No.

BASIC DESIGN STUDY
ON
THE PROJECT FOR
CONSTRUCTION OF THE EASTERN ARTERIAL ROAD
AND IMPROVEMENT OF EQUIPMENT FOR ROAD CONSTRUCTION AND MAINTENANCE IN MONGOLIA

March 2005

JAPAN INTERNATIONAL COOPERATION AGENCY
GRANT AID MANAGEMENT DEPARTMENT

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PREFACE

In response to a request from the Government of Mongolia, the Government of Japan decided to conduct a basic design study on the Project for Construction of the Eastern Arterial Road and Improvement of Equipment for Road Construction and Maintenance and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Mongolia a study team from June 26 to July 28 and from August 11 to September 18, 2004.

The team held discussions with the officials concerned of the Government of Mongolia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Mongolia in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Mongolia for their close cooperation extended to the teams.

March 2005

Seiji Kojima
Vice-President
Japan International Cooperation Agency

March 2005

Letter of Transmittal

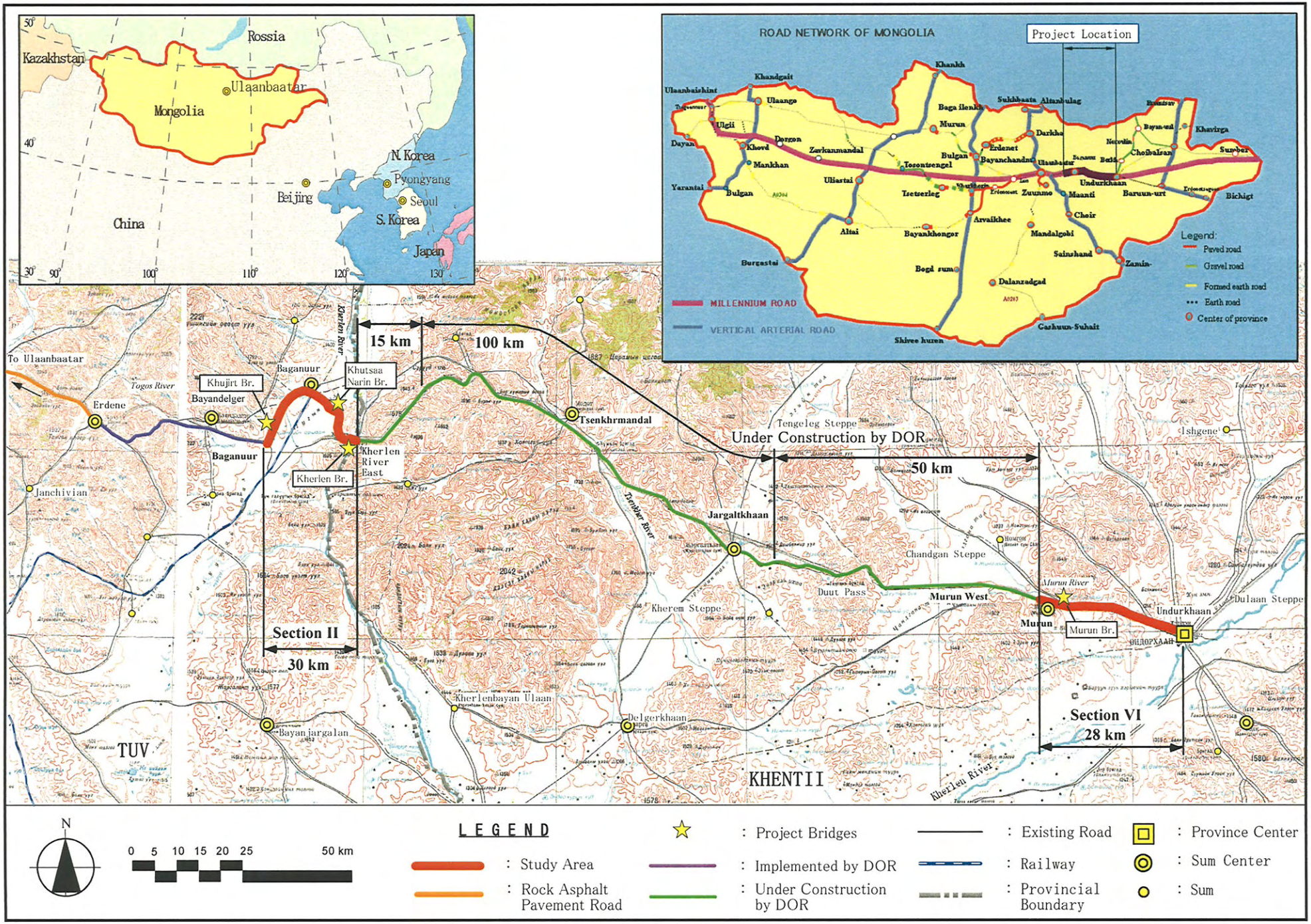
We are pleased to submit to you the basic design study report on the Project for Construction of the Eastern Arterial Road and Improvement of Equipment for Road Construction and Maintenance in Mongolia.

This study was conducted by the joint venture between Pacific Consultants International and Japan Overseas Consultants, under a contract to JICA, during the period from June 2004 to March 2005. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Mongolia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

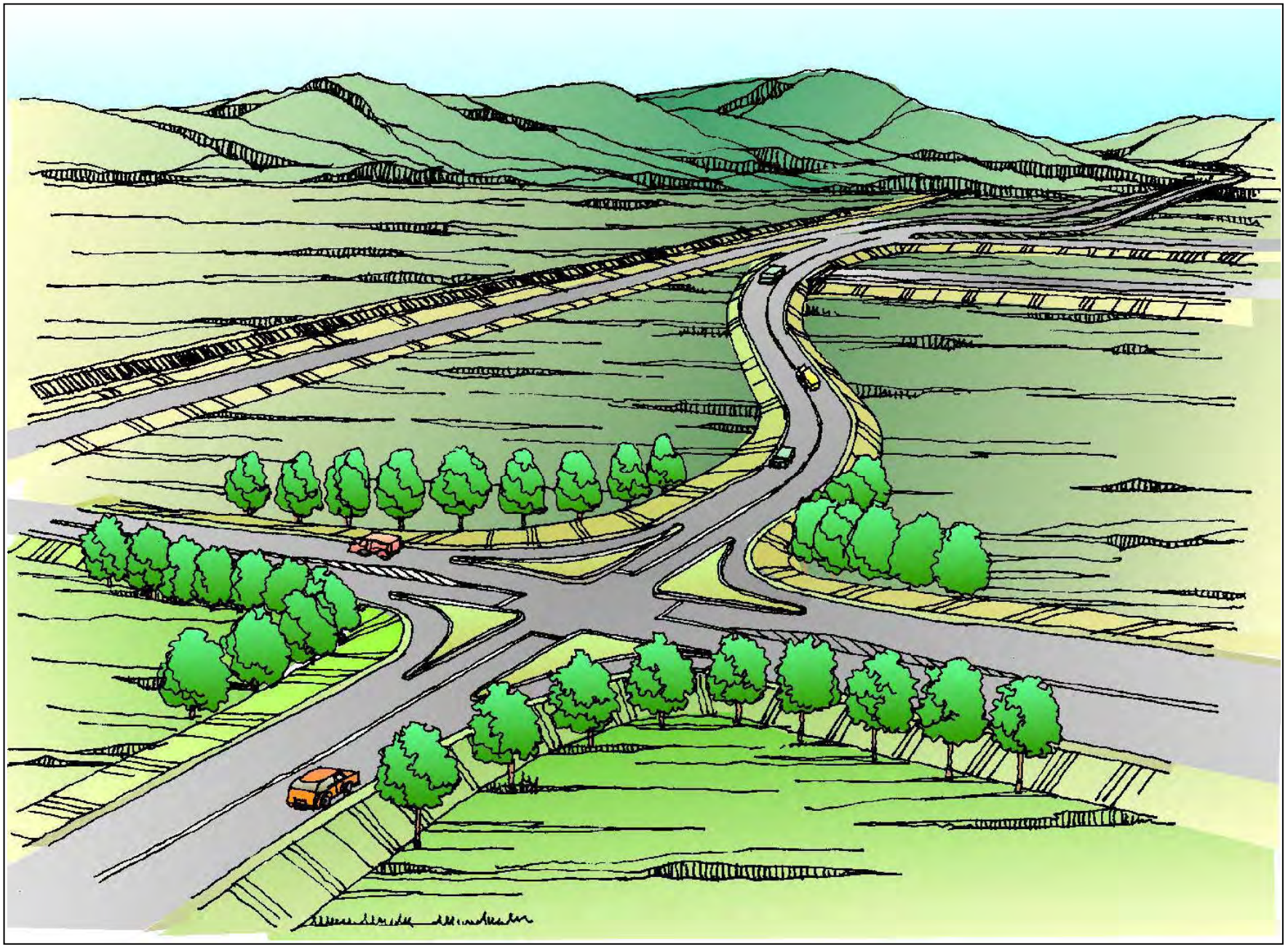
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

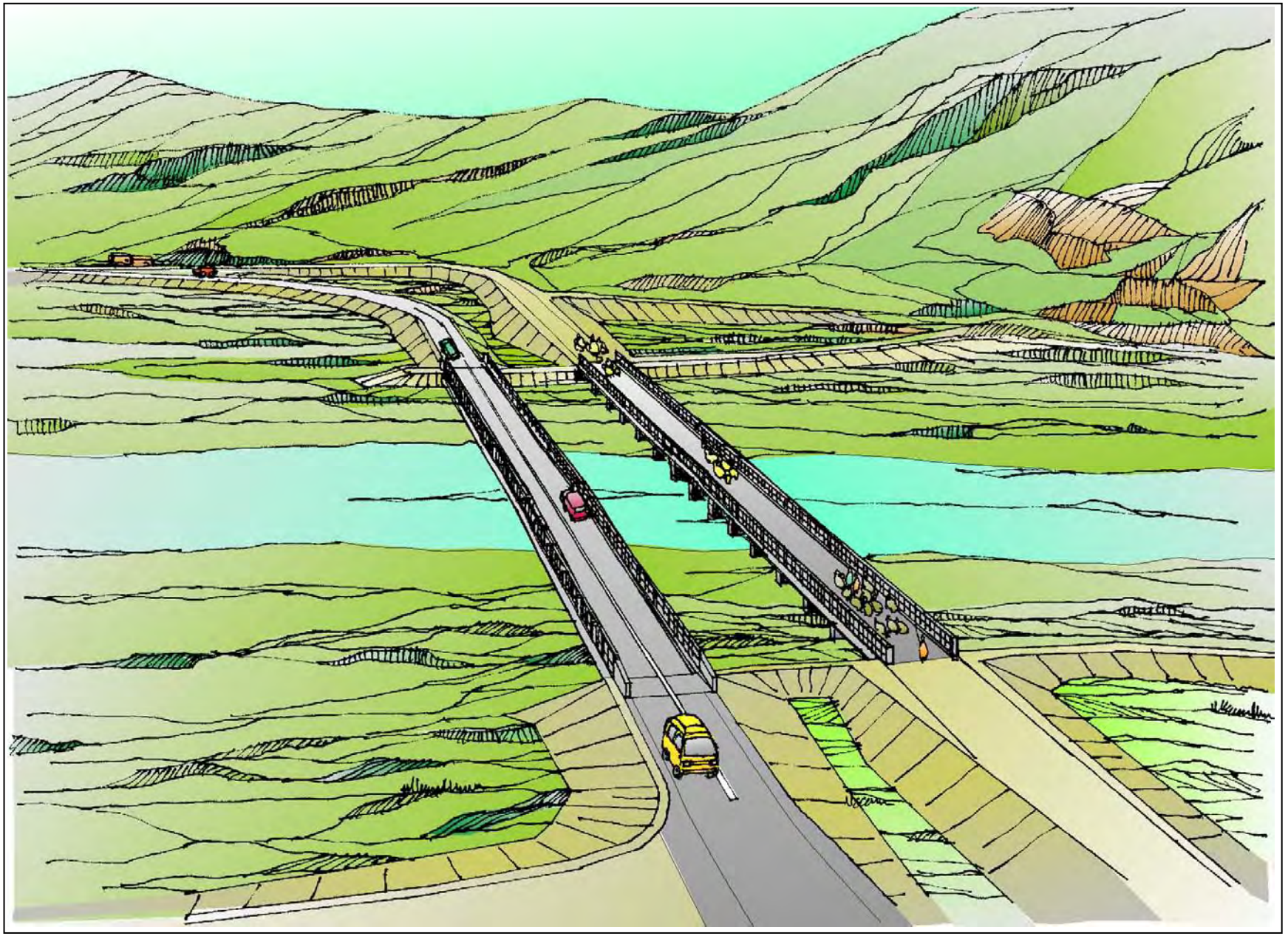
Kenji Maruoka
Chief Consultant,
Basic design study team on the Project for Construction of the Eastern Arterial Road and Improvement of Equipment for Road Construction and Maintenance
The Consortium of Pacific Consultants International and Japan Overseas Consultants



LOCATION MAP



Perspective for Baganuur Mining Intersection



Perspective for Kherlen Bridge

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Abbreviations

A, Authorities and Agencies

AASHTO	:	American Association of State Highway and Transportation Officials
ADB	:	Asian Development Bank
ASTM	:	American Society for Testing and Materials
DOR	:	Department of Roads
JGS	:	Japan Geometrical Society
JICA	:	Japan International Cooperation Agency
MOFE	:	Ministry of Finance and Economy
MOI	:	Ministry of Infrastructure
MRTT	:	Ministry of Road, Transport and Tourism (Former MOI)
RIRC	:	Road Inspection and Research Center (Former DOR)
WB	:	World Bank

B, Other Abbreviations

AH	:	Asian Highway
A/P	:	Authorization to Payment
B/A	:	Banking Arrangement
BC	:	Box Culvert
BH	:	Borehole
BP	:	Beginning Point
Br.	:	Bridge
℃	:	Degree Celsius
CBR	:	California Bearing Ratio
cc.	:	Cubic Capacity
CIP	:	Carriage Insurance Paid to
cm	:	Centimeter
Ctc	:	Center to Center
D/D	:	Detailed Design
ECC	:	Environmental Conservation Certification
EIA	:	Eminent Inpact Assessment
EL	:	Elevation
E/N	:	Exchange of Notes
EP	:	End Point
F/S	:	Feasibility Study

GDP	:	Gross Domestic Product
GL	:	Ground Level
GNP	:	Gross National Product
GVW	:	Gross Vehicle Weight
H	:	Height
Ha	:	Hectare
h , hr	:	Hour
HWL	:	High Water Level
I/C	:	Inception Report
JIS	:	Japanese Industrial Standard
kg	:	Kilogram
kh	:	Horizontal Seismic
km or KM	:	Kilometer
kw	:	Kilowatt
ℓ or l	:	Litter
M	:	Magnitude
m	:	Meter
MDF	:	Main Distribution Frame/Panel
Mil	:	Million
mm	:	Millimeter
M/P	:	Master Plan
MRP	:	Millennium Road Plan
N	:	N. Value
No., Nos.	:	Number
ODA	:	Official Development Assistance
PC	:	Prestressed Concrete
PCU	:	Passenger Car Unit
RC	:	Reinforced Concrete
S	:	Scale
SD	:	Deformed Steel Bar
sec	:	Second
STA	:	Station
t	:	Ton
Tg	:	Tugrik
TL	:	Traffic Load
UB	:	Ulaanbaatar
US$	:	United States Dollar
V	:	Voltage

Veh/day	:	Vehicle per Day
W/F	:	Weight Factor
%	:	Percent
σc	:	Concrete Compressive Stress
σca	:	Concrete Allowable Compressive Stress
σck	:	Concrete Specified Compression Strength
ΔH	:	Clearance under Girders
σpy	:	Concrete Yield Point Stress
σs	:	Steel Compressive Stress
σsa	:	Steel Allowable Compressive Stress
ϕ, Φ	:	Diameter

SUMMARY

Summary

In Mongolia, transportation of both people and commodity depends on road transport to a large extent. Therefore, poor road condition incurs adverse impacts to economic development. Particularly, east-westward transport from Ulaanbaatar which fully depends on road transport is far from safe and stable means through a year because of very few paved sections although railroad which connects Suhbaatar to Zamin Uud through Ulaanbaatar runs from north to south and plays vital roles as national transport axis.

