Mongolia
Ministry of Roads and Transportation (MRT)
Ulaanbaatar City Government (UBC)

PREPARATORY SURVEY FOR THE CONSTRUCTION OF AJILCHIN FLYOVER PROJECT IN ULAANBAATAR CITY

FINAL REPORT

JUNE 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.
CHODAI CO., LTD.
INFRASTRUCTURE DEVELOPMENT INSTITUTE – JAPAN

EI
JR
13-175

AJILCHIN

EXCHANGE RATE

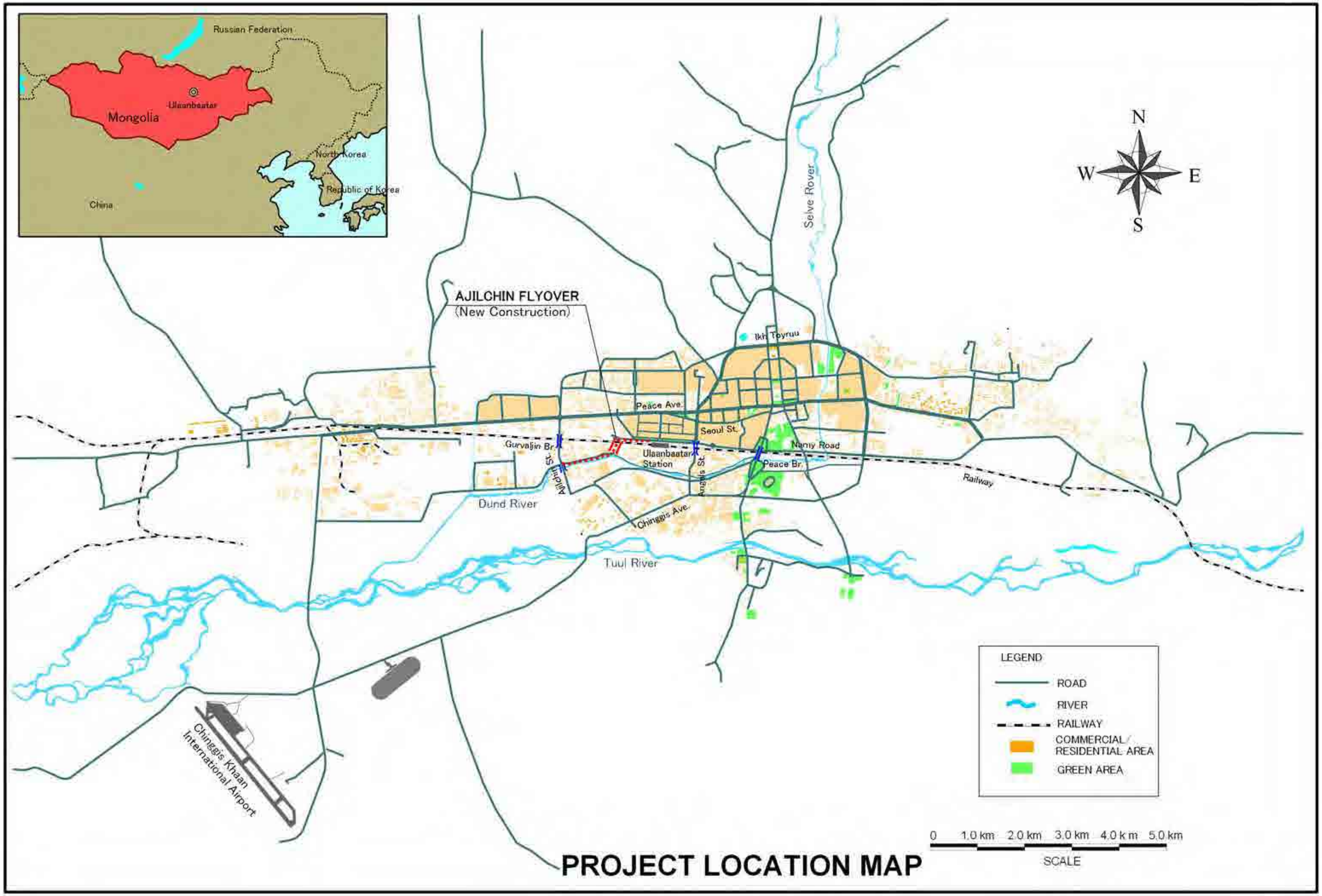
January, 2013

1MNT = 0.06 Japan Yen

1USD = 1390.5 Mongolia Tugrik

1USD = 89.2 Japan Yen

*JICA Exchange Rate



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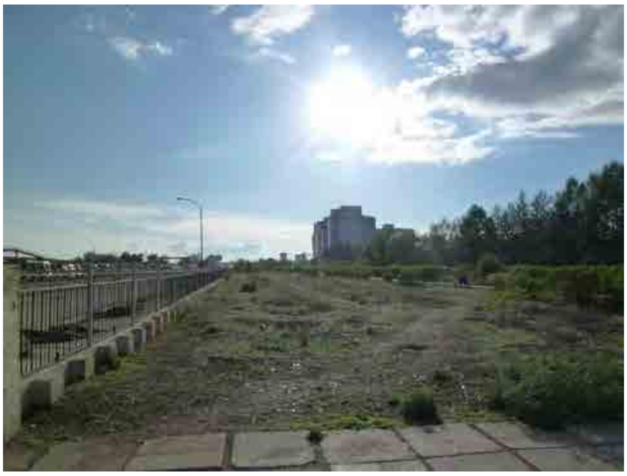

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<EXECUTIVE SUMMARY>

1. GENERAL

In Ulaanbaatar City, the capital city of Mongolia, where more than 40% of the national population is concentrated, traffic volume of vehicles has been rapidly increasing over the past few years in response to economic growth and the trend is expected to continue in the future.

The worsening traffic congestion raises concerns to its adverse negative impact on the socioeconomic development of Ulaanbaatar City. In addition, the limited number of railway crossing bridges hampers the north-south vehicular movement. The railway that runs at the heart of the city from east to west is the most important logistics carrier of the country. The existing three (3) railway crossing bridges experience serious traffic congestions that necessitate development of a new road crossing over the railway.

To address the above-mentioned issue, "the Study on City Master Plan and Urban Development Program of Ulaanbaatar City" (by JICA, 2007 to 2009; hereinafter referred to as "the JICA M/P") was implemented. The JICA M/P recommended that a new road network and public transportation system be established until 2030. The JICA M/P was reviewed and modified by the Construction Urban Development and Planning Department in Ulaanbaatar City (hereinafter referred to as UB M/P) and was approved by the diet in January 2013.

The Construction of Ajilchin Flyover (hereinafter referred to as "the Project") is one of the highest priority projects in the UB M/P, which will eliminate several missing-links caused by railway in the center of Ulaanbaatar City.

To facilitate the realization of the project, the Government of Mongolia discussed with JICA to conduct a preparatory survey for the Project and Minutes of Discussion was concluded between JICA and Government of Mongolia on 7th December 2011.

The objective of the preparatory survey is to collect relevant data and information, prepare project outline, cost estimate, implementation plan, environmental and social impact and so forth for appraisal of the Project under the scheme of Japanese yen loan.

2. CURRENT CONDITION OF SOCIO-ECONOMIC AND ROAD TRANSPORT

2.1 SOCIO-ECONOMIC CONDITION

(1) Economic Condition of Mongolia

After the dissolution of socialist system in 1992, the economic growth of Mongolia has been characterized by low growth until 2000 while it's in the process of development of market economy. However the country achieved stable economic growth from 2001 through 2008 mainly propelled by the export of mineral resources that had favorable price in the global market.

In 2008, the economic growth declined at a negative growth of -1.3%, due to the sudden increase of domestic inflation rate by the steep rise of oil products price and grain price as well as the influence of the global economic crisis partly result of Lehman Shock. Nevertheless, the economic growth in 2011 recovered to 17.3% under the financial support program of the International Monetary Fund (IMF), the World Bank (WB) and the Asian Development Bank (ADB). This was aided by the sound government policy of financial restraint, the economic recovery of China which is the largest export market for Mongolia and the re-ascension of mineral resource prices. In the near future, the economy of Mongolia is expected to have a stable growth in a similar manner before 2008 through the stable increase of the income from resource development such as coal and other minerals.

(2) Economic Growth in Ulaanbaatar City.

From 2007-2011, the growth rate of Gross Regional Domestic Production (hereinafter referred to as "RGDP") in Ulaanbaatar City is 14.1% on average, which far exceeds 7.6% of the GDP in Mongolia. Although GRDP in Ulaanbaatar City in 2008 was just 6.9%, drastic annual growth rate of 21.9% in average has been recorded from 2009 through 2011.

As for the share of GRDP by industry in Ulaanbaatar City in 2011, the share of primary industry is limited to 0.4%, and secondary industry and tertiary industry show high shares at 30.7% and 68.8%, respectively. The share of industry generally continues to be stable from 2006 thus it is estimated that the tendency will continue by increment of trade scale due to development of mineral resources and certain enhancement of transport sectors.

2.2 POPULATION AND CAR OWNERSHIP

(1) Populaion

The national population of Mongolia in the last decade increased from 2,475,000 persons in 2002 to 2,800,000 persons in 2011, i.e. approximately 1.13 times. Meanwhile, the population of Ulaanbaatar City increased from 847,000 persons to 1,201,000 persons, i.e. approximately 1.42 times, in the same period. The population growth rate of Ulaanbaatar City has reached up to 3.96% (annual range of 3.0%-5.5%), which clearly illustrate rapid increase of population inflow from the local region to the urbanized area.

(2) Car Ownership

The number of car ownership in Ulaanbaatar City increases 14.4% in annual average growth in the last decade of 2001-2010. The growth rate increased significantly in 2007-2010. The number of car ownership increased from 48,000 vehicles in 2001 to 162,000 vehicles in 2010, i.e. approximately 3.4 times in the past ten years indicating annual average growth rate of 25.3%.

2.3 CURRENT SITUATION OF THE ROAD NETWORK IN ULAANBAATAR CITY

The road network density in Ulaanbaatar City (6 administrative district excluding satellite towns) is approximately 0.14 km/km^2, which indicates extremely low grade of road improvement ratio compared with major cities in foreign countries. The traffic congestion on main roads in the Ulaanbaatar City is becoming chronic due to rapid increase in car ownership that exceeds 14% per year as described above. Specifically, the daily traffic volumes of 50,000 to 70,000 at "Peace Avenue" which is the only arterial road crossing the inner-city from east to west, and 62,200 at Peace Bridge located on the arterial road connecting north and south in the center of Ulaanbaatar City both observed in May 2012 indicate that current traffic volume has already reached the critical limit of traffic capacity of the respective main roads in Ulaanbaatar City.

On the other hand, the railway running east-west in Ulaanbaatar City is not only an important infrastructure functioning as main logistics system in the country, but also one of the deterrent factors for road traffic by dividing Ulaanbaatar City into north and south regions. Currently, there are only 6 railway crossings in the central city; Peace Bridge, Narny Bridge, Gurvaljin Bridge, and other 3 at-grade crossings.

This situation induces traffic bottleneck at intersections and corresponding access roads near the railway crossings, and is accelerating traffic congestion in the center of Ulaanbaatar City limiting the average traveling speed below 20 km/hour.

As an urgent solution to the above-mentioned problems, another flyover is required to form a part of east-west trunk road network as well as to cross over the railway.

3. TRAFFIC DEMAND FORECAST

3.1 FUTURE SOCIO-ECONOMIC FRAMEWORK IN ULAANBAATAR CITY

The future population of Ulaanbaatar City in 2030 is projected to be 1.739 million under JICA M/P. On the other hand, after the adjustment by the Urban Development Department of Ulaanbaatar Municipal Government, the future population of Ulaanbaatar City (6 districts) is projected to be 1.051 million in 2010 (average annual growth rate of 3.0%), 1.236 million persons in 2020 (ditto 1.6%) and 1.400 million persons in 2030 (ditto 1.3%). The traffic demand forecast during the preparatory survey was conducted on the basis of population frame adjusted by the Urban Development Department of Ulaanbaatar Municipal Government to accommodate the latest master plan. As for prospective GRDP in Ulaanbaatar City, the growth ratio provided in the JICA M/P was applied.

3.2 FUTURE TRAFFIC DEMAND FORECAST

The future traffic demand in 2020 and 2030 “with Project” and “without Project” at major road sections are estimated respectively as follows.

Table 3.2 Future Traffic Demand (Daily Two-Way Traffic Volume) in 2020/2030 in the Future Road Network

Section Number	Daily Two-Way Traffic Volume (Vehicle)			
	2020		2030	
	With	Without	With	Without
①	26,600	-	57,000	-
②	21,000	22,700	24,200	29,700
③	31,600	24,600	52,300	31,800
④	54,600	67,000	51,300	98,800
⑤	50,300	62,300	76,000	115,700
⑥	35,600	35,600	99,300	99,300
⑦	55,200	52,900	103.900	100,800

⑧	22,100	21,900	45,300	47,400
⑨	6,900	8,500	13,100	15,500
⑩	22,600	28,600	46,200	50,200
⑪	26,700	21,200	49,200	44,600
⑫	44,300	46,600	70,300	72,400
⑬	11,800	23,000	25,300	24,800
⑭	33,400	31,600	64,100	62,900
⑮	30,000	34,400	53,300	63,400
⑯	29,900	37,100	55,300	67,900
⑰	25,500	28.000	40.000	40,200

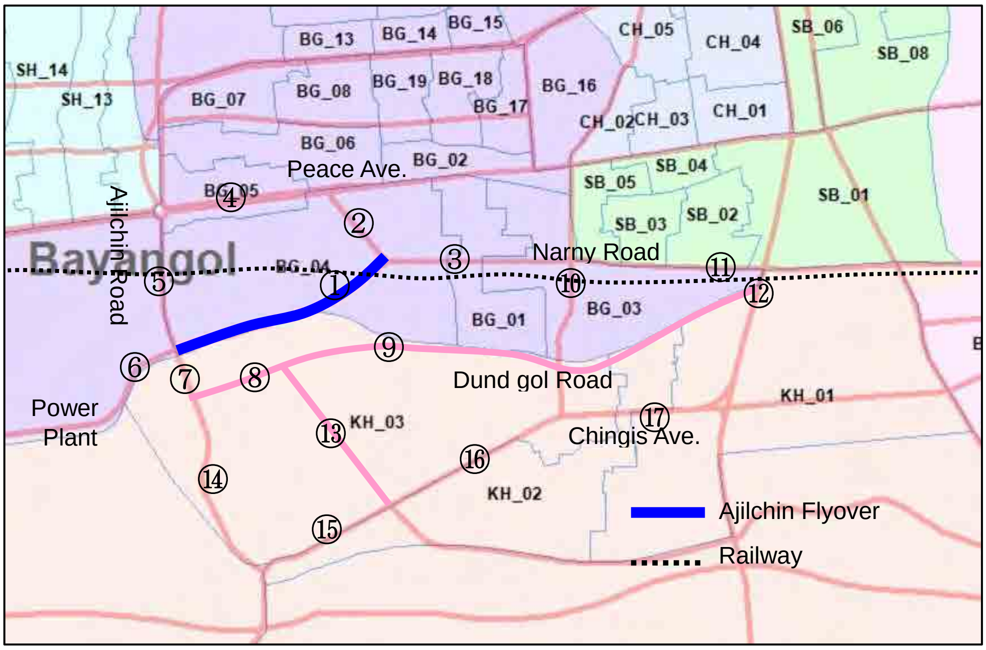


Figure 3.1 Location of Future Traffic Demand in Future Road Network

Based on the above forecast, the construction of Ajilchin Flyover will facilitate 26,600 and 57,000 vehicle traffics in 2020 and 2030, respectively, and will further have a significant effect on the alleviation of traffic congestion at ④Peace Avenue and three (3) existing railway bridge crossings; namely ⑤ Gurvaljin Bridge, ⑩ Narny Bridge and ⑫ Peace Bridge.

