concrete bridge type is to be applied for this Project.

The general characteristic of types for RC/ PC girders can be compared, and listed from structural, constructional and other aspects as shown in Table 9-4-6.(RC-T & PC-T Box)

The detailed comparison table of long scaled bridge (300m) for RC/ PC girder is referred in Clause 9.3.

Table 9-4-5 Comparison Table for Mongolian T Girder and Japanese T Girder

	Cross Section	in detail		Comments
Mongolian Standard		Part A		1. Cost for construction: 2. Contruction: Difficulties in pouring concrete to girders, because of shortage of space (cover). Cover between surface and re-bars is only 21mm, which causes homeycomb after concreting. 3. Erection: Girder weight : 17.2ton (length = 17.5m) 4. Structure: No cross beam between girders. Large deflection by heavy vehicle. Shortage thickness of slab (15cm) for heavy vehicle. 5. Others: Form work - curve, incline
		Part B		
Proposed Standard		Part A		1. Cost for construction: 2. Construction: Massive girder after concreting. Enough cover and space between surface and re-bars. 3. Erection: Girder weight : 29ton (length = 17.5m) 4. Structure: Rigidity for heavy vehicle. Cross beam at end and center parts. 5. Ohters: Easier form work-straight line.
		Part B		

Effect of the Cross Beam

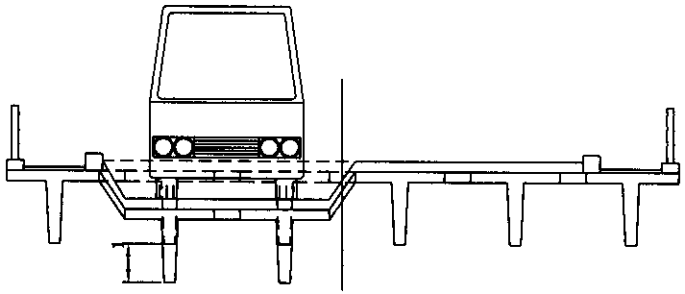
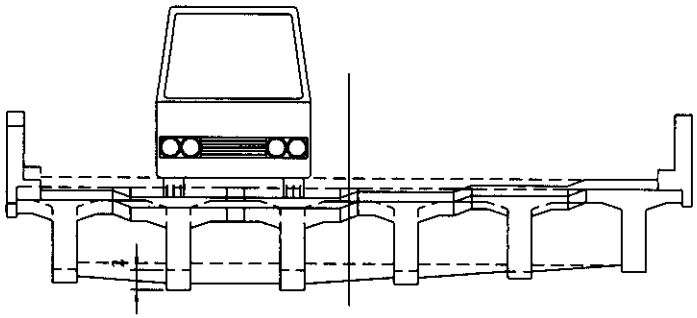
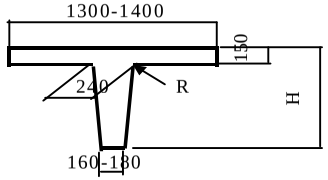
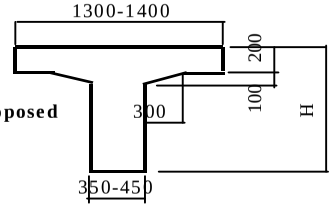
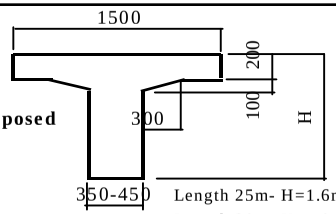
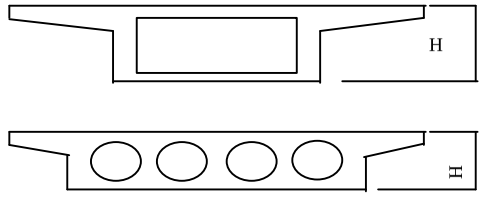
	Cross Section	Comments
Mongolian Standard		Big deflection by live load causes damage of girders. Reasons : Due to no-cross beam, and slender concrete girders.
Proposed Standard		Live load by heveay load is ditributed to other girders. Reasons : Due to cross beam, and massive concrete girders.

Table 9-4-6 Comparison Table of RC and PC Girder Type

Type	Standard Section of Girder	Characteristics
Mongolia Reinforced Concrete T- Shape Girder (RC- T)	 unit: mm Girder Length / Height H 12m 0.9m 15m 0.9m 18m 1.05m	1. Construction Cost: Economical 2. Construction: Difficulties in pouring concrete to girders because of shortage of space/cover between re-bars 3. Erection: Easy by crane, girder weight 17 ton(17.5m length) 4. Structure: Large deflection by heavy vehicle in cause of no-cross beam between girders Shortage: thickness of slab (15cm), and height of girder for heavy vehicle 5. Others: Difficulties of formwork due to incline, curve
Japan Reinforced Concrete T- Shape Girder (RC- T)	 Girder Length / Height H 15m 1.00m 17.5m 1.20m 20m 1.40m 22.5m 1.60m	1. Construction Cost: Intermediate 2. Construction: Easy to pouring concrete because of enough cover/space between re-bars, and massive concrete 3. Erection: Use of large scale crane, (T Girder17.5m-29ton/no.) Stable to set girders because of wide width of girder 4. Structure: Rigidity with cross beam at end/center of girders Durability for heavy vehicle Sufficient cover/space between re-bars 5. Others: Easier formwork- straight line, Materials: Available
Japan Prestressed Concrete T- Shape Girder (PC- T) AASHTO (PC- I)	 Length 25m- H=1.6m Length 30m- H=1.8m Length 25m- H=1.4m Length 30m- H=1.7m	For Prestressed Concrete Type: 1. Construction Cost: Not economical 2. Construction: Large/ heavy equipment Required import materials/ equipment (prestressed wire, tensioning jacks,), skilled Engineer for control/ supervision Required quality control for high concrete strength (σ 28 > 400kg/cm2) 3. Erection: Large scale- girder launching/ all staging support methods for concreting of girder (T Girder30m- 73ton/no.) 4. Structure: Rigidity/ durability for heavy vehicle 5. Others: Difficulties of formwork for box/ hollow/ I- types, except T- type * For I Shape Compound Girder, Box Girder, Hollow Slab--- Long construction period at bridge site (set form work, reinforcing bar arrangement, pouring concrete work, etc)
(Reference) Prestressed Concrete Box Girder (PC- Box) or (PC- Hollow Slab)	 Length 30m- H=1.5m Length 35m- H=1.7m Length 40m- H=1.9m Length 20m- H=1.1m Length 25m- H=1.3m Length 30m- H=1.5m	

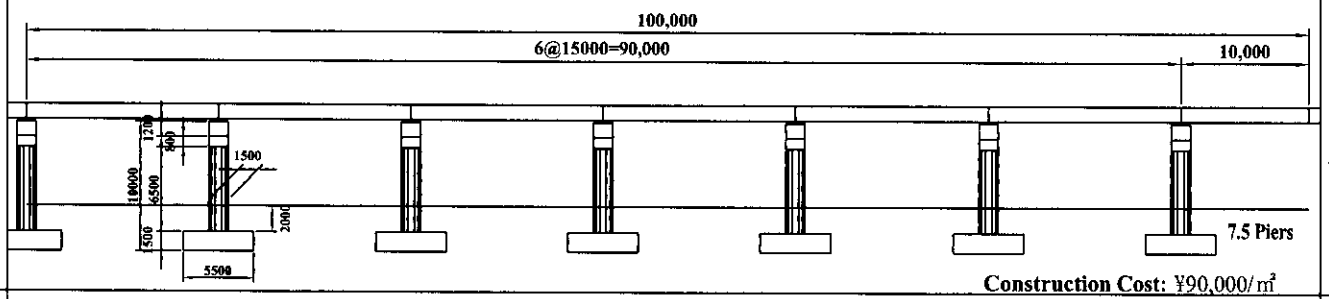
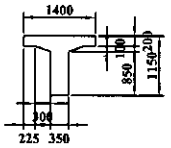
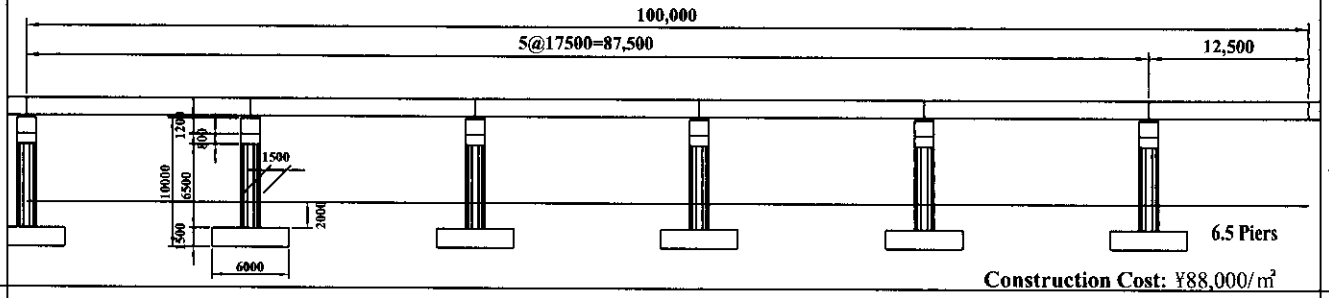
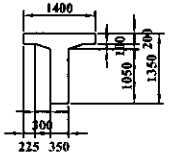
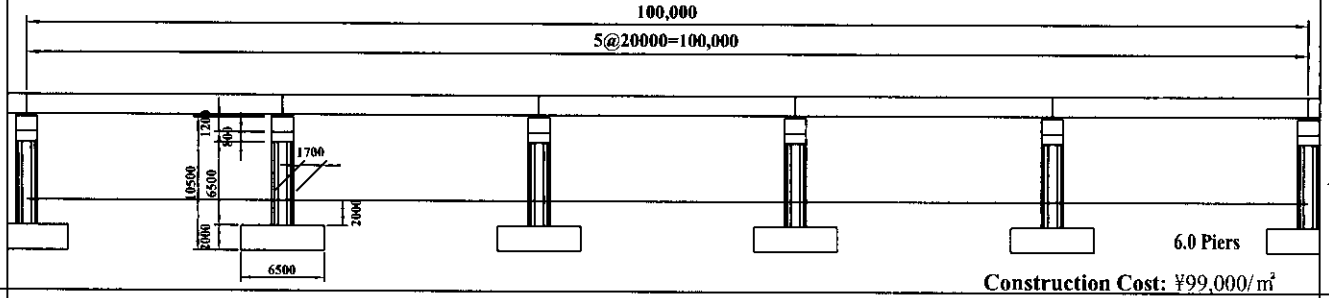
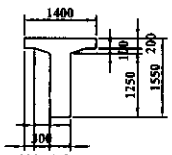
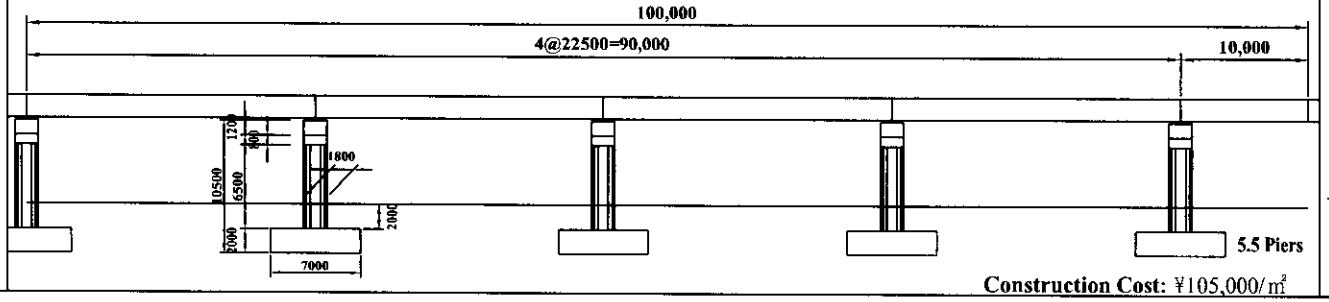
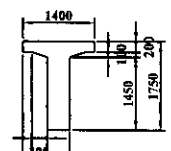
From these characteristics, the Japanese type of RC/PC T girder shall be proposed and standardized for this Project, Eastern International Millennium Arterial Road.

Furthermore, the appropriate span length of RC girder bridge (assumed standard bridge length 100m) including rough cost estimation was compared as shown in Table 9-4-7.

The RC T shape girders of 15, 17.5, 20 and 22.5m span length bridges shall be applied for this Project.

Table 9-4-7 Comparison Table of Middle/Short Scaled Bridge

Legend	Good ← Bad			F:Fair
	1	2	3	

	General View	Section of Reinforced Concrete T-Girder	Characteristic		
Case A : L=15.0m		 Girder Weight 24.1t	1. Construction Cost 2. Construction (Easy/Difficult) 3. Construction Period 4. Width of piers / River section ratio	1 1 3 3	
Case B : L=17.5m		 Girder Weight 31.2t	1. Construction Cost 2. Construction (Easy/Difficult) 3. Construction Period 4. Width of piers / River section ratio	1 1 2 2	F
Case C : L=20.0m		 Girder Weight 42.5t	1. Construction Cost 2. Construction (Easy/Difficult) 3. Construction Period 4. Width of piers / River section ratio	3 2 1 2	
Case D : L=22.5m		 Girder Weight 56.7t	1. Construction Cost 2. Construction (Easy/Difficult) 3. Construction Period 4. Width of piers / River section ratio	3 3 1 1	

a) Selection of Substructure Type

The type of substructure is selected based on the scale of superstructure (girder length, weight, etc.), the height of substructures, river section and geological conditions. The standard substructure types are shown in Table9-4-8.

Table 9-4-8 Relation between Substructure Type and Height

Type of Abutment	Structure Height (m)			
	10	20	30	
Gravity	═══			
Reversed T-shape	═══	═══		
Buttres		═══	═══	
Rigid Frame		═══	═══	
Box		═══	═══	

Type of Pier	Structure Height (m)			
	10	20	30	
Wall, Column	═══	═══	═══	═══
Two-column	═══	═══	····	
Rigid Frame	═══	═══	═══	

(═══ : Applied Type to the Project)

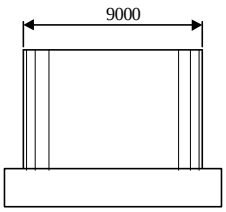
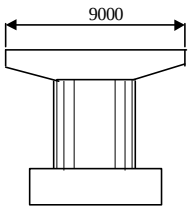
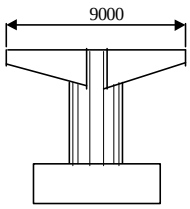
The type of abutment shall be reinforced concrete reversed- T type on account of superstructure scale with 15 to 20m girder length, abutment height with 5 to 10m, economy and easier construction.

The type of pier is classified into 3 types in the point of 5 to 10m height and river alignment. In the Project, reinforced concrete T- shape type with elliptic column shall be applied based on the economy, easier construction, hydrological condition and foundation type.

The type of standard pier in the Project will apply the RC elliptic column as shown in Table 9-4-9 from construction cost, method and period, etc.

The abutment and pier footing top shall be embedded more than 2m into the river bed against scouring from floods and permanent frost, etc. The revetment and/or guide bank shall be protected with appropriate materials, such as stone-pitching, concrete block.

Table 9-4-9 Comparison of Standard Type for Pier

	Case-A: RC Wall	Case-B: RC Elliptic Column	Case-C: RC Cylindrical Column
Type of Pier	 Pier H=5- 8m	 Pier H=5- 8m	 Pier H=5- 8m
Construction Cost	Not Economy	Economy	Economy
Construction Period	Easy Long	Easier Short	Not Easy Sorter
Disturbance Rate	Good	Fair	Not Good
Adoptability to River Flow	Not Good	Fair	Good
Foundation Scale	Large	Middle	Small
Adoption		**Adopt**	

b) Selection of Foundation Type

According to the results of geological survey in the Project area, bearing stratum can be seen 2 to 10m depth from existing ground. The foundation for spread or pile types shall be determined due to depth of bearing stratum. Almost foundations for the planning bridge site shall be spread footing because of hard stratum with more than N- value 30.

However, one location at proposed bridge site is to be pile foundation because the bearing stratum is more than 10-12m depth from existing ground.

The basis of bearing layer for foundation type is illustrated as below Figure 9-4-4.

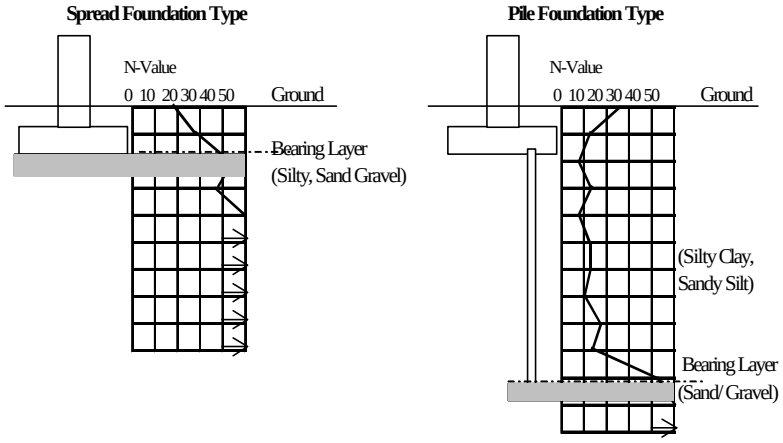


Figure 9-4-4 Foundation Type by Bearing Layer

The standard applicable pile types are shown in Table 9-4-10. Based on the scale of superstructure, geological conditions and depth of bearing stratum, the type of foundation is to be selected.

Table 9-4-10 Foundation Pile Types

Foundation Type		Depth to Bearing Layer (m) 10 20 30 40	Reference
Spread Footing			
Pile Foundation	Reinforced Concrete (dia. 30-50cm)		Small/Medium Bridge
	Prestressed Concrete (dia. 50-100cm)		Medium/small Bridge
	Steel Pipe Pile (dia. 60-150cm)		Big/Medium Bridge
	Cast-in-place Concrete (dia.80-200cm)		Big/Medium Bridge
	Bearing Layer for the Project Area	7-10m under foundation. Hard silty layer more than N-value 50	

(▬▬: Applied Type to the Project)

The pile length at bridge site is estimated 10 to 12m according to the results of geological survey.

The pile foundation shall be applied considering economy, easier fabrication of pile, use of country materials and piling equipment.

As mentioned **Appendix-C**, the Contractor has a pile driving diesel hammer of only small equipment (cross section of up to 50cm square and length of up to 12m) in Mongolia.

From the above aspects, the reinforced concrete pile (40cm square) type fabricating at camp/casting yard or bridge site shall be applied for the Project.

The piling method is driving with hammer considering the technical experience in the Mongolia.