The Government of Mongolia approved the implementation of the Millennium Road Project (total 2,200km long) to connect long-distance regions by arterial road, aiming to facilitate the transport efficiency, industries, and service capability, as well as regional development and improvement of the quality of life. The Millennium Road Plan (MRP) comprises one horizontal (east-west) arterial road as "Millennium Road" which advances the nation in the aspects of settlement and regional development project and five vertical (north-south) arterial roads to stimulate regional development.

The Eastern Arterial Road that is the road section from Erdene to Undurkhaan on National Highway No. 0501 is an eastern part of the Millennium Road, and it comprises 6 sections, total 260km long. Since the Eastern Arterial Road is expected to bring about high economic effects, the Government of Mongolia put highest priority to its development and Section I was constructed in 2002. In August 2002, the Government of Mongolia requested the Government of Japan to implement the construction of 2 sections including long bridge and improvement of equipment for maintenance under the Japan's Grant Aid.

The Government of Japan deferred responding the request because the construction of remaining 3 sections had not been implemented yet. However, the construction of these 3 sections commenced in 2003 appropriating Mongolian own fund. The Government of Japan decided to conduct a basic design study and entrusted the Japan International Cooperation Agency (JICA) after confirming the latest status of Environmental Impact Assessment. 1st site survey was conducted by the study team from June 26 to July 28, 2004 and 2nd site survey was from August 11 to September 18, 2004. The study team had a series of discussions with the Ministry of Road, Transport and Tourism as the responsible ministry about the content of request and conducted surveys/investigations, data collection and studies including their capability for project implementation and projects by other donors.

Based on the results of site surveys, the team studied the scope of work under the Grant Aid, type and size of the facilities, type of procured equipment and estimated the project costs. The Draft Report was prepared incorporating all the results of study. JICA dispatched the team to Mongolia from February 23 to March 5, 2005 to explain the content of the report and discuss about the draft basic design. The Government of Mongolia accepted the report including the basic design in principle, and both sides signed the attached Minutes of Discussion.

The followings contents of the basic design are confirmed by both sides, and it is envisaged that the implementation period including detail design phase will be 55 months.

Length of respective components

The length of respective components in 30.1km of Section II is as follows.

1. Rehabilitation of Existing Asphalt Pavement: L = 15,608m

- BP to Khujirt Bridge : L = 1,257m
- Khujirt Bridge to Baganuur Mining Intersection : L = 14,351m

2. Construction of New Road: L = 13,130m

- Baganuur Mining Intersection to Khutsaa Bridge : L = 5,343m
- Khutsaa Bridge to Kherlen Bridge : L = 7,525m
- Kherlen Bridge to EP : L = 262m

3. Replacement of Existing Bridge and Construction of Approach Road: L = 218m

- Khujirt Bridge : L= 17.5m
- Approach road : L = 200m

4. Construction of New Bridge and Approach Road: L = 1,131m

- Khutsaa Bridge : L = 17.5m
- Approach road : L = 200m
- Kherlen Bridge : L = 268.8m
- Approach road : L = 645m

The length of respective components in 28.1km of Section VI is as follows.

1. Rehabilitation of Existing Concrete Pavement: L = 250m

- West Undurkhaan Intersection to EP : L = 250m

2. Construction of New Road: L = 27,631m

- BP to Murun Bridge : L = 1,913m
- Murun Bridge to West Undurkhaan Intersection : L = 25,718m

3. Construction of New Bridge and Approach Road: L = 253m

- Murun Bridge : L = 52.5m
- Approach road : L = 200m

Bridge type

Bridge Name	Bridge Length (m)	Superstructure	Substructure			Approach Road Length (m)
			Abutment	Pier	Foundation	
Khujirt	17.5	RC-T	Reverse-T		Spread	200.00
Khutsaa Narin	17.5	RC-T	Reverse-T		Spread	200.00
Kherlen	268.8	RC-T	Reverse-T	T-shape	Spread	645.00
Murun	52.5	RC-T	Reverse-T	T-shape	Spread	-

Procurement of Equipment

No	Equipment	Specification	1st Pack.	2nd Pack.	Total Q'ty
1	Motor Grader	3.7m	-	2	2
2	Vibration Roller	7t (Combined type)	-	4	4
3	Asphalt Finisher	2.5-4m	-	2	2
4	Asphalt Plant	30t/hr	2	-	2
5	Water Tanker	8,000ℓ	-	2	2
6	Crusher Plant	30t/hr	2	-	2
7	Asphalt Cutter	30cm	-	7	7
8	Plate Compactor	80kg	-	5	5
9	Pick-Up Truck	4×4,double cab	-	7	7
10	Cargo Truck with crane	4ton with crane	-	2	2
11	Line Marker	15cm	-	2	2
12	Asphalt testing equipment		2	-	2
13	Backhoe Loader	75kw	-	7	7
14	Road Maintenance Truck	4t	-	5	5
15	Vibratory Rammer	70kg	-	7	7
16	Dump Truck	15t	-	6	6
17	Wheel Loader	2.3m^3	-	4	4
18	Trailer	20t	-	1	1
19	Asphalt Sprayer	400ℓ	-	2	2

For the implementation of "the Project for Construction of the Eastern Arterial Road and Improvement of Equipment for Road Construction and Maintenance" under the Grant Aid of Japan, the rough estimated cost is about 2,990 million yen (2,932 million yen from the Japanese side, and 58 million yen from the Mongolian side).

The following benefits are expected from the implementation of the Project:

Direct Benefits

- Average traveling speed between Baganuur and Undurkhaan will increase 60 km/h - 80 km/h although it is 20 km/h - 40 km/h at present, and vehicle operating costs may decrease considerably due to saving of traveling time and improvement of roughness.
- Many heavy vehicles will be able to pass on the road and especially it will enable to transport 40ft containers as these bridges are improved to an international standard as a part of Asian Highway and it may mitigate the weight restriction from of 14 ton to 20 ton for truck or 43 ton for trailer.

- Once multiple shifting tracks are changed to one paved road, grassland will be conserved from vehicular tracks and dust. Approximately the losing area of 12% will be reduced considering the loss by embankment of road.

Indirect Benefits

- Heavy vehicles will be able to pass on the road as the loading capacity is increased, and efficiency of vehicle operation is improved as average traveling speed increases and traveling time is saved. This, with Road-side Stations which are to be constructed by Mongolian Side, will stimulate economic activities in the region.
- It will be possible to secure traffic safety by changing multiple shifting tracks to one paved road to an all-weather standard and to have better access to social facilities including schools, hospitals and communication centers.
- Traffic volume as well as number of bus passengers will increase as the road is improved and bus services are improved in terms of frequency.

The following recommendations are made for the implementation of the Project:

1) Undertakings by the Mongolian Side

   It is recommended that the Mongolian Side should construct Road-side Stations, erect Monuments and plant trees along the road since the implementation of Road-side Stations and planting trees is required to enhance functions according to increment of road users and the erection of monuments aims to disseminate the background of the Project and its signification to the public.

2) Provision of Sure Transport Means through a Year

   The Project is planned to stimulate the development of the "Millennium Road Plan" to the border so as to induce incremental demand of domestic freight as well as international cargo to China. Accordingly, it is recommended to monitor the progress of the development of the "Millennium Road Plan".

3) Strengthening of Road Maintenance Capability

   Road construction and maintenance in Mongolia is heavily mechanized because of the low density of population and long distances to be covered. It is therefore necessary to strengthen the capability of road repair and maintenance by the procurement of modern equipment and improvement of repairing skill by group induction and technical training. It is recommended that the undertakings by the Mongolian side on the plan for the technical assistance and training for road maintenance, so called "Soft Components" should be carried out timely according to the implementation plan.

The Project for Construction of the Eastern Arterial Road and Improvement of Equipment for Road Construction and Maintenance in Mongolia

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CHAPTER 1

Background of the Project

CHAPTER 1 BACKGROUND OF THE PROJECT

1-1 Background of the Request

Mongolia is situated between 42～52 degrees North Latitude and 88～120 degrees East Longitude. Mongolia is a hill country between Russia (north boundary) and China (south, east and west). The area of Mongol is 1,566,500km^2, about 4 times as large as Japan. The population is 2.5 million in 2000, third of which (850,000) live in Ulaanbaatar. Particularly, in Ulaanbaatar increase in population is typically while in most rural district population tends to be decreasing.

In Mongolia, transportation of both people and commodity depends on road transport to a large extent. Therefore, poor road condition incurs adverse impacts to economic development. Particularly, east-westward transport from Ulaanbaatar which fully depends on road transport is far from safe and stable means through a year because of very few paved sections although railroad which connects Suhbaatar to Zamin Uud through Ulaanbaatar runs from north to south and plays vital roles as national transport axis.

Under that circumstance, the Government of Mongolia approved the implementation of the Millennium Road Project (total 2,200km long) to connect long-distance regions by arterial road, aiming to facilitate the transport efficiency, industries, and service capability, as well as regional development and improvement of the quality of life. The Millennium Road Plan (MRP) comprises one horizontal (east-west) arterial road as “Millennium Road” which advances the nation in the aspects of settlement and regional development project and five vertical (north-south) arterial roads to stimulate regional development.

Millennium Road was set as the Asian Highway route 32 (AH-32) in 2003 revision of AH road network plan. AH-32 is the alternative route of AH-6 which connect east and west Russia from Vladivostok, via north-east China. AH-32 will play an essential role in successful Asian Highway project.

The Eastern Arterial Road is the road section from Erdene to Undurkhaan of Millennium Road, and it comprises 6 sections, total 260km long. The feasibility study on construction of Eastern Arterial Road (hereinafter referred to as “F/S”) has been conducted by Japan International Cooperation Agency (JICA) and it justified the investment in construction of the Eastern Arterial Road to be extremely efficient. Furthermore, Environmental Impact Assessment (EIA) was carried out along the entire line.

In August 2002, the government of Mongolia requested the Government of Japan to implement the construction of 2 sections including long bridge and improvement of equipment for maintenance under grant aid scheme.

The Government of Japan deferred responding the request because the construction of remaining 3 sections had not been implemented yet. However, the construction of these 3 sections was commenced in 2003 appropriating Mongolia's own fund. Accordingly, the Government of Japan decided to conduct a basic design study and entrusted the Japan International Cooperation Agency (JICA) after confirming the latest status of Environmental Impact Assessment.

1-2 Request Components

The requested components to the government of Japan are as follows;

(1) Road construction of Section II : Baganuur - Kherlen river east, total 30.1km (15.8km repair of current road and 14.3km new road construction)

This includes construction of three bridges - Khujirut Bridge (length 17.5m), Khutsaa-Narin Bridge (length 17.5m), Kherlen Bridge (length 268.8km) and 14 sets of pipe culverts.

(2) Road construction of Section VI : Murun west - Undurkhaan, total 28.1km (all new road construction)

This includes Murun Bridge (length 52.5m), 22 sets of pipe culverts and 2 sets of box culverts.

(3) Procurement of equipment - total 19 items; motorized grader, vibration roller, asphalt finisher, asphalt plant, water tanker and others.

1-3 The Interpretation of Calendar Year and Month

The aim of the Basic Design Study is to provide a basic document necessary for the appraisal of the Project by the Government of Japan, and no commitment is made from the Japanese side concerning the realization of the Project at the stage of the Study. Accordingly, any calendar year and month expressed in the plan or schedule of this report are only tentative, and they do not represent the official policies, opinions or statements of JICA.

CHAPTER 2

Contents of the Project

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Basic Concept of the Project

2-1-1 Object of the Project

The Government of Mongolia approved the implementation of the Millennium Road Project (total 2,200km long) to connect long-distance regions which now are not adequately linked each other by arterial road, aiming to facilitate the transport efficiency, industries, and service capability, as well as regional development and improvement of the quality of life. The Millennium Road Plan (MRP) was proposed to comprise one horizontal (east-west) arterial road as "Millennium Road" which advances the nation in the aspects of settlement and regional development project and satisfy the international standards to play the role as a part of Asian Highway, and five vertical (north-south) arterial roads to stimulate regional development.

The Eastern Arterial Road that is the road section from Erdene to Undurkhaan on National Highway No. 0501 is an eastern part of the Millennium Road, and it comprises 6 sections, total 260km long. The feasibility study on construction of Eastern Arterial Road (hereinafter referred to as "F/S") has been conducted by Japan International Cooperation Agency (JICA). Since the Eastern Arterial Road is expected to bring about high economic effects, the Government of Mongolia put the highest priority to its development and Section I was constructed in 2002. The construction of Sections III through V commenced in 2003 and they are scheduled to be completed by 2005. The Basic Design Study (this study) on Sections II and VI that is the remaining sections is conducted by JICA.