4. NATURAL CONDITIONS

4.1 CLIMATE

Ulaanbaatar City has a continental climate, which is characterized by a cold climate from October to April with an average temperature of about 0°C or below (daily lowest temperature in January is -40°C) and a long spell of hot summer (daily highest temperature is 40°C) from May to September. Furthermore, daily temperature fluctuation reaches as large as 30°C to 40°C. Humidity exceeds 70% in winter season from November to February, and is less than 60% in March through October.

Based on meteorological data for the past 14 years (1998 to 2011), the annual average precipitation is 247.8 mm/year. As for monthly precipitation, they have comparatively large amounts of rain from May to September with the maximum monthly average precipitation occurring in July at 58.6 mm/month. The maximum monthly precipitation amount in the past 14 years is 137.7 mm/month in August 2000. Focusing on daily precipitation amounts, the maximum amount is 44.8 mm/day in July 2009.

4.2 GEOLOGICAL CONDITION

The geological formation of the Project site is classified as Diluvium and Alluvium of Quaternary Period in Cenozoic mainly consisting of loose sand, clayey gravel and sand with boulder (maximum diameter of 75mm).

As a result of boring investigation at 11 locations in the Project site, embankment consisting of a gravel layer with clay and sand exist with 1 - 2m thick. Especially, the top layer of embankment up to one meter deep from the surface is loose. Relatively dense sand and gravel bearing boulders underlies with 4 – 8m thick. Groundwater level is stably observed at around 3.2 – 4.5m below existing ground surface (approx. elevation of 1,275m). No permafrost soil was observed in the Project site.

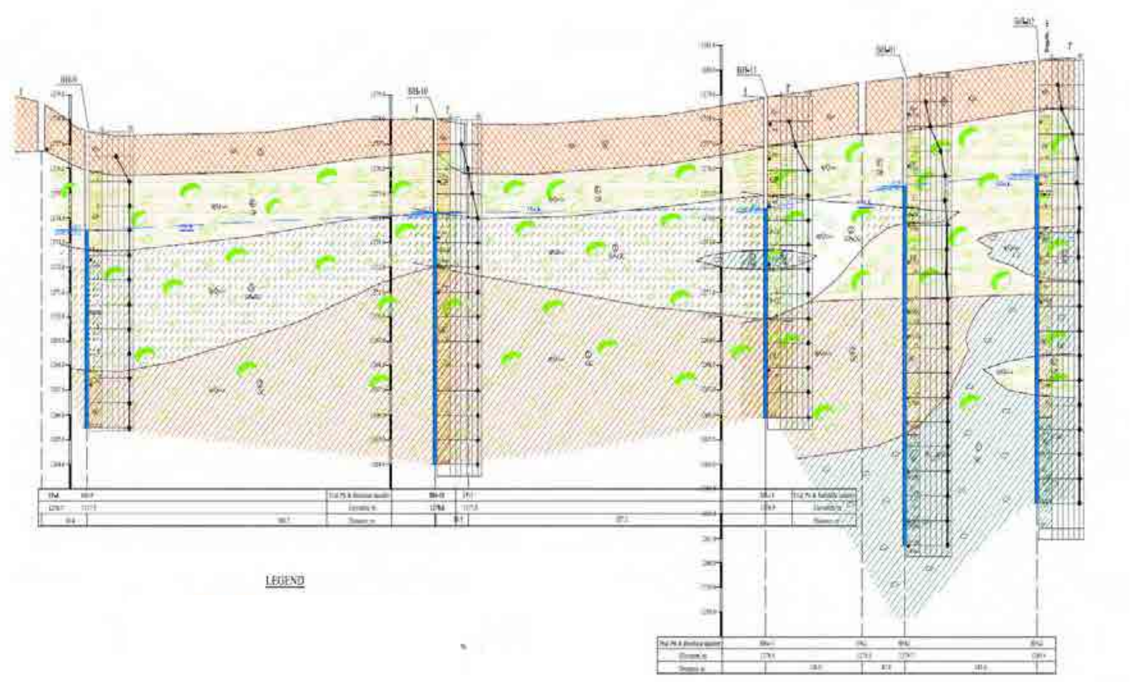


Figure 4.2 Geological Section of Project Site

5. ROUTE SELECTION FOR AJILCHIN FLYOVER

5.1 STUDY OF BRIDGING ROUTE

Alternative routes of Ajilchin Flyover are proposed as 1) East-West Route (from Narny Road to West Industry Road) and 2) North – South Route (from Narny Road to Dund gol Road). The results of the comparative study during the preparatory survey indicated that the East-West Route is the best possible option because of the aspects of traffic safety, project feasibility and environmental issues.

1) Higher traffic demand is expected on East West Rout. (E-W; 57,000vehicle/day, N-S; 41,000vehicle/day)
2) No resettlement and less compensation for land and facilities expected on East West Rout.
3) Higher traffic safety is expected on East Wes Route due to crossing condition of railway feeder line.

5.2 DEFINITION OF PROJECT AREA

(1) Starting/Ending Points of Project

Starting point: Intersection between Ajilchin Street and West Industrial Road

Ending point: Intersection of Narny Road in front of Ulaanbaatar Railway Station

(2) Flyover: From Narny Road to West Industrial Road.

(3) Access Road

North Side: Since widening of Narny Road from 2-lane to 4-lane is ongoing, the area of access road for Ajilchin Flyover shall be adjusted to the widening plan.

South Side: West side from the railway feeder line to Power Plant No.3 to the intersection with Ajilchin Street.

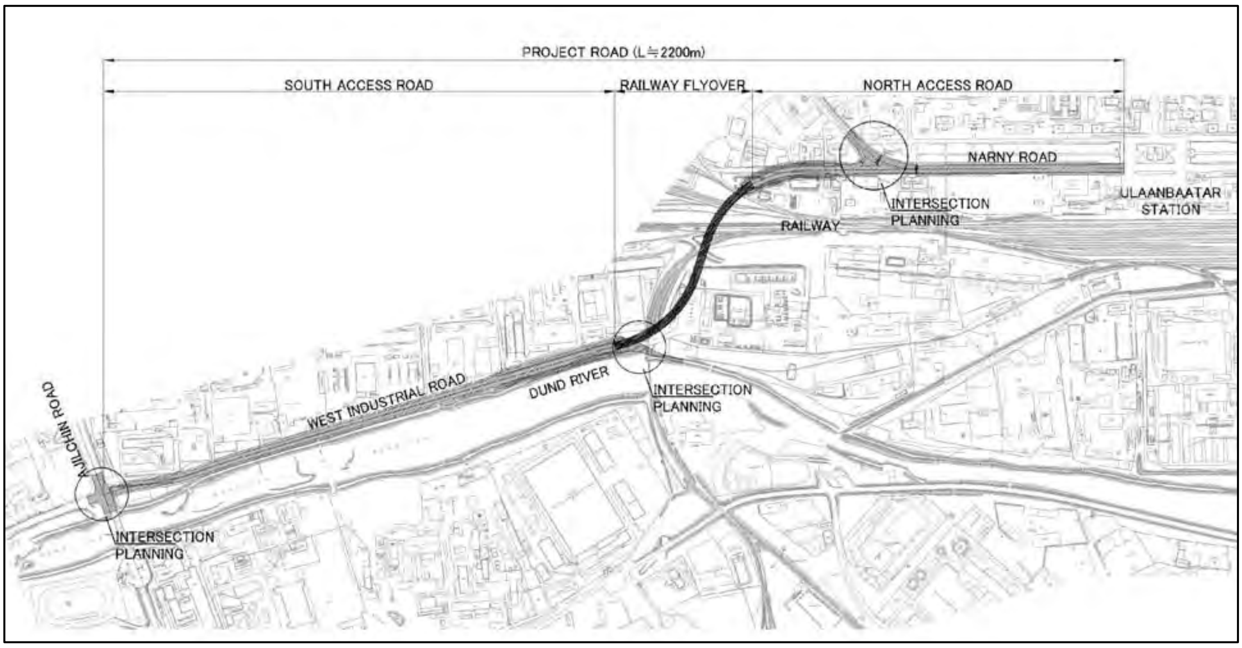


Figure 5.1 Project Area

6. UTILITY RELOCATION PLAN

As the result of utility survey and subsequent discussion with related utility administration offices, the following relocation works have been identified to be necessary for smooth implementation of the Project. Underground utilities will be relocated principally to outside of carriage way such as under the sidewalk for easy maintenance.

Table 6.1 Utility Relocation Plan

Type	Type (Title)of Utility	Specification	Relocation Plan	Implementation
Heating Pipe	SOT-3	ø350mm x 2	Relocate to cross the new road ensuring regulated vertical clearance (H=5.0m)	After Land Acquisition
Electricity	Underground cable at Intersection of Narny Road	10 kV x 2 L=250m	Relocate to sidewalk at south side of new road.	After Land Acquisition and Relocation of Railway Facility
	Underground cable in the existing river dike along Dund River	10 kV x 2 L=500m	Relocation to new traffic strip.	Before Land Acquisition
	Underground cable at intersection with West Industrial Road.	10 kV x 2 L=50m	Elevation shall be change in accordance with new road profile..	Before Land Acquisition
	Cables along Water Pipe crossing Dund River.	10 kV x 4 L=50m	Elevation shall be change in accordance with new road profile.	Before Land Acquisition
	Underground Cable at intersection with Ajilchin Road.	10V x 1 L=100m	Elevation shall be change in accordance with new road profile..	Before Land Acquisition
	POL-J 42/1x120-240	35kV L=250m	Relocate to under the new side walk along Narny Road.	After Land Acquisition and Relocation of Railway Facility
	Underground High Voltage Line	ø50(x2) 5000V L=30m	Relocate to northern side where is in the side of private facility near P2.	Before Land Acquisition
		ø50(x2) 5000V L=20m	Relocate with protection at the location of water pipe bridge to withstand new road widening.	Before Land Acquisition
	Low Voltage Overhead Line and Poles	220V L=1200m Pole 16pcs	Relocate the overhead cable and poles along existing dike to road side of West Industrial Road.	Before Land Acquisition
Water Supply and Sewage	Water Supply Steel Pipe	Ø500 L=20m	Relocate to cross the new road and dike with appropriate clearance.	After Land Acquisition

	Sewage Pipe (Under Construction)	ø1200 L=380m	Relocate the extent interfered by bridge foundation to north side side-walk of new road.	After Land Acquisition and Relocation of Railway Facility
	Sewage Pipe (No.24)	ø600 L=380m	Relocate to under the side walk on the north side subjecting to the section interfering in piers/foundations of bridge.	After Land Acquisition and Relocation of Railway Facility
Communication	Main Cable	M1-7-14 SC1-7-13 SD10-2-3 SD10-2-4	Deepen to withstand the improvement of intersection at Ajilchin Street.	Before Land Acquisition
		81(0) L=60m	Re-routing along West Industry Road	After Land Acquisition
		55(B) L=220m	Re-routing along railway feeder line.	After Land Acquisition
Railway Facility	High Voltage Underground Line	9.6kV 3x185: 20m 6.0kV 3x185: 20m 6.0kV 3x185: 5m No5 3x240: 5m No6 3x240: 5m Joint: 10 Locations	Re-routing in the Railway Premises to avoid piers.	Before Land Acquisition
	Fiber Optics Cable for Communication	Ø130x2 L=200m	Relocate to northern side walk to avoid P9-P11.	After Land Acquisition
	Communication Cable for Traffic Sign	Ø4x4	Re-routing in the Railway Premises to avoid piers.	Before Land Acquisition
	Heating Pipe for Railway	Ø300x2 L=250m	Relocate to railway premises at south side of new road or to under the new side walk.	After Land Acquisition
	Water Supply	Ø150 L=750m Protection Cover Valve ϕ 200 x 2 Valve ϕ 1000x1 Joint ϕ 200 x 12	Relocate to southern side of new road in railway premises. Pipe shall be under passing of Railway.	Before Land acquisition
Total				

7. DESIGN OF FLYOVER AND ACCESS ROAD

7.1 ROAD PLAN

The geometric design criteria and conditions adopted for this Project are set as follows.

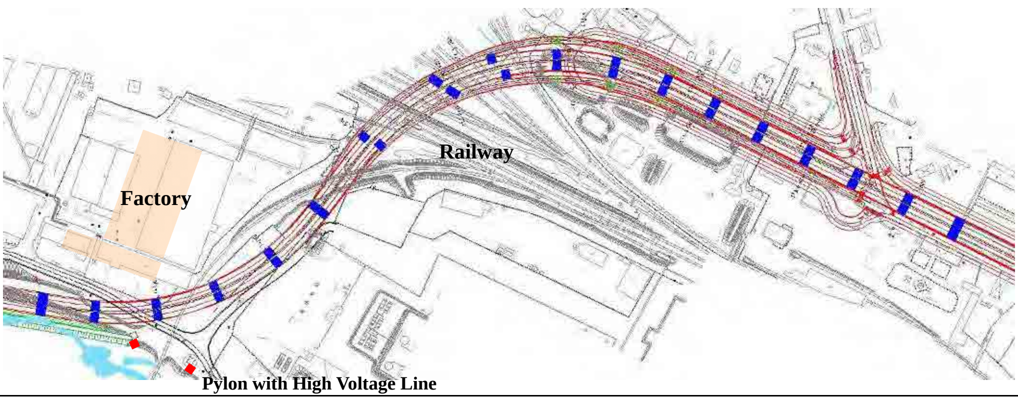
Table 7.1 Road Design Criteria

Item		Main Road	ON-OFF Ramp	Remarks
Design Speed V km/hour		60	40	
Lane Width m		3.5	3.25	
Median Zone (Marginal Strip) m		2.0 (0.25)	–	
Shoulder Width	General Part (m)	1.0	–	
	Bridge Part (m)	0.50	1.50 (External Side) 0.75 (Internal Side)	
Minimum Curve Radius R		200m	160m	
Maximum Super-elevation e%		4%	4%	
Minimum Radius without Super-elevation		2000 (Standard Grade 2%)	800	
Minimum Horizontal Curve Length		100 (θ<7:700/θ)	70	
Easement Curve	Curve Length	35	35	
	Minimum Parameter	90	35	
	Minimum Radius without Clothoid Curve	500	140	
Maximum Longitudinal Grade		4.5%	4.5%	
Vertical Curve	Crest	1400	450 (Minimum Value)	
	Sag	1000	450 (Minimum Value)	

7.2 BRIDGE PLAN

Pier location and span arrangement are as follows.