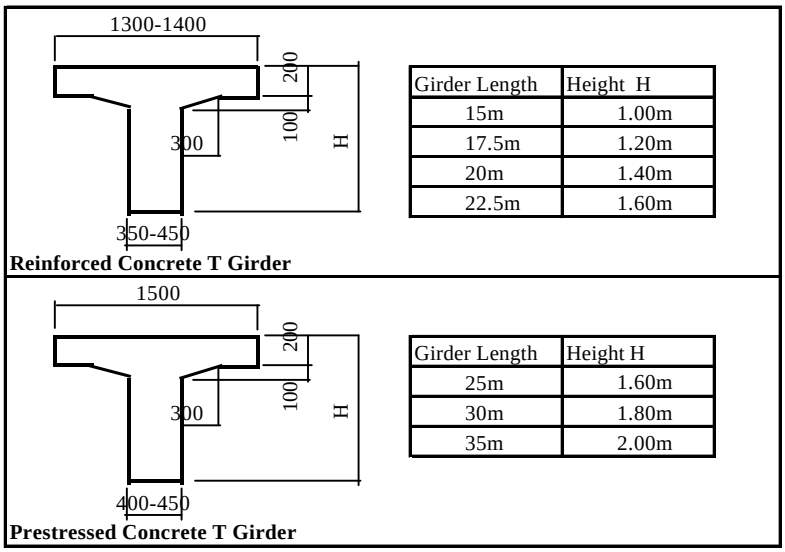
9.4.3 Standard Type for the Structures

(1) Bridges

The appropriate span length for the Project is expected to use 15m to 22.5m span length of RC T girder, and 25m to 35m span length of PC T girder from the Table 9-4-11 from results of comparison in the previous Clauses.

As attached "**DRAWINGS**" and below Table 9-4-12, standard types of bridge in the Project shall be stated 15m and 17.5m of girder length with combination to apply in viewpoints of construction economy, easier construction according to design discharge of river, geological, and topographic aspects.

Table 9-4-11 Standardized RC/ PC T Shape Girder for the project



Girder Length	Height H
15m	1.00m
17.5m	1.20m
20m	1.40m
22.5m	1.60m

Girder Length	Height H
25m	1.60m
30m	1.80m
35m	2.00m

Table 9-4-12 Standard Scale of RC T Girder for the Project

Type No.	Bridge Length (m)	Span Length (m)	Girder Type
1	15	1@ 15	RC T Type
2	17.5	1@ 17.5	RC T Type
3	35	2@ 17.5	RC T Type
4	52.5	3@ 17.5	RC T Type
5	70	4@ 17.5	RC T Type

Based on "Agreed Minutes of Amendment to the Scope of Work, for The Feasibility Study on Construction of Eastern Arterial Road, between upon Department of Roads and JICA, on September 10, 2001" and several Technical Meetings, the results of this feasibility study will be respected and reflected the construction works by Department of Roads for Millennium Arterial Road.

Therefore, these above standardized types of girders applying International Design Criteria will be expected to adopt the bridge works for Millennium Arterial Road, in place of Mongolian original type of girders.

(2) Box and Pipe Culverts for the Crossing River/ Waterway

The crossing box and/or pipe culverts are proposed and standardized seven types according to scale of design discharge of waterway/ river for the Project. These scale and dimension are listed in Table 9-4-13 and Figure 9-4-5 referring Mongolian Standard.

Table 9-4-13 Design Standard for Culverts (Pipe & Box)

Type	Area of Design Discharge	Construction Method
A- Pipe Φ1.0m	0.63m^2	Pre-cast
B- Pipe Φ1.5m	1.41m^2	Pre-cast
C- Pipe Φ1.5m@ 2	2.82m^2	Pre-cast
D- Box H2.5*B2.5- 1 Box	5.00m^2	Pre-cast or Cast in Place
E- Box H2.5*B2.5- 2 Box	10.00m^2	Pre-cast or Cast in Place
F- Box H2.5*B2.5- 3 Box	15.00m^2	Pre-cast or Cast in Place
G- Box H3.0*B3.0- 3 Box	21.60m^2	Pre-cast or Cast in Place

Note: Bridge construction is more than 30m^2 design discharge (Bridge length: min. 15m)

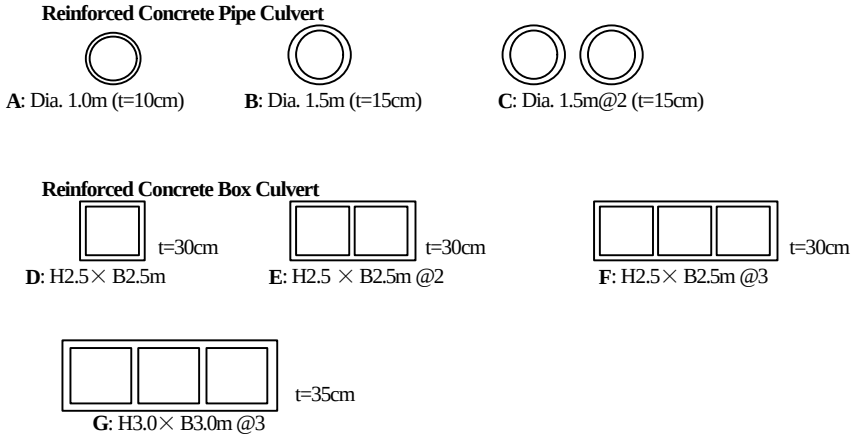


Figure 9-4-5 Standard Section for Crossing Culverts

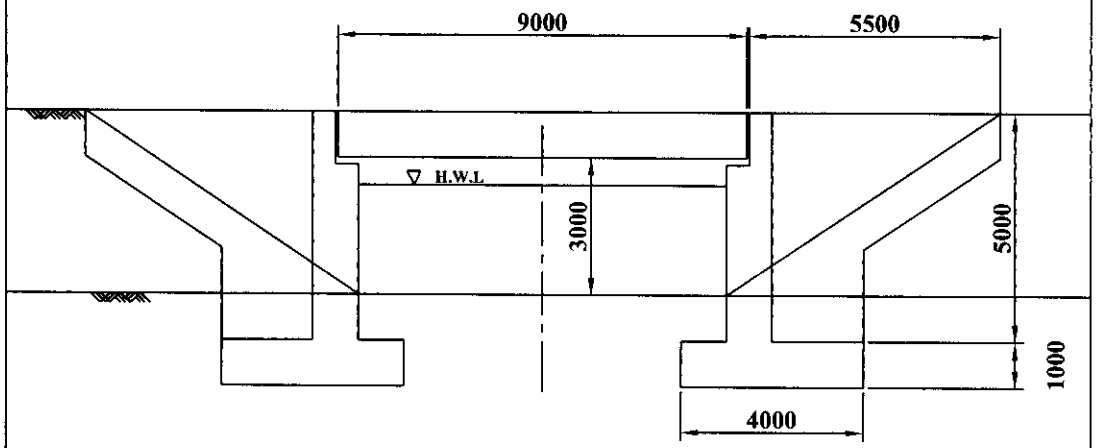
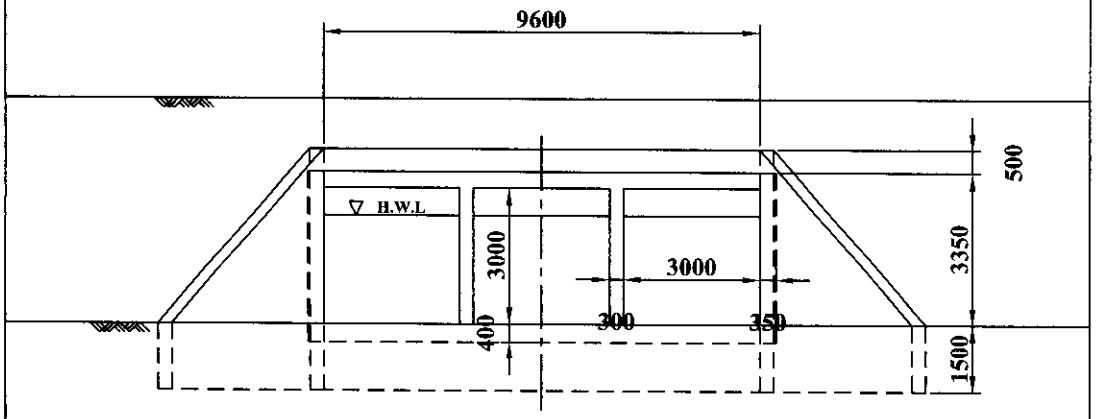
In case of construction of box culverts, pre-casting method in base camp or fabrication factory will be recommended because of easier quality control and short construction period on sites.

The scale of designed bridges by Department of Roads for the Project route is planned short length with 6 to 9m. Generally, the construction cost for bridge of short span length is not economical because of large scale of abutments and required shoes, expansion joints, handrail, etc. Also, erection equipment for girders is required for bridges.

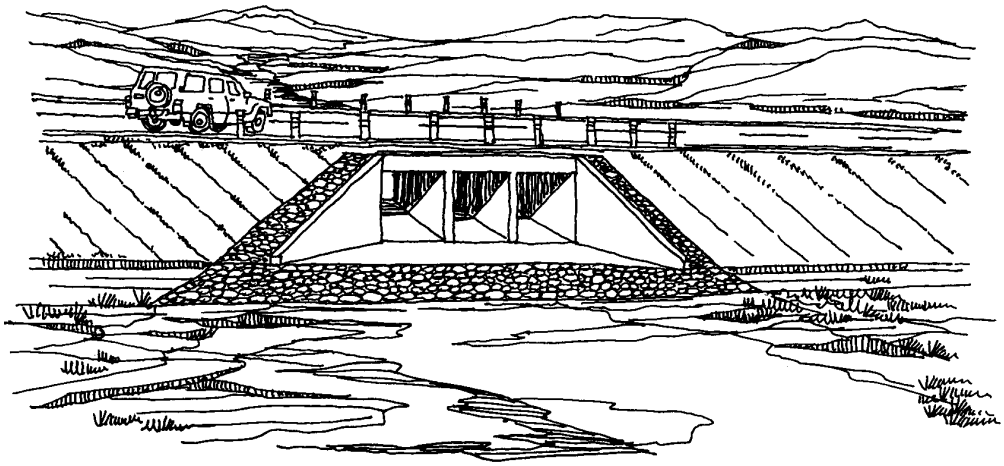
The characteristics between bridge (length 9m) and box culvert (3@ 3m: type G) are compared as shown in Table 9-4-14.

Therefore, the box culvert type shall be applied the maximum 10m length of design river/ water way section.

Table 9-4-14 Comparison of Bridge and Box Culvert

	Profile 1:150	Comments	
Brigde Detail Designed by DOR		Not Economical Construction Cost Total Cost : US$ 57,200 Diffecult to Construct Long Construction Period No obstacles in River Section	
Box Culvert planned by FS Study Team	TypeG 	Economical Construction Cost Total Cost : US$ 47,500 Easy to Construct Short Construction Period Walls in River Section	Acceptable

CHAPTER 10 REVIEW AND EVALUATION OF ROAD MAINTENANCE SYSTEM



CHAPTER 10 REVIEW AND EVALUATION OF ROAD MAINTENANCE SYSTEM

10.1 Road Maintenance Practices

10.1.1 Road Maintenance Works

Road maintenance works are classified into three types: namely, routine, periodic and emergency. Routine maintenance is based on routine (daily) inspection of the condition of pavement, cut and fill slopes, drainage, bridges and other structures and facilities to monitor any defects and damage. The results of routine inspection will be promptly reported to the operation office for follow-up maintenance works to be undertaken either continually throughout a year or at certain intervals every year. The term "preventive maintenance" refers to repair that addresses causes of deterioration leading to the need for costly rehabilitation work in future.

Periodic maintenance is based on detailed inspection performed at certain time intervals such as seasonally or yearly depending on the type and kind of facilities. It includes checking and testing the conditions of various structures and facilities. Defects and damage will be reported for repairs or remedies. Maintenance plans covering several years will be developed.

Emergency maintenance basically comprises works to restore road and road related facilities to their normal operating conditions after they are damaged by road accidents or natural causes. It is impossible to foresee the frequency, but such maintenance requires immediate action. Table 10-1-1 summarizes typical activities of each type of maintenance work.

Table 10-1-1 Typical Maintenance Activities

Type	Activity
Routine	Clearing of pavement
	Mowing and maintenance of plants
	Clearing of ditches and culverts
	Repair of traffic signs and road markings
(Preventive)	Shoulder grading
	pothole patching and crack sealing
	Repair of sealants and expansion joints of bridges
	Repair of cut and fill slopes
Periodic	Regraveling
	Resealing/surface dressing
	Overlay
	Maintenance of traffic signs and road markings
Emergency	Removal of debris or obstacles from natural causes
	Repair of damage caused by traffic accidents

For routine maintenance activities, an appropriate mix of labor and equipment is required to provide works of adequate quality in a cost-effective manner. In a "labor-based" economy, the aim is to apply a labor/equipment mix that gives priority to labor, but supplements it with light/intermediate equipment where necessary for reasons of quality or cost. The term "labor-based" thus indicates that flexible and optimal use is made of labor as the predominant resource in so far as cost-effectiveness and quality aspects are ensured. It is important to distinguish between an optimal use of labor and maximum use of labor. The latter could degenerate into a "make work" approach where cost-effectiveness and quality aspects are ignored.

Equipment-based is the opposite of labor-based in that most of the work is done by labor-replacing equipment, supported by a small labor force.

10.1.2 Present Financial Situation

The maintenance situation for existing roads has been discussed in a number of recent studies under the sponsorship of the World Bank, the Asian Development Bank and Japanese Government. It is a well-established finding that the maintenance of the existing roads in Mongolia is in general highly inadequate because of low availability of funds and institutional weakness.

According to data of the Department of Roads (DOR), the funds that have been allocated for the maintenance of roads and bridges in Mongolia during period 1997-2000 is shown in Figure 10-1-1:

Year	Maintenance Funding (Tg.)	Exchange Rate	Maintenance Funding (US$)
1997	921,300,000	720	1,279,583
1998	1,297,700,000	885	1,466,328
1999	373,500,000	1,000	373,500
2000	1,489,900,000	1,070	1,392,430
2001	2,025,700,000	1,090	1,858,440

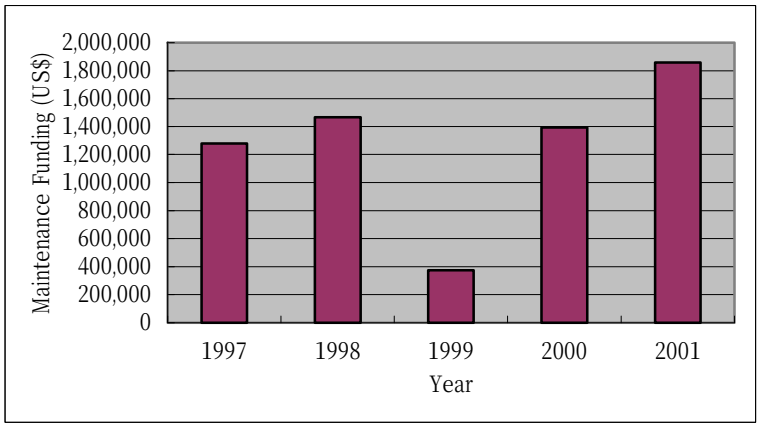


Figure 10-1-1 Funds Allocation for Road Maintenance (Source: DOR)

The available information indicates that funding for road maintenance has increased year by year until year 2000. Maintenance funding level in 1999 was inadequate for the predominantly low-grade earth roads to keep them serviceable. In addition, some of the funding went to local or town roads, which further reduced the funds available for maintenance of national roads. In year 2000, the funds for road maintenance suddenly increased with the introduction of a new maintenance standard formulated by the domestic project for development of maintenance management. Another reason for the increase was the necessity for continuous high maintenance works needed to cope with constant high traffic volume on the following roads:

- Ulaanbaatar - Darkhan - Altanbulag,
- Ulaanbaatar - Erdenesant - Kharkhorin - Tsetserleg and
- Ulaanbaatar - Nalaikh - Erdene sum.

Under the present budgetary system, operation expenditure is categorized into construction and maintenance even though the indicators are that a majority of the maintenance funds probably are spent on emergencies, thus leaving very little for conventional maintenance activities. The Road Fund has been used for construction work, resulting in reduction of the amount available for maintenance. The Road Fund should only be used for the maintainable road network and all road construction work should be financed by other sources including the donor community. Funds for construction work should be kept separate from the Road Fund.

On the institutional side, one fundamental problem of road maintenance lies in the fact that existing road sections are scattered in relatively small stretches in 21 provinces and the maintenance work available in most provinces is too small to sustain even resourceful road maintenance organizations. Road companies have been nominally privatized over the past few years, but the major share in most cases still remains related to the Government. The interdependence between the DOR and road maintenance corporation/companies continues to exist because DOR has to depend on road corporation/company in a particular provinces for getting road maintenance done and the road corporation/company also depend on DOR for getting work to sustain themselves. The Government issued a decentralization policy is still in the process of being implemented.

10.2 Present Maintenance System and its Organization

In accordance with the recommendations of the Asian Development Bank and in order to implement the Law on Roads, DOR established the Road Repair and Maintenance Management Unit within his organization in 1990. After institutional restructuring of the road sector in 1997, the Government established the state-owned Road Repair and Maintenance Corporation (AZZAN) in order to undertake road repair and maintenance works in order to provide safe roads. DOR is still responsible for maintenance of

national roads and road facilities through the establishment of maintenance corporation/companies including AZZAN and the involvement of the private sector in remote provinces which are regional zoned.

At present, there are a variety of road construction and maintenance companies of various types. Fifteen (15) road maintenance units, which previously were under DOR and were responsible for road maintenance, were restructured as one (1) state-owned corporation, six (6) state stock-shared companies, five (5) region stock-shared companies and two (2) privatized companies as shown in Figure 10-2-1.

The Government changed the organization into a company according to the Law on Company in 1992 and appointed the State Property Committee as a founder and stockholder. The State Property Committee is mandated to control property, while the DOR controls utilization of the state property.

The state-owned corporation is “Road Repair and Maintenance Corporation” (AZZAN) who consists of one (1) equipment lending company (TTT) and ten (10) branch companies, and both are responsible for maintenance of national roads. As for road construction, fifteen (15) road & bridge construction units were controlled under the DOR in the past. At present, there are one (1) state-owned company, one (1) state stock-shared company and 70 private companies. The state-owned company is “Erdene Zam” that is established to undertake road construction works as well as to lend heavy equipment, some of which was procured by Japan’s Grant Aid. Another state stock-shared company for road construction works is “Dar Zam”.

Among 6 state stock-shared companies for maintenance, 5 state stock-shared companies (such as “Arkhangai Avto Zam”, “Dornod Avto Zam”, “Ulbaa”, “Altain Zam” and “Khuvsgul Zam”) are not only limited to their maintenance activity but also undertake road construction works. 62 private road & bridge construction companies and 2 privatized road maintenance companies are able to undertake both maintenance and construction works.