The objectives of the Project are to construct the Section II and VI of Eastern Arterial Road which have not been improved yet, and 4 bridges which are not satisfy international standard and cause transportation bottle neck. This, with the other Sections which Mongolian government are constructing by themselves, will play the role of east-west bind to eastern part of Mongolia.

2-1-2 Basic Concept

The Basic Design Study is conducted to clarify the following points against the requests from the Mongolian side:

i) To identify and confirm the components of the proposed Project
ii) To coordinate with development plan at national, regional, sectional and other level

iii) To appraise and evaluate the technical viability of the Project
iv) To appraise and evaluate the economic viability of the Project
v) To make a general layout and basic design
vi) To estimate the cost of the Project and the schedule required for implementing its construction and procurement.

2-1-3 Implementation Agency

The Ministry of Infrastructure together with the Department of Roads (the governmental agency) was responsible for the Project as the implementing agency until the new government announced the administrative organization at the beginning of November 2004. The Coordinating Ministry is the Ministry of Finance and the Ministry of Road, Transport and Tourism (MRTT) is responsible for the Project as the Responsible Ministry after the administrative re-structure. The Road Inspection and Research Center under the MRTT that is transferred from the Department of Roads is responsible for the implementation of the Project as the Implementing Agency.

The organization chart of respective agencies is shown in Figure 2-1-3-1 and Figure 2-1-3-2.

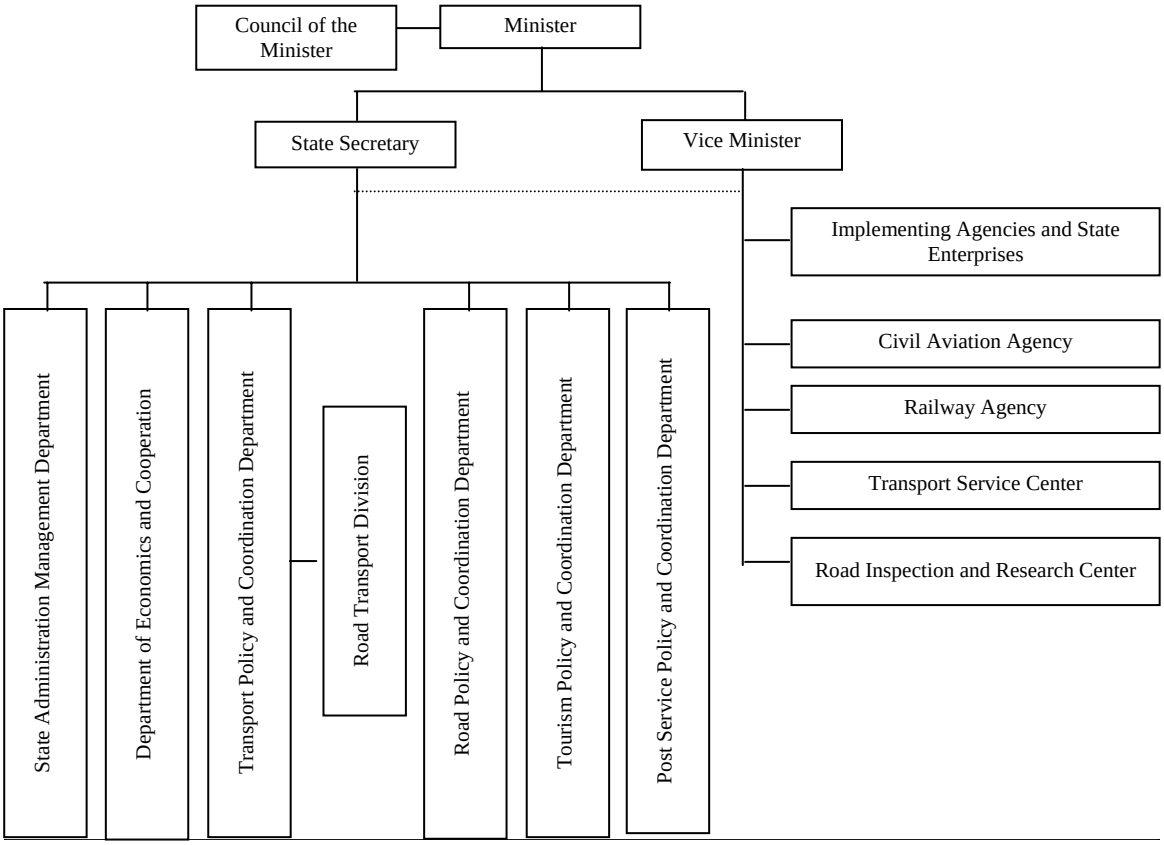


Figure 2-1-3-1 Organization Chart of Ministry of Road, Transport and Tourism

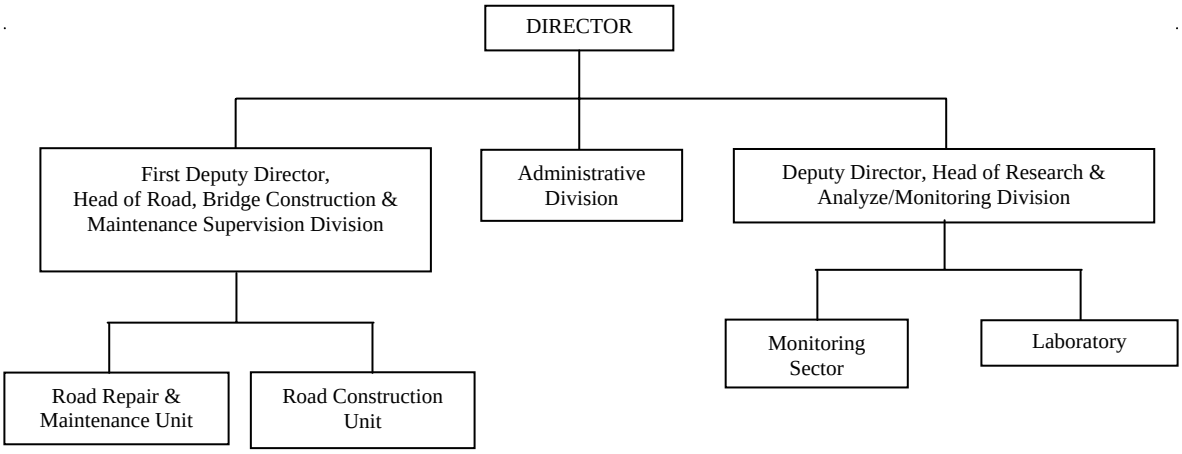


Figure 2-1-3-2 Organization Chart of Road Inspection and Research Center

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Highway Design

(1) Highway Design Standard

The Road Design Standard in Mongolia applies to the basic design for obtaining the approval from the Mongolian side.

The Eastern Arterial Road which is a part of the Millennium Road Plan is designated as Asian Highway No.32 (AH-32) in the Asian Highway Network revised in 2003. Therefore, the design of highway should comply with the Mongolian Standard as well as the Asian Highway Standard (international standard).

(2) Type of Road

Section II and Section VI of Eastern Arterial Road is classified into Category III in Mongolian Standard (Refer to Table 2-2-1-1).

Table 2-2-1-1 Road Category in Mongolian Standard

Road Type	Road Category	Number of Lanes	Functional Classification	AADT, equivalent passenger cars per day or level of service*	Divided/ Undivided	Access Control
Freeways		Multi-lane Highways	Arterials	B	Divided	Restricted
Expressways			Arterials and regional	B	Divided	Partially Restricted
Conventional Highways	I			C	Divided or Undivided	Can be partially restricted
	II			C	Undivided	Unrestricted
	III	Two-lanes Roads	Arterials, regional and local roads	C	Undivided	Unrestricted
	IV		Regional and local	400-2000	Undivided	Unrestricted
Low Volume Roads		One-two Lane	Local	< 200 Mixed Traffic	Undivided	Unrestricted

* Level of Service ; A : Highest, B : High, C : Average, D : Low, E : Very Low, F : Failure

Design Speed for Category III is selected from 100km/h, 80km/h and 60km/h in consideration of terrain type as shown Table 2-2-1-2. Design Speed of respective sections is as follows.

Table 2-2-1-2 Design Speed

Road Type	Road Category	Number of Lanes	Design Speed (km/h)		
			Flat	Rolling	Mountainous
Freeways		Multi-lane Highways	140	120	80
Expressways			120	100	80
Conventional Highways	I		120	100	60
	II		120	100	60
	III	Two-lanes Roads	100	80	60
	IV		80	60	40
Low Volume Roads		One-two Lane	60	40	30

(3) Setting of Alignment

Sections II and VI of the Eastern Arterial Road is located mostly in the flat terrain except the new construction section of Section II of which some section is planned to pass in the rolling terrain. Excessive earthwork should be avoided in vertical alignment design, especially in the rolling terrain.

(4) Rehabilitation Method of Rehabilitation Section

Section II of Eastern Arterial Road consists of two kinds of work sections, namely new construction and rehabilitation. The rehabilitation section starts from the beginning point and ends at Baganuur Mining Intersection, totaling 15.8 km in length, while the new construction

section starts from Baganuur Mining Intersection and ends at the ending points, totaling 14.3km in length.

Section VI comprises 28.1km long new construction section except the last 250 m long rehabilitation section.

Rehabilitation method is selected from 4 types shown in Table 2-2-1-3 in consideration of Subjective Evaluation, Objective Evaluation and Cracking Ratio.

Table 2-2-1-3 Rehabilitation Method

Type	Rehabilitation Method
Type A	No Rehabilitation
Type B	Sealing, Patching, Overlay
Type C	Surface Replacing
Type D	Replacing of Surface, Base Course and Subbase Course

(5) Metrological Conditions

The climate of Mongolia is categorized as continental climate with long low temperature and very limited precipitation. The average monthly temperature of Eastern Mongolia over 5 degrees is only 4 months from May to September (refer to Figure 2-1-1-1) and the lowest temperature sometimes records -40 degrees.

The planning of highway structure or construction schedule should be made in consideration of this extreme climate.

(6) Road-side Station (the "Michi-no-Eki")

The drivers are forced to drive a long distance on the Eastern Arterial Road because very limited rest facilities are found along the road in vast grassland. A long-distance drive may induce fatigue to drivers and it will cause traffic accident. A Road-side Station, which is called as "Michi-no-Eki" in Japanese, and comprises rest area, toilet, gas station and so forth will be constructed along the Eastern Arterial Road.

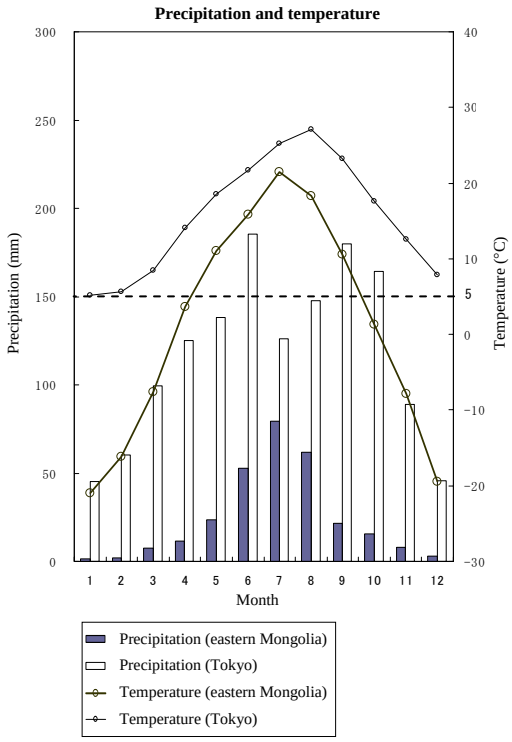


Figure 2-2-1-1
Precipitation and Temperature
(Ulaanbaatar and Tokyo)

2-2-1-2 Bridge Design

(1) Bridge Design Standard

4 bridges located in Section II and VI of the Eastern Arterial Road are designed as a part of the Millennium Road and Asian Highway. It is not efficient to rehabilitate these bridges satisfying Asian Highway Standard as the soundness of those is low.

Three bridges; Khutsaa Narin, Kherlen, and Murun, out of 4 existing bridges are on new construction section and Khujirt Bridge is on rehabilitation section.

The existing Khutsaa Nariin Bridge and Murun Bridge are wooden bridge and the strength is pretty low. These 2 brides shall be constructed on the new road alignment as a new concrete bridge.

Khujirt Bridge is located in rehabilitation section of Section II. This bridge shall be reconstructed without changing alignment after removal of existing bridge.

Kherlen Bridge shall be constructed at 30m lower side of existing bridge which will be not demobilized and remained. In Feasibility Study, it was confirmed that Mongolia side utilizes the existing Kherlen Bridge for Pedestrian and livestock. In this study, it was confirmed again not to change the policy.

Although the Bridge Design Standard (BNbD 32.02.03) in Mongolia applies to the basic design, the Japanese standards also apply to supplement the Mongolian standards. AASHTO as the Asian Highway standard applies to the design load.

(2) Grade of Bridge

The grade of 4 bridges shall be determined based on the AASHTO. These bridges as a part of Asian Highway are identified as the “Interstate Highway or other Highway which may carry heavy truck traffic” in AASHTO. This category coincides the Category III of Mongolian Standard, therefore the bridge shall be designed as Category III.

(3) Hydrological Conditions

For the design of the bridges such as position, span, structure, bank protection works, the results of the hydrological analyses should be taken into account adequately. The design high water level is to be determined based on the comparative analysis on the 50 years and more period discharge or previous data.

Both the Khujirt River and the Khutssa have sometimes water flow, not through a year, while both the Kherlen River and the Murun have water flow through a year but the surface of stream is frozen in winter. The bridge design and construction schedule should be made considering these hydrological conditions.

(4) Seismic Conditions

As the seismic conditions of Mongolia, "BNbD22-01-01" is to be applied.

In Mongolia, a design procedure on seismic factor (kh) has not determined yet. And the earthquake-resistant design has not been considered due to the circumstance that the Earthquake has not occurred in this area to date. In this project, seismic factor of kh = 0.1 is adopted as a safe factor.

2-2-1-3 Scheme of Improvement of Equipment

Based on the request from the Government of Mongolia, equipment will be selected from the following viewpoints to make equipment plan suitable, efficient, economic and rational under Japan' Grant Aid scheme.

1) Proper items and quantity in accordance with the future plan

2) Total quantity to meet budgetary constraint and ability of maintenance and management

3) Natural conditions

Temperature in winter sometimes decrease -40°C, and it is very severe condition for operating equipment. Once specifications for frigid district are applied to equipment, costs of equipment increase considerably and high maintenance and repair techniques will be required due to complicated structure. On the other hand, equipment is hardly used in winter because of no maintenance work, and accordingly it is kept at garage with roof. However, there is some equipment such as motor grader with possibility to operate in winter is applied to the cold-district specification. Since the altitude of jobsites such as Ulaanbaatar is around 1,350m, no special specification such as high- altitude specification is required.