Table 7.2 Summary of Bridge Plan

<table>
<tr><td></td><td>Flyover Section</td><td>Narny Road Section</td></tr>
<tr><td>Plan</td><td colspan="2">
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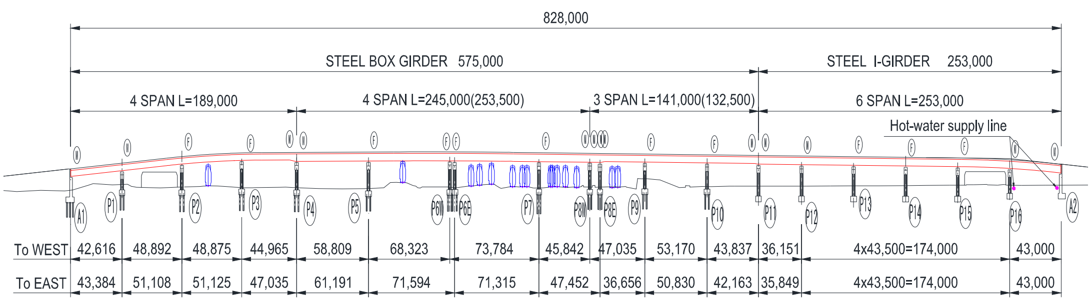
<tr><td>Profile</td><td colspan="2">
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7.3 BASIC DESIGN CONDITIONS OF BRIDGES

The basic design conditions for bridges are set as a follows.

Table 7.3(1) Bridge Design Criteria-1

Planned Location		Narny Road to West Industry Road, in Ulaanbaatar City
Bridge Length		828 m
Standard Road Width		8.0 m
Horizontal Alignment		A=100 ~ R=200 ~ A=100 ~ R=200 ~ A=100 ~ ∞
Design Live Load		B-Live Load in Specifications for Highway Bridges by Japan Road Association
Thermal Load		-40℃≦T≦40℃
Design Horizontal Seismic Coefficient		Level 1 Earthquake Motion: kh = 0.10, Level 2 Earthquake Motion: kh = 0.50 (Own Natural Period: Approximately 0.4 seconds)
Superstructure	Type	Each Line Separated Structure (Main Line) Continuous Structure Twin Box Girder, Continuous Structure Steel I Girder (Ramp Section) Multi-span Continuous Box Girder
	Slab Type	Steel-Concrete Composite Deck Slab: Slab thickness is 210 mm to 250 mm.
	Bearing Type	Steel bearing
Sub-structure	Abutment and Pier	Reversed T Type Abutment, Overhang Type Cylindrical Pier, Rigid Frame Pier
	Foundation	Rotary Penetration Steel Pipe Pile: φ1000, Spread Foundation
	Bearing Stratum	GP-GC Layer

Materials to be applied for bridge design should conform to the following standards.

Table 7.3(2) Bridge Design Criteria-2

Material	Applied to	Specification
Concrete	Abutment, Pier, Wall Rail	σck=24 N/mm2
	Steel-Concrete Composite Deck Slab	σck=30 N/mm2
Reinforcing Bar		SD345 (JIS)
Steel for Structure	Superstructure	SM520, SM490Y, SM490, SM400, SS400 (JIS)
Steel Pipe for Structure	Rotary Penetration Steel Pipe Pile	SKK490 (JIS)

7.4 RESULTS OF DESIGN

Results of bridge and road design in this study are summarized as below.

Section	Item	The contents of the facility and renovation
1. Bridge Section		
	Superstructure	【No.1 Bridge】 4 span continuous multi box steel girder (L=189m, W=8.89m, Each lane separated structure) 【No.2 Bridge】 4 span continuous multi box steel girder (L=245m, W=8.89~17.2m, Each lane separated structure) 【No.3 Bridge】 3 span continuous multi box steel girder (L=141m, W=8.89m, Each lane separated structure) 【No.4 Bridge】 6 span continuous steel I girder (L=253m, W=8.89m, Each lane separated structure) 【ON Ramp】 3 span continuous steel box girder (L=150.9m, W=6.39m) 【OFF Ramp】 3 span continuous steel box girder (L=123.6m, W=6.39m)
	Deck Slab	Steel Concrete Composite Slab (A=18,150m^2)
	Erection Method	Crane vent method and Launching erection method (Above railway tracks)
	Substructure	Abutment: Reversed T Abutment, n=4 (Main bridge: n=2, Ramp: n=2)

Section	Item	The contents of the facility and renovation
		Pier: (P1~P5, P9~P16) Cylindrical Pier (with Beam), n=30 (Main bridge: n=26, Ramp: n=4) (P6~P8) Frame rigid with cylindrical pier, n=6 Foundation: (A1~P10) Rotary Penetration Steel Pipe Pile (φ1000, t=14mm, n=167, L=897m), (P11~A2) Spread Foundation, n=12
	Accessory	Road lighting, Drainage, Heat insulating plate, Guard fence, Unseating prevention device
2. East Approach Road		
	Road Length	Main road: 515 m【With earth wall: 167m, Without earth wall: 348 m】、 Side road: 700 m【North side: 350m, South side: 350m】, Service road: 510m
	Other Facility	Drainage, Guard fence, Road marking, Street lighting, Anti-skid pavement, Gravity retaining wall, Reinforced earth wall (Terre Arme)
3. West Approach Road		
3.1 Approach Road		
	Road Length	1000 m【With earth wall: 167m, Without earth wall：833m】
	Other Facility	Drainage, Road marking, Street lighting
3.2 Levee Construction		
	Levee Length	915 m (Crown width: 3.0m, Slope Gradient: 1:2.0)
	Other Facility	Concrete covering slope, Ramp way to Dund river
3.3 West Industrial Road		
	Road Length	1,370m
	Other Facility	Drainage, Guardrail, Road marking, Street lighting
4. Intersection:		
	Location	5 locations: Beginning of this project, Connect with west industrial road, Crossing with railway feeder line, Under grade separation at Narny road, End of this project
	Other Facility	Drainage, Road marking, Street lighting, Traffic light

7.5 APPLICATION OF JAPANESE TECHNOLOGY

In implementing this project, it is crucial to apply the following Japanese technologies to achieve successful completion of the construction work. Significance of these technologies has been verified in the construction work of Narny Bridge completed in November 2012 under Japan's Grant Aid.

(1) Rotary Penetration Steel Pipe Pile Method

Ajilchin Flyover has a road alignment which strides over the railway premises where the railway main lines and feeder lines are closely laid. Therefore, multiple piers need to be placed in the railway premises despite railway tracks are closely laid and limit space for arranging the piers. The rotary penetration steel pipe pile method enables to conduct construction in a limited space without harmful impact against railway operations.

(2) Rational Structure Bridge

It is necessary to consider the site conditions, i.e. it is not possible to conduct construction work in winter and it is strongly required to safely conduct girder erection work above railway tracks. Therefore, steel concrete composite slab and steel rationalized girder structure need to be adopted to reduce site works as well as to take advantage of fabrication in winter period.

(3) Launching Erection Method

Erection work above railway tracks shall have no influence to railway operations, and thus launching erection method applied for Narny Bridge is the best way to erect girders above railway tracks. It is required high level construction technology because road alignment has a tight 200m radius.

8. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

8.1 PROCEDURE FOR ENVIRONMENTAL IMPACT ASSESSMENT

(1) Status of GEIA for the Project

The Road Department of Ulaanbaatar City Government submitted a GEIA application to MNET on 05 April 2012. As a reply, MNET provided the department with the result of GEIA on 26 April 2012, as per attached, with instruction to carry out the DEIA.

(2) Latest Status of DEIA

DEIA for the Project was executed with assistance of Ulaanbaatar City and JICA Survey Team. The DEIA report, following confirmation by Ulaanbaatar City, was submitted to Ministry of Environment and Green Development (re-named from MNET by restructuring of government organization) on 07 December 2012 and was concurred in January 2013.

8.2 RESULT OF DEIA

The following table proposed mitigation measures for expected environmental impact for the Project.

Table 8.1 Prospective Environmental Impact and Mitigation Measures for the Project

Stage	Issue	Mitigation or Safeguard Measures	Executing Organization (Responsible Organization)
During Preparation/ Construction	Air Quality	• For dust emission reduction, (i) use sheet covers and (ii) spray water on construction sites and material handling areas where dust is generated. • For mitigation of negative impacts from vehicle emissions, (i) plan routes and timetable carefully, (ii) comply with the speed limit, and (iii) conduct maintenance activities of vehicles and machinery appropriately.	Construction company (PIU) Construction company (PIU)
	Waste Management	• Recycle construction residuals as much as possible. For the un-recyclable construction waste and soil, hand over them to the approved contractors and make sure that they are disposed at the disposal site designated by UB City Government.	Construction company (PIU)
	Soil Contamination	• Appropriately store chemicals and hazardous materials such as oils for construction machinery.	Construction company (PIU)
	Noise and Vibration	• Use low-noise and low-vibration machinery and apply such methods. • Use mobile noise barriers and comply with the environmental standard on noise. • Carry out any other measures which mitigate noise and vibration, i.e., (i) restrict construction activities at night, (ii) plan carefully routes and timetable of construction vehicles and (iii) appropriate maintenance of construction machinery and vehicles. • Monitor noise and vibration around construction sites.	Construction company (PIU) Construction company (PIU) Construction company (PIU) Construction company (PIU)
	Topography and Geology	• Design access road to minimize difference of elevation between access road and the existing road.	Detailed design consultant (PIU)

		• Ensure conformity with the Dound River embankment planned by UB City Government.	Construction company (PIU)
	Resettlement	• Conduct land acquisition appropriately by Department of Road and Department of Land Administration in accordance with Resettlement Report prepared by the JICA Survey Team.	UB Land Dept. (PIU)
	Existing social infrastructures and services	• Pay special attention to routes and timetable of construction vehicles and place traffic control officers in order not to cause traffic jam. • Apply methods which requires least time for flyover construction above the railway, and coordinate with the railway authority in order to minimize the construction impacts to railway timetables. • Secure users' access to existing facilities along the access roads.	Construction company/ Traffic police (PIU) Construction company (PIU) Detailed design consultant
	Landscape	• Consider applying a method with many piers and less walls, which secure least-obstructed view. • The expansion of access road along Narny Zam near the Ulaanbaatar central station will require felling of trees. Transplant stumps/ roots of such trees if possible or replant similar trees.	Detailed design consultant PIU
	Working Conditions (Occupational Safety)	• Pay attention to working conditions and occupational safety of construction workers in line with Mongolian laws and regulations and take measures in accordance with international standards on occupational health set by International Labor Organization, if necessity arises.	Construction company (PIU)
	Accident Prevention	• Measures to prevent work-related accidents are mentioned above. • Consult and coordinate with traffic police before the construction starts, and follow their advices. • Place traffic control officers near exit/entrance points of traffic vehicles in order to secure pedestrians' safety and avoid traffic jam.	Construction company (PIU) Construction supervising consultant/ PIU Construction company
During Operation	Noise and Vibration	• Consider employing consecutive bridge-girder method which requires fewer joints; as a result, noise and vibration caused by running over joints will be minimized. • Monitor noise and vibration around the project site, and take necessary measures such as placement of noise barrier, if necessity arises.	Detailed design consultant PIU/Road Dept. of UB City
	Poverty	• Secure sidewalks for pedestrians along the access roads.	Detailed design consultant
	Existing social infrastructures and services	• Take safety measures such as placement of traffic lights and traffic signs of speed limits, etc, and also construction of medians.	Detailed design consultant/ Construction company

8.3 LAND ACQUISITION AND RESETTLEMENT FOR THE PROJECT

The following are major findings from the preparatory survey.

1) "Possessed Land" are subject to the land acquisition for the Project. No owned land and or private land locate in the Project site.

2) The Project will not induce involuntary resettlement.

Table 8.2 and Table 8.3 respectively show the area of lands to be acquired and facility to be relocated and/or compensated. Table 8.4 illustrates proposed implementation schedule for land acquisition issues.

Table 8.2 Area of Land Acquisition

Item No.	Possessor	Land Use	Area to be acquired (m^2)
PAP-02	SJBU LLC	Commercial	63.2
PAP-03	UB Railway Mongolian-Russian Joint Venture	Commercial	375.6
PAP-03(2)	UB Railway Mongolian-Russian Joint Venture	Green tract	3410
PAP-05	Railway Department 2	Commercial	1,919.1
PAP-06	Railway system's Commercial business center	Commercial	4,701.8
PAP-07	Just Group LLC	Commercial	512.4
PAP-08	Railway Fire Station	Railway facility	1,890.0
PAP-09	Road transport service center of Railway	Railway facility	1,786.4
PAP-10	Khuvsgul Trade LLC	Commercial	687.5
PAP-11	Tsuurden LLC	Commercial	797.6
PAP-12	Gatsuurt LLC	Commercial	147.7
PAP-13	NOTS LLC	Commercial	2,797.2
PAP-14	Mon Carotage LLC	Commercial	1230
PAP-15	Erdenebaatar	Commercial +Housing*	400.0
PAP-16	Erdenebayar	Commercial	488.2
PAP-17	Mongol Tulkhuur LLC	Commercial	559.6
Total			21,766

Source: JICA Survey Team
* No relocation is required.