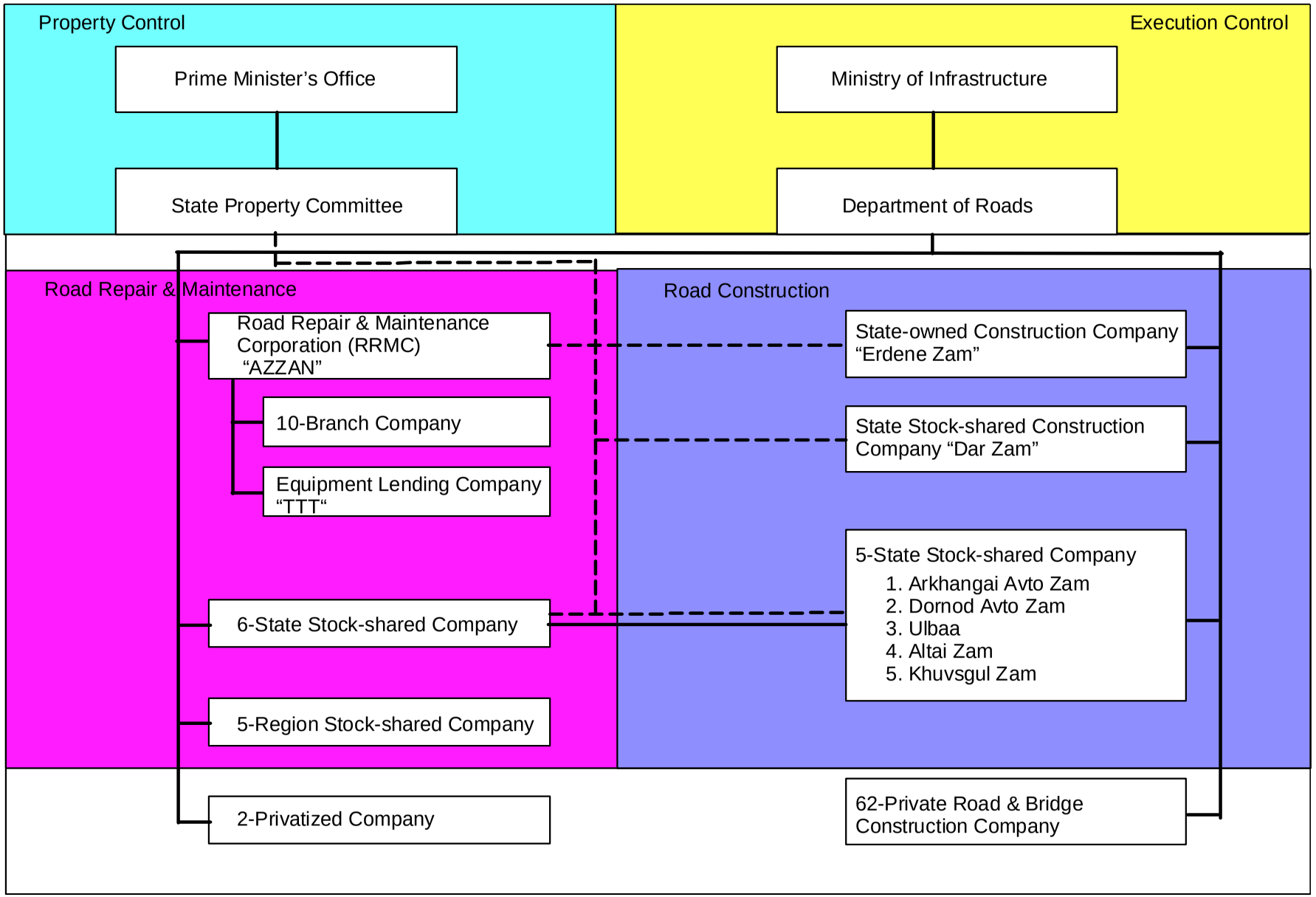


Figure 10-2-1 Present Maintenance System and its Organization

10.3 Evaluation of Road Maintenance System

10.3.1 System Improvement Measures

The maintenance quality depends on supervision of maintenance works. The following is the situation with regard to effectiveness of supervision, work quality and task allocation:

- Supervising engineers are now responsible for maintenance of roads and road facilities in a certain area. They are able to implement or execute maintenance works, to supervise and control their quality and progress, and to certificate the completion of works using drawings, photographs and other necessary documents.
- Maintenance costs of roads and road facilities are reimbursed according to actual works that are carried out referring to preliminary repair and maintenance plan/drawing and its estimated costs.
- Taking into consideration the fact that damaged roads are a major cause of traffic accidents, the Government formulated the policy to prevent traffic accidents and implemented the program to take necessary measures to maintain national roads.

The following jurisdictions are set forth on the national road in the stretch of Erdene - Undurkhaan under current road maintenance system in the project area:

- Nalaikh branch of Road Repair and Maintenance Corporation "AZZAN" maintains 70 km from the beginning point.
- AZZAN has jurisdiction over the Kherlen River Bridge.
- Road Maintenance State-owned Company of Khentii "HARGUI" maintains the remainder of the project road.

Present road maintenance system will be able to meet incremental demand brought about by the government policy of road improvement, especially development of "Millennium Road", provided that equipment be increased and skilled operators be brought up. Almost all materials necessary to build a road exist along its route, and such equipment and skilled operators will be utilized for repair and maintenance after the road is open to the public.

10.3.2 Equipment Capability

At present, equipment utilized in the Erdene - Undurkhaan road sector was mostly procured from Russian Federation as shown in Table 10-3-1. Almost all road companies have much obsolete equipment and its operation life has already expired. It is reported that only 57% of equipment was operated in 1995.

Table 10-3-1 Equipment List of Road Repair & Maintenance Corporation "AZZAN"

No.	Equipment	Model	Capacity	Qty	Country of origin	year	condition
1	Truck	ZIL-130	5 t	1	Russia	1985	Good
2	Truck	GAZ-53	3 t	1	Russia	1986	Good
3	Water lorry	ZIL-130	6000 L	1	Russia	1999	Good
4	Dump truck	ZIL-555		1	Russia	1986	Fair
5	Dump truck	ZIL-555		1	Russia	1985	Fair
6	Dump truck	ZIL-555		1	Russia	1988	Fair
7	Dump truck	ZIL-5054		1	Russia	1993	Good
8	Dump truck	ZIL-555		1	Russia	1985	Fair
9	Dump truck	KAMAZ-5511		1	Russia	1990	Fair
10	Dump truck	KRAZ-256	12 t	1	Russia	1988	Fair
11	Bitumen lorry	KAMAZ-53213		1	Russia	1989	Fair
12	Bitumen lorry	KAMAZ-53213		1	Russia	1990	Fair
13	Bitumen lorry	KAMAZ-53213		1	Russia	1990	Fair
14	Bitumen lorry	KAMAZ-53213		1	Russia	1990	Fair
15	Agitator truck	KAMAZ-54112		1	Russia	1989	Fair
16	Agitator truck	KAMAZ-54112		1	Russia	1989	Fair
17	Agitator truck	KAMAZ-54112		1	Russia	1990	Fair
18	Agitator truck	KAMAZ-54112		1	Russia	1990	Fair
19	Truck	ZIL-131		1	Russia	1988	Bad
20	Mobile workshop	GAZ-66		1	Russia	1988	Bad
21	Snow removal machine	ZIL-1314		1	Russia	1990	Good
22	Cement truck	ZIL-130		1	Russia	1990	Fair
23	Truck crane	KE-4561		1	Russia	1984	Fair
24	Dump truck	ZIL-4505		1	Russia	1987	Fair
25	Dump truck	ZIL-4505		1	Russia	1987	Good
26	Dump truck	ZIL-4505		1	Russia	1987	Good
27	Truck crane	KRAZ-256	16 t	1	Russia	1988	Fair
28	Motor grader	DZ-180		1	Russia	1994	Fair
29	Motor grader	DZ-143		1	Russia	1990	Fair
30	Excavator	JCB		1		1996	Good
31	Excavator	EO-2621		1	Russia	1989	Fair
32	Wheel loader	TO-18		1	Russia	1991	Fair
33	Tractor	UMZ-6	50 HP	1	Russia	1986	Not operable
34	Asphalt finisher	DS-143	3.5 m	1	Russia	1991	Good
35	Macadam roller	DU-47	5 t	1	Russia	1990	Fair
36	Macadam roller	DU-47	5 t	1	Russia	1987	Fair
37	Macadam roller	DU-47	5 t	1	Russia	1987	Fair
38	Bulldozer	DZ-116	116 HP	1	Russia	1988	Fair
39	Bulldozer	DZ-110	110 HP	1	Russia	1991	Fair
40	Bulldozer	DZ-42		1	Russia	1990	Fair
41	Trailer	4 MZAP		1	Russia	1991	Fair
42	Motor grader	DZ-122	2.8 m	1	Russia	1986	Fair
43	Excavator	EO-2621		1	Russia	1985	Good
44	Bulldozer	D-606		1	Russia	1985	Fair
45	Macadam roller	DU-47	5 t	1	Russia	1989	Fair
46	Air compressor	PR-10	6 atm.	1	Russia	1986	Fair
47	Air compressor	PR-10	6 atm.	1	Russia	1990	Fair
48	Air compressor	PKS-5.25		1	Russia	1988	Fair
49	Welding apparatus	SAK		1	Russia	1993	Fair
50	Welding apparatus	SAK-16		1	Russia	1986	Fair
51	Welding apparatus	TD-300		1	Russia	1985	Not operable
52	Welding apparatus	TD-300		1	Russia	1986	Not operable
53	Welding apparatus	PSO-300		1	Russia	1987	Not operable
54	Welding apparatus	TDM-401		1	Russia	1992	Good
55	Welding apparatus	TDM-401		1	Russia	1990	Good
56	Welding apparatus	TDM-401		1	Russia	1990	Fair
57	Welding apparatus	BB-400		1	Russia	1992	Good
58	Drilling machine	211-1353		1	Russia	1990	Good
59	Drilling machine	2M-112		1	Russia	1989	Fair
60	Grindstone			1	Russia	1985	Fair
61	Vibration roller			1	Russia	1993	Good
62	Steamer	E-01		1	Russia	1989	Good
63	Steamer	E-01		1	Russia	1996	Good
64	Asphalt mixer	DE-117		1	Russia	1988	Fair
65	Asphalt mixer	DE-117		1	Russia	1987	Fair
66	Asphalt mixer	D-508		1	Russia	1985	Not operable
67	Concrete mixer	SB-75		1	Russia	1987	Good
68	Clay mixer			1	Russia	1989	Not operable
69	Crusher	CM-561		1	Russia	1987	Not operable
70	Compactor			1	Great Britain	1997	Good
71	Compactor			1	Great Britain	1997	Good
72	Bitumen sprayer			1	Great Britain	1997	Good
73	Cutter			1	China	1999	Good

From year 1996, modern equipment started to be procured by official development assistance (ODA) to the road sector.

The following equipment was procured in these four years:

- In 1996 - 7 excavators, 12 compactors, 26 computers - total cost US$ 603,478 (World Bank loan). This equipment has been supplied to the road companies.
- In 1999 - 3 rollers, 1 excavator, 3 motor graders, 2 wheel loaders, 5 water lorries, 5 sets of laboratory equipment - total cost US$ 1,997,258 (World Bank loan) and spare parts (US$ 44,448).

Based on this procured equipment, the Equipment Lending Company "TTT" within AZZAN was established to provide road companies with construction equipment. The list of equipment owned by TTT Company is tabulated in Table 10-3-2, and the equipment list owned by AZZAN and its company/unit is shown in Table 10-3-3.

On the other hand, the State-owned Construction Company "Erdene Zam" was established in 1996 to utilize 41 items of road construction equipment that were procured under Japanese Grant Aid. The list of equipment owned by Erdene Zam is tabulated in Table 10-3-4.

It is planned to establish an equipment-lending company for each regional zone to solve the problem of equipment shortage, and it is estimated that it will require funding of US$ 25 million.

Table 10-3-2 Equipment List of Equipment Lending Company "TTT"

No.	Equipment	Model	Capacity	Qty	Country of Origin	Produced year	Present condition
1	Motor grader Komatsu	GD-611	2.8 m	1	Japan	1999	Operable
2	Motor grader Komatsu	GD-611	2.8 m	1	Japan	1999	Operable
3	Motor grader Komatsu	GD-611	2.8 m	1	Japan	1999	Operable
4	Wheel Loader Komatsu	WA-180	1.4 m^3	1	Japan	1999	Operable
5	Wheel Loader Komatsu	WA-180	1.4 m^3	1	Japan	1999	Operable
6	Excavator Komatsu	PW-150	1 m^3	1	Japan	1999	Operable
7	Tire Roller Dynapac	CP-221	12.5 t 21 t with ballast	1	Sweden	1999	Operable
8	Tire Roller Dynapac	CP-221	12.5 t 21 t with ballast	1	Sweden	1999	Operable
9	Tire Roller Dynapac	CP-221	12.5 t 21 t with ballast	1	Sweden	1999	Operable
10	Water lorry with sprayer, broom and cutter	ZIL-130 MDK-433360	6,000 L	1	Russia	1998	Operable
11	Water lorry with sprayer, broom and cutter	ZIL-130 MDK-433360	6,000 L	1	Russia	1998	Operable
12	Water lorry with sprayer, broom and cutter	ZIL-130 MDK-433360	6,000 L	1	Russia	1998	Operable
13	Water lorry with sprayer, broom and cutter	ZIL-130 MDK-433360	6,000 L	1	Russia	1998	Operable
14	Water lorry with sprayer, broom and cutter	ZIL-130 MDK-433360	6,000 L	1	Russia	1998	Operable

Table 10-3-3 Equipment List of AZZAN Central Unit and each Company/Unit

Equipment List 2001

	Name of Company	Arkhangai	Western Direction Road Construction Trast	Bayan-ulgii	Bulgan	Bayankhongor	Govi-altai	Darkhan Road and Bridge Repaire and Maintenance Company	Dar-Zam	Dornod	Dornogovi	Zavkhan	Erdenet	Uvurkhangai	Sukhbaatar	Selenge	Tuv	Uvs Road Repair and Maintenance Company	Uvs Munkhjim	Khovd	Khuvsgul	Khentii Road Repaire and Maintenance Company	Erdenesant	AZZAN	Bat Zam	Ganguur	Erdene Zam	TTT Company	Techno-Arch Co.,ltd	Sum
A	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
1	Motor grader D3-98(99)					1	1												2					1						5
2	Motor grader D3-557	3			1			1		2	2				1						1			1		1				13
3	Motor grader D3-122		2	2	1	1		2	2	1	1	1	2	2		3	3	2	2	1	1	1	2	1	1					34
4	Motor grader D3-143																1			1	1			1						4
5	Motor grader D3-180						1					1												1						3
6	Motor grader GD-511																										2			2
7	Motor grader GD-611																											3		3
																														64
8	Macadam roller DU-47	2	2		1	1	2	2	2	2	1			1	2	3	2		3	1			1	4	1	1				34
9	Macadam roller DU-48			1		1			1	1				2			2			1	1				1					11
10	Macadam roller DU-50											1									1									2
11	Macadam roller CP-201																										2			2
12	Tire-roller DU-16	2				1					1	1	1	1		1	3	1	2	1		1		1						17
13	Tire-roller CS-12																										2			2
14	Tire-roller CP-221																											3		3
15	Vibration-roller CA-251																										1			1
																														72
16	Excavator EO-2621	1					1			1		1		1	1		1				1	1	1	2						12
17	Excavator JCV-3X							1						1		1	1	1					1	1						7
18	Excavator EO-3322	1	1	2	2	2	1	2	1	1	1	1	1	1	1	2	2	1		2	1	1	1		1	1				30
19	Excavator EO-4121	1											1			1	1		2		1									7
20	Excavator CAT-330																										1			1
21	Excavator CAT-320																										6			6
22	Excavator PW-150																											1		1
23	Excavator Solar-200W																											1		1
																														65
24	Wheel loader TO-10(18)		1			1			1					1			1		2	1			1	1						10
25	Tractor Shovel CAT-938F																										2			2
26	Tractor Shovel CAT-910F																										2			2
27	Wheel loader WA-180																											3		3
																														17
28	Bulldozer DZ-42			1		1	2		1	1	1				1	1	1			2		2	1	2						17
29	Bulldozer DZ-110(117)	2		3		1	1	2	1	1	1	1	2	2		1	2	1	6	2	2			4	1	1				37
30	Bulldozer D-155																										1			1
31	Bulldozer D-85																										2			2
32	Bulldozer D-65																										1			1
																														58
33	Asphalt finisher DS-126(143)	1		1		1			1			1		1		1	1		3	1				1	1					14
34	Asphalt finisher NF-130DM																										1			1
																														15
35	Crane KS-2561	1			1	1		1		1	1						1									1				8
36	Crane KS-4561	1	2	2		1						1		1		1		1	4	3	1			1		2			1	22
37	Crane KS-5363	1										1							1							1				4
38	Crane 25t TL-250E																										1			1
39	Crane 8t FH-2245A																										1			1
																														36
40	Trailer 40t ChMZAP											1							1					1						3
41	Trailer 20t ChMZAP	1									1					1			1											4
42	Trailer 40t SS-633																										1			1
43	Trailer 40t SS-2FKSA																											1		1
																														9

Table 10-3-4 Equipment List of Road construction Company "ERDENE ZAM"