4) Technical Level

Heavy construction equipment operators and vehicle drivers have sufficient skill and in usual operation and maintenance, and inspection capability is of no matter. They have knowledge of equipment structure and daily preventive maintenance. Since they are used to equipment made in ex-Soviet Union and ex-East European countries, the high-tech

specification using electronic device should be applied to the minimal extent because they can operate and maintain equipment by their own skills.

5) Technical Training

Mongolian operators have sufficient operating practices and experiences since sufficient number of equipment made in ex-Soviet Union and ex-East European countries are available. However, they have rather limited practices and experiences of operation against recent sophisticated equipment. Accordingly, an introductory training and training of equipment management will be carried out by a Japanese supplier at the time of delivery of equipment.

2-2-1-4 Other Policies

(1) Procurement of Materials and Construction Equipment

Major construction materials including cement, re-bars and straight asphalt are available in Mongolia. However, the prices of straight asphalt and the fuel are influenced by the Russian economy because they are imported from Russia in principle.

Major construction equipment such as bulldozer, back hoes and dump trucks are available in Mongolia. It is noted that a Japanese contractor for the Project may use without charge one set of asphalt plant and crushing plant which will be procured for the Improvement of Equipment that is one of components of the project, and the priority is given to a Japanese contractor for the Project to use another set of asphalt plant without charge.

The procurement of construction materials and equipment from markets in Mongolia should be maximized because of construction economy and ease of maintenance.

(2) Use of Local Contractors

The local construction companies were united under the state-owned construction trust in the past. However, they have been restructured and divided into self-sustained companies since 1990. Recently some companies were merged with foreign company and become foreign-affiliated entity. 145 contractors are registered to date.

The private companies are different from the state-owned companies in the aspect of property ownership, but there is no discrimination for selection of contractor by tendering. In recent years, they carry out their activities as a main contractor or a sub-contractor for road construction projects financed by foreign assistance.

A Japanese contractor for the Project will procure some local companies as sub-contractors or companies leasing equipment or supplying manpower.

(3) Maintenance Capabilities of the Executing Agency

The governmental companies of AZZA Tuv and HARGUI execute the maintenance work for their road section, having jurisdiction on the Eastern Arterial Road.

The present method of road maintenance is to cover cracks or potholes with asphalt mixture that are identified by visual inspection. Neither investigation of cause of defects nor sound design to keep good condition is conducted.

Under such circumstances, it is necessary to provide the technical guidance by soft component to improve maintenance capabilities of executing agency.

(4) Establishment of Construction Schedule

The detailed design should be approved by the authority concerned in due course if the Ministry of Road, Transport and Tourism implement a public work. It takes three weeks for obtaining approval at least. It is necessary to secure this period to make an implementation schedule for the Project.

Meteorological conditions in winter are so severe that no construction work is carried out in principle in order to keep quality of work and efficiency. However, production of crushing stone will be able to continue even in winter and pre-cast concrete products may be manufactured in the factory provided it enables to make construction plan reasonable as a whole.

Two sets of asphalt and crushing plants procured for the Improvement of Equipment under Japan's Grant Aid will be utilized by a Japanese contractor for the construction of road. Timely delivery of asphalt and crushing plants will become critical to make construction plan realistic and practical because asphalt pavement can be constructed only from May to September. Accordingly, any delay of delivery will shorten construction period in summer and affect overall construction schedule considerably.

(5) Package of Project

It takes several years to complete the construction of road for the Project, considering location of sites, meteorological conditions and scale of construction works.

Considering earlier commencement of works and timing of delivery of equipment procured under Japan's Grant Aid, two packages of civil work as well as procurement of equipment for the Project are deliberated. 2 sets of asphalt plant and crusher plant together with asphalt testing equipment will be procured and delivered to the Mongolian side to meet the requirement for 1st package of civil work. 1st package of civil work initially consisted Section

II new construction (L=13,130m), but most of those are determined to be comprised in 2nd package and the road length for 1st package is shortened, considering the budgetary constraint of the project.

(6) Institutional Arrangement for Project Implementation

The restoration of work roads, temporary sites such as borrow pits and construction yards and so on should be carried out by the contractors in compliance with the Mongolian Environmental Laws although the MNE has approved the Project officially.

2-2-2 Basic Plan

2-2-2-1 Design Concept

(1) Section II (Baganuur - Kherlen Bridge East)

1) Beginning Point and End Point of Section II

Beginning point of Section II coincides with the starting point of old pavement that was constructed 20 years ago (Refer to Figure 2-2-2-1).

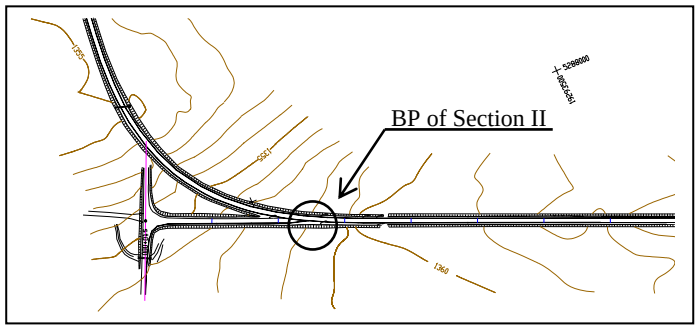


Figure 2-2-2-1 Beginning Point of Section II

Ending point of Section II coincides with the starting point of Section III that is under construction now (Refer to Figure 2-2-2-2).

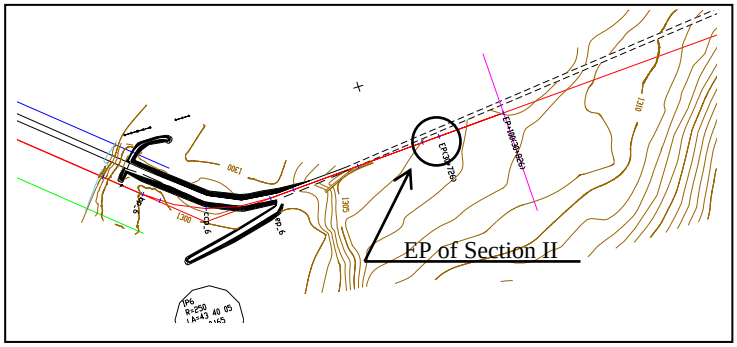


Figure 2-2-2-2 End Point of Section II

2) Length of respective components regarding Section II

The length of respective components in 30.1km of Section II is as follows.

1. Rehabilitation of Existing Asphalt Pavement: L = 15,608m

- BP to Khujirt Bridge : L = 1,257m
- Khujirt Bridge to Baganuur Mining Intersection : L = 14,351m

2. Construction of New Road: L = 13,130m

- Baganuur Mining Intersection to Khutsaa Bridge : L = 5,343m
- Khutsaa Bridge to Kherlen Bridge : L = 7,525m
- Kherlen Bridge to EP : L = 262m

3. Replacement of Existing Bridge and Construction of Approach Road: L = 218m

- Khujirt Bridge : L= 17.5m
- Approach road : L = 200m

4. Construction of New Bridge and Approach Road: L = 1,131m

- Khutsaa Bridge : L = 17.5m
- Approach road : L = 200m
- Kherlen Bridge : L = 268.8m
- Approach road : L = 645m

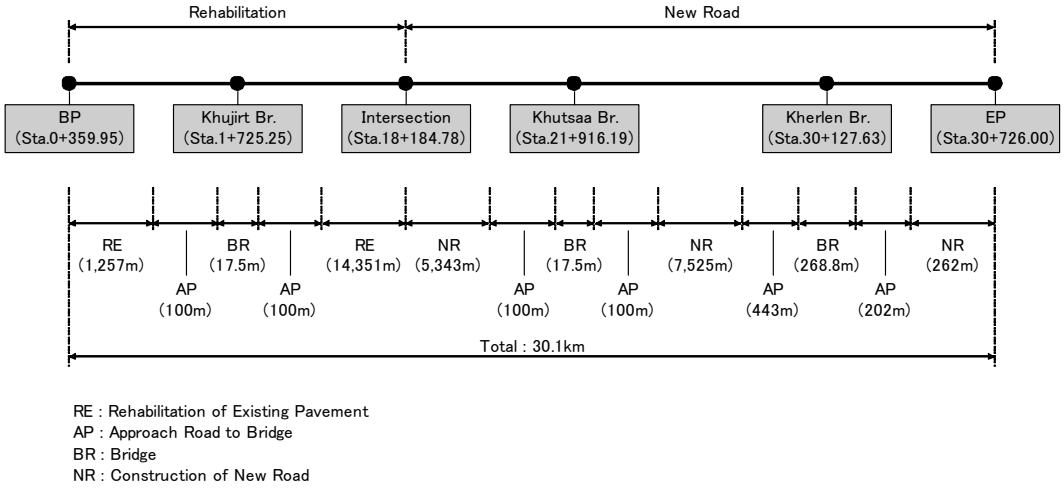


Figure 2-2-2-3 Length of respective components regarding Section II

(2) Section VI (Murun Bridge west – Undurkhaan)

1) Beginning Point and End Point of Section VI

At the beginning point of Section VI, some difference between Section V and Section VI happen as shown in Figure 2-2-2-4. The planned alignment of Section V passes the existing

National Road No.0501 where freeze-thaw cycle and frost susceptible area exist nearby the Murun River (Refer to Figure 2-2-2-5).

Study team proposed new alignment which passes over the hill to avoid permafrost area. However, Mongolian side didn't accept its proposal but approved to make End Point of Section V coincide to Beginning Point of Section VI.

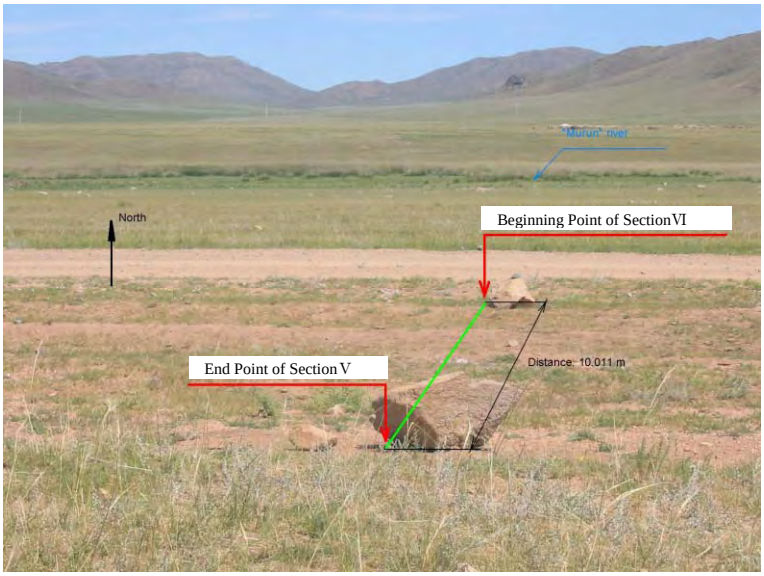


Figure 2-2-2-4 Difference between Section V and Section VI

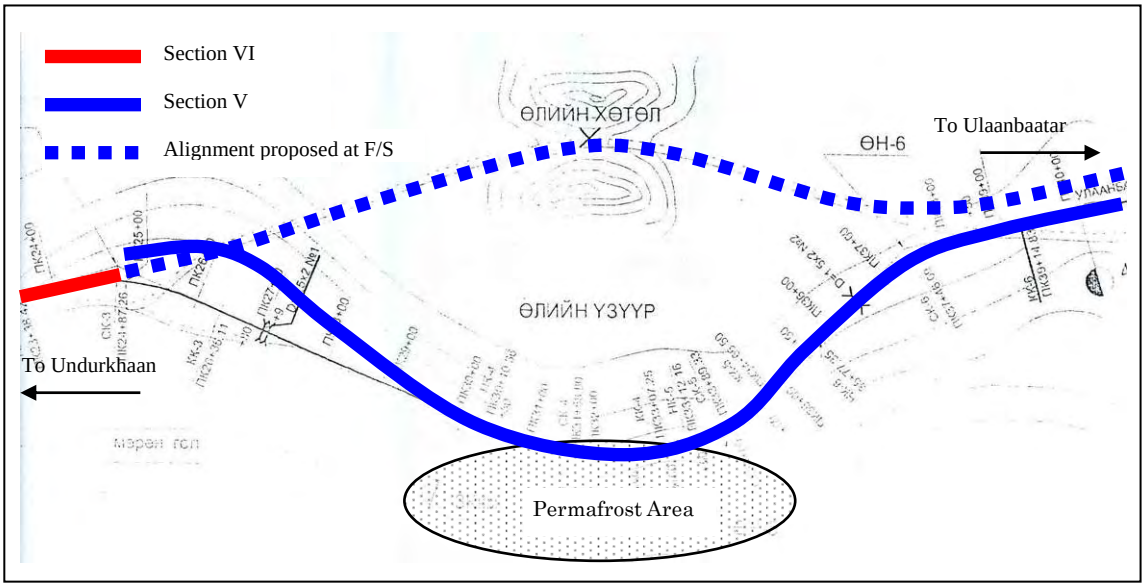


Figure 2-2-2-5 On-going Alignment and Alignment proposed at F/S

End Point of Section VI coincides with the center of intersection in Undurkhaan as shown in Figure 2-2-2-6.

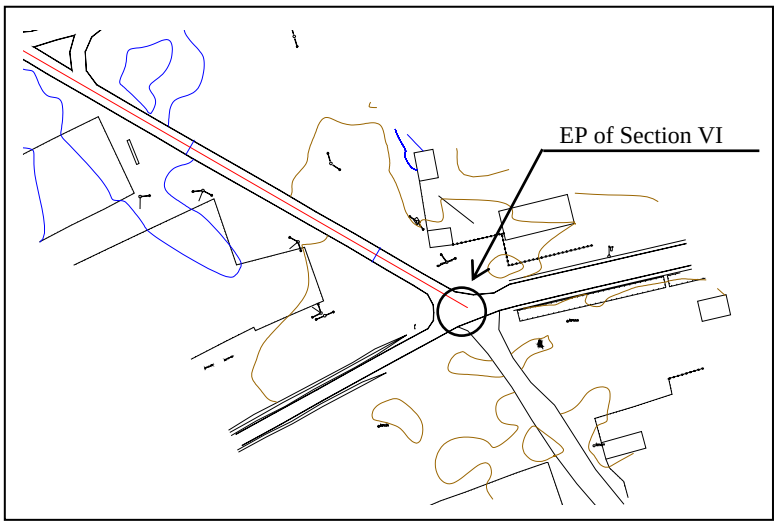


Figure 2-2-2-6 End Point of Section VI

2) Length of respective components regarding Section VI

The length of respective components in 28.1km of Section VI is as follows.