Table 8.3 Affected Facilities and Buildings

No.	Type of Structure	Unit	Quantity	Remarks
PAP-01	Steel Fence w/concrete foundation	m	50	
PAP-02	Steel Fence w/concrete foundation	m	20	
PAP-03	Steel Fence w/concrete foundation	m	120	
PAP-03(2)	Steel Fence	m	477	
PAP-04	Gas Station (Roof and Petrol Pump)	L.S.	1	
PAP-05	Fuel Storage Tank	L.S.	1	
	2 Story building	m^2	2,304	1 Nos

	Brick Building	m^2	106.2	3 Nos.
	Cement square	m^2	54.6	
	Removable Concrete Panel	M	117	
	Steel Fence w/concrete foundation	m	26	
	Wooden Garage	m^2	1100	1 Nos.
PAP-06	Warehouses for vegetable storage pit	m^2	2,138	3 Nos.
	Removable Concrete Panel	M	220	
PAP-08	Office Building	m^2	1206.6	1 Nos.
	Shelter (corrugated-roof)	m^2	12.6	1 Nos.
	Cement square	m^2	124.5	
	Fountain	Nos.	1	
	Steel Fence w/concrete foundation	M	235	
PAP-09	2 story building for office	m^2	829	1 Nos.
	Guard Post	m^2	62	2 Nos.
	Cement square	m^2	135	
	Wooden fence／wire net	M	210	
PAP-10	Removable concrete panel	M	65	
	Steel Fence w/concrete foundation	M	16	
PAP-11	Concrete Block Building	m^2	15	1 Nos.
	Latrine	Nos.	1	
	Steel Fence w/concrete foundation	M	176	
PAP-12	Removable Concrete Panel	M	44	
PAP-13	Building	m^2	245.6	1 Nos.
	Pre-fabricated building	m^2	1000	1 Nos.
	Bick Building	m^2	50	1 Nos.
	Garage (Brick)	m^2	72.5	1 Nos.
	Cement square	m^2	120	
	Iron shed for high-voltage facilities	Nos.	1	
	Latrine	Nos.	1	
	Water kiosk	Nos.	1	
	Steel Fence w/concrete foundation	M	320	
PAP-14	Pre-fabricated building	m^2	133	1 Nos.
	Brick building	m^2	36	1 Nos.
	Green House	m^2	288	2 Nos.
	Latrine	Nos.	1	
	Removable Concrete Panel	M	244	
PAP15	Wooden Fence	M	37	
PAP-16	Wooden Building	m^2	52	2 Nos.
	Latrine	Nos.	1	
	Wooden Fence	M	53	
PAP-17	Steel Fence w/concrete foundation	M	150	

Table 8.4 Implementation Schedule for Land Acquisition

Work Items	1st Year				2nd Year				3rd Year				4th Year				5th Year				6th Year			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Detailed engineering design		■	■	■	■																			
Tender and construction						▒	▒	▒	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Public consultation					■																			
Cadastral survey			■																					
Identification of affected plot and buildings			■																					
Review of Land Acquisition and Resettlement Plan				■																				
Valuation of compensation cost				■																				
Disclosure of compensation framework to PAPs					■																			
Approval for land acquisition plan				■																				
Processing of payment					■																			
Securing land for relocation						■	■																	
Restoration of affected structures on the remaining land and/or replacement land							■																	
Implementation of livelihood rehabilitation measures								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Internal monitoring		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
External monitoring				■				■				■				■								
Formation of Grievance Redress Committee				■																				

9. CONSTRUCTION PLAN

9.1 BASIC POLICY OF THE CONSTRUCTION PLANNING

(1) Procurement of Materials and Equipment and Work Schedule

As site construction work can be implemented only in the period between May and September, shop fabrication and procurement and transport of materials and equipment will be implemented during the rest of the year. A plan with careful consideration for the efficient implementation will be formulated so that the project can be completed in the shortest schedule. Such construction materials as concrete, asphalt, etc. will be procured from the closest existing plants as much as possible.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Construction period	Severe winter season				Period for outdoor construction work					Severe winter season		
Rainy season						Rainy season						
Activities	Shop fabrication and transport of materials and equipment				Concrete work, paving work and girder erection work					Shop fabrication and transport of materials and equipment		

Figure 9.1 Basic policies for the formulation of work schedule

(2) Bridge Girder Erection Methods

Either the "launching erection method" or the "crane erection method" will be applied for construction of the viaduct in accordance with the positional relation between the construction sites, the railway lines and the existing roads. Although the schedules of international passenger trains on the main tracks cannot be changed, those of freight trains may be rescheduled for the construction work subject to prior coordination with the railway company. It is estimated that the length of such time in which trains can be stopped (window time) is approx. six hours per day.

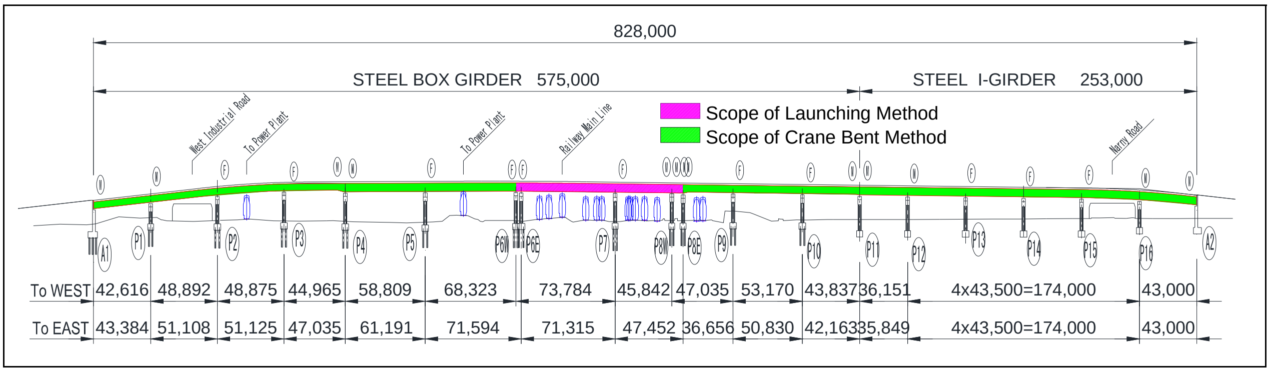


Figure 9.2 Girder erection methods for the construction of the viaduct

9.2 WORK SCHEDULE

Work schedule for the construction is shown in Figure 9.3. Total construction period will be 48 months.

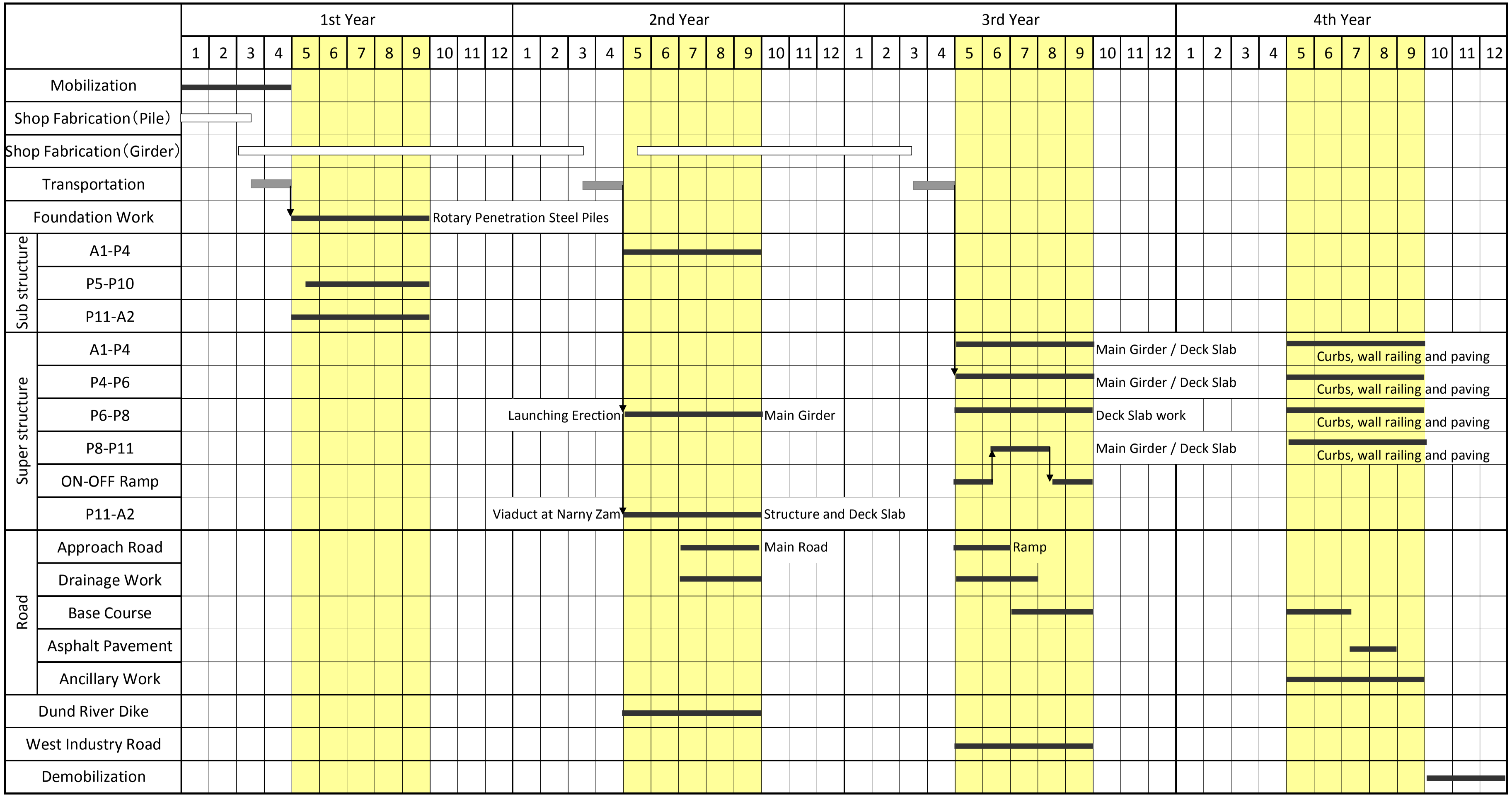


Figure 9.3 Schedule of Construction Work

10. OPERATION AND MAINTENANCE SYSTEM

10.1 INSTITUTIONAL FRAMEWORK OF PROJECT IMPLEMENTATION

According to “the Law of Mongolia on Coordination of Foreign Loans and Grant Aid (2003)”, it is stipulated that Project Implementation Unit (PIU) shall be organized in the implementation agency (e.g. Ministry of Roads and Transportation for the Project) to manage implementation of the individual project financed by foreign loan and/or grant aid.

For implementation of road projects in Ulaanbaatar City, Ulaanbaatar City has to play a role as an implementing agency such as coordination with connecting roads improvement, drainage plans, relocation of underground utilities and land acquisition. Therefore, it is important that a PIU shall be organized at the starting time of the detailed design with the staff members of the Road Department and Engineering Facility Office in charge of utility relocation and Land Administration Office in charge of land acquisition.

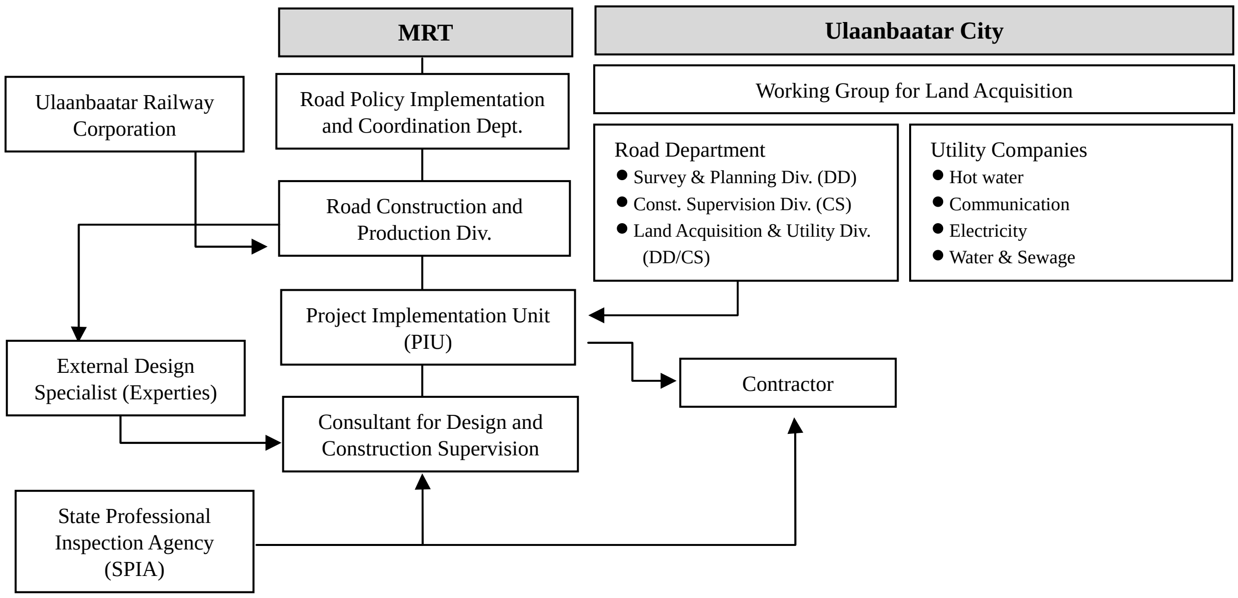


Figure 10.1 Institutional Frame of Project Implementation

10.2 MAINTENANCE SYSTEM

After completion of the Project, maintenance is managed by the Road Department in Ulaanbaatar City. As special maintenance work without routine maintenance such as cleaning and minor repair of surfacing of the bridge is not required for the Ajilchin Flyover for 10-20 years after construction, it is expected that Ulaanbaatar City will accumulate and improve their technologies necessary for steel bridge maintenance through several opportunities such as Technical Cooperation Scheme by JICA.

11. PROJECT COST ESTIMATE

Table 11.1 Summary of Project Cost

(Confidential)

Table 11.2 Annual Fund Requirement

(Confidential)

12. ECONOMIC EVALUATION

12.1 PROJECT BENEFIT

(1) Road Network for Evaluation

(Confidential)

(2) VOC and Time Value

(Confidential)

12.2 RESULT OF ECONOMIC EVALUATION

(Confidential)

13. ROAD BRIDGES CONDITION IN ULAANBAATAR CITY

(1) General

The bridge condition survey was implemented on existing 67 road bridges in Ulaanbaatar City. Soundness and seismic resistance was analyzed and evaluated for each bridge on the basis of inventory survey (collection of drawing data), visual inspection of structures, measurement of major structural dimensions, concrete strength, bar arrangement and grade of damage.

(2) Survey Result

Among all bridges in Ulaanbaatar City, most of which are Reinforced Concrete Bridges, with one steel bridge and one wooden bridge. The oldest bridge was constructed in 1960 and about 25% of all bridges were constructed more than 30 years ago. Regarding soundness of bridges, serious damages to be repaired urgently were observed in seven bridges (10% of all bridges), damages to be rehabilitated were observed in 48 bridges (72% of all bridges). Regarding seismic resistance, a relatively small number of bridges would be considered high risk due to the limited height. However, five bridges (7% of all bridges) have serious issues on safety and thus require certain measures on enhancement of seismic resistance.

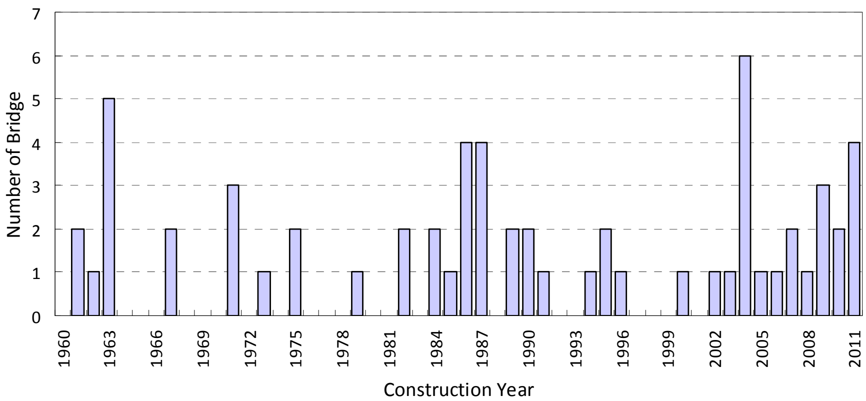
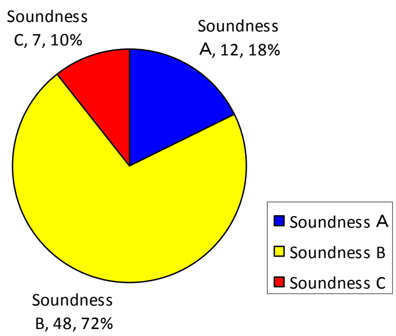
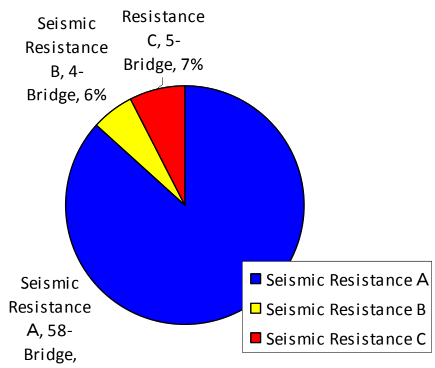


Figure 13.1 Construction Year of Road Bridge in Ulaanbaatar City



A: less damage and problems in bridge soundness
B: some damage but the risk of the entire bridge is low
C: damages in the wide area and low soundness

Figure 13.2 Summary of Bridge Soundness



A: Less problem in earthquake resistance
B: Seismic resistance is partially deteriorated.
C: low earthquake resistance

Figure 13.3 Summary of Seismic Resistance

14. PROJECT IMPLEMENTATION PLAN

(Confidential)

(Confidential)

15. PROJECT EFFECT

15.1 OPERATION INDICATOR

Daily traffic volume (vehicles/day) is defined as an indicator to quantitatively measure operational indicator of the Project.