No	Equipment	Model	Capacity	Qty	Country of origin	Produced year	Present condition	Location	Service meter	
									Motor/hour	Km
1	Excavator	CAT-330	1.4m^3	1	USA	1996	Operable	Sharin-Gol		
2	Excavator	CAT-320	0.65m^3 No1	1	USA	1996	Operable	Arkhangai, Ikh Tamir	4.442	
3	Excavator	CAT-320	0.65m^3 No2	1	USA	1996	Operable	Khutel		
4	Excavator	CAT-320	0.65m^3 No3	1	USA	1996	Operable	UB		
5	Excavator	CAT-320	0.65m^3 No4	1	USA	1996	Operable	Arkhangai, Ikh Tamir		
6	Excavator	CAT-320	0.65m^3 No5	1	USA	1996	Operable	Arkhangai, Ikh Tamir	2.712	
7	Excavator	CAT-320	0.65m^3 No6	1	USA	1996	Operable	Sharin-Gol		
8	Tractor shovel	CAT-938F	2.1m^3 No1	1	USA	1996	Operable	UB-Baganuur		
9	Tractor shovel	CAT-938F	2.1m^3 No2	1	USA	1996	Operable	Arkhangai, Ikh Tamir		
10	Tractor shovel	CAT-910F	1.2m^3 No1	1	USA	1996	Operable	UB		
11	Tractor shovel	CAT-910F	1.2m^3 No2	1	USA	1996	Operable	Arkhangai, Ikh Tamir	4.132	
12	Crawler-Drill	HCR-9DS	Hydraulic 180 kg	1	Japan	1996	Operable	UB	330	
13	Hydraulic Breaker	H10XB	Hydraulic 130 kg	1	Japan	1996	Operable	UB		
14	Vibration-Roller	CA-251STD	10 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir	3.840	
15	Tire-Roller	CP-201	10 t (No1)	1	Japan	1996	Operable	UB	2.160	
16	Tire-Roller	CP-201	10 t (No2)	1	Japan	1996	Operable	UB	2.460	9.404
17	Macadam Roller	CS-12	10 t (No1)	1	Japan	1996	Operable	UB	2.239	
18	Macadam Roller	CS-12	10 t (No2)	1	Japan	1996	Under repair	UB		
19	Bulldozer	D-155A	32 t	1	Japan	1996	Operable	Sharin Gol		
20	Bulldozer	D-85A21	21 t No1	1	Japan	1996	Operable	Sharin Gol		
21	Bulldozer	D-85A21	21 t No2	1	Japan	1996	Operable	Arkhangai, Ikh Tamir	4.229	
22	Bulldozer	D-6555E12	15 t	1	Japan	1996	Operable	UB		
23	Motor-Grader	GD-511A1	3.7 m No 1	1	Japan	1996	Operable	Arkhangai, Ikh Tamir	5.076	

No	Equipment	Model	Capacity	Qty	Country of origin	Produced year	Present condition	Location	Service meter	
									Motor/hour	Km
24	Motor-Grader	GD-511A1	3.7 m No 2	1	Japan	1996	Under repair	UB		
25	Asphalt-finisher	NF-130VDM	2.5-4.5 m	1	Japan	1996	Operable	UB		
26	Water-lorry	FF-3HJSA	6000 l No1	1	Japan	1996	Operable	UB		60.000
27	Water-lorry	FF-3HJSA	6000 l No2	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		68.810
28	Fuel-lorry	FF-3HJSA	6000 l No1	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		53.368
29	Fuel-lorry	FF-3HJSA	6000 l No2	1	Japan	1996	Operable	UB		56.546
30	Crane	FH-224SA	8 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		
31	Crane	TL-250E	25 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir	2.369	18.931
32	Trailer	SS-633	30 t	1	Japan	1996	Operable	UB		70.178
33	Mobile work-shop	HZ-227SA	No1	1	Japan	1996	Operable	UB		37.220
34	Mobile work-shop	HZ-227SA	No2	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		100.000
35	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		160.000
36	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		
37	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		
38	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		140.000
39	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		
40	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		
41	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		
42	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		87.070
43	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB, Baga Nuur		
44	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		120.000
45	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		
46	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		100.000
47	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		
48	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		
49	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		
50	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		

No	Equipment	Model	Capacity	Qty	Country of origin	Produced year	Present condition	Location	Service meter	
									Motor/hour	Km
51	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		127.000
52	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		73.527
53	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		100.000
54	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Sharin Gol		
55	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		110.000
56	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		80.000
57	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		34.711
58	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		45.225
59	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		170.000
60	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		
61	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		100.000
62	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		120.000
63	Dump-truck	KY-220	11 t	1	Japan	1996	Operable	UB		39.700
64	Electro-generator	SD-6-60S	45KUA	1	Japan	1996	Operable	Tuv, Erdene sum		
65	Electro-generator	SD-6-60S	45KUA	1	Japan	1996	Operable	Arkhangai, Ikh Tamir	4.541	
66	Electro-generator	SD-6-60S	45KUA	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		
67	Electro-generator	SD-6-60S	45KUA	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		
68	Electro-generator	SD-6-60S	45KUA	1	Japan	1996	Operable	UB		
69	Concrete mixer	PSM-18HE-FL	0.5 m^3	1	Japan	1996	Operable	UB		
70	Vibratory Plate Compacter	LF-110	110 kg	1	Japan	1996	Operable	UB		
71	Vibratory Plate Compacter	LF-110	110 kg	1	Japan	1996	Operable	UB		

No	Equipment	Model	Capacity	Qty	Country of origin	Produced year	Present condition	Location	Service meter	
									Motor/hour	Km
72	Vibratory Plate Compacter	LF-90	90 kg	1	Japan	1996	Operable	UB		
73	Vibratory Plate Compacter	LF-90	90 kg	1	Japan	1996	Operable	UB		
74	Vibratory Plate Compacter	LF-90	90 kg	1	Japan	1996	Operable	UB		
75	Vibratory Plate Compacter	LF-90	90 kg	1	Japan	1996	Operable	UB		
76	Compressor	PDS-265-414	30 kg	1	Japan	1996	Operable	UB		
77	Compressor	PDS-265-414	30 kg	1	Japan	1996	Operable	UB		
78	Compressor	PDS-265-414	30 kg	1	Japan	1996	Operable	UB		
79	Compressor	PDS-265-414	30 kg	1	Japan	1996	Operable	UB		
80	Asphalt sprayer (auto)	FK-615HAL	25-30 l/min	1	Japan	1996	Operable	UB		
81	Asphalt sprayer (hand)	TES-200	25 l/min	1	Japan	1996	Operable	UB		
82	Radio communication	FTL-1011/10		1	Japan	1996	Operable	Arkhangai, Ikh Tamir		
83	Laboratory testing equipment	Complete set		1	Japan	1996	Operable	Arkhangai, Ikh Tamir		
84	Wheeler for carrying explosives	HZ-J75LP-MR	1 t	1	Japan	1996	Operable	UB		
85	Dump truck	BY-211LTM	4 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		
86	Small truck	BY-100LPCB	1.5 t	1	Japan	1996	Operable	Arkhangai, Ikh Tamir		126.037
87	Micro bus	TCR-10LRPS		1	Japan	1996	Operable	UB		
88	Crusher	PGJ-6	90 t/hour	1	Japan	1996	Operable	Tuv, Erdene		
89	Crusher	PFJ-4	30 t/hour	1	Japan	1996	Operable	Tuv, Erdene		
90	Asphalt plant	NR-600BR	30 t/hour	1	Japan	1996	Operable	Tuv, Erdene		
91	Hand guide type vibration roller	LP-650	0.6 t	1	Japan	1996	Operable	UB		

10.3.3 Capacity Building of Road Maintenance

(1) Jurisdiction and Mandate

The Department of Roads (DOR) was established in 1995 by Order No. 213 of Minister of Infrastructure Development through the reorganization of Mongolian Road Company. In 1996, DOR was organized as a government-implementing agency by Resolution No. 300 of Government of Mongolia for implementation of the policy of the government.

Ministry of Infrastructure (MOI) formulates government policy to develop national road network, supervises and coordinates its implementation through its agencies and departments, while DOR under MOI conducts studies for development of sector, organizes policy implementation, formulates projects for development of road network and owns state roads.

"Road Repair and Maintenance Corporation" (AZZAN) is a state-owned road maintenance corporation under DOR, into which all state-owned companies conducting repair and maintenance of state roads in the past were combined. AZZAN is mandated to undertake integrated and professional management of road repair and maintenance in Mongolia and to have separate administration from DOR.

(2) Organization and Personnel

DOR is legislatively defined to function as the government-implementing agency by the national "Law on Roads" ratified in 1998 and other relevant acts and regulations.

DOR operates four (4) divisions, two (2) client representative office, one (1) material testing laboratory and project implementation units responsible for foreign funded projects as shown in Figure 10-3-1.

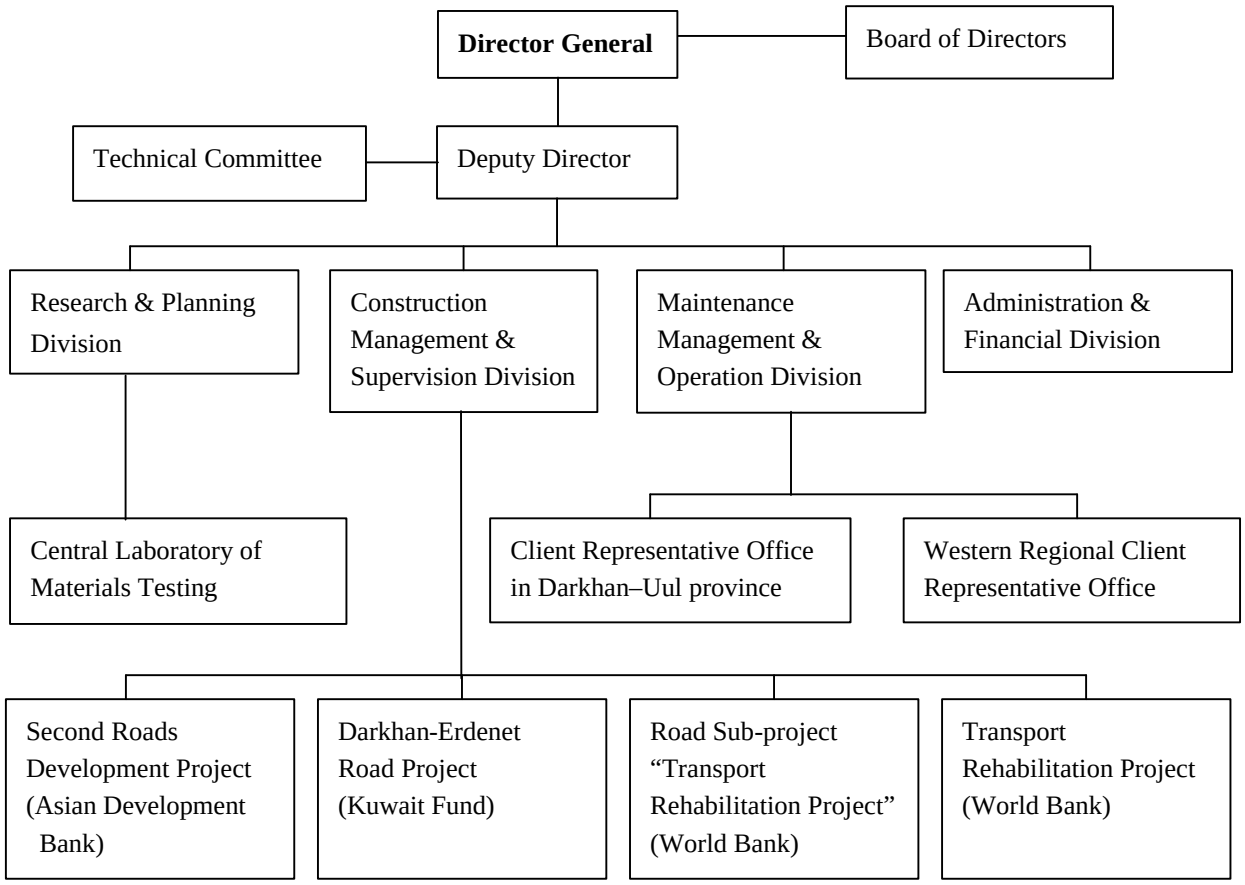


Figure 10-3-1 Organization Chart of DOR

DOR was financed from revenues of technical supervision in the period of 1996 to 1998. It started to receive revenues from both the technical supervision and national budget since 1999. Table 10-3-5 shows budget and personnel of DOR.

Table 10-3-5 Budget and Personnel of DOR

Thousand Tg.

No.	Item	1996	1997	1998	1999
1	Revenue from Technical Supervision	102,636	147,700	156,938	49,758
2	National Budget				75,536
	Total Revenue	102,636	147,700	156,938	125,294
4	Expenditure on Administration	97,959	120,411	150,527	138,440
5	Salary Fund	19,758	30,720	37,944	41,594
	Total Expenditure	117,718	151,131	188,471	180,034
6	No. of personnel	41	54	56	50

The Road Repair and Maintenance Corporation "AZZAN" is under the Maintenance Management & Operation Division of DOR, and has the organization and staff as shown below:

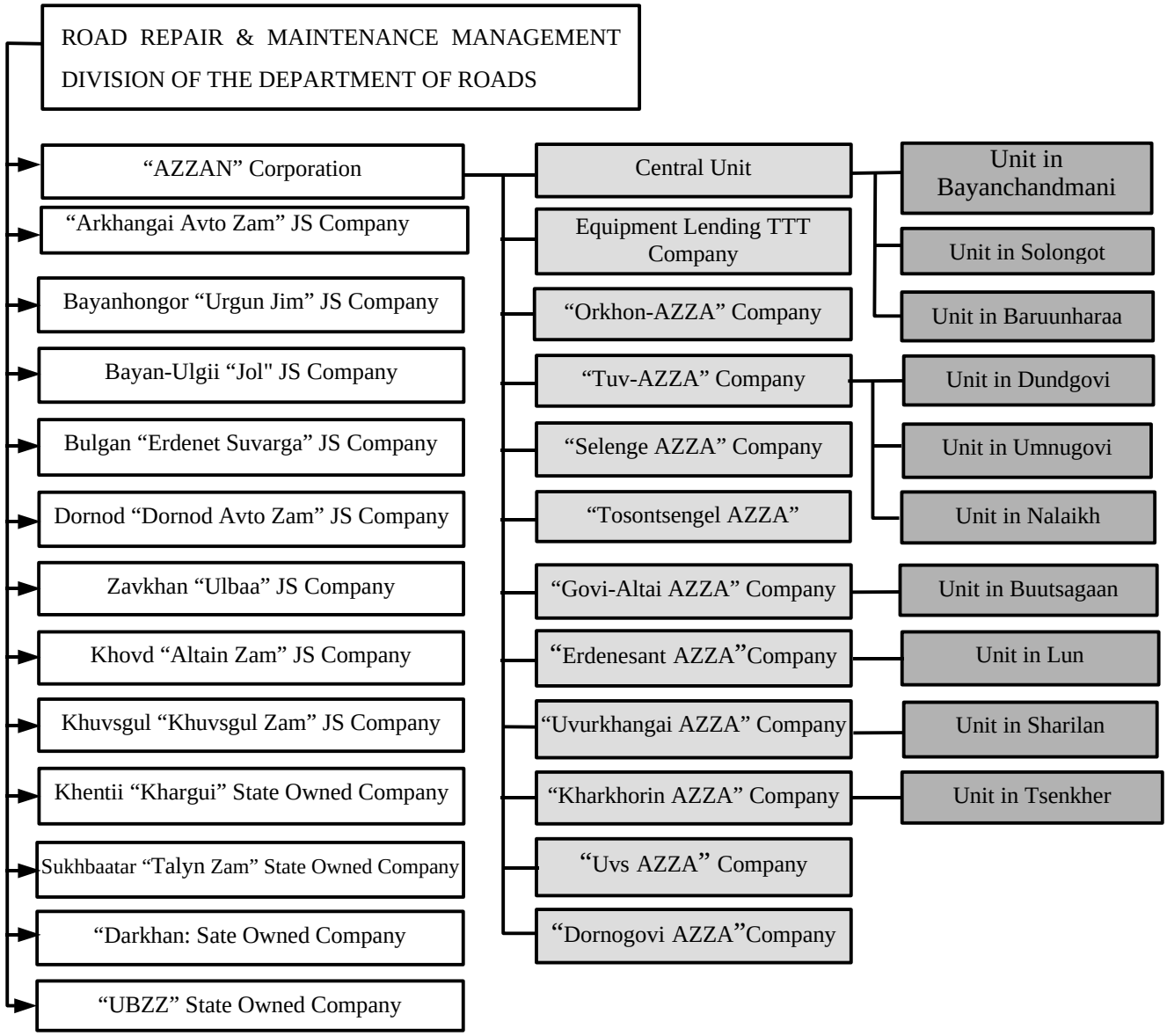


Figure 10-3-2 Organization Chart of AZZAN

Table 10-3-6 Personnel of AZZAN Corporation and "Hargui" Company

(Khentii province)

		AZZAN	Kharkhorin AZZAN	Govi-Altai AZZAN	Selenge AZZAN	Erdenesant AZZAN	Dornogovi AZZAN	Uvs AZZAN	Tuv AZZAN	Uvurhangai AZZAN	TTT Company	"Hargui" Company (Khentii)
Quota of Employees		150	67	39	56	41	34	38	170	59	27	34
Wages (Thousand Tg.)		90,000	21,000	16,380	23,520	12,000	13,950.2	13,000	102,000	24,780	16,200	9,550.4
Total No. of Employees		150	67	39	64	40	34	35	164	59	24	34
Including	Engineers	27	9	2	5	2	4	1	21	9	6	2
	Technicians	15	7	7	8	6	5	6	18	7	-	5

(3) Strengthening of Road Maintenance Capability

Meeting the increasing requirement for service of the road system is critical to the country's economic development. The Government gives highest priority to arterial road improvement, especially development of the "Millennium Road". Most roads are natural earth roads and they require both paving and improving alignment. Moreover, many bridges, which also play an important role as a part of the road system, remain in serious condition and deteriorated due to lack of repair and maintenance and recent increase of heavy traffic. Accordingly, damaged bridges become traffic bottlenecks, jeopardize road safety, and hinder smooth road transportation.

"Subproject for Improvement of Road Maintenance" was conducted as a part of the "Transport Rehabilitation Project" funded by World Bank in 1995. The study concluded that US$13 million for road maintenance would be required annually to keep the road network in normal condition based on the survey carried out on the existing condition of the national road network.

The state-owned Road Repair and Maintenance Corporation "AZZAN" and the state stock-shared maintenance company "HARGUI" will undertake road repair and maintenance works on the project road according to the present maintenance system of national road.

Both legal entities have the same issues to solve: namely,

- Ways by which adequate funds can be allocated for routine and periodic maintenance such that the Project Road can be properly maintained during its design life.
- Measures to ensure the efficient delivery of road maintenance-periodic maintenance using equipment-based methods supported by light equipment such as tractor/trailers.
- Initiatives to encourage routine maintenance activities being carried out by local people/villages under contract with the Department of Roads through AZZAN and HARGUI, particularly in areas where local labor is readily available.
- Ways to boost road maintenance training capacity, both for equipment-based methods and for labor-based/light equipment methods.

Moreover, these two entities as well as other maintenance and construction companies have similar problems as follows:

- Shortage of road and bridge construction equipment and machinery.
- Shortage of local engineers qualified in managing and supervising the operation of road and bridge construction equipment and machinery.
- Lack of skillful construction equipment operators, mechanics, and electricians.
- Lack of repair facilities and tools.

In order to strengthen road maintenance capability and to cope with incremental demand brought about by the government policy of road improvement, especially development of “Millennium Road”, it is necessary to enhance funding availability and to remedy institutional weakness.

A road rehabilitation/maintenance center will aim to establish personnel training with construction equipment and machinery required for road development within AZZAN as shown in Figure 10-3-3, combining similar functions of TTT company and other 5 state stock-shared companies that presently work in the field of road maintenance and construction.