1. Rehabilitation of Existing Concrete Pavement: L = 250m

- West Undurkhaan Intersection to EP : L = 250m

2. Construction of New Road: L = 27,631m

- BP to Murun Bridge : L = 1,913m
- Murun Bridge to West Undurkhaan Intersection : L = 25,718m

3. Construction of New Bridge and Approach Road: L = 253m

- Murun Bridge : L = 52.5m
- Approach road : L = 200m

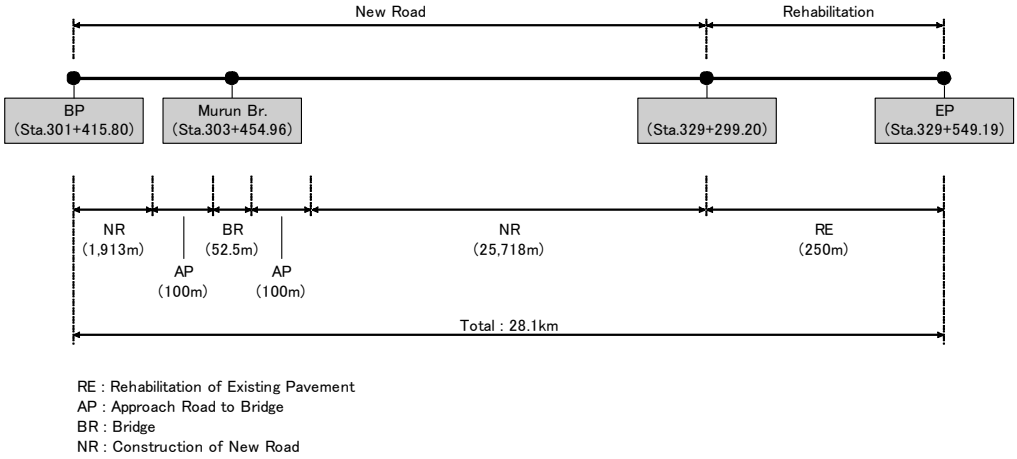


Figure 2-2-2-7 Length of respective components regarding Section VI

2-2-2-2 Basic Plan for Construction

(1) Highway Design

1) Design Speed

Design Speed is selected as follows in consideration of terrain type.

- Section II new construction : 80km/h
- Section II rehabilitation : 100km/h
- Section VI : 100km/h

2) Typical Cross Section in Earthwork Section

The proposed road is undivided 2-lane where through-traveled lane width shall be 3.5m together with 1.5m wide shoulder. 0.3m wide marginal strip will be provided for the purpose of driver's guidance, allowance for miss-steering and protection of pavement structure. Typical Cross section is shown in Figure 2-2-2-8.

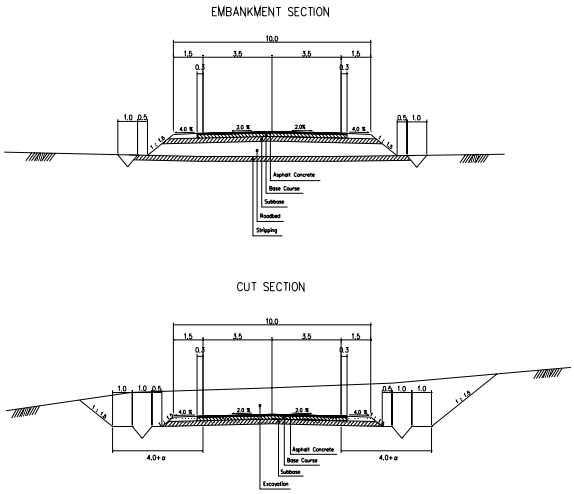


Figure 2-2-2-8 Typical Cross Section in Earthwork Section

3) Geometric Standard

Proposed geometric standard is summarized as shown in Table 2-2-2-1. This standard satisfied Asian Highway Standard as well as Mongolian Standard.

Table 2-2-2-1 Summary of Geometric Criteria for Eastern Arterial Road

Item	Unit	Design Criteria		
0. Terrain	-	Flat	Rolling	Mountainous
1. Design Speed	km/h	100	80	60
2. Traveled Land Width	m	3.5		
3. Shoulder Width	m	1.5		
4. Marginal Strip Width	m	0.3		
5. Cross fall of Traveled Way	%	2.0		
6. Cross fall of Shoulder	%	4.0		
7. Type of Pavement	-	AC Pavement		
8. Stopping Sight Distance	m	205	140	85
9. Maximum Super elevation	%	6.0		
10. Minimum Horizontal Curve Radius	m	450	250	150
11 Minimum Horizontal Curve Length	m	170* or 1,200/θ	140* or 1,000/θ	100* or 700/θ
12. Minimum Transition Curve Length	m	85	70	50
13. Sharpest Curve without Transition Curve	m	1,500	1,000	500
14. Sharpest Curve without Super elevation	m	5,000	3,500	2,000
15. Max. Relative Slope for Super elevation Runoff	-	1:175	1:150	1:125
16. Maximum Grade	%	4.0	6.0	7.0
17. Minimum Vertical Curve Length	-	85	70	50
18. Horizontal Clearance	-	Roadway Width		
19. Vertical Clearance	m	4.3		

4) Alignment

Horizontal alignment is determined with small modification in terms of avoiding existing steel tower, straightening in bridge section and so forth from F/S.

Vertical alignment is determined in consideration of minimum height of road surface shown in Table 2-2-2-2. The minimum height of road surface from ground is set as 80cm because the maximum snowfall depth in two decades is 20cm in this area.

Table 2-2-2-2 Minimum Height of Road Surface

Road Type	Minimum Height from Top of Snow
All multi lane Highway	1.2 m
Category II	0.7m
Category III	0.6m
Category IV	0.5m
Low volume roads	0.3-0.4m

5) Alternative route in Baganuur Area

Regarding the alignment in Baganuur, Mongolia side petitioned to change the existing alignment which passes 2 intersections because it is not appropriate as the Millennium Road.

Therefore, 4 alternative routes were prepared.

- Alternative 1 : Rehabilitation of existing road (Original)
- Alternative 2 : Rehabilitation of part of existing road and new construction of other part
- Alternative 3 : New construction without railway crossing
- Alternative 4 : New construction with railway crossing

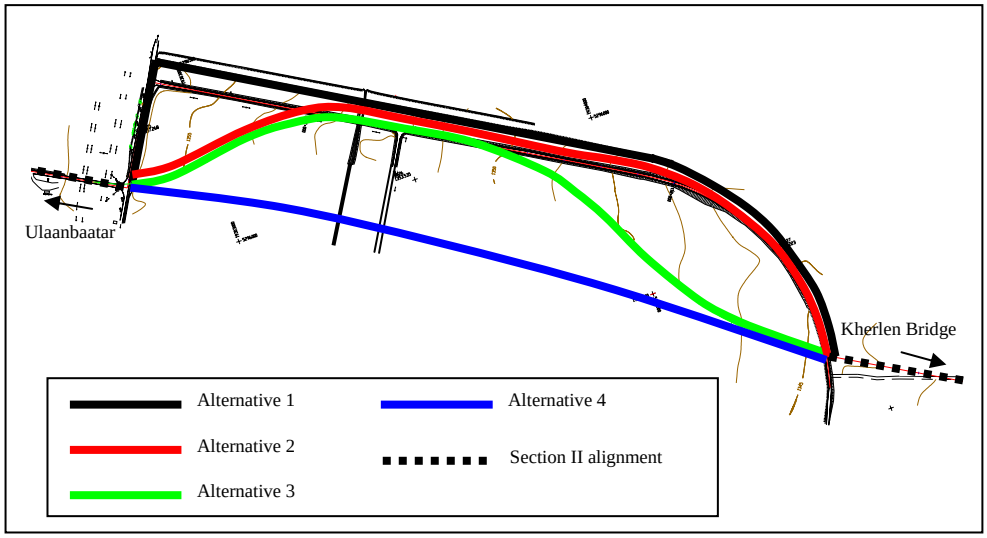


Figure 2-2-2-9 Alternative route in Baganuur

Alternative 4 was recommended from the following aspect.

- Alignment is almost straight, that is appropriate for Millennium Road.
- Alternative 4 is the most economical route of four routes.
- The number of intersection can be reduced from 4 to 3 compared with Alternative 1 (Original).

  DOR had the negotiation with the Railway Authority to obtain the permission of railway crossing. However, it was not approved as the frequency of train service is large, especially in winter and stop time at the crossing is 7 or 8 minutes. (Refer to Appendices 4)

  Therefore, Alternative 3 is adopted as ultimate route in Baganuur.

Table 2-2-2-3 Comparison of alternative routes in Baganuur

Description	Alternative 1 (Original)	Alternative 2	Alternative 3	Alternative 4
Total Length of Alternative Alignment	2,371 m	2,167 m	2082 m	1,927 m
	(1.23)	(1.12)	(1.08)	(1.000)
Construction Cost (US $)	223,361	217,185	217,028	201,162
	(1.11)	(1.08)	(1.08)	(1.00)
Alignment	This alignment is used existing road alignment. But there are crank turn and curve. Alignment is not so good for as Millennium Road.	This alignment is used part of existing road alignment and new alignment. But there are four curves. Alignment for traffic safety wise is not so good.	This alignment is totally new construction and avoid railway crossing. Alignment is shorter than alternative 1 and 2	This alignment is totally new construction and straight alignment. Alignment is good for as Millennium Road.
Number of Intersection	4 (T-shape : 4)	3 (T-shape : 2 , Cross-shape : 1)	3 (T-shape : 2 , Cross-shape : 1)	3 (Cross-shape : 3)
Construction	Existing Baganuur Road will be rehabilitated by overlay and reconstruction with widening.	737m from Baganuur mining intersection will be new construction and remaining is rehabilitation of existing road.	The whole of road will be new construction.	The whole of road will be new construction.
Comments	This alignment is just using existing road alignment and alignment is based on F/S.	This alignment is better than Alternative-1.	This alignment is smoothly connects between baganuur mining intersection and Baganuur Storage intersection and avoid existing railway crossing. This alternative is a little bit costly compare with Alternative 4.	This alignment is smoothly connects between baganuur mining intersection and Baganuur Storage intersection and most Economical with compare other alternative alignment. Alignment crosses the railway for mining.
Consultation with other agency	Not necessary	Not necessary	Not necessary	Need negotiation with Railway Authority for railway crossing
Remark			○	◎

6) Rehabilitation Section in Section II

a) Road Inventory Survey

Road Inventory Survey was conducted in order to determine the rehabilitation method for respective sections. The sample of Road Inventory Survey result is shown in Figure 2-2-2-10.

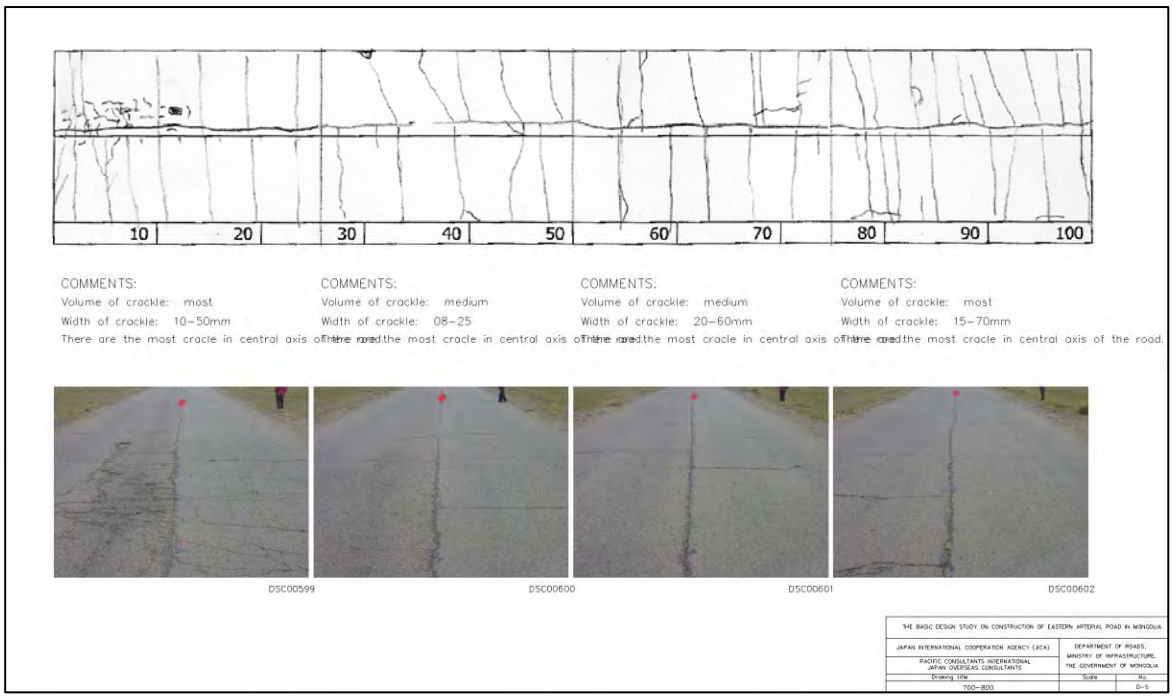


Figure 2-2-2-10 Result of Road Inventory Survey, Sample Sheet

b) Rehabilitation Method

Rehabilitation methods consist of four types as shown in Table 2-2-2-4 based on the result of Road Inventory Survey. Each design section is approximately 500m long considering practicability and efficiency of work and the comprehensive evaluation of each design section is made accumulating evaluation results of each 100m long sub-section.

Table 2-2-2-4 Rehabilitation Method

Type	Rehabilitation Method
Type A	No Rehabilitation
Type B	Sealing, Patching, Overlay
Type C	Surface Replacing
Type D	Replacing of Surface, Base Course and Subbase Course

c) Criteria for Evaluation

Rehabilitation type is determined taking following three aspects into consideration.

i) Subjective Evaluation

The comfort of car riding is the factor for subjective evaluation. The criteria are given in Table 2-2-2-5.