Table15.1 Daily Traffic Volume as Operation Indicator for the Project

		Base Line (as of 2012)	2021 (vehicles/day)	
			WO/ Case	W/ Case
1	Ajilchin F.O.	--	--	29,640
2	Narny Bridge[1)]	24,120	30,760	24,960
3	Peace bridge	49,300	49,240	46,900
4	Gulvaljin Bridge	48,700	67,640	52,870
5	Peace Avenue[2)]	66,900	70,180	55,270

WO/Case; Without Project, W/Case; With Project

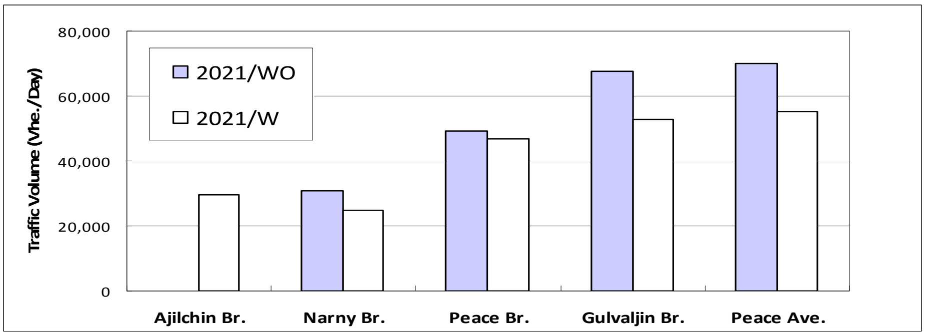


Figure 15.1 Daily Traffic Volume in 2020（Without Case / With Case）

15.2 EFFECT INDICATOR

i) Travel Time

Travel time is one of the Effect Indicators for the Project. Average of inbound and outbound from Ulaanbaatar railway station to intersection of Ajilchin Street and West Industrial Road (L=3.5km) is the Base Line as of 2012. “With Case” is measured by the Travel Time of Project road including Ajilchin Flyover (L=2.25km).

Table 15.2 Travel Time Indicator

	2012	2021
	BASE LINE	Target
A.M. Peak Hour (8:00-10:00)	17 minutes	-
Mid day (12:00-14:00)	14 minutes	
P.M.Peak Hour (18:00-20:00)	28 minutes	
Daily Average	20 minutes	4minutes*1

*1: Average Vehicle Speed $V_{ave.}$＝31km/h (based on JICA STRAD)

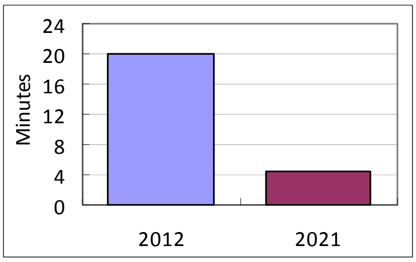


Figure 15.2 Comparison of Travel Time

ii) Travel Time Saving

Based on the travel time estimated as above, Daily Travel Time Saving will reach to 7,736 hours/day in 2021 with Project as shown below

Table 15.3 Travel Time Saving

	Daily Traffic Volume	Travel Time	Travel Time (Vehicle-Hour/day)
1) 2021 Without Case	29,640 (vehicle./day)	0.33-hour (20minutes)	9,781
2) 2021 With Case		0.069-hour (4minutes)	2,045
Travel Time Saving 1)－2)			7,736

iii) Vehicle Operation Cost (VOC) Saving

(Confidential)

16. CONCLUSION AND RECOMMENDATION

16.1 CONCLUSION OF PREPATORY SURVEY

- The Project is feasible from the viewpoints of technical, environmental and economic aspects. The Project fully complies with Ulaanbaatar Master Plan and Ajilchin Flyover will function as a part of east-west major corridor in the prospective road network of Ulaanbaatar City.
- Realization of the Project will induce alleviation of traffic congestion and travel time saving in the Project area resulting in significant economic effect.
- It is quite effective to apply advanced bridge construction technology from Japan pertinent to girder erection above the railway, piling work adjacent to railway in service, stable structure with highly durable steel members and so forth.

16.2 RECOMMENDATION FOR IMPLEMENTATION OF THE PROJECT

- Project Implementation Unit (PIU) shall be established under the Ministry of Roads and Transportation (Implementing Agency of Mongolian Government) at the commencement of detailed engineering design work to execute ultimate management for the implementation of the Project including construction of 828m long bridge.
- It is crucial to complete relocation of existing utilities prior to commencement of construction work. To attain this task, it is necessary to identify the utilities to be relocated and to execute actual relocation work in the stage of detailed engineering design. It is also required for Ulaanbaatar City to control the Project site so that no additional utilities are installed prior to project implementation.
- It is necessary to review and update resettlement action plan in the stage of detailed engineering design in accordance with the final Right-of-Way. For thorough completion of land acquisition prior to commencement of construction work, it is crucial to start resettlement action along with detailed engineering design work.
- It is recommended to carry-out i) widening of road in front of Power Plant No.3 to 4-lane and ii) grade separation of Ajilchin Road.
- Drainage design in urbanized area shall be carefully studied during the detailed engineering design.
- After completion of the Project, maintenance will be managed by the Road Department in Ulaanbaatar City. Thus it is important that Ulaanbaatar City will accumulate and improve their technology necessary for steel bridge maintenance through Technical Cooperation Scheme by JICA.

Abbreviations

A. Relevant Ministries and Agencies

AASHTO	American Association of state Highway and Transportation Officials
ADB	Asian Development Bank
ASTM	American Society for Testing and Materials
CLEM	Central Laboratory of Environment and Meteorology
DOR	Department Of Roads
EOJ	Embassy Of Japan
GOJ	Government Of Japan
GOM	Government Of Mongolia
ITS	Intelligent Transport System
JGS	Japan Geometrical Society
JICA	Japan International Cooperation Agency
JRA	Japan Road Association
MOFE	Ministry Of Finance and Economy
MRT	Ministry Of Road, Transport
MRTCUD	Ministry Of Road, Transport, Construction and Urban Development
UB	Ulaanbaatar
WB	World Bank

B. Others

A/P	Authorization to Payment
B/A	Banking Arrangement
BCR	Benefit / Cost Ration
BH	Borehole
BP	Beginning Point
CBR	California Bearing Ratio
D/D	Detail Design
DEIA	Detailed Environmental Impact Assessment
ECC	Environmental Clearance Certification
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevating
EMA	External Monitoring Agency
EMP	Environmental Management Plan

E/N	Exchange of Notes
EP	End Point
F/S	Feasibility Study
GDP	Gross Domestic Product
GEIA	General Environmental Impact Assessment
GL	Ground Level
GNP	Gross Nation Product
GRDP	Gross Regional Domestic Product
GVW	Gross Vehicle Weight
HWL	High Water Level
I/C	Inception Report
JIS	Japanese Industrial Standard
JPY	Japanese Yen
Kh	Horizontal Seismic
MNT, Tg	Mongolian Tugrik
M/P	Master Plan
N	N. Value
NPV	Net Present Value
OCC	Opportunity Cost of Capital
ODA	Official Development Assistance
PAPs	Project Affected Persons
PC	Pre-stressed Concrete
PCU	Passenger Car Unit
PIU	Project Implementation Unit
RC	Reinforced Concrete
ROW	Right of Way
S	Scale
STA	Station
TL	Traffic Load
UBMP	Ulaanbaatar Master Plan
USD	United States Dollar
V	Voltage
Veh/day	Vehicle per Day
VOC	Vehicle Operation Cost
W/F	Weight Factor
σc	Concrete Compressive Stress

σca	Concrete Allowable Comp
σck	Concrete Specified Compression Strength
σpy	Concrete Yield Point Stress
σs	Steel Compressive Stress
σsa	Steel Allowable Compressive Stress
Φ , φ	Diameter

PREPARATORY SURVEY
FOR
THE CONSTRUCTION OF AJILCHIN FLYOVER PROJECT
IN
ULAANBAATAR CITY

FINAL REPORT

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CHAPTER 1

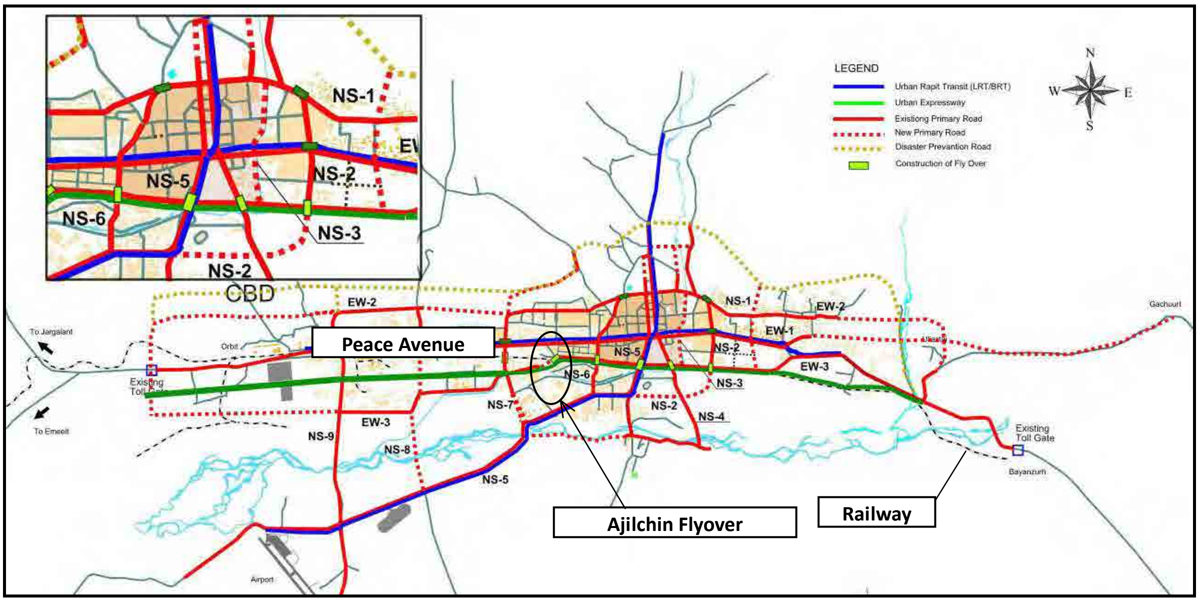
BACKGROUND AND BASIC CONCEPT OF THE SURVEY

1.1 BACKGROUND

In Ulaanbaatar City, the capital city of Mongolia, where more than 40% of the national population is concentrated, traffic volume of vehicles has been rapidly increasing over the past few years as a consequence of the economic growth, and this trend is expected to be maintained in the future.

It was concerned that the worsen traffic situation would adversely affects to the socioeconomic in Ulaanbaatar City. In addition, the railway which is most important logistic system for Mongolia has been crossing center of Ulaanbaatar City from east to west, and it is accordingly hamper the road traffic flow of north-south direction since only three (3) railway crossing bridge are existing. Traffic congestion on the bridges and its access roads are much serious so that new road network development crossing the railway has been urgently required.

To improve such situation, JICA executed "The Master Plan Study on Improvement and Rehabilitation of Road Network in Ulaanbaatar in Mongolia" in 1999 to formulate the Road Network Master Plan and conduct the feasibility study (F/S) of prioritized projects based on the Ulaanbaatar City Planning Master Plan (2020) formulated by the Ulaanbaatar City Government at that time. In addition, to accommodate the progress of urbanization at a greater-than-expected speed, "the Study on City Master Plan and Urban Development Program of Ulaanbaatar City" (by JICA, 2007 to 2009; hereinafter referred to as "the JICA M/P") was implemented. The JICA M/P suggested that new road networks and public transportation system be established by 2030.



Source: Study on City Master Plan and Urban Development Program of Ulaanbaatar City (JICA, March 2009)

Figure 1.1.1 Road Network Development Plan (2030) Proposed under the JICA M/P.

The JICA M/P was reviewed and modified by the Construction Urban Development and Planning Department in Ulaanbaatar City (hereinafter referred to as UB M/P) and was approved by the diet in January 2013. The Construction of Ajilchin Flyover (hereinafter referred to as “the Project”) is one of the highest priority projects in the UB M/P, which will eliminate several missing-links caused by railway in the center of Ulaanbaatar City.

Based on such situation stated above, Government of Mongolia discussed with JICA to conduct a preparatory survey for the Project and Minutes of Discussion was concluded among JICA and Government of Mongolia on 7th December 2011.

1.2 OBJECTIVE OF THE SURVEY

The objective of the preparatory survey is to provide such crucial data and information as the project outline, cost estimate, implementation plan, environmental and social impact and so forth for appraisal of the Project realization under the scheme of Japanese yen loan.

1.3 SURVEY ITEMS

The following surveys and studies have been carried out in the respective stages of the Survey:

Stage 1: Formulation of Project Components based on Background and Necessity of the Project

- i) Preparation of Inception Report and discussions on the methodology of the Survey
- ii) Investigation and confirmation of the background of the Project/Data collection on laws and regulations related to the road and transport sector
- iii) Site condition survey/study on road alignment, bridge location and project coverage
- iv) Investigation on condition of existing roads and bridges in Ulaanbaatar City
- v) Survey on environmental and social considerations
- vi) Formulation of project components and framework

Stage 2: Study on the Basic Contents of the Project

- i) Natural Condition Survey
- ii) Selection of bridge type and road planning for access roads
- iii) Construction planning/Operation and maintenance planning
- iv) Maintenance plan for existing bridges in Ulaanbaatar City and proposal of technical assistance plan
- v) Proposal of basic contents of the Project

Stage 3: Basic Design of the Project and Examination of Project Effect

- i) Basic design of the Project
- ii) Project implementation plan
- iii) Cost estimate of the Project
- iv) Evaluation of the Project

Stage 4: Reporting

- i) Preparation and presentation of Draft Final Report
- ii) Seminar on technology of bridge design and construction
- iii) Preparation and submission of the Final Report

1.4 SURVEY IMPLEMENTATION FRAMEWORK

The JICA Survey Team conducted the preparatory survey from 26 March 2012 until the beginning of 2013 in corroboration with MRTCUD, UBC and the JICA Mongolia Office through a series of discussions in the Working Group (WG) meetings chaired by the Deputy Mayor of Ulaanbaatar City and the Joint Coordination Committee (JCC) meetings chaired by the State Secretary of MRTCUD. Practical and specific discussion in the above meetings, premised on project implementation, were held to obtain a consensus with the Ulaanbaatar Railway, utility agencies relevant to relocation, and the Land Administration Department of Ulaanbaatar City.