It is expected that a road rehabilitation/maintenance center will undertake actual practice as a pilot model to train operators, mechanics and managers, and that such trained skills will eventually contribute to deliver effective construction equipment and to strengthen the road rehabilitation/maintenance system.

The training center and its accumulation of road and bridge construction technology will also serve as a facility for educating construction equipment operators and mechanics in the transport sector.

The road rehabilitation/maintenance center aims:

a) To establish one road rehabilitation/maintenance center that will serve as a training facility for construction operators and mechanics.
b) To procure equipment and machinery necessary for training and road rehabilitation/maintenance.
c) To train operators, mechanics, road-maintenance personnel, and managers.
d) To advance technically skilled operators, mechanics, road-maintenance personnel, and managers at the well-established center.
e) To utilize and accumulate those skills through actual practices as a pilot model.
f) To establish regional sub-centers for further development.

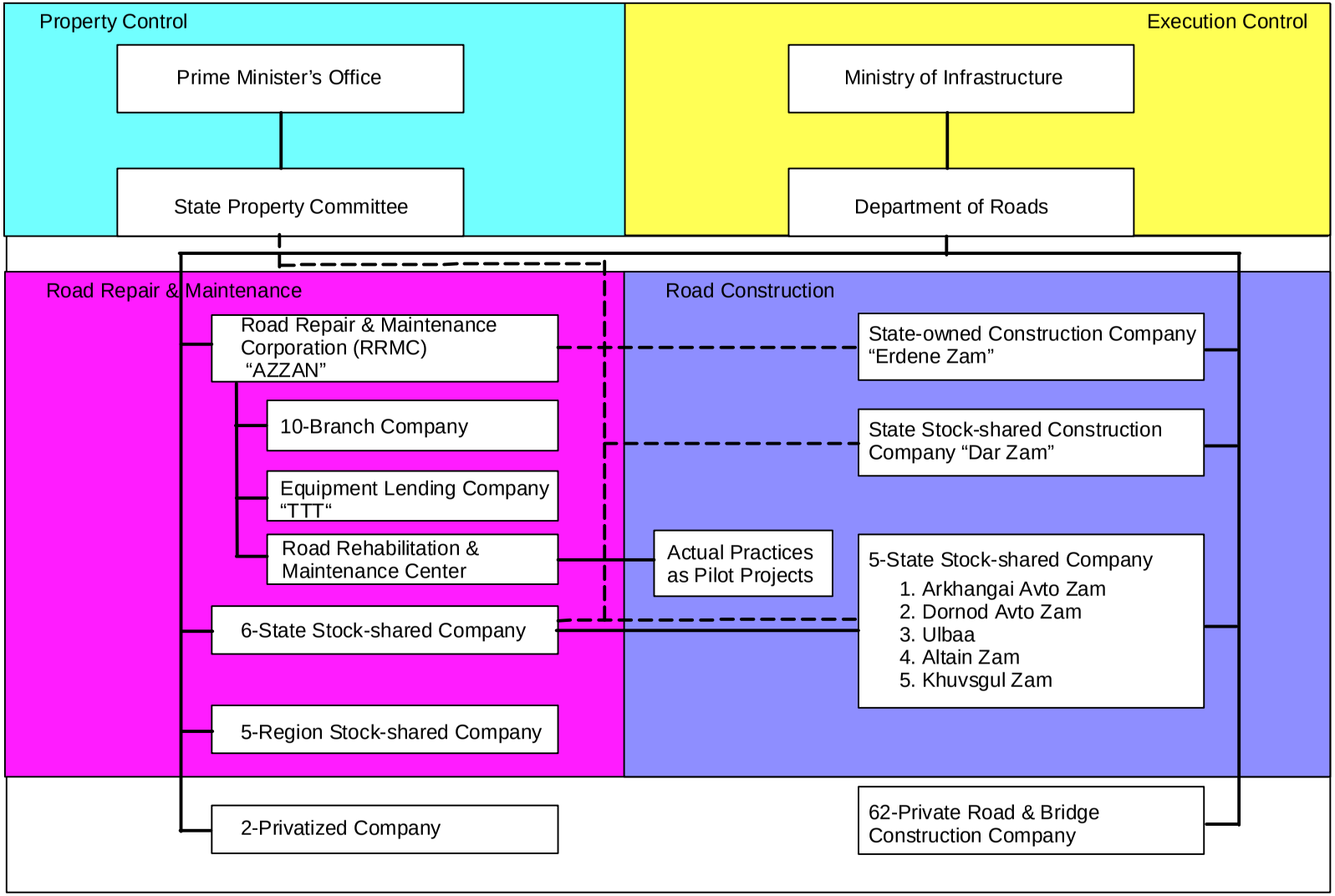


Figure 10-3-3 Proposed Road Rehabilitation & Maintenance Center in AZZAN

10.4 Estimated Cost of Routine Maintenance for the Project

DOR has unit cost records analyzing annual maintenance by each type of pavement and type of bridge, and the annual required fund for each road link estimated using unit cost multiplied by its length. Roads are classified into five types: namely, asphalt concrete, cement concrete, gravel, surface treatment and improved earth. There are two types of bridges: reinforced concrete and wooden. DOR uses this analysis for budgeting and refers to it as the basis to allocate annual funds to each maintenance company.

The unit cost analysis for asphalt pavement consists of major works such as leveling and compaction of shoulders, slope stabilization, overlaying by asphalt concrete and guard post repair. The average area of overlaying per year is 52.5 sq. m per kilometer. That of surface treatment consists of similar works excluding surface dressing, and the average area of dressing per year is 70 sq. m per kilometer. The normative unit costs by type of pavement and bridge are summarized in Table 10-4-1.

Table 10-4-1 Normative Unit Cost

in March 2000 Prices

No.	Type of Pavement & Bridge		Unit	Unit Cost (Tg)
1	Road	Asphalt Concrete	km	1,821,931
		Cement Concrete	km	2,034,032
		Gravel	km	1,679,189
		Surface Treatment	km	1,801,913
		Improved Earth	km	1,029,624
2	Bridge	Reinforced Concrete	m	36,811
		Wooden	m	34,042

Actual practice for road maintenance is to carry out prioritized works within the allocated budget. In case of funding constraints, maintenance activities are limited to only the most seriously deteriorated road sections as emergency maintenance. However, no provision is made for preventive and periodic maintenance, and even routine maintenance is performed on an ad hoc basis.

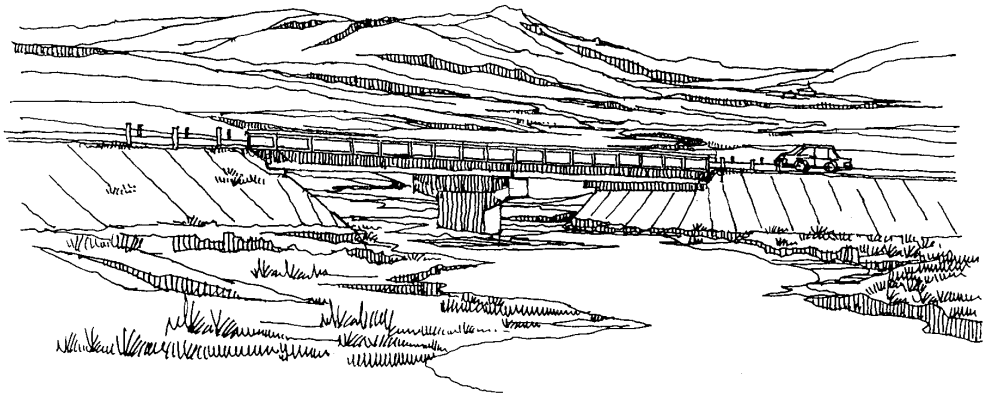
The maintenance cost for the study road is estimated as shown in Table 10.4.2, based on normative unit costs.

Table 10-4-2 Annual Required Fund for the Study Road

Unit: 1,000 Tg

	Road Length (km)	Bridge Length (m)	Total Required Fund
Section-I : Erdene～Baganuur	37.0	75.7	70,198
Section-II : Baganuur - Kherlen River East	30.3	301.3	66,296
Section-III : Kherlen River East - Tsenkhermandal	49.7	0	90,550
Section-IV : Tsenkhermandal～Jargaltkhaan	44.6	67.5	83,743
Section-V : Jargaltkhaan～Murun West	50.0	0	91,097
Section-VI : Murun West - Undurkhaan	46.8	52.5	87,199
Total	258.4	497.0	489,082

CHAPTER 11 STUDY ON INSTITUTIONAL CAPABILITY OF ROAD DEVELOPMENT FUND



CHAPTER 11 STUDY ON INSTITUTIONAL CAPABILITY OF ROAD DEVELOPMENT FUND

11.1 Status Quo of Road Fund

In 1995 by the decision of the Government, the Road Fund has been established for construction and maintenance of roads and bridges in accordance with the Law on Taxes on gasoline and diesel fuel. The Road Fund (RF) comprises revenues of a part of fuel tax, vehicle registration fee, allocation of national treasury and other incomes. The RF is split into two, namely RF for DOR and RF for Ulaanbaatar City Government, and the revenue from vehicle registration fee accrued from Ulaanbaatar City is transferred to the RF for Ulaanbaatar City Government since 1999.

In recent years, the Road Fund is not sufficient to cover needs of the road sector. The main reason is that the fuel tax proceeds have not been completely transferred to the Road Fund (72.6% in 1999 and 79.7% in 2000) and the allocation of national treasury depends upon the government policy. Other incomes are revenues of fine for traffic offense, leasing equipment, consulting fees, donation and so forth. This "diversion" of funds reflects the Government's budgetary constraints, by which RF for DOR that should be used only for road maintenance is used in other sectors. Such diversion of road funding to other uses clearly requires to be discontinued and most of the additional funds so made available should be spent on maintenance.

At present, most of the Road Fund revenues are used for development/rehabilitation works (including periodic maintenance), with routine maintenance receiving only very small allocations. For expansion of revenue sources of the Road Fund, the Department of Roads proposes to the Government not to transfer the revenue of fuel special tax from state budget but to transfer it directly to the Road Fund. (Fuel tax comprises custom, normal and special.)

Table 11-1-1 Breakdown of Revenue of the Road Fond

Revenue	1997	1998	1999	2000
Fuel tax (M. Tg.)	4,200	4,434	3,481	4,234
State budget (M. Tg.)	51	1,156	2,341	3,716
Others (M. Tg.)	52	307	601	47
TOTAL (M. Tg.)	4,303	5,897	6,423	7,997
Exchange Rate (Tg./US$)	720	885	1,000	1,070
Equivalent US$ (Thousand $)	5,976	6,663	6,423	7,474

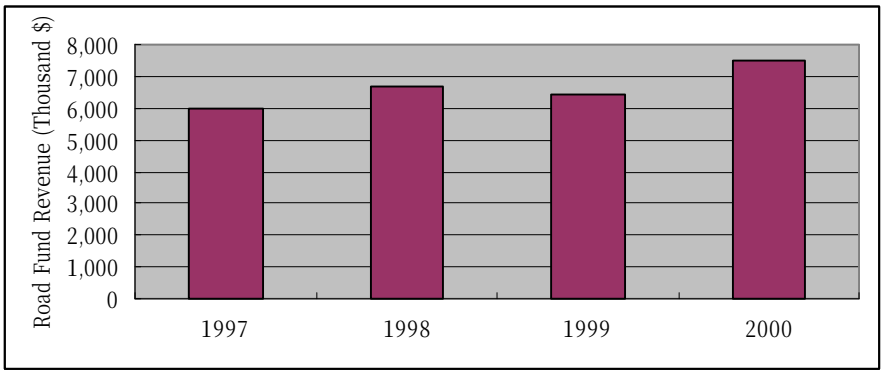


Figure 11-1-1 Road Fund Revenues

To cope with incremental fund requirement by increase of Road Fund revenue, the MOI/DOR examine the possibility to levy a toll on certain arterial roads or long-span bridges, to charge the private sectors for the privilege of utilizing the roadside spaces and to restructure the State-owned Road Repair and Maintenance Corporation (AZZAN) by privatization. The Government approved the contracting-out for road maintenance work since 2001, and the maintenance work of roads between Ulaanbaatar and Darkhan and between Ulaanbaatar and Kharkhorin is now carried out under contracting basis.

41 items of road construction equipment that were procured under the Japan's Grant Aid in 1995 have been handed over to the State-owned Construction Company "Erdene Zam". The State Property Committee appointed as a founder and stockholder for state-owned companies shares the profits accrued from such equipment. Accordingly, the DOR examines the possibility to procure equipment using the RF to cope with the deterioration of equipment for road maintenance.

11.2 Investment to the Sector and Accomplishment

In 1996 - 2000 total investment to the road sector has reached Tg. 53.1 billion including foreign loans, grants and domestic investments, from which:

- For construction and improvement of roads and bridges - Tg. 51.6 billion
- For maintenance of roads and bridges - Tg. 1.2 billion
- For strengthening of industrial base - Tg. 0.3 billion

Source of investments:

- From the Road Fund - Tg. 17.6 billion (33.0%)
- From foreign loans - Tg. 28.1 billion (53.0%)
- From grant aids - Tg. 7.4 billion (14.0%)

134 km of asphalt paved road, 105.7 km of gravel road, 1574.8 m of RC bridges and 353.6 m of wooden bridges were constructed in the period of 1996 - 1999.

The following major projects are implemented in this period:

(1) Ulaanbaatar - Altanbulag Road, Route A3 of the Asian Highway:

The construction work started in 1996 to carry out the reconstruction of 312 km road between Darkhan and Altanbulag, the construction of RC bridges over the Orkhon and the Burgaltai rivers under ADB loan of 25 million US$.

(2) Nalaikh - Choir Road, Route A3 of the Asian Highway:

The project is the construction of road between Nalaikh and Choir under ADB loan of 25 million US$. The tender evaluation is underway.

(3) Darkhan - Erdenet Road, Route A83 of the Asian Highway:

The construction work started in 1998 to carry out the construction of 184 km asphalt paved road between Darkhan and Erdenet under ADB loan of 18.2 million US$.

(4) Erdenet - Bulgan - Murun Road, Route A83 of the Asian Highway:

The feasibility study was conducted with the technical assistance of Kuwait Fund (435 thousand US$).

The list of projects of road sector is shown in Table 11-2-1.

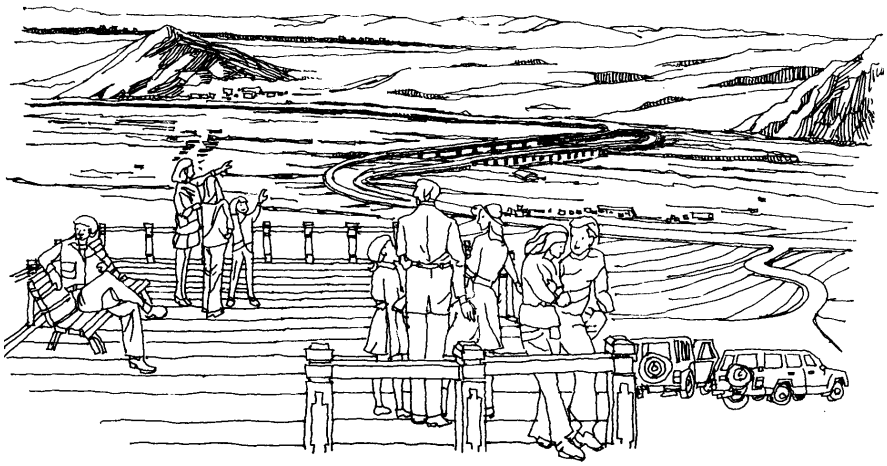
In 2000 reconstruction of 312 km asphalt paved road, construction of 123 km gravel road, 1117.8 m of RC bridges and 87.8 m of wooden bridges will be completed.

Table 11-2-2 Implemented and Ongoing Projects of Road Sector in 1996 - 2000

No.	Project Name	Date	Implementation Period	Project Cost (mln US$)	Effect
1	World Bank Roads subproject	1995, soft loan	1995-2000	8.3	• Establishment of laboratories for supervision of repair and maintenance works • Preparation of road repair and maintenance manual, manual of ASTM and AASHTO standards • Construction of gravel road sections with total length of 89.4 km on Kharkhorin - Tsetserleg - Tosontsengel road decreased vehicle operation cost and reduced travel time and improved western region road network. • Computerization of the Department of Roads, construction and maintenance companies and laboratories brought high quality of designing and interpretation of field surveys.
2	Grant aid of the Government of Japan Project for construction of road utilizing rock asphalt	1995	1995 - 1998	25	• Construction of Bayandavaa - Erdene sum road (13.3 km) • Pilot project for utilization of local material such as rock asphalt • Modernization of road sector equipment through suplly of equipment • Technology transfer through the on the job training
3	ADB Development of structure and organization of the road sector	1996, technical assistance	1996-1997	0.9	Recommendations on how to manage and reorganize road sector in market oriented economy
4	ADB Formulation of road design and construction standard	1997, regional technical assistance	1997-1998		Standard applicable for design and construction of roads under foreign and domestic funding
5	European Union TRASECA project	1997, technical assistance	1997-1998		Winter road maintenance standard Road materials standard
6	ADB Second roads project	1997, technical assistance	1998.3-1998.9	0.6	Control of realization of recommendations formulated in previous project and definition of next technical assistance Feasibility study of Nalaikh-Choir, Ulaanbaatar-Atar, Erdenet-Bulgan roads
7	Government of Japan Master plan study on improvement of road network in Ulaanbaatar	1997, grant aid	1998-1999	3.011	Definition of road improvement project list from which high priority project is now under preparation for implementation.

No.	Project Name	Date	Implementation Period	Project Cost (mln US$)	Effect
8	Kuwait Fund Darkhan - Erdenet road project	1996, loan	1996-2000	18.2	Ongoing construction of Darkhan - Erdenet asphalt paved road (184 km). This road a part of Asian Highway route.
9	ADB Road development	1995, loan	1995-2000	22.2	Construction is started in 1997. Reconstruction Ulaanbaatar - Altanbulag road (314 km) is under completion. This road is a part of Asian Highway route. Also construction of RC bridges over Orkhon and Burgaltai rivers is under completion.
10	ADB Second roads project	2000, loan	2000-2004	25.0	Link of Asian Highway Nalaikh - Choir road will be constructed.
11	Kuwait Fund Feasibility study of Erdenet - Bulgan - Murun road	2000	2000.5-2000.11	0.433	Definition of Erdenet - Bulgan - Murun road alignment (Asian Highway link A83).
12	Government of Japan Supply of materials	1998	1998	3.8	Supply of equipment spare parts for continuous construction activity.
13	ADB Promotion of road sector policy	2000	2000.3-9	0.675	• Development of financial management • Improvement of Road Fund management • Privatization in road sector • Improvement of equipment utilization Methods of Road Fund management, related legal aspects, increase of its capacity, involvement of road users, changes in policy to expense Road Fund for road maintenance will be studied.
14	World Bank Transport development project				Reconstruction of Erdenesant - Arvaiheer paved road, construction of gravel road sections on Kharkhorin - Tsetserleg - Tosontsengel and Arvaiheer - Bayanhongor - Govi-Altai - Khovd roads. Feasibility study was conducted under domestic fund.
15	USA Wheat Fund Grant Aid	2000	2000	1.1	70 km gravel road section to be constructed on Zuunmod - Mandalgovi road.