Table 2-2-2-5 Criteria for Subjective Evaluation

NO.	Subjective Evaluation	Comfort of Car Riding	Rehabilitation Type
1	Very good	Very comfortable	A
2	Good	Comfortable	A
3	Fair	Feel vibration but not painful	B/C
4	Poor	Feel painful if continue long duration	B/C
5	Bad	Feel painful even short time	D

ii) Objective Evaluation

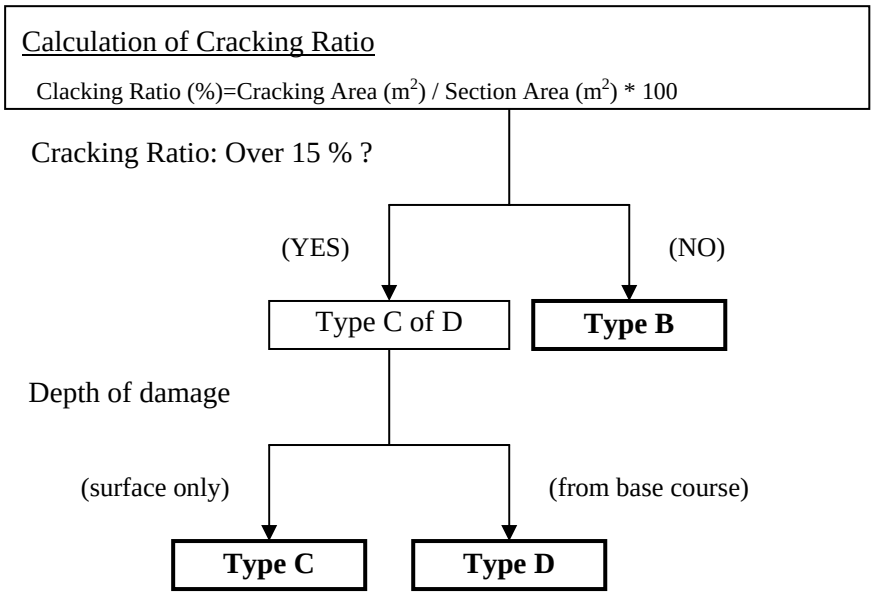
The surface condition is the factor for objective evaluation. The criteria are shown in Table 2-2-2-6.

Table 2-2-2-6 Criteria for Objective Evaluation

NO.	Surface Condition	Cause of deterioration	Rehabilitation Type	Sample
a	Alligator Crack	Low asphalt quality Harden asphalt Bad drainage condition	D	
b	Linear Cracks	Low asphalt quality Harden asphalt Low temperature	B/C	
c	Pot holes	Low asphalt quality Harden asphalt	B/C	
d	Rutting	Excessive asphalt content Poor aggregate material	C	
e	Surface irregularities	Excessive asphalt content Bad drainage condition Poor base material	D	

iii) Cracking Ratio

The following flowchart shows the evaluation method for cracking ratio. The cracking area is obtained accumulating the areas of which one or more cracks exist in every 50 cm long square.



d) Comprehensive Evaluation

Figure 2-2-2-11 shows the result of evaluation for 100m long sub-section from three aspects as a sample, and the results of whole section are given in Appendices 2. The following items are shown in the sheet.

- Sketch of damage
- Evaluation from subjective viewpoint
- Evaluation from objective viewpoint
- Cracking ratio
- Rehabilitation type

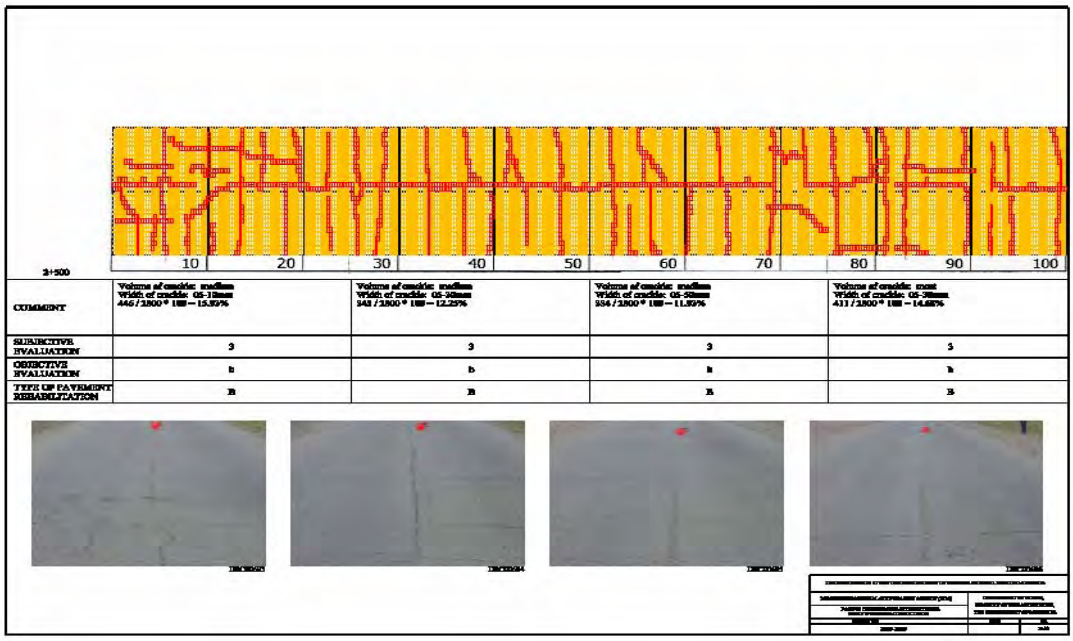


Figure 2-2-2-11 Result of Evaluation for Each Sub-section

The comprehensive evaluation for each 500m long section is summarized in Table 2-2-2-7. Each types of rehabilitation comprises the following length.

- Type A : 0m (0%)
- Type B : 11,615m (76%)
- Type C : 2,954m (19%)
- Type D : 810m (5%)

Table 2-2-2-7 Rehabilitation Type

STA.	Subjective Evaluation						Objective Evaluation						Cracking Ratio		Evaluation
	1	2	3	4	5	ELN	a	b	c	d	e	ELN	Ratio	ELN	
0 + 360 ~ 0 + 400			○			B,C		○				B,C	12.58	B	D
0 + 400 ~ 0 + 500				○		B,C		○	○			B,C	11.66	B	
0 + 500 ~ 0 + 600				○		B,C	○	○	○			D	19.63	C,D	
0 + 600 ~ 0 + 720			○			B,C	○	○	○			D	17.59	C,D	
0 + 720 ~ 0 + 800			○			B,C		○				B,C	14.47	B	B
0 + 800 ~ 0 + 900			○			B,C		○				B,C	13.72	B	
0 + 900 ~ 1 + 000			○			B,C		○	○			B,C	15.98	C,D	
1 + 000 ~ 1 + 100			○	○		B,C		○	○			B,C	17.33	C,D	
1 + 100 ~ 1 + 200			○	○		B,C		○	○			B,C	18.89	C,D	
1 + 200 ~ 1 + 300				○		B,C		○	○			B,C	18.70	C,D	
1 + 300 ~ 1 + 400				○		B,C		○	○	○		C	13.48	B	C
1 + 400 ~ 1 + 500				○		B,C		○	○			B,C	15.04	C,D	
1 + 500 ~ 1 + 537				○		B,C		○	○	○		C	16.34	C,D	
1 + 537 ~ 1 + 717	Approach Road (New Construction)														
1 + 717 ~ 1 + 734	Khujirt Bridge														
1 + 734 ~ 1 + 982	Approach Road (New Construction)														
1 + 982 ~ 2 + 000			○	○		B,C		○	○	○		C	13.23	B	B
2 + 000 ~ 2 + 100			○			B,C		○	○			B,C	12.30	B	
2 + 100 ~ 2 + 200			○			B,C		○				B,C	14.22	B	
2 + 200 ~ 2 + 300			○			B,C		○				B,C	13.65	B	
2 + 300 ~ 2 + 400			○			B,C		○				B,C	13.87	B	
2 + 400 ~ 2 + 500			○			B,C		○	○			B,C	10.23	B	
2 + 500 ~ 2 + 600			○			B,C		○				B,C	13.70	B	B
2 + 600 ~ 2 + 700			○			B,C		○	○			B,C	12.30	B	
2 + 700 ~ 2 + 800			○			B,C		○				B,C	9.50	B	
2 + 800 ~ 2 + 900			○			B,C		○				B,C	11.51	B	
2 + 900 ~ 3 + 000			○	○		B,C		○	○			B,C	11.69	B	
3 + 000 ~ 3 + 100			○	○		B,C		○	○		○	D	12.40	B	B
3 + 100 ~ 3 + 200			○			B,C		○				B,C	12.59	B	
3 + 200 ~ 3 + 300			○			B,C		○				B,C	11.76	B	
3 + 300 ~ 3 + 400			○			B,C		○				B,C	8.72	B	
3 + 400 ~ 3 + 500			○			B,C	○	○				D	10.86	B	
3 + 500 ~ 3 + 600			○			B,C		○	○			B,C	8.98	B	B
3 + 600 ~ 3 + 700			○			B,C		○				B,C	8.72	B	
3 + 700 ~ 3 + 800			○			B,C		○				B,C	6.14	B	
3 + 800 ~ 3 + 900			○			B,C		○				B,C	9.75	B	
3 + 900 ~ 3 + 950			○			B,C		○				B,C	7.13	B	
3 + 950 ~ 4 + 100			○		○	D		○	○		○	D	10.54	B	D
4 + 100 ~ 4 + 200					○	D		○			○	D	12.75	B	
4 + 200 ~ 4 + 300				○		B,C		○	○		○	D	14.30	B	
4 + 300 ~ 4 + 400				○		B,C		○	○		○	D	12.89	B	
4 + 400 ~ 4 + 500			○	○		B,C		○	○	○		C	11.55	B	B
4 + 500 ~ 4 + 600			○	○		B,C		○		○		C	10.21	B	
4 + 600 ~ 4 + 700			○			B,C		○				B,C	10.02	B	
4 + 700 ~ 4 + 800			○			B,C		○				B,C	9.84	B	
4 + 800 ~ 4 + 900			○	○		B,C		○		○		C	8.98	B	
4 + 900 ~ 5 + 000			○			B,C		○				B,C	8.51	B	
5 + 000 ~ 5 + 100			○			B,C		○		○		C	9.37	B	B
5 + 100 ~ 5 + 200			○			B,C		○				B,C	10.17	B	
5 + 200 ~ 5 + 300			○			B,C		○				B,C	10.05	B	
5 + 300 ~ 5 + 400			○			B,C		○	○	○		C	7.82	B	
5 + 400 ~ 5 + 500			○			B,C		○				B,C	8.97	B	
5 + 500 ~ 5 + 600			○			B,C		○				B,C	11.24	B	B
5 + 600 ~ 5 + 700			○			B,C		○	○			B,C	9.62	B	
5 + 700 ~ 5 + 800			○			B,C		○	○			B,C	8.18	B	
5 + 800 ~ 5 + 900			○			B,C		○	○			B,C	11.07	B	
5 + 900 ~ 6 + 000			○			B,C		○		○		C	8.11	B	
6 + 000 ~ 6 + 100			○			B,C		○	○			B,C	7.47	B	B
6 + 100 ~ 6 + 200			○			B,C		○	○			B,C	7.17	B	
6 + 200 ~ 6 + 300			○			B,C		○				B,C	8.31	B	
6 + 300 ~ 6 + 400			○	○		B,C		○	○	○		C	8.51	B	
6 + 400 ~ 6 + 500			○	○		B,C		○	○	○		C	6.28	B	
6 + 500 ~ 6 + 600			○			B,C		○		○		C	6.49	B	B
6 + 600 ~ 6 + 700			○			B,C		○	○			B,C	9.09	B	
6 + 700 ~ 6 + 800			○			B,C		○	○			B,C	7.10	B	
6 + 800 ~ 6 + 900			○			B,C		○				B,C	9.21	B	
6 + 900 ~ 7 + 000			○			B,C		○	○			B,C	9.28	B	