Though the members of the JCC were replaced after July 2012 due to reorganization of the implementing agency, i.e. from MRTCUD to newly established Ministry of Roads and Transport (MRT), the preparatory survey was carried out without significant delay. The meetings and their agenda are as shown in the table below.

Table 1.4.1 List of Meetings held in the Survey

Meeting	Date	Agenda
Kick-off Meeting	29 March 2012	Methodology of the Survey and its Schedule based on the Inception Report.
1st WG Meeting	26 April 2012	Result of site condition survey based on the Progress Report
2nd WG Meeting	03 May 2012	Traffic Study and Route Selection
1st JCC Meeting	03 July 2012	Confirmation of Bridge Route and Project Components
3rd WG Meeting	19 October 2012	Presentation of Road and Bridge Plan based on the Interim Report.
2nd JCC Meeting	07 November 2012	Confirmation of Road and Bridge Plan
4th WG Meeting	27 February 2013	Presentation of Basic Design and Project
3rd JCC Meeting	27 February 2013	Presentation of Basic Design and Project Confirmation of the Draft Final Report.

1.5 MEMBERS OF THE JICA SURVEY TEAM

The members of the JICA Survey Team are as shown in the following table.

Table 1.5.1 List of Members of the JICA Survey Team

Name of Expert	**Designation/Expertise**
Mr. NAGATA Tsunemi	Team Leader/Road Planning
Mr. OKAZAKI Akio	Deputy Team Leader/Bridge Planner (1)
Mr. KANEKO Kimio	Traffic Planner
Mr. NAKAMURA Hitoshi	Bridge Planner (2)
Mr. OYAMA Mitsuhiro	Construction Planner/Existing Utility Survey Expert
Mr. GOTANDA Ichiro	Economic Analysis Expert
Ms. OISHI Misa	Natural and Social Environment Consideration Expert
Mr. KITAMURA Takayoshi	Existing Bridge Inspection Expert/Technical Assistance Advisory
Mr. SATO Toshiyuki	Bridge Design Assistant/Survey Coordinator
Mr. OGAWA Tsutomu	Natural Condition Survey Expert
Mr. WATANABE Masatoshi	Procurement Planner and Cost Estimator

CHAPTER 2

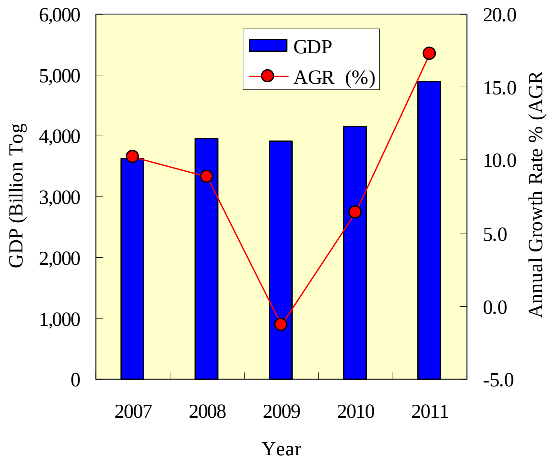
CURRENT SOCIO-ECONOMIC AND ROAD TRANSPORT CONDITIONS

2.1 SOCIO-ECONOMIC CONDITION

(1) Gross Domestic Product (GDP)

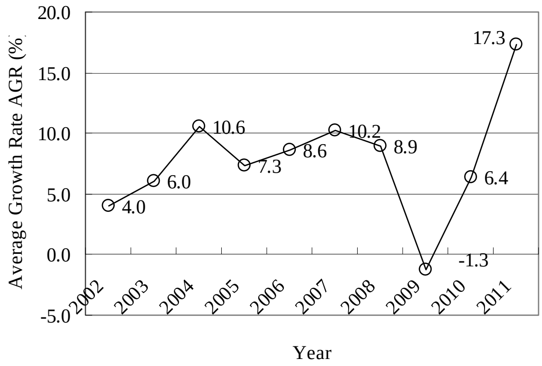
After dissolution of socialist system in 1992, the economic growth in the Mongolia has been changed by low growth until 2000 along with development of market economy. However, mainly in appreciation of steep rise of price in the global market of the mineral resources which are main export commodities, Mongolia continues stable economic growth from 2001 through 2008.

In 2008, the economic growth declined to a negative economic growth at -1.3%, due to the sudden increase of the domestic inflation rate by the steep rise of oil products price and grain price as well as the influence of the worldwide economic crisis of Lehman Shock. Nevertheless, the economic growth in 2011 recovered to 17.3% through the financial support program of the International Monetary Fund (IMF), the World Bank (WB) and the Asian Development Bank (ADB), the government policy of financial restraint, the economic recovery of China which is the largest export market for Mongolia and the re-ascension of mineral resource prices. In the near future, the economy of Mongolia is expected to have a stable growth in a similar condition before 2008 through the stable increase of the income by resource development such as coal and other minerals.



Source: Mongolian Statistical Yearbook, 2002-2011

Figure 2.1.1 GDP and Annual Average Growth Rate



Source: Mongolian Statistical Yearbook, 2002-2011

Figure 2.1.2 Trend of Annual Average Growth Rate

(2) Gross Domestic Product by Industry

In 2007-2011 with influence of the worldwide economic crisis of Lehman Shock, the growth rate of gross domestic product by industry registered 0.86% for primary industry, 1.91% for secondary industry and 13.3% for tertiary industry. The tertiary industry is the most predominant and constant. Annual growth rate of each industry varies widely such as -7.1% to 4.7% for primary industry, -9.8% to 12.5% for secondary industry and -3.5% to 25.6% for tertiary industry (see Table 2.1.1). In 2010, the second and tertiary industries greatly rebound compared with the previous year, and contributes to the GDP growth rate of 6.4%. On the other hand, the growth of primary industries became negative due to heavy Zud (snow) damage to agriculture and livestock in spite of steep rise in price of mineral resources. With the stable price of mineral resources, however, a favorable economic growth is predicted.

Table 2.1.1 Gross Domestic Product (GDP) in Mongolia (2007-2011)

Year	Gross Domestic Product (GDP) by Industry (Billion Tog)						Total	AGR
	Primary Industry		Secondary Industry		Tertiary Industry			
	Production	AGR	Production	AGR	Production	AGR		
2007	1,417.9	-	439.7	-	1,782.4	-	3,640.0	-
2008	1,441.1	1.6	442.7	0.7	2,080.2	16.7	3,964.0	8.9
2009	1,507.8	4.6	399.3	-9.8	2,006.8	-3.5	3,913.7	-1.3
2010	1,401.1	-7.1	421.5	5.6	2,340.1	16.6	4,162.7	6.4
2011**	1,467.4	4.7	474.3	12.5	2,939.8	25.6	4,881.5	17.3
2007-2011	-	0.86	-	1.91	-	13.3	-	7.6

Source: Mongolian Statistical Yearbook, 2002-2011
Note: ** Preliminary estimates; AGR: Average Growth Rate (%)

(3) Economic Growth in Ulaanbaatar City

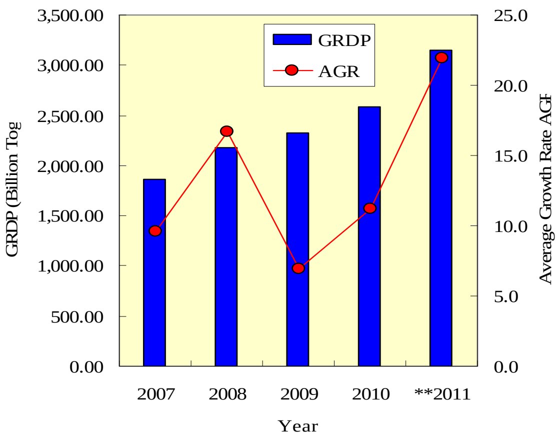
In last years of 2007-2011, the growth rate of Gross Regional Domestic Production (hereinafter referred to as “RGDP”) in Ulaanbaatar City is 14.1% in average, which far exceeds 7.6% of the GDP in Mongolia. Though GRDP in Ulaanbaatar City in 2008 was 6.9%, less than 16.7% in 2007 by 9.9%, drastic annual growth rate of 21.9% in average has been recorded from 2009 through 2011.

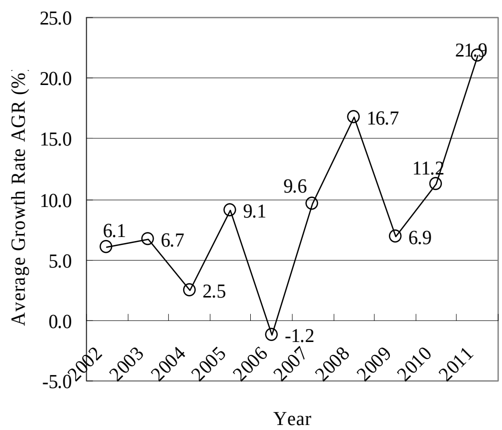
As for the share of GRDP by industry in Ulaanbaatar City in 2011, the share of primary industry is limited to 0.4%, and secondary industry and tertiary industry show high shares at 30.7% and 68.8%, respectively. The share of industry constitution generally continues to be stable from 2006, and thus it is estimated that the tendency will be continued by increment of trade scale due to development of mineral resources and certain enhancement of transport sectors.

Table 2.1.2 Gross Regional Domestic Product (GRDP) in Ulaanbaatar City (2007-2011)

Year	GRDP (Billion Tog)	AGR
2007	1,862.2	-
2008	2,173.7	16.7
2009	2,324.2	6.9
2010	2585.9	11.2
2011**	3151.3	21.9
2007-2011	-	14.1

Source: Mongolian Statistical Yearbook, 2002-2011
** Preliminary estimates; AGR: Average Growth Rate (%)





Source: Mongolian Statistical Yearbook, 2002-2011

Figure 2.1.3 GRDP and Annual Growth Rate in Ulaanbaatar City

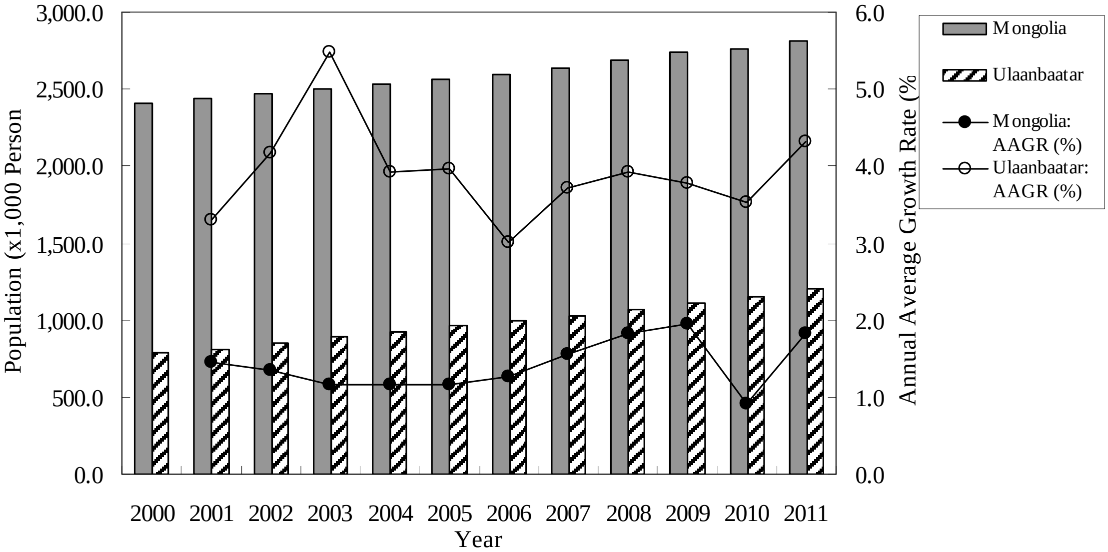
Figure 2.1.4 Annual Growth Rate of GRDP

2.2 POPULATION AND CAR OWNERSHIP

(1) Population

The national population of Mongolia in the last decade increased from 2,475,000 persons in 2002 to 2,800,000 persons in 2011, i.e. approximately 1.13 times. Meanwhile, the population of Ulaanbaatar City increased from 847,000 persons to 1,201,000 persons, i.e. approximately 1.42 times, in the same period. The population growth rate of Ulaanbaatar City has reached up to 3.96% (annual range of 3.0%-5.5%), which clearly illustrate rapid increase of population inflow from the local region to the urbanized area.

The population movement in the country was managed by immigration control until early 1990s. However, the population inflow to Ulaanbaatar City increased with the liberalization of movement in 1997. Mongolia experienced heavy Zud (snow) damages in 2003, and the annual population growth rate in Ulaanbaatar City significantly increased to 5.5%. Afterwards, the growth rate has been kept around 3.5% or more. In connection with population growth and economic growth in Ulaanbaatar City, it is predicted that traffic congestion in the city will become more serious corresponding to the increase in traffic volume.



Source: Mongolian Statistical Yearbook, 2000-2011
Note: AAGR, Annual Average Growth Rate

Figure 2.2.1 Annual Trend of Population in Mongolia and Ulaanbaatar City (2000-2011)

Ulaanbaatar City is composed of six (6) administrative districts and three (3) satellite cities (see Figure 2.2.2). The population growth rate in the past decade (2001-2010) of Songinokhairkhan District (population share by 24.8%) and the Bayanzurkh district (population share by 26.2%) occupying about half of the whole city population is remarkably high at 5.0% and 6.3%, respectively (see Figure 2.2.3). In future, it is predicted that trips derived from east-west direction turning out to the city center will increase.