CHAPTER 12 PROPOSED ROAD IMPROVEMENT PLAN



CHAPTER 12 PROPOSED ROAD IMPROVEMENT PLAN

12.1 Project Component of Road Improvement Plan

The Road Improvement Plan aims to improve National Highway No. A0501 from the existing multiple shifting tracks to an all-weather paved road together with horizontally and vertically well-designed alignment. The improvement plan also aims to provide an arterial road to an international standard and to maintain it effectively upon the completion. The following components are proposed to improve the road section between Baganuur and Undurkhaan including existing five (5) bridges:

1) New construction of asphalt concrete pavement whose structure consists of roadbed embankment including sub-grade, sub-base course, base course and surface course;
2) Existing three (3) wooden bridges replaced by new reinforced concrete bridge;
3) Existing one (1) concrete bridge replaced by new reinforced concrete bridge;
4) Existing one (1) bridge supplemented by construction of additional pre-stressed concrete bridge;
5) Construction of three (3) new reinforced concrete bridges and twenty nine (29) new box culverts at major watercourse crossings;
6) Installation of one hundred ninety seven (197) pipe culverts at minor watercourse crossings;
7) Traffic safety measures installed by road markings, guard posts, regulatory & warning signs, guide signs, kilometre posts, and approach slopes for domestic animals; and
8) Amenity enhancement installed by resting-places for long-distance drivers (Road Station) and observation platforms at mountain passes.

In addition to such facilities improvement, the followings are proposed to maintain the project road effectively by re-structuring the present road maintenance system as an institutional measure and by procuring equipment at a road rehabilitation/ maintenance center. This will serve not only for training and equipment leasing but also for undertaking actual construction practices as a pilot model:

1) Establishment of a road rehabilitation/ maintenance center in AZZAN;
2) Equipment procured for a road rehabilitation/ maintenance center; and
3) Construction of operation depot including workshop in State Stock-shared Road Maintenance Company of Khentii Province

12.2 Road Improvement

(1) Road and Pavement Structure

The project route will be improved by each design section and will be designed based on the following criteria:

1) Highway Classification: Category III (as per Mongolian Standards)
2) Road Width: 7m + 2@1.5m (total 10m road width)
3) Design Speed: 100 km/h for flat terrain, 80 km/h for rolling and 60 km/h for mountainous
4) Design Axle Load for Pavement: 8.2 ton (18 kips)

The horizontal and vertical alignments are selected to secure driving safety considering Mongolian weather condition and to minimize earthwork volume.

The road embankment is designed to consider embankment height and non-frost susceptible materials to prevent frost actions such as swelling or capillary action.

The pavement thickness is designed to apply AASHTO design method on the basis of each design CBR of pavement design section and cumulative 8.2 ton equivalent axle load applications in one direction over ten years.

For road construction, the following three types of improvement method will be used.

Improvement Type I: Flat section that average embankment height is relatively low (Min. 0.5 m high) and basically consists of filling on natural ground where neither water table nor seeping/boggy ground is expected.

Improvement Type II: Rolling section that average embankment height is relatively medium and basically consists of filling on natural ground where either water table or seeping/boggy ground is expected.

Improvement Type III: Mountainous section that average embankment height is relatively high and basically consists of cutting and filling where storm water drainage is expected.

(2) Road Ancillaries

1) Road Markings

Road markings are particularly important to help in regulating of traffic and warning or guiding road users. Road markings, like other traffic control devices should be uniform in design, position and application so that they may be recognized and understood immediately by all road users.

Principal road markings will be of Centerline and Roadside line and they will be painted on pavement.

2) Guard Posts

Guard posts are to function to redirect errant vehicles away from the roadside hazard and decelerating the errant vehicles to a stop.

Horizontally sharp curves, bridge and box culvert approaches and high embankment sections warrant installing guard posts to delineate them. Traffic volume is also taken into account when deciding where to install guard posts.

3) Regulatory & Warning Signs

Regulatory & Warning signs are to inform road users of traffic rules and regulations and to appeal for enforcement and caution that would not otherwise be apparent.

Regulatory & Warning signs are planned to be installed at the locations where enforcement appeals and caution is given such as vicinity of village, domestic animal crossing, steep slope, sharp curve, etc.

4) Guide Signs

Guide signs are to convey to drivers information such as destination and distance, service facilities and route confirmation.

Guide signs are planned to be installed in the vicinity of major intersections, road stations, observation platforms and gas stations.

5) Kilometer Posts

Kilometer posts are to function serve to inform road users as well as to locate and orient them. The also serve a useful function in the future for the work of inspection and maintenance.

(3) Road Related Facilities

1) Road Station

Road Station is a functional and desirable element of a high class road and provides road users with traffic safety and convenience. Road station is located at the roadside together with parking lots, resting facilities and gas stations. Road Station may provide services such as drinking & eating, toilets, tables and benches, telephones, information and other necessary facilities for travellers.

Road Station will be planed based on geometric design standard, considering existing Ger restaurants and gas stations at the following locations:

- Kherlen River Check point
- Ogzam Valley (Tsenkher West)
- Tsenkher Bridge East
- Jargaltkhaan
- Murun

2) Approach Slope for Domestic Animals

The slope of embankment is designed to be of 1 to 2, and it is so steep that domestic animals could not cross the road in case of high embankment. Domestic animals will cross the road where a box culvert is installed in the vicinity of high embankment. However, an approach slope will be required for domestic animals to cross the road where embankment is too high and no box culvert is found in its surrounding.

3) Observation Platform

Observation platform will be located away from the road providing motorists with a place to stay and to enjoy tourism views. These platforms will also have parking lots, observation platform, restaurant and play ground.

Observation platform will be planned to locate at existing fine views such as the following locations:

- Kherlen River East
- Duut Pass

12.3 Bridge and Structure Improvement

The bridge and structure improvement plan includes construction of bridges, construction of box culverts and installation of pipe culverts. The type and location of each structure are determined based on the preliminary design referring to the results of engineering site survey.

The outline of bridge and structure improvement plan is envisaged as follows:

(1) Construction and Rehabilitation of Bridges

8 bridges are proposed currently on the proposed route. 3 existing wooden bridges are to be replaced by RC-T girder bridges. There are only two existing RC bridges on the proposed route and these are located on the Khujirt River and the Kherlen River. These two bridges have been investigated by inventory survey and been analysed. There are 3 new proposed bridges, which cross watercourses on the proposed route.

1) Replacement of Existing Three (3) Wooden Bridges

Three bridges are located at the Khutsaa River, the Tsenkher River and the Murun River. The conditions of these bridges are so insufficient that heavy vehicles cannot go across. Especially the Tsenkher river bridge is not safe for even light vehicles, and the traffic crosses the river passing on the riverbed when the water level of the river is low enough.

The RC-T girder bridges with the standard width of 8 m are proposed to meet the technical requirements of Millennium Road Plan.

2) Construction and Rehabilitation of Kherlen Bridge

The existing Kherlen River Bridge is far from sound condition in many aspects. The bridge structure does neither have structural strength for the design load of heavy vehicle nor the required width for design vehicle. The opening beneath the bridge is insufficient for the peak discharge and some damage on the surface of the bridge detracts from the smooth riding condition. The existing bridge is planned to be repaired but will be used only for non-motorized vehicles, pedestrians and domestic animals.

The new PC-girder Bridge is proposed to meet the technical requirements of Millennium Road Plan. At the first stage, 8-span of 268.8m long bridge with 9.0m in width will be constructed to meet the requirements on an international standard.

3) Replacement of Khujirt Bridge

The existing Khujirt River Bridge will be replaced by RC-T girder bridges, since the bridge does neither have structural strength for the design load of heavy vehicle nor sufficient opening for the peak discharge.

The replacement bridge will meet the technical requirements of Millennium Road Plan and obtain sufficient discharge capacity.

4) Construction of Three (3) New Concrete Bridges

There will be three new bridges to be constructed in the project and they are located at the Togos River, the Chandaruu valley and the Urt Valley. The detail design of these bridges was made by DOR in the past. The former two bridges are planned to cross waterway/ wadi due to high flood run-off, and the latter requires pile foundation due to soft ground condition.

(2) Construction of Twenty Nine (29) New Box Culverts

The route passes through the swamps and valleys and a large number of watercourses exist in mountainous and marsh area. Box culverts will be installed at the crossing point of major watercourses to ensure that their flow is not affected by the new embankments. The box culverts will be utilized by stock-farming and wild animals to cross the high road embankment at times when the watercourses have no water.

The preliminary design determines that the location of each box culvert and its dimension are as shown in Volume III: Drawings.

(3) Installation of Pipe Culverts

The study road will necessitate numerous cross drainages to drain storm water on pavement and its adjacent area, especially in the mountainous and rolling area.

Pipe culverts are planned to be installed at the sag point of vertical alignment, in between box culverts and at the places where storm water will converge.

One hundred ninety seven (197) pipe culverts are estimated to require installation, and the preliminary design determines not exact location but only the dimension as shown in Volume III: Drawings.

12.4 Strengthening Road Maintenance Capability

The capability of road repair and maintenance will be strengthened by adequately re-structuring the present road maintenance system and procurement of modern equipment.

(1) Establishment of Road Rehabilitation/Maintenance Center in AZZAN

The scheme of a road rehabilitation/maintenance center aims to establish for personnel training with construction equipment and machinery required for the road development, combining similar functions of TTT Company in AZZAN and other 5 state stock-shared companies that presently work in the field of road maintenance and construction.

It is expected that a road rehabilitation/ maintenance center may undertake actual practices as a pilot model to train operators, mechanics and managers, and such trained skills will eventually contribute to deliver effective use of the construction equipment, to strengthen road maintenance capability and to cope with incremental demand in the standard of the maintenance.

(2) Equipment procured for Road Rehabilitation/Maintenance Center

The following equipment will be procured and will be commonly utilized for construction/ rehabilitation and maintenance for operator training, lending and actual practices as a pilot model.

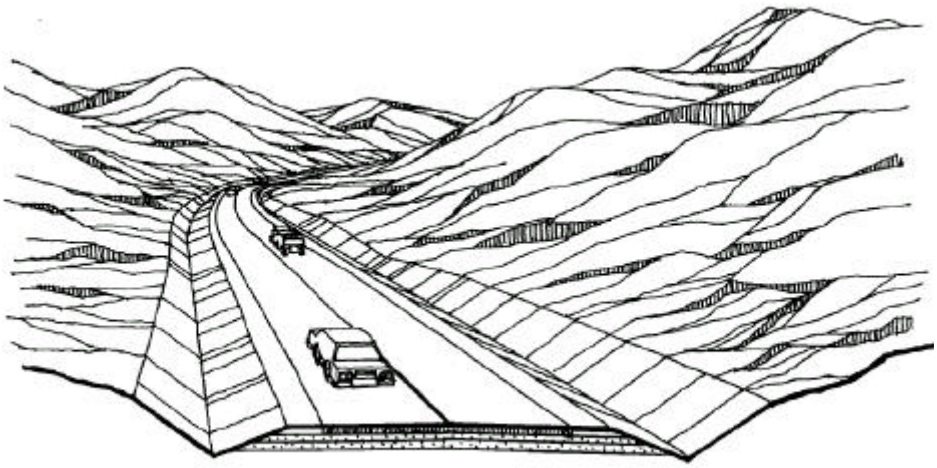
Table 12-4-1 Equipment List for Road Rehabilitation/Maintenance Center

Item	Description	Specification	Construction	Maintenance
1	Bulldozer	28 ton	0	-
2	Bulldozer	7 ton	0	-
3	Hydraulic Excavator	0.7 m^3	0	-
4	Wheel Loader	2.1 m^3	0	-
5	Wheel Loader	1.3 m^3	0	0
6	Dump Truck	11 ton	0	-
7	Motor Grader	3.7 m	0	0
8	Vibration Roller	10 ton	0	0
9	Tire Roller	10 ton	0	0
10	Asphalt Finisher	4 m	0	0
11	Asphalt Plant	60 ton	0	0
12	Water Tanker	8000 liter	0	-
13	Asphalt Sprayer	1500 liter	0	0
14	Chip Spreader	Vessel mount type	0	0
15	Tractor Head with Trailer	35 ton	0	-
16	Crusher Plant	Jaw 60t & Cone 49t	0	-
17	Asphalt Cutter	-	-	0
18	Air Compressor	180 PSI	0	0
19	Plate Compactor	60 kg	0	0
20	Pnuematic Breaker	30 kg	0	0
21	Dump Truck	4 ton, 4 x 4	0	0
22	Truck with 3 ton Crane	5 ton	0	0
23	Road Patrol Car	4 x 4	-	0
24	Double Cab Pick-up	4 x 4	0	0
25	Line Marker Truck	-	0	0
26	Mobile Workshop	GVW 13 ton, 4 x 4	-	0
27	Rotary Snow Remover	Unimog type	-	0
28	Asphalt Testing Equipment	-	0	0
29	Radio Communication	Base / Mobile	0	0
30	Road Measure (wheel type)	5 digits	-	0

(3) Construction of Operation Depot including Workshop in the State Stock-shared Road Maintenance Company of Khentii Province

To establish a regional sub-center for further development, it is proposed to construct the operation depot including workshop in the State Stock-shared Road Maintenance Company of Khentii Province. The State Stock-shared Road Maintenance Company of Khentii Province is responsible for the road maintenance of study road in Khentii Province and the operation depot will consist of equipment pool yard, warehouse, administration office and other ancillary buildings and facilities. In the interests of cost efficiency, the existing facilities renovated as much as possible.

CHAPTER 13 PRELIMINARY DESIGN



CHAPTER 13 PRELIMINARY DESIGN

13.1 Highway Design

13.1.1 General

The total length of selected route is approximately 259 km in the road section between Erdene and Undurkhaan based on the alternative route study engineering surveys. However, the Mongolian side has determined that the section from Erdene to Baganuur (T-shape paved intersection) with approximately 37 km length would be accomplished by the Government's own budget. Therefore, the preliminary design is carried out in the road section between Baganuur and Undurkhaan in accordance with the amended Scope of Work.

13.1.2 Design of Roadway

(1) Design Section and Required Number of Lanes

Three types of design sections of the Eastern Arterial Road (EAR) are determined due to the following features:

- The terrain varies, classifies into three types: namely, flat, rolling and mountainous.
- Other conditions are uniform or similar such as road function, traffic volume and land use through the stretch.

Design sections should vary depending on the change of terrain because of economic and environmental viewpoints. Although the design criterion is established for each design section in Chapter 7, desirable road length of each design section should be kept for the purpose of traffic safety and driver's comfort. The standard length of design section for rural arterial roads is recommended by "Road Design Standard" of Japan as shown in Table 13-1-1.

Table 13-1-1 Minimum Length of Design Section

	Desirable	Minimum
Minimum Length of Design Section	20 km	5 km

The design sections in the project road are proposed as shown in Figure 13-1-1, where some design sections are having road length less than the desirable value from economic viewpoint.

To determine the required number of traffic lanes in the design sections, the levels-of -service of the project road is to be examined based on forecasted traffic characteristics. Undivided 2-lane rural arterial road normally has allowable flow rate of 750 pcu per hour on flat terrain, and it increases up to 1,200 pcu per hour even on mountainous terrain.

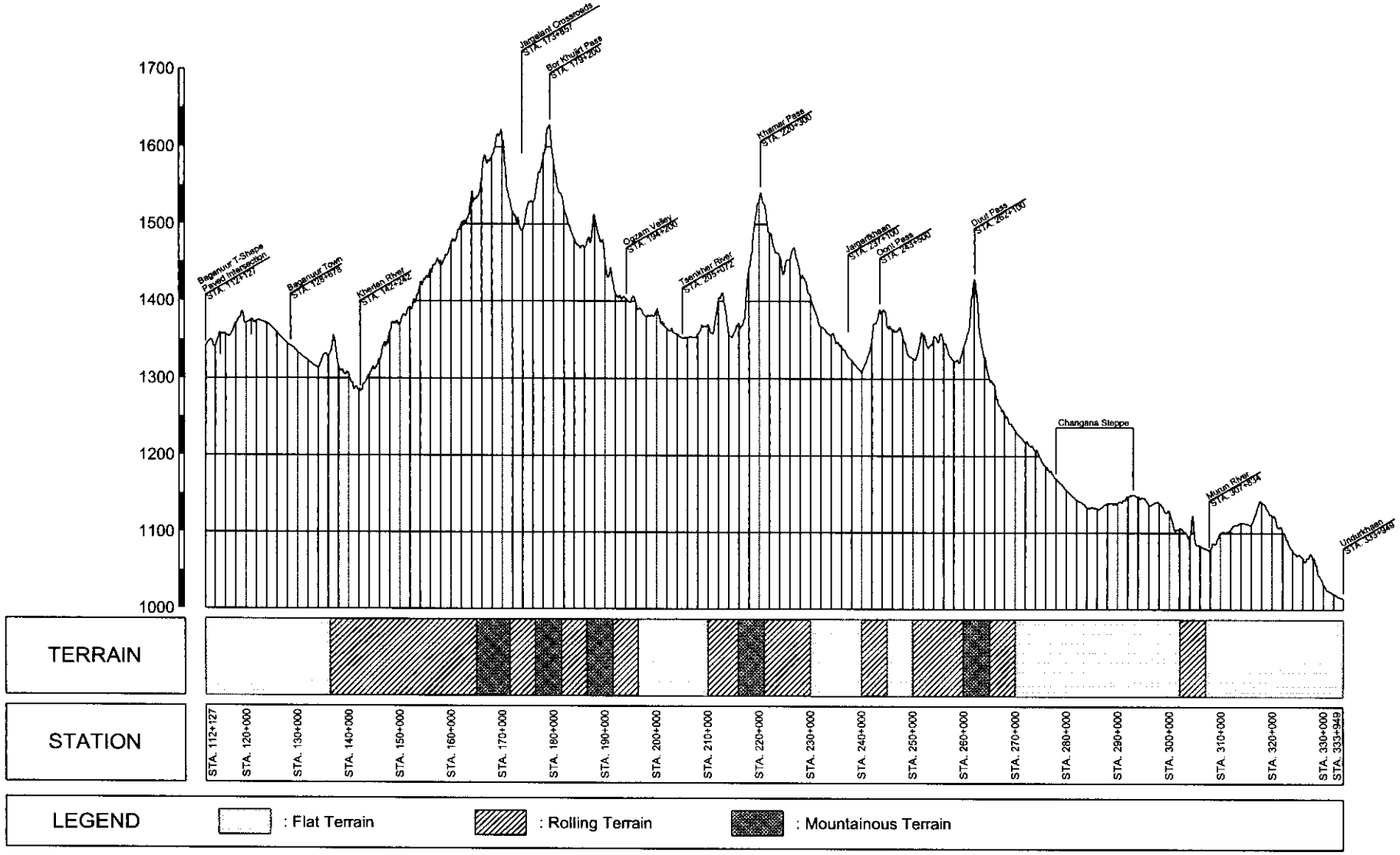


Figure 13-1-1 Design Section for the Study Route

The traffic demand for the year 2015 is forecasted in Chapter 3, and peak hourly rate of 9 % is selected as maximum rate because the ratio of peak volume to 24 hours traffic volume was observed to ranges between 7 % and 9 % in the traffic count survey of the study. Table 13-1-2 summarized the design traffic volume in each traffic section.