STA.	Subjective Evaluation						Objective Evaluation						Cracking Ratio		Evaluation
	1	2	3	4	5	ELN	a	b	c	d	e	ELN	Ratio	ELN	
7 + 000 ~ 7 + 100			○			B,C		○	○			B,C	8.39	B	
7 + 100 ~ 7 + 200			○			B,C		○				B,C	10.28	B	
7 + 200 ~ 7 + 300			○			B,C		○				B,C	6.31	B	**B**
7 + 300 ~ 7 + 400			○			B,C		○				B,C	6.91	B	
7 + 400 ~ 7 + 500			○			B,C		○	○			B,C	5.37	B	
7 + 500 ~ 7 + 600			○			B,C		○				B,C	5.01	B	
7 + 600 ~ 7 + 700			○			B,C		○				B,C	5.05	B	
7 + 700 ~ 7 + 800			○			B,C		○	○			B,C	8.75	B	**B**
7 + 800 ~ 7 + 900			○			B,C		○				B,C	8.60	B	
7 + 900 ~ 8 + 000			○			B,C		○	○			B,C	10.54	B	
8 + 000 ~ 8 + 100			○			B,C		○	○			B,C	9.47	B	
8 + 100 ~ 8 + 200			○			B,C		○				B,C	10.93	B	
8 + 200 ~ 8 + 300			○			B,C		○	○			B,C	9.94	B	**B**
8 + 300 ~ 8 + 400			○			B,C		○				B,C	12.56	B	
8 + 400 ~ 8 + 500			○	○		B,C	○	○				D	11.98	B	
8 + 500 ~ 8 + 600			○			B,C		○				B,C	9.29	B	
8 + 600 ~ 8 + 700			○			B,C		○				B,C	10.59	B	
8 + 700 ~ 8 + 800			○			B,C		○				B,C	8.60	B	**B**
8 + 800 ~ 8 + 900			○			B,C		○				B,C	1.33	B	
8 + 900 ~ 9 + 000			○			B,C		○				B,C	1.29	B	
9 + 000 ~ 9 + 100			○			B,C		○				B,C	4.05	B	
9 + 100 ~ 9 + 200			○			B,C		○				B,C	7.96	B	
9 + 200 ~ 9 + 300			○			B,C		○	○			B,C	9.84	B	**B**
9 + 300 ~ 9 + 400			○			B,C		○	○			B,C	11.92	B	
9 + 400 ~ 9 + 500			○			B,C		○	○			B,C	8.86	B	
9 + 500 ~ 9 + 600			○			B,C		○				B,C	8.10	B	
9 + 600 ~ 9 + 700			○			B,C		○	○			B,C	8.11	B	
9 + 700 ~ 9 + 800			○			B,C		○				B,C	10.47	B	**B**
9 + 800 ~ 9 + 900			○			B,C		○				B,C	15.25	C,D	
9 + 900 ~ 10 + 000			○			B,C		○				B,C	13.52	B	
10 + 000 ~ 10 + 100			○			B,C		○	○			B,C	9.23	B	
10 + 100 ~ 10 + 200			○			B,C		○	○			B,C	14.33	B	
10 + 200 ~ 10 + 300			○			B,C		○	○			B,C	11.09	B	**B**
10 + 300 ~ 10 + 400			○			B,C		○	○			B,C	11.13	B	
10 + 400 ~ 10 + 500			○			B,C		○				B,C	10.04	B	
10 + 500 ~ 10 + 600			○			B,C		○	○			B,C	9.58	B	
10 + 600 ~ 10 + 700			○			B,C		○				B,C	10.19	B	
10 + 700 ~ 10 + 800			○			B,C		○	○			B,C	10.26	B	**B**
10 + 800 ~ 10 + 900			○			B,C		○	○			B,C	14.66	B	
10 + 900 ~ 11 + 000			○			B,C		○	○			B,C	15.20	C,D	
11 + 000 ~ 11 + 100			○			B,C		○	○			B,C	15.07	C,D	
11 + 100 ~ 11 + 200			○			B,C		○	○			B,C	14.80	B	
11 + 200 ~ 11 + 300			○			B,C		○	○			B,C	14.82	B	**B**
11 + 300 ~ 11 + 400			○			B,C		○	○			B,C	11.14	B	
11 + 400 ~ 11 + 500			○			B,C		○	○			B,C	12.18	B	
11 + 500 ~ 11 + 600			○			B,C		○	○			B,C	13.42	B	
11 + 600 ~ 11 + 700			○			B,C		○				B,C	8.65	B	
11 + 700 ~ 11 + 800			○			B,C		○	○			B,C	9.09	B	**B**
11 + 800 ~ 11 + 900			○			B,C		○	○			B,C	13.08	B	
11 + 900 ~ 12 + 000			○			B,C		○	○			B,C	14.03	B	
12 + 000 ~ 12 + 100			○			B,C		○	○			B,C	14.25	B	
12 + 100 ~ 12 + 200			○			B,C		○	○			B,C	11.00	B	
12 + 200 ~ 12 + 300			○			B,C		○	○			B,C	12.29	B	**B**
12 + 300 ~ 12 + 400			○			B,C		○	○			B,C	13.22	B	
12 + 400 ~ 12 + 500			○			B,C		○				B,C	12.64	B	
12 + 500 ~ 12 + 600			○			B,C		○				B,C	11.06	B	
12 + 600 ~ 12 + 700			○			B,C		○	○			B,C	13.45	B	
12 + 700 ~ 12 + 800			○			B,C		○	○			B,C	10.38	B	
12 + 800 ~ 12 + 900			○			B,C		○	○			B,C	9.38	B	**B**
12 + 900 ~ 13 + 000			○			B,C		○				B,C	12.97	B	
13 + 000 ~ 13 + 100			○			B,C		○	○			B,C	11.88	B	
13 + 100 ~ 13 + 200			○			B,C		○	○			B,C	12.65	B	
13 + 200 ~ 13 + 300			○			B,C		○	○			B,C	13.56	B	
13 + 300 ~ 13 + 400				○		B,C		○	○	○		C	11.45	B	
13 + 400 ~ 13 + 500				○		B,C		○	○	○		C	14.84	B	
13 + 500 ~ 13 + 600				○		B,C		○	○	○		C	18.03	C,D	**C**
13 + 600 ~ 13 + 700			○			B,C		○	○			B,C	11.46	B	
13 + 700 ~ 13 + 800			○			B,C		○	○			B,C	12.22	B	
13 + 800 ~ 13 + 900				○		B,C		○	○	○		C	11.43	B	
13 + 900 ~ 14 + 000				○		B,C		○	○	○		C	11.97	B	

STA.	Subjective Evaluation						Objective Evaluation						Cracking Ratio		Evaluation
	1	2	3	4	5	ELN	a	b	c	d	e	ELN	Ratio	ELN	
14 + 000 ～ 14 + 100				○		B,C		○	○	○		C	11.86	B	
14 + 100 ～ 14 + 200				○		B,C		○	○	○		C	9.15	B	
14 + 200 ～ 14 + 300				○		B,C		○	○	○		C	9.79	B	**C**
14 + 300 ～ 14 + 400				○		B,C		○	○	○		C	10.18	B	
14 + 400 ～ 14 + 500				○		B,C		○	○	○		C	10.81	B	
14 + 500 ～ 14 + 600				○		B,C		○	○	○		C	9.44	B	
14 + 600 ～ 14 + 700				○		B,C		○	○	○		C	11.26	B	
14 + 700 ～ 14 + 800				○		B,C		○		○		C	11.26	B	**C**
14 + 800 ～ 14 + 900				○		B,C		○	○	○		C	10.48	B	
14 + 900 ～ 15 + 000				○		B,C		○		○		C	11.07	B	
15 + 000 ～ 15 + 100			○			B,C		○	○	○		C	10.52	B	
15 + 100 ～ 15 + 200				○		B,C		○		○		C	11.73	B	
15 + 200 ～ 15 + 300				○		B,C		○	○	○		C	10.89	B	**C**
15 + 300 ～ 15 + 400			○			B,C		○		○		C	10.12	B	
15 + 400 ～ 15 + 500			○			B,C		○		○		C	12.42	B	
15 + 500 ～ 15 + 600			○			B,C		○		○		C	11.34	B	
15 + 600 ～ 15 + 700			○			B,C		○	○	○		C	10.01	B	**C**
15 + 700 ～ 15 + 800			○			B,C		○		○		C	13.66	B	
15 + 800 ～ 15 + 900				○		B,C		○		○		C	15.29	C,D	
15 + 900 ～ 16 + 000			○			B,C		○				B,C	13.39	B	
16 + 000 ～ 16 + 100			○			B,C		○				B,C	11.31	B	**B**
16 + 100 ～ 16 + 185			○			B,C		○				B,C	7.66	B	

※ Rehabilitation Method
TypeA: No Rehabilitaion
TypeB: Sealing, Patching, Overlay
TypeC: Surface Replacing
TypeD: Replacing of Surface, Base Course and Subbase Course

※ Subjective Evaluation
1 : Very Good
2 : Good
3 : Fair
4 : Poor
5 : Bad

※ Objective Evaluation
a : Alligator Crack
b : Linear Clacks
c : Pot holes
d : Rutting
e : Surface irregularities

7) Future Traffic Demand

In F/S, future traffic demand was forecasted based on the future OD tables. Future traffic demand for this project is updated from F/S with traffic survey result (September 2004) conducted in this study.

Traffic volumes of Section II and Section VI are projected as 780 vehicles/day, and 396 vehicles/day for year 2010, and 1,161 vehicles/day, and 606 vehicles/day for year 2015, respectively.

Table 2-2-2-8 Traffic Volume of Section II

(veh/day)

Year	ALL	Car	BUS	S-Truck	M-Truck	L-Truck
2004	500	250	60	90	70	30
2005	541	269	66	101	76	33
2010	780	384	98	152	107	45
2015	1,161	564	152	208	164	65
2020	1,691	821	221	304	238	95
2025	2,461	1,196	321	444	347	137

Table 2-2-2-9 Traffic Volume of Section VI

(veh/day)

Year	ALL	Car	BUS	S-Truck	M-Truck	L-Truck
2004	250	130	60	10	40	10
2005	269	139	65	11	43	11
2010	396	202	100	16	64	15
2015	606	308	153	24	102	21
2020	882	448	223	35	147	31
2025	1,284	652	325	51	215	44

8) Pavement

a) Design Standard

"GUIDE FOR DESIGN OF PAVEMENT STRUCTUERES, AASHTO" is applied as a design standard of pavement.

b) Design Section

Design section is classified into 3 sections which comprise Section II new construction, Section II rehabilitation and Section VI by the difference of future traffic demand or construction type.

c) Pavement design for new construction section

The design CBR value for new construction section is applied as 12 based on F/S and CBR test. The design of pavement is made on condition that overlay will be required every 7 years due to deterioration of serviceability index.

As a result of design in accordance with AASHTO, the thicknesses of pavement of Section II new construction and Section VI are calculated as shown in Table 2-2-2-10 and Table 2-2-2-11 respectively. The detail of calculation is shown in Appendices 8.

Table 2-2-2-10 Pavement Structure for New Construction in Section II

	CBR = 12
Surface	5 cm
Base Course	10 cm
Subbase Course	22 cm
Total	37 cm

Table 2-2-2-11 Pavement Structure for New Construction in Section VI

	CBR = 12
Surface	5 cm
Base Course	10 cm
Subbase Course	20 cm
Total	35 cm

d) Pavement design for Rehabilitation section

Section II rehabilitation section is divided by approximately 500m and rehabilitation type of respective sections is selected from overlay, surface replacing and replacing of surface, base course and subbase course.

The thicknesses of pavement for surface replacing and replacing of surface, base course and subbase course are the same as new construction section as shown below.

- Surface replacing : surface 5 cm
- Replacing of surface, base course and subbase course
  : surface 5cm, base course 10 cm, subbase course 22 cm

The thickness of overlay is applied as 5 cm based on the design with AASHTO. Design period is applied as 7 years and overlay will be implemented every 7 years. The detail of calculation is shown in Appendices 8.

9) Intersection

3 intersections in Section II and 1 intersection in Section VI shall be constructed. The locations of respective intersections are shown in Figure 2-2-2-12 and Figure 2-2-2-14.

1. Baganuur Mining Intersection
2. Baganuur Power Plant Intersection
3. Baganuur Storage Intersection

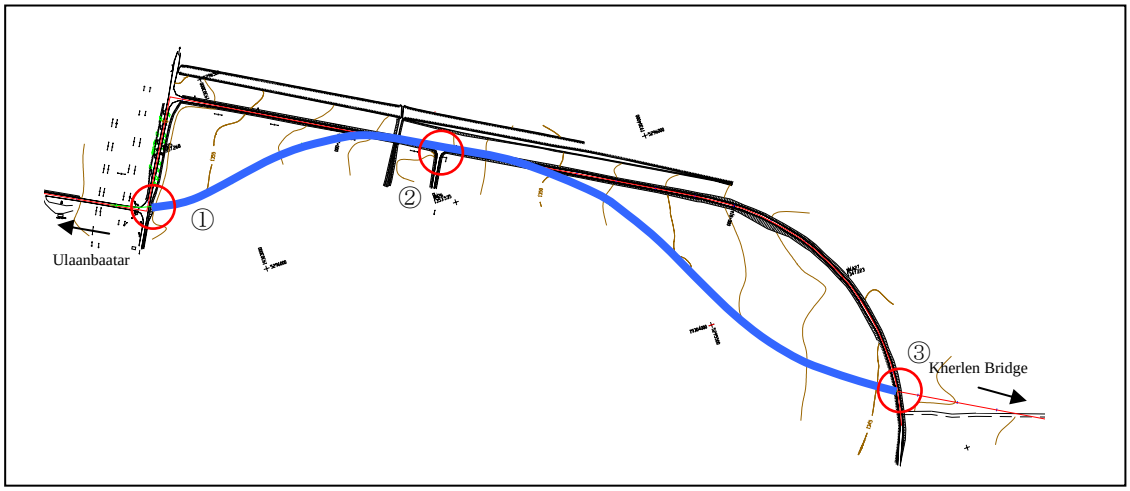


Figure 2-2-2-12 Location of Intersection in Section II

The image of canalized Baganuur Mining Intersection is shown in Figure 2-2-2-13. The drawings of respective intersections are shown in "2-3 Basic Design Drawings".

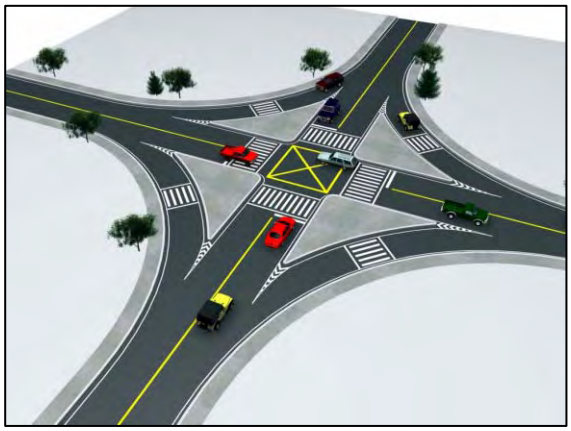


Figure 2-2-2-13 Image of Baganuur Mining Intersection

4. West Undurkhaan Intersection

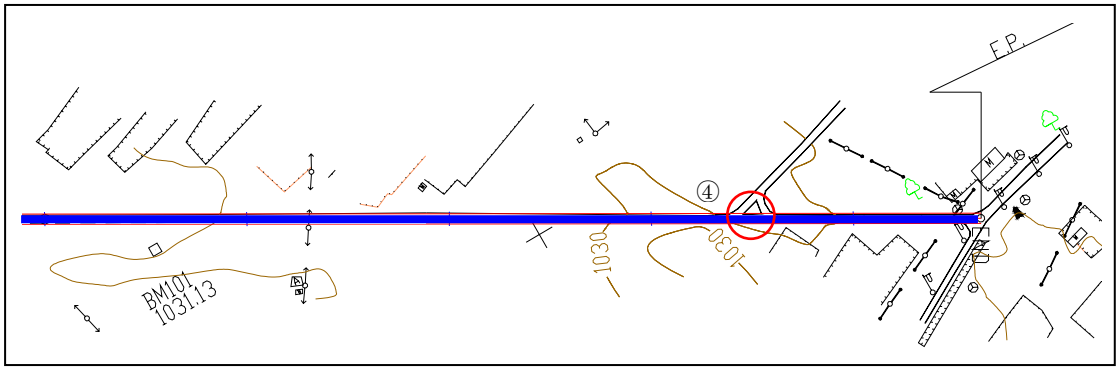


Figure 2-2-2-14 Location of Intersection in Section VI

Baganuur Mining Intersection and West Undurkhann Intersection are connected with the road to Baganuur city and Undurkhaan city respectively. Therefore, these intersections shall be channelized on account of traffic safety.