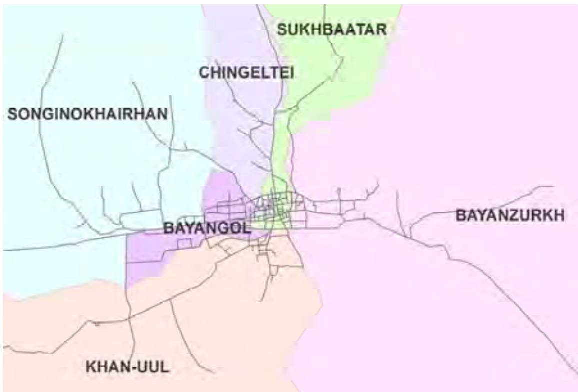


Figure 2.2.2 Administrative Districts in Ulaanbaatar City

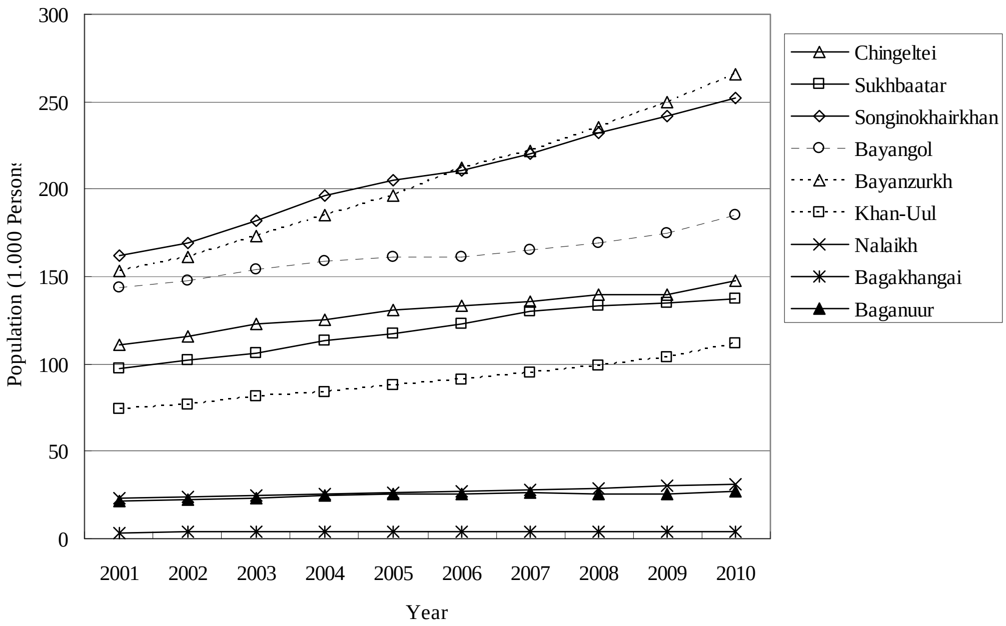
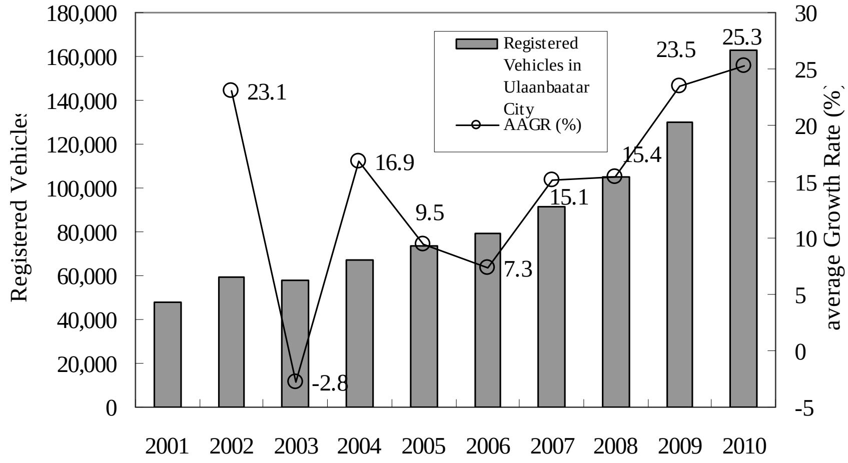


Figure 2.2.3 Annual Trend of Population by District in Ulaanbaatar City (2001-2010)

(2) Car Ownership

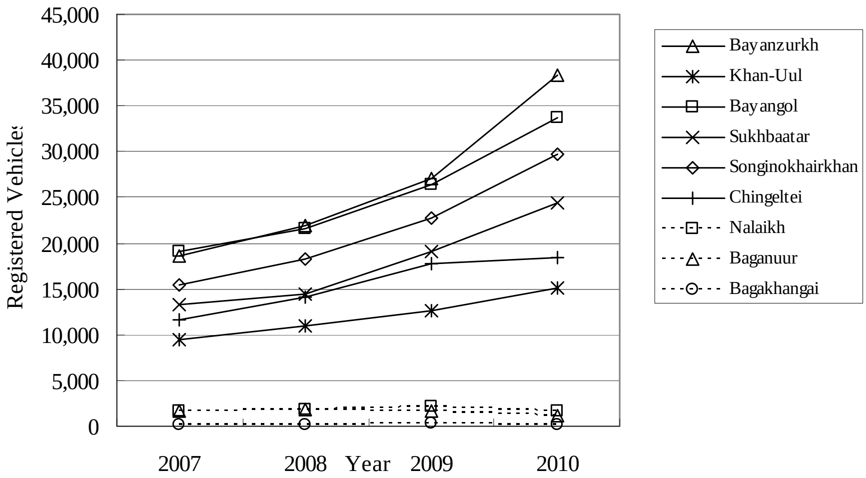
The number of car ownership in Ulaanbaatar City increases 14.4% in annual average growth in the last decade of 2001-2010 (see Figure 2.2.4). The growth rate of car ownership decreased temporarily due to the influence of heavy Zud (snow) damages in 2003; however, the growth rate increased significantly in 2007-2010. The number of car ownership increased from 48,000 vehicles in 2001 to 162,000 vehicles in 2010, i.e. approximately 3.4 times in the past ten years indicating annual average growth rate of 25.3%.

Figure 2.2.5 shows the trend of car ownership number in Ulaanbaatar City in 2007-2010. In 2010, the districts with high car ownership ratio were Bayanzurkh District (23.6%), Bayangol District (20.7%) and Songinokhairkhan District (18.3%) in proportion to their population, and the total number of car ownership in these three districts accounts for approx. 63%. Particularly, the annual average growth rate is high in the populous Songinokhairkhan District (24.8%) and Bayanzurkh District is (24.6%).



Source: Mongolian Statistical Yearbook, 2002-2010, Department of Roads, Ulaanbaatar City, 2011

Figure 2.2.4 Annual Trend of Car Ownership Number in Ulaanbaatar City (2001-2010)



Source: Mongolian Statistical Yearbook, 2002-2010, 2002-2010,
Department of Roads, Ulaanbaatar City, 2011

Figure 2.2.5 Annual Trend of Car Ownership by District in Ulaanbaatar City (2001-2010)

2.3 CURRENT SITUATION OF THE ROAD NETWORK IN ULAANBAATAR CITY

Table 2.3.1 Urban Road Network Rate of Various Countries

	Road Extension (km)	Urban Area (km^2)	Road Network Rate (km/km^2)
UB City	460	3,257	0.14
Tokyo 23 Wards	11,841	622	19.04
Fukuoka City	3,938	342	11.51
London	14,681	1,570	9.35
Seoul	7689	605	12.70

Source: JICA Fact-Finding Team

The road network density in Ulaanbaatar City (6 administrative district excluding satellite towns) is approximately 0.14 km/km^2, which indicates extremely low grade of road improvement ratio compared with major cities in foreign countries. The traffic congestion on main roads in the Ulaanbaatar City is becoming chronic due to a rapid increase in car ownership that exceeds 14% per year as described above. Specifically, the daily traffic volumes of 50,000 to 70,000 at “Peace Avenue” which is the only arterial road crossing the inner-city from east to west, and 62,200 at Peace Bridge located on the arterial road connecting north and south in the center of Ulaanbaatar City, both observed in May 2012, indicate that current traffic volume has already reached the critical limit of traffic capacity of the respective main roads in Ulaanbaatar City.

To cope with this serious situation, JICA M/P and the UB M/P recommend improvement of arterial road and development of public transportation system such as BRT and MRT. Consequently, Ulaanbaatar City has established a medium-term development plan for future road network including grade separation at main intersections (see 2.4) and 212 km long new road development (see 2.5) targeting the year 2016 in conformance with the UB M/P to expand the road network and to eliminate the traffic bottleneck at the existing intersections.

UB M/P states that establishment of efficient road network in Ulaanbaatar City is a principal issue to facilitate further land utilization including development at western area of Ulaanbaatar City and southwestern area in the vicinity of the existing airport as a sub-center of Ulaanbaatar City.

On the other hand, although the railway running east-west in Ulaanbaatar City is, an important infrastructure functioning as main logistics system in the country, it is one of the deterrent factors for road traffic by dividing Ulaanbaatar City into north and south regions. Currently, there are only 6 railway crossings in the central city; Peace Bridge, Narny Bridge, Gurvaljin Bridge, and the other 3 at-grade crossings. Flyovers for grade separation of road and railway are limited to three (3) locations including Narny Bridge completed in October 2012 under Japan’s Grant Aid scheme.

Table2.3.2 Current Situation of Railway Crossing in Ulaanbaatar City

Location	Current Situation
1.Peace Bridge	Constructed in 1960 by Chinese assistance. Heavy vehicles are excluded due to insufficient durability to traffic loads.
2.Narny Bridge	Constructed in 2012 by Japan’s Grant Aid. Sufficient design capacity for heavy vehicles.
3.Gurvaljin Bridge	Constructed in 1980s by Russian assistance. Superstructure was replaced in 2011 due to progressive deterioration. Problem in seismic resistance.
4.Crossing in front of Narantuur Market	Grade separation plan was cancelled due to financial constraints. At-grade crossing was opened in 2012. Serious congestion induces safety problem.
5. Crossing on Olympic Avenue	Dual single lane crossing with quite limited traffic capacity.
6. Crossing at Sonsogolon	Intersection of Peace Avenue and Ulaanbaatar Railway. Grade separation with ADB fund was proposed. Details have not been fixed.

This situation induces traffic bottleneck at intersections and corresponding access roads near the railway crossings, and is accelerating traffic congestion in the center of Ulaanbaatar City represented by average traveling speed below 20 km/hour in the day time and below 10 km/hour in the peak hours on such main roads as Peace Avenue, Chinggis Avenue, and Ajilchin Street [see 3.3(2)].

As an urgent measure for the above-mentioned problems, another flyover is required to form a part of east-west trunk road network as well as to cross over the railway.

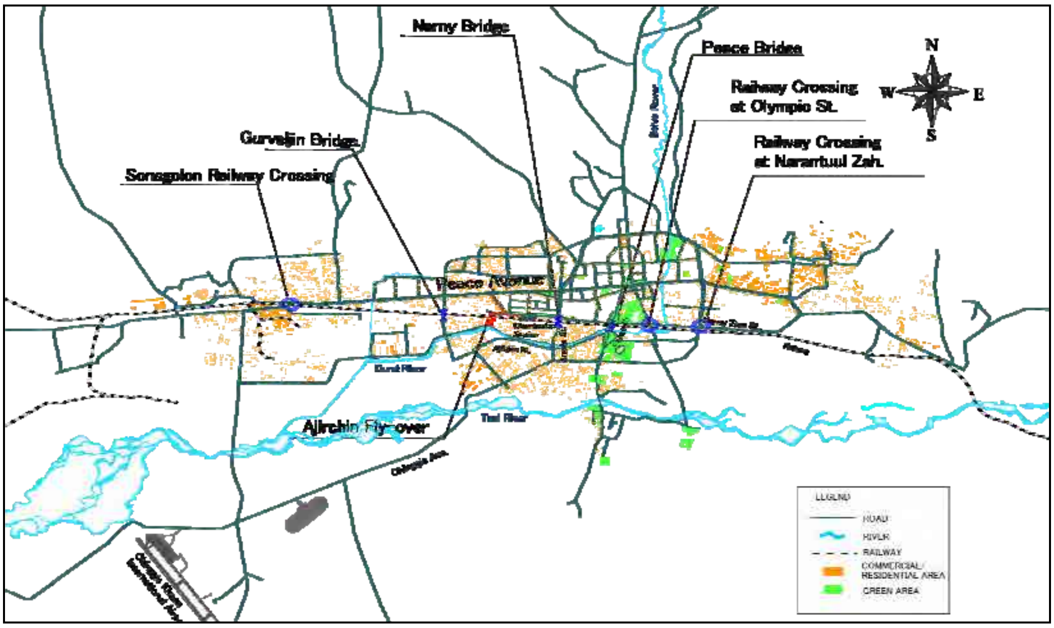


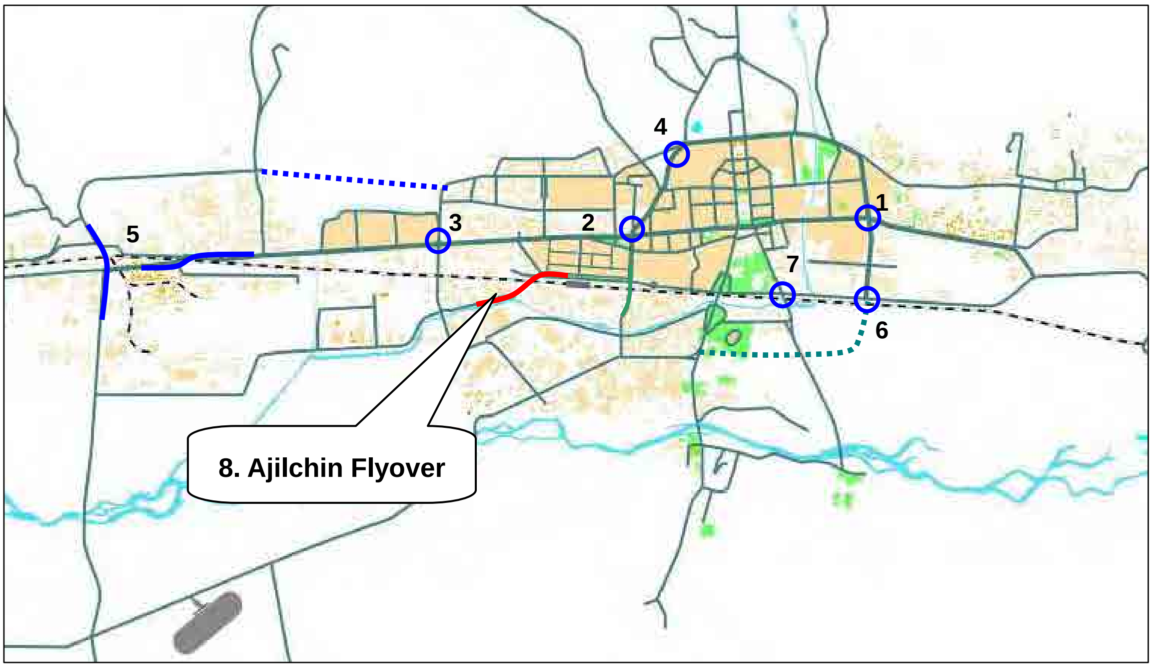
Figure 2.3.1 Railway Crossing Locations in Ulaanbaatar City

2.4 FLYOVER CONSTRUCTION PLAN OF MAIN INTERSECTIONS AND ITS PROGRESS

The flyover construction plan of main intersections being planned by Ulaanbaatar City consists of 8 locations as shown below including the Ajilchin Flyover Construction Project. Among the 4 flyover construction projects of which China expressed its assistance, detailed engineering design for the West Intersection has been completed and the tender process is ongoing. The other 3 intersections are going to be implemented under the Design Build Method scheme (called as “Turn-Key Method” in Mongolia).