Table 13-1-2 Design Traffic Volume in Each Segment (2015)

Section	Erdene - Baganuur	Baganuur - Jargaltkhaan	Jargaltkhaan - Murun	Murun - Undurkhaan
Traffic Demand (pcu/hour)	179	177	134	142

The design traffic volume is far lower than the traffic capacity of undivided 2-lane rural road, and it is obvious that undivided 2-lane roadway can accommodate future traffic demand.

(2) Cross Sectional Configuration

Depending on the design sections, change of shoulder width is not necessary from the viewpoints of traffic capacity, traffic safety and driver's comfort, and the proposed cross sectional configuration has following advantages and justifications.

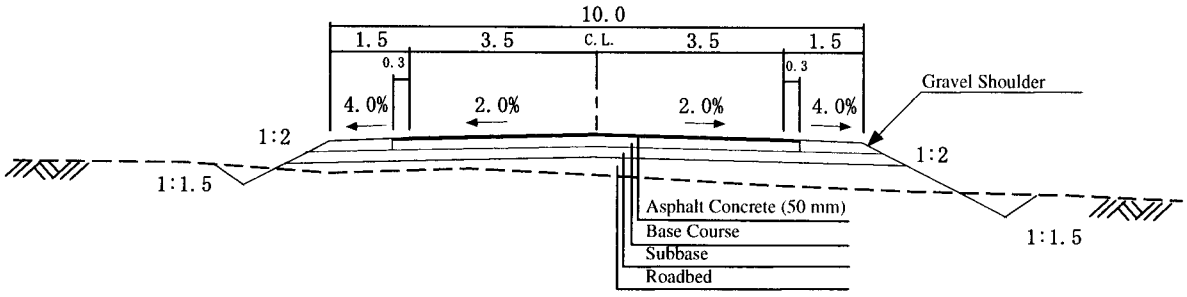
i) The Eastern Arterial Road is located in the rural area and planned to avert the town and the villages except Baganuur and Undurkhaan. Number of stopping and parking vehicles on shoulder is estimated negligible because traffic volume is far small and resting-places for long-distance drivers are well designed. On the other hand, the proposed shoulder width is wide enough to ensure lateral clearance against stopping and parking and it is possible for passenger car to stop on shoulder in case of emergency.

ii) Proposed cross section configuration is satisfied with the standard cross section adopted in the "Millennium Road Plan", which AASHTO recommends the minimum roadway width of combining through-traveled lanes and shoulders in rural arterial road depending on design speed and average daily traffic.

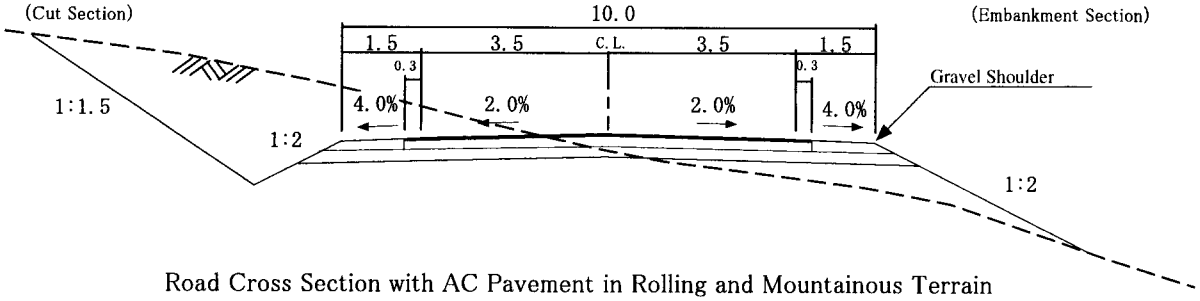
iii) In case of proposed cross section configuration, adjustment factor for restricted shoulder width is 1.00 and 0.96 in Japanese Standard and "Highway Capacity Manual, USA" respectively, and adjusted traffic capacity is sufficient for future traffic demand. It is confirmed that neither hamper to drive nor climbing lane is require for proposed cross section configuration.

iv) Uniform cross section configuration will make construction and maintenance easier to result in lower cost.

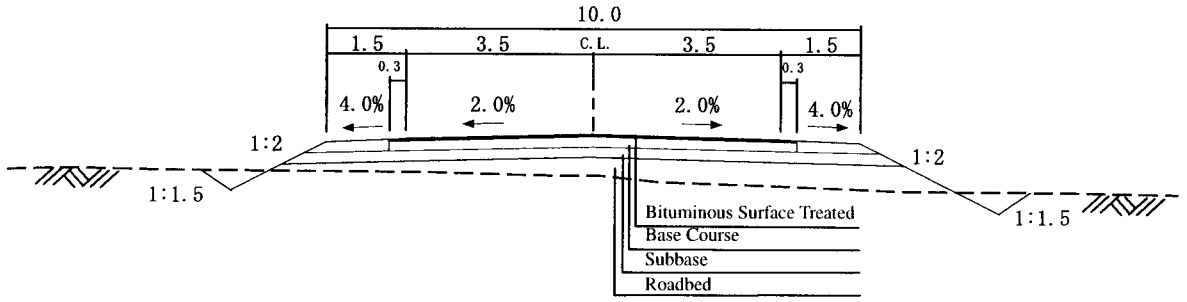
Figure 13-1-2 shows proposed typical cross section for the Eastern Arterial Road.



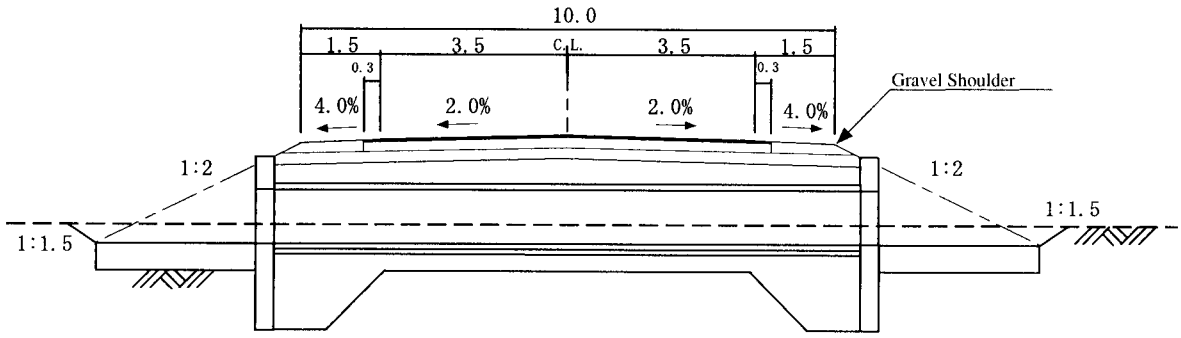
Road Cross Section with AC Pavement in Flat Terrain



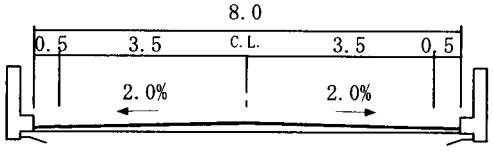
Road Cross Section with AC Pavement in Rolling and Mountainous Terrain



Road with Bituminous Surface Treated



Road with Culvert



Bridge Section

Figure 13-1-2 Proposed Typical Gross Section

13.1.3 Alignment

(1) Centerline

Horizontal and vertical alignment shown in Vol. III: Drawings are located at the center of roadway as shown in Figure 13-1-3.

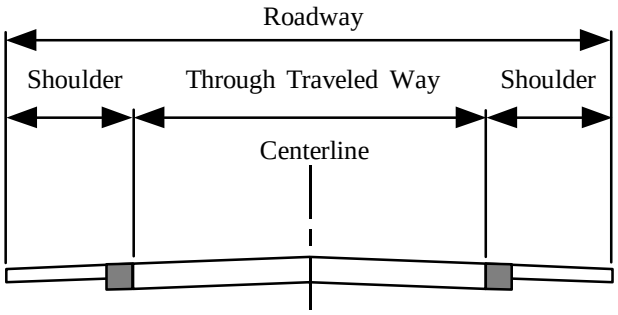


Figure 13-1-3 Position of Centerline

(2) Design Concept of Horizontal Alignment

Horizontal alignment along the selected route is set based on the road section and geometric design standard, taking into following considerations.

- Horizontal alignment starts from T-shape paved intersection at Baganuur.
- Horizontal alignment connects to existing road in Undurkhaan.
- Horizontal alignment is planned to use existing paved in Baganuur.
- Horizontal alignment is planned to use existing gravel road, if any.
- New Kherlen Bridge is planned downstream parallel to the existing bridge at a distance of 30 m .
- Horizontal alignment is planned to avoid secondary controls such as residence area, steel pylon of high voltage power line, permafrost and Ovoo as far as possible.
- Horizontal alignment is planned to avert form frost susceptible soils and bottom of valley as far as possible.

(3) Design Concept of Vertical Alignment

Vertical alignment along the selected route is set based on the road section and geometric design standard, taking into following considerations.

- Vertical alignment is controlled by the embankment height free from freeze-thaw cycle and to conserve natural environment as much as possible.
- Vertical alignment is planned to follow the existing paved road in Baganuur.
- Vertical alignment is set to connect the height of existing road in Undurkhaan.
- Vertical alignment is set to provide enough high clearance of bridge at river crossings, enough high headroom of box culvert at major watercourse crossings and that for pipe culvert at minor watercourse crossings.

(4) Minimum Embankment Height on Natural Ground

The road structure comprised lower roadbed, upper roadbed including sub-grade, sub-base course, base course and surface course. An embankment height is totaling of these thickness in case of embankment on natural ground. In Mongolia, low embankment on natural ground has many advantages in the aspects of smaller volume of materials, facilitation of way-off car returning, less adverse effects on pedestrian and animal crossing. However, pavement structure is designed depending upon the strength of sub-grade in terms of design CBR. Accordingly, low embankment may have disadvantage in aspects of thicker pavement thickness in case that natural ground is weak enough to have small design CBR, bigger earthwork in case of replacement of soft soil. It is also important to consider practical countermeasures against storm water drainage and heavy snowfall.

For example, Chandagan Steppe of which the terrain is flat with no risk of flood by storm water and covered with snowfall, and the natural ground is strong enough is the most suitable area how high the minimum embankment height on natural ground is examined. According to interview to drivers and statistical data of maximum snowfall in the study area, 50 cm is to be the minimum embankment height on natural ground from the following justifications:

1) 20 cm is the maximum snowfall depth according to the records of these two decades.
2) No driver faces difficulty to drive his vehicle on paved road at Bayangol Pass even in winter where some stretch is located in cut section, namely the vertical alignment located at less natural ground level.
3) Design CBR of more than 10 is surely expected because CBR test of collected soil from natural ground shows the value of 14.
4) Total pavement thickness is designed around 40 cm in case of design CBR of 10 on condition that increase of heavy vehicles is forecasted. It is possible to construct pavement structure on natural ground without significant excavation and replacement of soil.

It is probably possible that the earthwork volume will be reduced at a detailed design stage by reviewing the vertical alignment using more detailed topographic map at a scale of 1:1,000.

(5) Alignment of Design Section by DOR

It is determined that DOR will accomplish to construct the road from Erdene to Baganuur (T-shape paved intersection) by their design. However, it is necessary to evaluate the design elements in the viewpoint of keeping unification.

The section was divided into two design components. One was from Erdene to Bayandelger, another was form Bayanderger to Baganuur.

Minimum horizontal curve radius and maximum vertical grade were applied 150 m and 6.07 % respectively between Erdene and Bayandelger. Inferring from the topography, mountainous terrain contains in this section. Comparing with these design elements and applied geometric standard in the study, both design elements are appropriate for the study route on mountainous terrain.

On the other hand, minimum horizontal curve radius and maximum vertical grade were applied 250 m and 6.0 % respectively between Bayandelger and Baganuur. Inferring from the topography, this section consists of flat and rolling terrain. Comparing with these design elements and applied geometric standard in the study, both design elements are also appropriate for the study route on rolling terrain.

(6) Existing Pavement in Baganuur

Existing paved road in Baganuur is planned to use for the study route as design concept. The alignment in this section is also examined in the viewpoint of keeping unification. However, as built drawings and design drawings in this section are missing because this section was constructed over 20 years ago. Then, alignment is reset for checking of design elements in this section.

Minimum horizontal curve radius and maximum vertical grade were applied 600 m and 4.97 % respectively in this section. Judging from the topographic map, this section is classified in flat terrain. Comparing with these design elements and applied geometric standard in the study, minimum horizontal curve radius is appropriate, but minimum vertical grade is not suitable for the study route. It is desirable to reconstruct in order to fit for the geometric standard in the study.

And, there is staggered intersection near Baganuur town. In general, staggered intersection is one of reasons of traffic congestion. Even though, influence of the intersection is insignificant because the distance between intersections is approximately 300 m widely and traffic volume is low.

And, existing Khujirt Bridge is required to replace owing to shortage of discharge capacity. Reconstruction section extends over a length of 445 m by the influence of bridge replacement because planned height of new bridge is higher than existing height for securing discharge capacity.

(7) Surroundings at Kherlen Bridge

New Kherlen Bridge is planned downstream parallel to the existing bridge at a distance of 30 m in consideration with construction and maintenance as design concept. On the other hand, Mountains close in on east end of the bridge in particular. To connect existing approach road, horizontal curve radius of 250 m is installed without influence on the bridge.

(8) Cover on Box Culvert

Generally, box culverts is installed with cover for the purpose of prevention to be broken by direct load, absorption of difference levels by settlement and so on. And, thickness of cover is usually used 50 cm, which is almost same as pavement structure thickness.

On the other hand, it is necessary to adjust shape of its top to road alignment excluding vertical grade is level, when top of box culverts is set on road level.

In the study, thickness of cover was applied 30 cm, which secure the thickness of surface course and base course. It is probably possible that the earthwork volume will be reduced at a detailed design stage by clarifying the control points using more detailed topographic map at a scale of 1:1,000.

(9) Resettlement and Removal

Resettlement is not necessary because the route is planned to avert residential area. While, it is necessary that the ovoo located at Bor Khujirt Pass and Murun Pass are removed on the roadside of new road in consideration with construction, otherwise very high embankment is required before and behind pass because pass is narrow or slope is steep or ovoo is located at center of pass.

It is probably possible that the ovoo will be averted at a detailed design stage by reviewing the horizontal and vertical alignment using more detailed topographic map at a scale of 1:1,000.

13.1.4 Design of Pavement

(1) Design of Pavement

Pavement design was carried out by AASHTO design method because its design is used widely in Mongolia.

Design load was calculated and expressed in cumulative ESAL, based on future traffic demand by vehicle type and ESAL, which is set in consideration with the results of axis load survey.

Design section of pavement was divided two sections in the economical viewpoint, namely one is form Baganuur to Jargaltkhaan and another is form Jargaltkhaan to Undurkhaan because it is obvious that cumulative ESAL is quite different each other.

On the other hand, CBR values of existing ground vary from 4 to 15 through the study route by the results of geological survey. Based on these data and the results of material test for borrow pits, Design CBR was prepared three kinds such as 8, 10 and 12 in consideration with the ease to design, construction and maintenance.

Before design pavement structure number (SN) was selected, following maintenance period was assumed in consideration of life cycle cost analysis within 20 years.

- Case-1: first overlay at 7 years and second overlay at 14 years from year 2005
- Case-2: first overlay at 10 years and second overlay at 16 years from year 2005
- Case-3: first overlay at 13 years from year 2005
- Case-4: first overlay at 15 years from year 2005

Comparing with computed SN for these cases, it was obvious that 7 years design period is most effective. Then, Design period was adopted in 7 years.

Based on cumulative EASL for design period, six classes of design SN was set by design section by design CBR for AC pavement. And, pavement structures were selected to be satisfied each design SN using results of material test for aggregates.

While, six classes of pavement structures for bituminous surface treatment (BST) were set in the same way for the purpose of EIRR.

Comparing with AC and BST, BST is economical in the analysis of 20 years. But, BST is required to maintain in 2 or 3 years interval. Depending on the result of EIRR, AC is preferable in consideration of performance and LCC in long period over 20 years.

(2) Existing Pavement

Existing pavement in Baganuur consists of asphalt concrete pavement with 16.551 km in length and bituminous surface treatment with 2.091 km in length. These surface conditions are marked as poor for each pavement because already passed more than twenty years. Even though, the lower parts than surface are still in good condition because there is no settlement or large pothole.

Based on inventory survey and design SN, existing pavement structures are evaluated that AC overlay with 5 cm for AC section and AC overlay with 6 cm for BST section respectively are satisfied design SN.

13.1.5 Design of Road Crossing Structure and Road Drainage

(1) Road Crossing Structures

1) General

Major meteorological feature in Mongolia is very little precipitation and severe low temperature in winter. Major geographical feature in the study area is variable and wild. Rivers excluding Kherlen River has scarcely water and run dry with the exception of thawing season and rain. But, many waterways

appear along the slope of terrain after rain. The study route is planned to cross the Kherlen River as well as these waterway to maintain necessary discharge capacity so as to keep opening horizontally and vertically by structures. Simultaneously, such road crossing structures control a horizontal and vertical alignment of the study route, and accordingly road embankment height is also affected.

2) Rivers and Main Stream

Discharge is calculated by rational formula based on catchment area and riverbed slop. Based on site investigation and technical clarification such as calculated discharge, disposal capacity and so on, type of structures are planned to set in the consideration of geography, geology, ease of construction and maintenance and economy.

Six bridges and twenty-nine box culverts are planned to set in the study route by the results.

3) Minor Stream

Pipe culverts are planned to install where road embankment interrupt water flow of minor stream. Type of pipe culverts is prepared in three types such as 1.0m diameters, 1.5 m diameters and 2-cell with 1.5 m diameters, which are named type A, B and C respectively, in the consideration of discharge capacity.