10) Box Culvert and Pipe Culvert

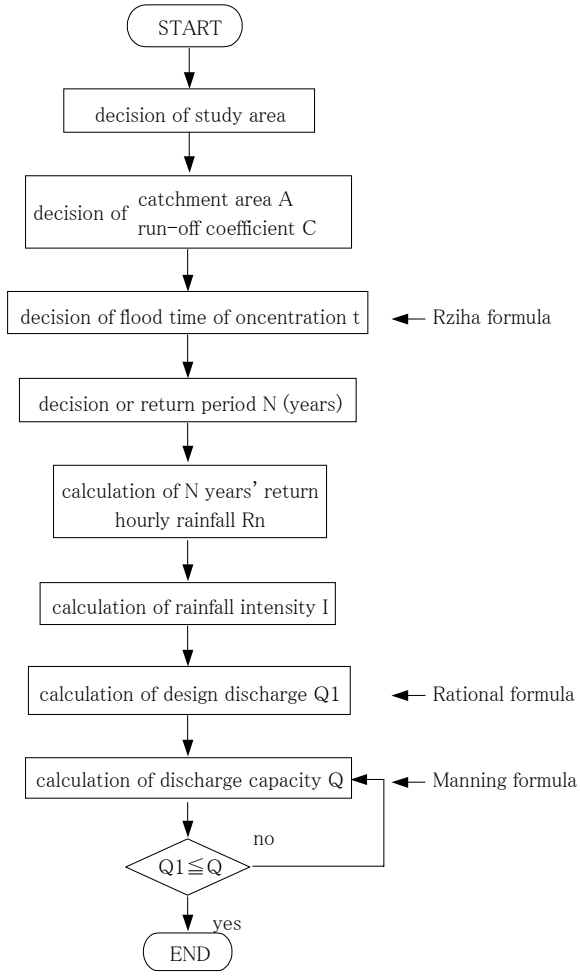
a) Drainage Design

Drainage design start by deciding the flood time of concentration (t). The flood time of concentration consists of the inflow time (t_1) and the time of flowing down (t_2). The time of flowing down is approximately calculated by dividing the length of drain at upper stream of the target point by the mean velocity at that drain.

Then the rainfall intensity corresponding to the flood time of concentration (R_t) is decided. Design discharge is calculated by using Rational formula with R_t.

The drainage work is designed as the discharge capacity of it is larger than the design discharge.

Discharge capacity is the product of the cross-sectional and the mean velocity through culvert.



b) Rainfall Intensity

Ten years' return rainfall intensity is calculated using the flood time of concentration and the rainfall amount corresponding to t as follows;

$I_n = R_n^t/t$

where,

I_n: n Years' Return Rainfall intensity (mm/h)

R_n^t: n Years' Return Rainfall Amount for the Time Period

t: Time of Concentration

To calculate R_n^t, the only available data are the graph and equation of 100 year return 24 hours rainfall amount in Uranbaatar City, and 24 hours rainfall amount in several cities.

Using these factors, R_n^t is calculated as follows;

$R_n^t = 8.7381\ln(t) + 45.565 - (R_n^{24} - R_{0n}^{24})$

where,

$R_n^{24} = 8.7381\ln(24) + 45.565 = 73.335$mm

R_{0n}^t: n Years' Return 24 Hours Rainfall Amount at study area

The flood time of concentration consists of the inflow time (t_1) and the time of flowing down (t_2).

To calculate t, Rizhiha formula is used.

$t = 1.3L/W + t_1$

$W = 20(h/L)^{0.6}$

where,

L: Length of drain (m)

t: Inflow Time = 0.5 (h)

W: Mean Velocity (m/sec)

h: Difference in Elevation between River Source and Bridge Site (m)

c) Design Discharge / Discharge Capacity

i) Design Discharge (Q_p)

To calculate design discharge, Rational formula is used.

$Q_0 = 1/3.6*10^6CIA$

where,

Q_0: Design Discharge (m^3/sec)

C: Run-Off Coefficient

I: Rainfall Intensity (mm/h)

A: Catchment Area (m^2)

Since this formula tends to overestimate for Mongolian basis, Q_0 is corrected as follows;

$Q_p = \alpha_0 * Q_0$

where,

α_0: Correction Ratio =0.61

Run-Off Coefficient for various kinds of soil

		Run-Off Coefficient C
Road	Paved	0.70 - 0.95
	Dirt	0.30 - 0.70
Road shoulder, Slope etc.	Fine grained soil	0.40 - 0.65
	Coarse grained soil	0.10 - 0.30
	Hard rock	0.70 - 0.85
	Soft/fragile rock	0.50 - 0.75
Grass on sandy soil	Gradient 0-2%	0.05 - 0.10
	Gradient 2-7%	0.10 -0.15
	Gradient 7%-	0.15 -0.20
Grass on cohesive soil	Gradient 0-2 %	0.13 - 0.17
	Gradient 2-7%	0.18 - 0.22
	Gradient 7%-	0.25 - 0.35
Ridge		0.75 - 0.95
Open space		0.20 - 0.40
Grassy/woody park		0.10 - 0.25
Hill		0.20 - 0.40
Mountain		0.40 - 0.60
Paddy		0.70 - 0.80
Field		0.10 - 0.30

ii) Discharge Capacity (Q)

$Q = \alpha Av$

where,

Q: Discharge Capacity (m^3/sec)

α : Safety Factor for discharge = 1.0

v: mean velocity (m/sec)

The mean velocity is calculated using Manning formula as follows;

$v = (1/n) * R^{2/3} * I^{1/2}$

where,

R: Hydraulic Radius (m)

R = A/W

W: Wetted Perimeter (m)

n: Coefficient of Roughness = 0.013

I: Slope

Coefficient of Roughness

Type	Condition	n	n (standard)
Culvert	Cast-in-place concrete		0.015
	Concrete pipe		0.013
	Corrugated metal		0.024
	PVC pipe		0.010
	Pre-cast concrete		0.013
Lined	Steel, non-coated, smooth	0.011 - 0.014	0.012
	Mortar	0.011 - 0.015	0.013
	Wood, planed	0.012 - 0.018	0.015
	Concrete, troweled	0.011 - 0.015	0.015
	Concrete, graveled	0.015 - 0.020	0.017
	Masonry, mortared	0.017 - 0.030	0.025
	Dry masonry	0.023 - 0.035	0.032
	Asphalt, smooth	0.013	0.013
Non-lined	Soil, straight, uniform section	0.016 - 0.025	0.022
	Soil, straight, w/weed	0.022 - 0.033	0.027
	Gravel, straight	0.022 - 0.030	0.025
	Rock, straight	0.025 - 0.040	0.035
Natural	Uniform section	0.025 - 0.033	0.030
	Rough	0.075 - 0.150	0.100

d) Culvert section/arrangement

i) Section II

The run-off coefficient is 0.48, considering the condition of the site which is mountainous and the gradient is around 5 - 8%. 50 years return 24 hours rainfall amount is 75mm (from Baganuur).

The culvert arrangement plan in section II is shown in Table 2-2-2-12.

Table 2-2-2-12 Culvert section/arrangement (Section II)

Station	Type	No of pcs	Gradient i %	Design Discharge Qp m3/sec	Discharge Capacity Q m3/sec	Qp/Q
1 Sta. 16 + 830	φ1000	1	1.0	0.379	2.346	0.16
2 Sta. 18 + 350	φ1000	1	1.0	1.062	2.346	0.45
3 Sta. 19 + 400	φ1500	1	1.5	8.122	8.468	0.96
4 Sta. 20 + 147	φ1500	1	1.5	7.604	8.468	0.90
5 Sta. 23 + 780	φ1500	2	1.0	12.497	13.828	0.90
6 Sta. 25 + 900	φ1500	1	1.0	3.215	6.914	0.46
7 Sta. 26 + 285	φ1500	1	1.0	5.760	6.914	0.83
8 Sta. 26 + 433	φ1000	1	1.0	1.537	2.346	0.66
9 Sta. 26 + 932	φ1000	1	1.0	2.020	2.346	0.86
10 Sta. 27 + 176	φ1000	1	1.0	2.247	2.346	0.96
11 Sta. 27 + 537	φ1500	1	1.0	2.964	6.914	0.43
12 Sta. 28 + 385	φ1500	1	1.5	7.048	8.468	0.83
13 Sta. 28 + 871	φ1500	1	1.0	2.608	6.914	0.38
14 Sta. 29 + 627	φ1000	1	1.0	0.104	2.346	0.04

ii) Section VI

The run-off coefficient is 0.30 considering the condition of the site which is shelving and the gradient is around 1 - 3%, Except mountainous place where the run-off coefficient is fix accordingly. 50 years return 24 hours rainfall amount is 95mm (average of Baganuur and Ulaanbaatar).

The culvert arrangement plan in section VI is shown in Table 2-2-2-13.

Table 2-2-2-13 Culvert section/arrangement (Section VI)

	Station	Type	No of pcs	Gradient i %	Design Discharge Qp m3/sec	Discharge Capacity Q m3/sec	Qp/Q
1	Sta. 304 + 206	φ1000	1	1.0	1.647	2.346	0.70
2	Sta. 304 + 600	φ1500	1	1.0	4.181	6.914	0.60
3	Sta. 305 + 530	3.0m*1.5m	1	3.0	30.175	31.724	0.95
4	Sta. 306 + 509	φ1500	1	1.0	5.323	6.914	0.77
5	Sta. 307 + 23	φ1500	2	1.0	10.413	13.828	0.75
6	Sta. 308 + 335	φ1500	2	1.0	11.703	13.828	0.85
7	Sta. 309 + 58	3.0m*1.5m	2	2.3	54.374	55.555	0.98
8	Sta. 310 + 318	φ1500	1	1.0	6.472	6.914	0.94
9	Sta. 311 + 200	φ1500	2	2.0	16.974	19.555	0.87
10	Sta. 311 + 422	φ1500	2	2.5	20.810	21.863	0.95
11	Sta. 314 + 0	φ1500	1	1.0	3.971	6.914	0.57
12	Sta. 315 + 181	φ1500	1	2.0	8.832	9.778	0.90
13	Sta. 315 + 700	φ1500	2	1.0	10.822	13.828	0.78
14	Sta. 316 + 857	φ1500	1	1.5	7.720	8.468	0.91
15	Sta. 317 + 763	φ1000	1	1.0	1.543	2.346	0.66
16	Sta. 318 + 458	φ1500	1	1.0	4.278	6.914	0.62
17	Sta. 319 + 529	φ1500	1	1.0	3.115	6.914	0.45
18	Sta. 320 + 600	φ1500	2	1.0	13.461	13.828	0.97
19	Sta. 321 + 300	φ1500	1	1.0	5.284	6.914	0.76
20	Sta. 322 + 0	φ1500	2	2.5	20.343	21.863	0.93
21	Sta. 322 + 700	φ1500	1	1.0	2.632	6.914	0.38
22	Sta. 323 + 552	φ1000	1	1.0	1.722	2.346	0.73
23	Sta. 324 + 68	φ1000	1	1.0	2.211	2.346	0.94
24	Sta. 326 + 0	φ1500	1	1.0	3.276	6.914	0.47

11) Traffic Safety Facilities

a) Regulatory and Warning Signs

Regulatory and warning signs shall be installed at the following locations.

- Horizontally sharp curve (R≦600m)
- Vertically steep grade (steeper than ±5 %)

b) Guide Signs

Guide signs shall be installed at the following locations.

- Direction at diverging/merging point
- Road station, gas station

c) Road Markings

Road Marking shall be painted for the following lines.

- Centerline
- Roadside line on marginal strip

d) Guard Posts

Guard Post shall be installed at the following locations.

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

e) Kilometer Posts

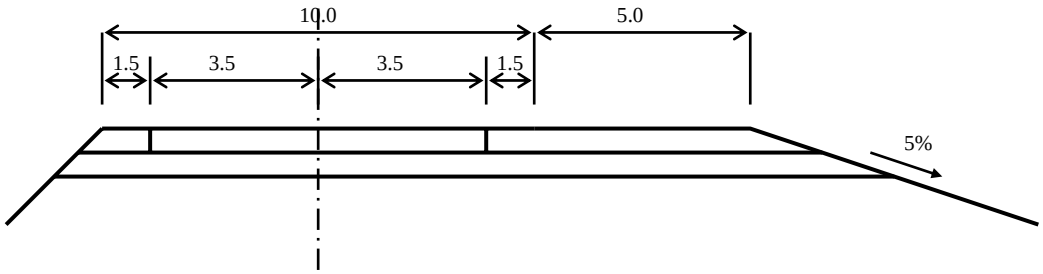
Kilometer posts are installed at 1km intervals.

12) Approach Slope for Local Access

Approach slope shall be provided at the crossing points with following local access.

- Sta.30+300
- Sta.303+300

The slope is planned with maximum 5.0% of grade, 3.0m of width and 5.0m of flat area for car stop and also used for animal crossing.



13) Road-side Station (Michi-no-Eki)

The Road-side Station (Michi-no-Eki) shall be developed at the following location in this project.

- Kherlen River (130km from UB)

On the other hand, it is desirable to develop some more Road-side station (Michi-no-Eki) in whole Eastern Arterial Road since the standard interval of Road-side Station (Michi-no-Eki) is 50 km in Japan. It is proposed to develop Road-side Station (Michi-no-Eki) at the following locations by Mongolia in future.

- Tsenkher River (185 km from UB, 135 km from Undurkhaan)
- Murun River (300 km from UB, 30km from Undurkhaan)

The Road-side Station (Michi-no-Eki) provides parking facilities, rest facility (restaurant, toilet) and gas station. The layout and image of Road-side Station are shown in Figure 2-2-2-15 and Figure 2-2-2-16.

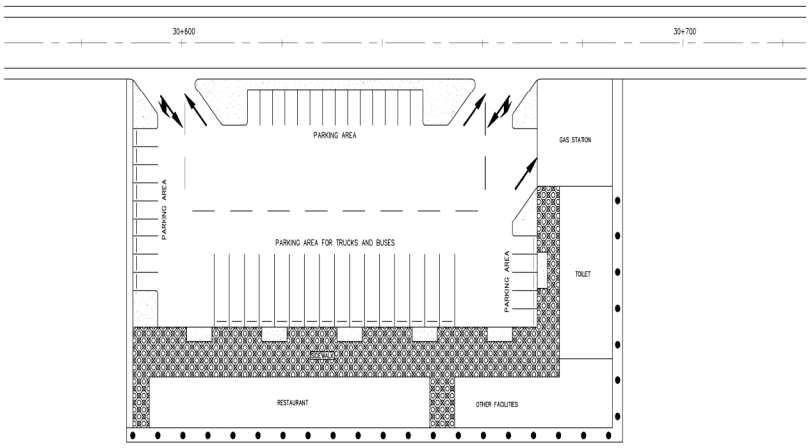


Figure 2-2-2-15 Layout of Road-side Station (Michi-no-Eki)

Figure 2-2-2-16 Image of Road-side Station (Michi-no-Eki)