Pipe culverts should be installed at the following locations and types basically:

- The sag point on the road profile: Type A,
- The crossing point with valleys: Type B for small, Type C for large,
- Not more than 2 km intervals: Type A

(2) Road Drainage Channels

1) General

Generally, surface water disposal consists of road surface drainage and roadside drainage. Namely, road surface drainage is set for removing rainfall from road surface quickly, because of keeping to drive safety in rain and protecting pavement structure from water. On the other hand, roadside drainage is set for guiding to the river or culvert, because of protection embankment and roadbed.

It is not necessary to set up road surface drainage for the study because of undivided 2-lane road in rural area.

2) Roadside Channels

Roadside drainage channels are planned to install between toe-of-slopes along the road. In cut sections and flat terrain, roadside channels are set in both sides of roadway. While, roadside channels are set on only mountain side in rolling and mountainous terrain, because depending on slope of terrain, rainfall flows down and leave the road naturally. The roadside drainage should be connect to the existing river and planned culvert.

The shape of roadside channel is adopted a V-shape open-channel ditches as shown in Figure 13-1-4. The depth of channel should be sufficient to remove the water without saturation of the subgrade.

It is presumed to occur the erosion because the velocity of flow exceeds permissible velocities. Prevention of erosion in channels is accomplished by concrete lining that withstands the velocity of storm runoff.

Lined ditches are planned to install at grades over 4 % of profile.

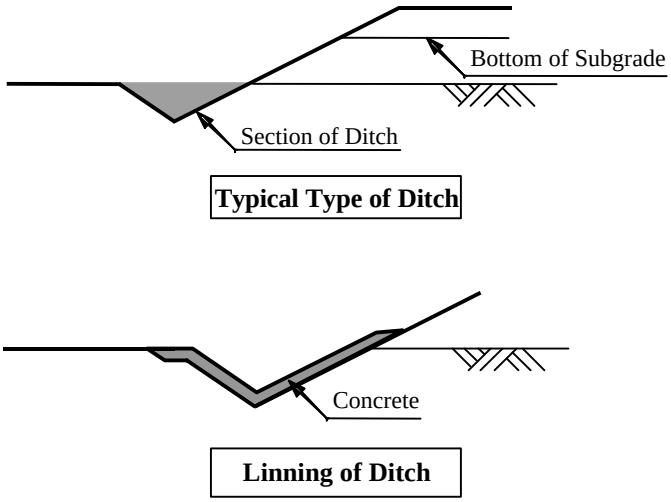


Figure 13-1-4 V-Shape Open-Channel Ditch

13.1.6 Traffic Safety Facilities

The objectives of the road supporting facilities are to maintain smooth and safe traffic flow as well as ensure the benefits of users.

Following road supporting facilities are considered normally:

- Traffic Signs
- Road Markings
- Guard Posts
- Kilometer Posts

(1) Traffic Signs

Traffic sings are one of the traffic control devices, which are used to regulate, warn or guide road users. Traffic signs should meet following requirements:

i) to fulfill as important need
ii) to command attention
iii) to convey a clear, simple meaning
iv) to give adequate time for proper response

Traffic signs are stipulated in Mongolian Standard MNS 4596-98 and 4597-98. Traffic signs shall be installed to satisfy the requirements.

1) Regulatory and Warning Signs

Regulatory signs inform road users of traffic rules and regulations and indicate the applicability of legal requirements that would not otherwise be apparent.

Warning signs are used when it is deemed necessary to warn traffic of existing or potentially hazardous condition on or adjacent to a road.

Principal regulatory and warning signs are planned to install at the following locations in the study:

- Horizontally sharp curve (R<600m)
- Vertically steep grade (steeper than ±5 %)
- Domestic animal crossing

2) Guide Signs

Guide signs are to convey to drivers information such as destination and distance, service facilities and route confirmation. These signs play an important role in informing drivers in advance of correct traffic lane for making an exit or entry at merging /diverging points and roadside facilities.

Principal guide signs are planned to install at the following locations in the study:

- Direction at diverging/merging point
- Road station / observation platform / gas station

(2) Road Markings

Road markings include all traffic lines, symbols, words, object marks, delineators, cones or other devices, except signs that applied or attracted to the pavement or mounted at the side of the road to guide traffic or warn of an objection.

Road markings are particularly important to help in regulation traffic, warning or guiding road users. Road markings, like other traffic control devices should be uniform in design, position and application so that they may be recognized and understood immediately by all road users.

Road marking is stipulated in Mongolian Standard MNS 4596-98 and 4759-99. Road markings shall be installed to satisfy the requirements.

Principal road markings will be painted on pavement and be consisted of the following type in the study:

- Centerline
- Roadside line

(3) Guard Posts

Guard posts are to function as redirecting errant vehicles away form the roadside hazard and decelerating errant vehicles to a stop.

Guard post warrants are delineated in term of geometry and location of roadside features and traffic volume is also a decision factor. Height and slope of embankment and radius of horizontal curve are principle features.

Guard posts are planned to install at the following locations in the study:

- High embankment sections (H>4.0m)
- Horizontally sharp curve (R<600m)
- Bridge and box culvert approaches

(4) Kilometer Posts

Kilometer posts are to function as informing road users as well as to locate and orient them. Besides, It is useful for maintenance because the location of repair work become clear.

Kilometer posts are planned to install at 1 km intervals.

13.1.7 Road Related Facilities

Major features through highway planning in Mongolia are long travel distance and delicate environment. Long travel distance coerce driver into long time driving. There is a strong probability to occur traffic accident due to get more and more tired, so much the worse in winter. Therefore, it is considered to rest from their drive at periodic intervals and care for them by provision of landscape. While, to maintain desirable road structure and show favorable scenery are expected to restrain from traffic accident because it contributes to reduce a severe burden from driver. Traffic safety facilities and road landscape measure are planned from these standpoints.

Following traffic safety facilities are considered specially:

- Road Stations
- Observation Platform

Following countermeasures, which are described in detail in Environmental Impact Assessment, should be not only set for the mitigations of the environmental impact and also provide road users with fine view for relaxation against driving strain and maintain landscape and road structure.

- Countermeasure for permafrost
- Approach slopes for domestic animal crossing
- Tree planting for environmental protection of inhabitants beside road
- Reinstate of hauling road
- Recovery measure after excavation at borrow pit and quarry site

(1) Road Station

Road station is the functional and desirable elements of road and provides road users with the traffic safety and convenience. Road station is located at a roadside together with parking facilities, rest facilities, gas station and repair shop separated from the roadway, provided for the motorist to stop and rest for short periods.

The rest area may provide services such as drinking water, restaurant, toilets, tables and benches, telephones, information facilities, and other necessary facilities for travelers. Only parking facilities and approach road is recommended to provide as minimum requirement in the study. Other facilities are preferable to provide by private sector.

Site selection for safety rest areas should consider the scenic quality of the area, accessibility, and adaptability to development. Other essential considerations include an adequate source of water and a means to treat and /or properly dispose of sewage. The objective is to give maximum weight to the appropriateness of the site rather than adherence to constant distance or driving time between sites

Space between sites is preferably 40 km to 60 km from the viewpoint of driving time and refueling. The maximum space is 100 km, if there is no suitable site at interval of 60 km.

Scale of road station is calculated on the basis of future traffic demand as shown in Table 13-1-3. It is necessary for parking lots of six passenger cars and six heavy vehicles such as bus, truck and trailer by the result. Layout is shown in Figure 13-1-5 for reference as sample.

Table 13-1-3 Required Number of Parking Lots

	Car	Bus	Small Truck	Medium Truck	Large Truck
Required Number of Parking Lots	6	2	0	3	1

Based on site investigation and referred to existing ger type restaurants and gas stations, road station will be planed as the following locations:

- Kherlen River Check point
- Ogzam Valley (Tsenkher West)
- Tsenkher Bridge East
- Jargaltkhaan
- Murun

Figure 13-1-6 shows each space between sites.

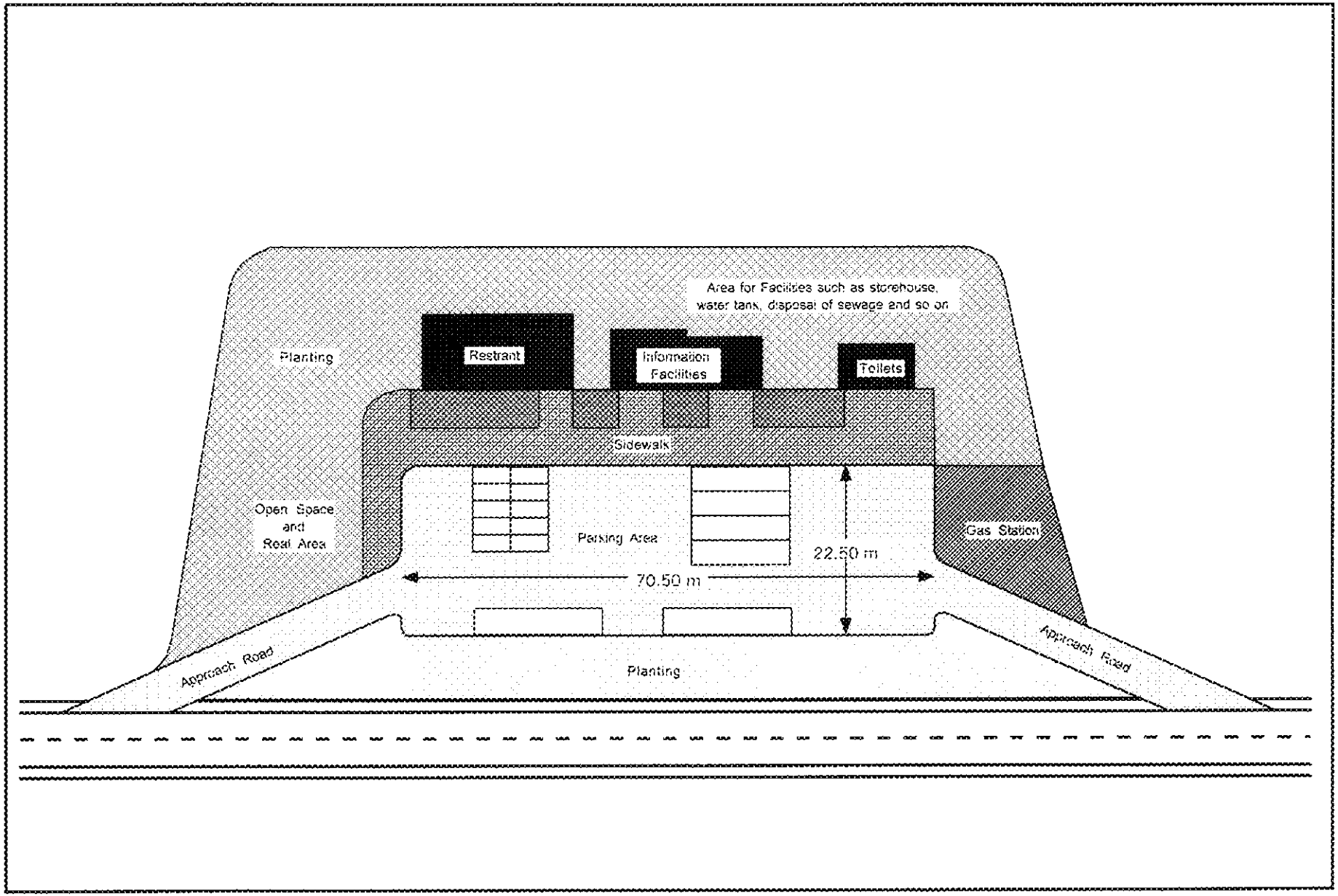


Figure 13-1-5 Sample Layout of Road Station

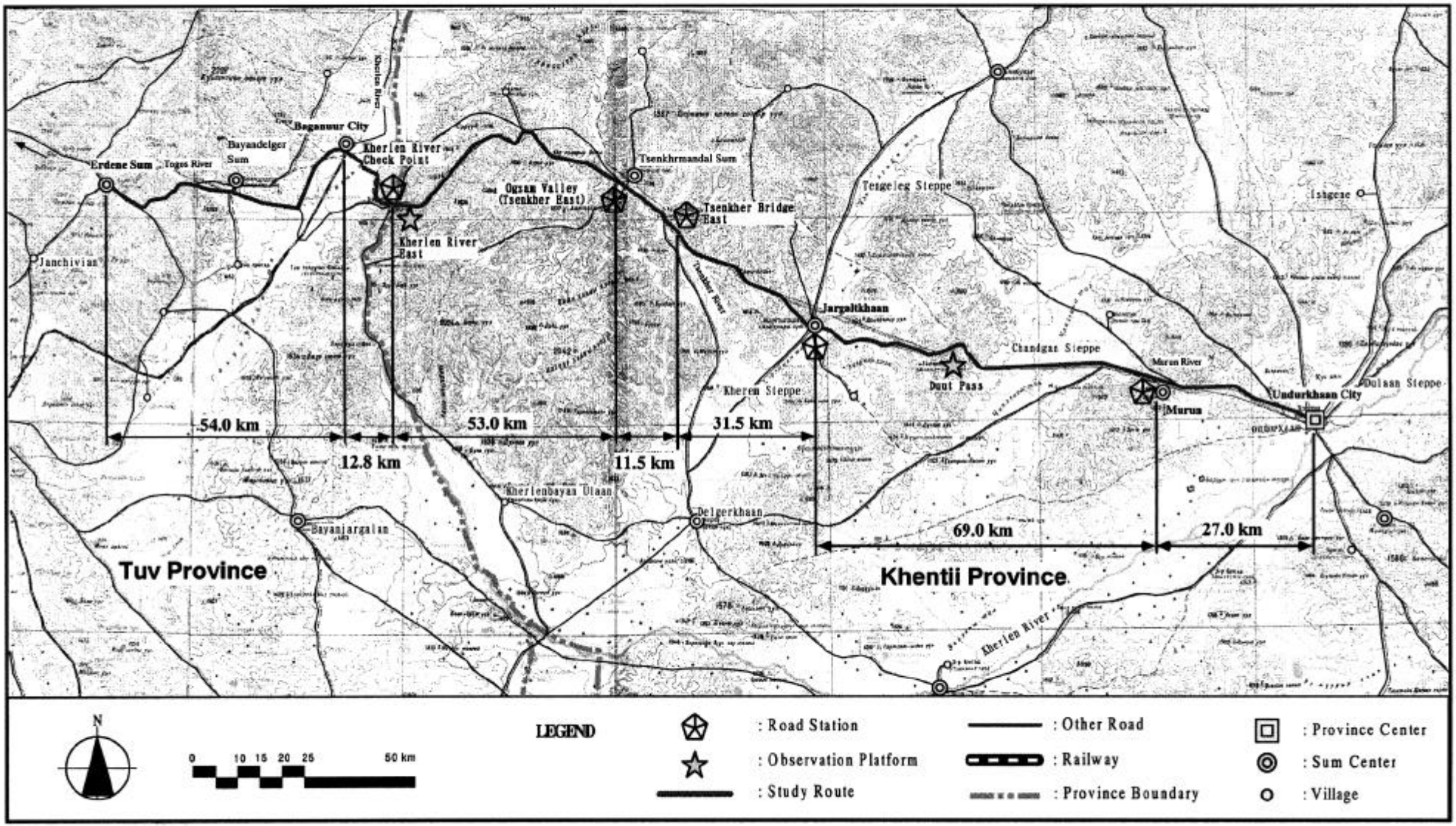


Figure 13-1-6 Location of Road Station and Observation Platform

(2) Observation Platform

Observation platform will be located for from the road providing motorists with staying to enjoy tourism spots together with parking lots, observation platform, restaurant and play ground.

Scale of observation platform is presumed as road station. Only parking facilities, approach road and terrace is recommended to provide as minimum requirement in the study. Other facilities are preferable to provide by private sector. Figure 13-1-7 shows as image of the observation platform.

Observation platform will be planned referred to existing fine viewpoints as the following locations:

- Kherlen River East
- Duut Pass

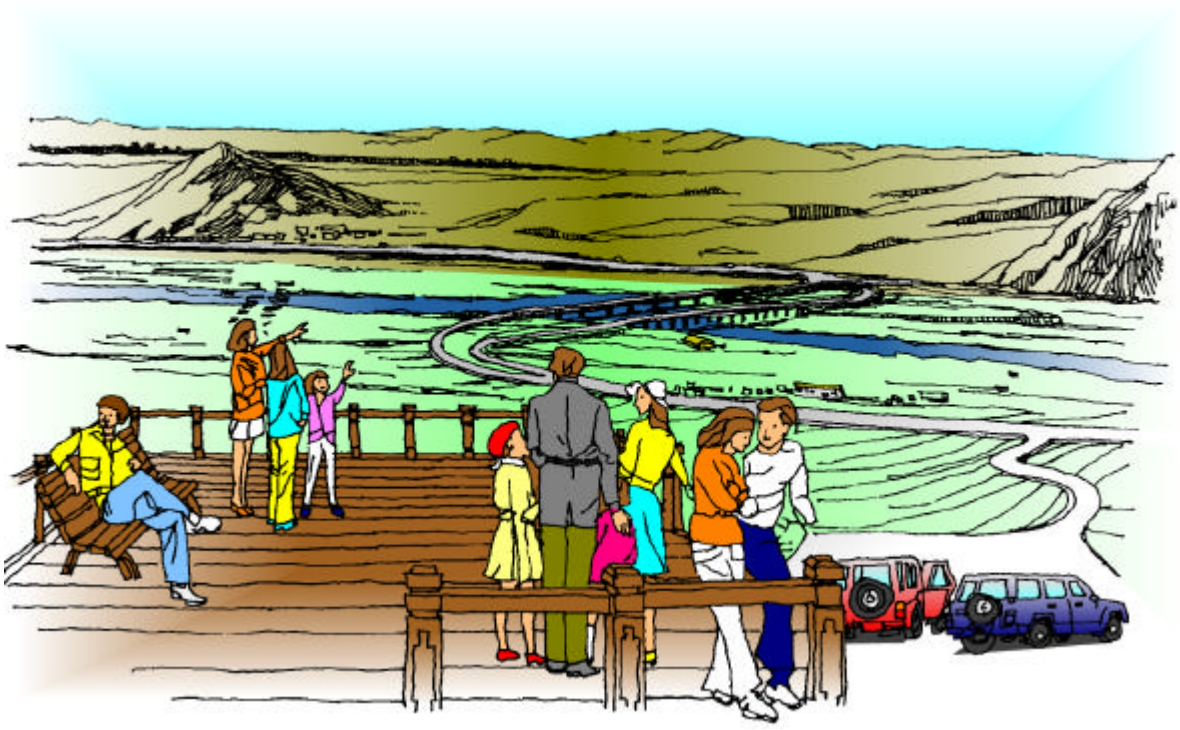


Figure 13-1-7 Image of Observation Platform