Table 2.4.1 Intersections Subject to Ulaanbaatar City Flyover Construction Plans and their Progress

Item No.	Name of Intersection	Finance Resource	Progress	Remarks
1	East Intersection	Mongolian Government	(terminated)	Designing is finished.
2	West Intersection	Chinese Government	(terminated)	No coordination with Metro project
3	Sapporo Roundabout	Chinese Government	(terminated)	Designing is finished.
4	Bayanburd Intersection	Chinese Government	(terminated)	
5	Sonsogolon Intersection.	ADB	F/S completed	
6	Narantuul Flyover	Mongolian Government	Detailed Design	Opened at-grade crossing
7	Olympic Street Flyover	Chinese Government	(terminated)	
8	Ajilchin Flyover	-	JICA Preparatory Survey is ongoing.	JICA Survey Team



Source: JICA Study Team

Figure 2.4.1 Location of Proposed Ulaanbaatar City Flyover Construction Plan

2.5 ULAANBAATAR CITY ROAD RESTORATION PLAN

Ulaanbaatar City formulated the medium-term plan aiming at improvement of road network and new construction of 212 km road by 2016. With the budget for fiscal year 2012, the construction work indicated in Figure 2.5.1 and Table 2.5.1 (road extension is approximately 164 km and bridge length is approximately 1,046 m) is expected to be implemented. The following 3 projects are pointed out as associated projects with the Ajilchin Flyover Construction Project.

(1) Narny Road Widening Project (Project No. 2.3)

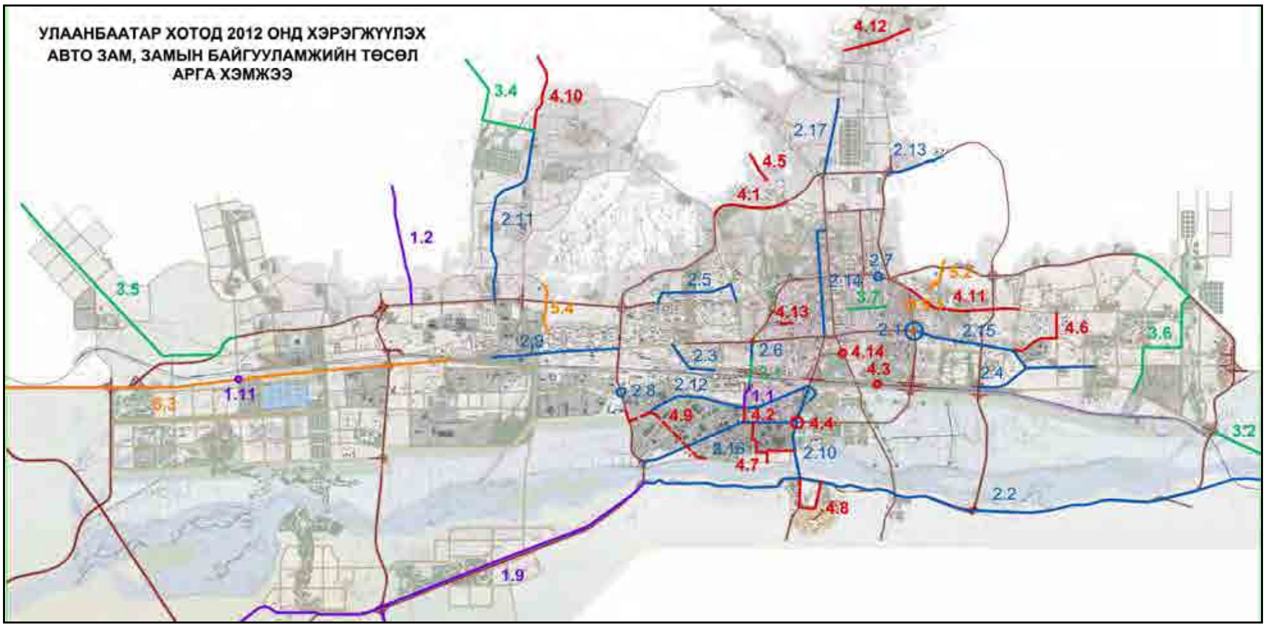
Approximately 1.0 km long road in the west end of Narny Road (From Ulaanbaatar Station to the intersection of Peace Avenue) is to be widened from 2 lanes to 4 lanes. Detailed engineering design was completed and the construction work is ongoing.

(2) Dund River Bridge 4-Lane Plan (Project No. 2.8)

Existing bridge is currently a bottleneck of Ajilchin Street. Improvement of Dund River Bridge to 4-lane bridge by installing a new 2-lane bridge as duplication of the existing 2-lane Dund River Bridge is ongoing. According to Ulaanbaatar City, the contractor is being selected.

(3) Dund Gol Street 4-Lane Plan (Project No. 2.12)

Widening of 2-lane Dund Gol Street (4 km section from the intersection of Engels Street to the intersection of Ajilchin Street) to 4-lane road is scheduled. Detailed engineering design was completed and the contractor is being selected.



Source: Department of Roads, Ulaanbaatar City

Figure 2.5.1 Ulaanbaatar Inner City Road Improvement Project 2012

Table 2.5.1 Ulaanbaatar Inner City Road Improvement Project, 2012

(Confidential)

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(Confidential)

2.6 TREND OF ASSISTANCE FROM JAPAN

Technical and economic assistance by the Japanese Government in the past related to the Mongolian road and transport sectors are as summarized below. JICA study on “The Project for Construction of Railway Fly-Over in Ulaanbaatar City” was completed as Narny Bridge in October 2012 and, together with the Narny Road, the “Project for Improvement of the Roads in Ulaanbaatar” (1998 to 2003) contributes to formulating major road network in the central part of Ulaanbaatar City.

Table 2.6.1 Summary of Road and Transport Sector Projects Assisted by the Japanese Government

Cooperation	Implementation Fiscal Year	Project/Plan Name	Outline
Development Investigation	1998-1999	The Master Plan Study on Improvement and Rehabilitation of Road Network in Ulaanbaatar in Mongolia	Master plan and feasibility study related to road network development in Ulaanbaatar City (hereinafter referred to as UB City)
	2001-2002	The Feasibility Study on Construction of Eastern Arterial Road in Mongolia	Feasibility study of intercity main road development
	2007-2009	The Study on City Master Plan and Urban Development Program of Ulaanbaatar City	City structure and city infrastructure system development desired for UB City
Grant Aid	1994-1995	Project for Enhancement of Public Transportation in Ulaanbaatar City	Enhancing bus transport in the city (3.399 billion yen)
	1994-1997	The Project for the Pilot Construction Work of Ulaanbaatar-Baganuur Section of the State Road	Repair of approximately 18 km existing road between Nalaikh (suburb of UB) and Erdenet, pilot construction of approximately 13 km long new road, procurement of equipment (2.638 billion yen)
	1998-2003	The Project for Improvement of the Roads in Ulaanbaatar	Widening and rehabilitation of existing approximately 8.4 km long road, including improvement of 3 intersections, reconstruction of a bridge (L=51.12 m), and procuring equipment for road maintenance (1.948 billion yen)
	2005-2008	The Project for Construction of the Eastern Arterial Road and Improvement of Equipment for Road Construction and Maintenance in Mongolia	Intercity main road development and procurement of road construction equipment (2.856 billion yen)
	2008-2012	The Project for Construction of Railway Fly-Over in Ulaanbaatar City	Building a flyover (262 m) for crossing the railway in the east side of Ulaanbaatar Station (3.658 billion yen)
Grassroots Technical Cooperation	2010-2012	Niigata Prefectural Technical Assistance Project for Implementation of Street Drainage in Ulaanbaatar	Road drainage plan in Ulaanbaatar and construction technology transfer
	2007	Technical Assistance Project for Road Construction by Community Participation for Creation of Employment	Technical assistance in planning, designing, and constructing community roads at low cost
Dispatching Experts	2011-2013	Advisor on Improvement of Urban Traffic System in Ulaanbaatar City	Establishing an appropriate urban traffic system, planning details, providing advice and guidance of urban traffic project requested to Japan

Source: JICA Survey Team

2.7 TREND OF ASSISTANCE FROM OTHER DONORS/INSTITUTIONS

Assistance in the road and transport sector provided by other donors and institutions are listed in the table below. Grade separation projects planned at major intersections and railway crossings in Ulaanbaatar City with prospective loans from China were terminated in 2013. ADB launched a technical assistance project for capacity development on operation and maintenance of road sectors in 2012 under the Japan Fund for Poverty Reduction (JFPR).

Table 2.7.1 List of Assistance Projects with Funds from Other Donors

Implementation Fiscal Year	Name of Institution	Name of Plan/Project	Amount (Million USD)	Assistance Form	Outline
1995-2001	World Bank	Silk Road A	25.00	Non-free	Improvement of existing asphalt pavement; Construction of asphalt pavement road and new bridge
2001-2004	World Bank	Silk Road B	25.00	Non-free	Construction of new asphalt pavement road
2004	World Bank	Silk Road C	23.90	Non-free	Construction of new asphalt pavement road.
1996-2000	ADB	Asian Highway Route 3, Phase I	9.78	Non-free	Construction of low-cost pavement road (gravel paving)
2000-2005	ADB	Asian Highway Route 3, Phase II	30.13	Non-free	Reconstruction of the existing asphalt pavement. Construction of low-cost pavement road (laterite surface)
2012-2013	ADB (JFPR)	Road Sector Capacity Development Project	2.00	Technical assistance	Technical assistance project related to road maintenance operation, and quality control
2006-2009	ADB/ Korea Collaboration	Asian Highway Route 3, Phase III	3.60	Non-free	Reconstruction of the existing asphalt pavement road
1996-2002	Kuwait Fund	Asian Highway Route 83, Phase I	18.20	Non-free	Construction of asphalt pavement road
2004-2007	Kuwait Fund	Asian Highway Route 83, Phase II	19.50	Non-free	Construction of asphalt pavement road
2005-2007	Kuwait Fund	Local Road	5.00	Non-free	Reconstruction of existing asphalt pavement road
2005-2007	Turkish International Cooperation and Development Agency	Silk Road	4.80	Non-free	Reconstruction of the existing asphalt pavement road

Source: JICA Survey Team

CHAPTER 3

TRANSPORT PLANNING AND ANALYSIS

3.1 REVIEW OF URBAN DEVELOPMENT PLAN IN ULAANBAATAR CITY

(1) Ulaanbaatar Urban Development Master Plan in 2030

i) Background

The study on land use plan for Ulaanbaatar City was carried out before 1980 and the Ulaanbaatar Urban Development Master Plan 2020 was formulated in 2001. To address the rapid population growth, the City Master Plan and Urban Development Program for Ulaanbaatar City was formulated by JICA in the period 2007-2009. In this study, JICA M/P was formulated by updating and/or revising the Urban Development Master Plan 2020. JICA M/P was reviewed and updated by the Urban Development Department of Ulaanbaatar Municipal Government, and was approved by the National Diet in January 2013 as UB M/P.

ii) Plan Overview

(a) Future Population Framework

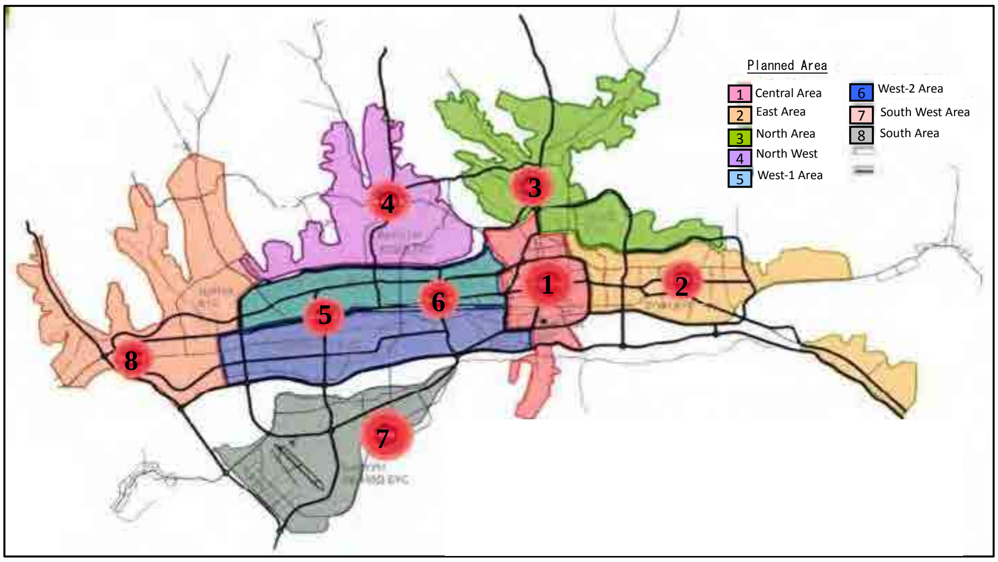
The future population framework in the Ulaanbaatar Urban Development Master Plan 2020 shows 1,250,000 persons in the target area of 35,200ha in 2020. On the other hand, the UB M/P specifies 1,400,000 persons in the target area of 47,000ha which is divided into eight (8) zones. The population framework assumed the urbanized pattern in the “compact city scenario” based on the JICA M/P. Population, urbanized area and population density are formulated corresponding to four (4) regional zones, i.e. central business district (hereinafter referred to as “CBD”), central area, urban area and suburban area. For the population frame in Ulaanbaatar City in 2030, the future population in the JICA M/P was predicted to be 1,740,000 persons (see Table 3.1.1); however, the future population in the UB M/P was reduced to 1,240,000 persons in 2020 and 1,400,000 persons (19.5% decrease) in 2030 by the UB M/P (see Figure 3.1.1).

Table 3.1.1 Comparison of Urbanization between Trend and Compact City Scenarios

Area	(A) Population			(B) Urbanized Area (ha)			(C) Population Density (A/B) (Person/ha)		
	Present (2007)	Trend (2030)	Compact (2030)	Present (2007)	Trend (2030)	Compact (2030)	Present (2007)	Trend (2030)	Compact (2030)
CBD	77,800	107,200	134,900	540	570	570	144.1	188.1	236.7
Central	469,100	588,100	657,400	4,490	5,690	4,800	104.5	103.4	137.0
Urban	243,200	394,800	547,800	4,300	6,130	5,950	56,6	64.4	92.1
Suburban	155,600	648,900	398,900	6,590	12,670	8,010	23.6	51.2	49.8
Total	945,700	1,739,000	1,739,000	15,920	25,060	19,330	59.4	69.4	90.0

Note: Urbanized Area in the "Compact City Scenario" includes the urbanized area outside of the Urbanization Promotion Area (UPA). The total area of UPA in the Zoning Map is about 18,500 ha.

Source: JICA Survey Team



No.	Zone	Total Area (ha)	2010		2020		2030	
			Households (x1,000)	Person (x1,000)	Households (x1,000)	Person (x1,000)	Households (x1,000)	Person (x1,000)
1	Central area	2,025	59.8	228.8	71.1	263.0	74.9	269.8
2	East area	3,642	42.2	159.7	51.5	190.5	59.8	215.1
3	North area	4,233	41.3	166.3	53.9	199.6	59.4	213.7
4	North-west area	2,819	31.6	127.2	33.0	122.0	33.3	120.0
5	West-1 area	2,036	58.8	239.9	86.2	241.2	66.2	238.4
6	West-2 area	3,414	16.4	60.7	24.1	89.3	28.9	104.0
7	South area	3,288.8	12.4	49.0	20.4	75.6	47.4	170.6
8	New area	4,791	39.7	19.8	14.7	54.4	19.1	68.8
	Total	26,249	302.2	1,051.4	354.9	1,235.6	389.0	1,400.4

Source: Department of Roads, Ulaanbaatar City, 2012

Figure 3.1.1 Future Population Frame in Ulaanbaatar City in 2030

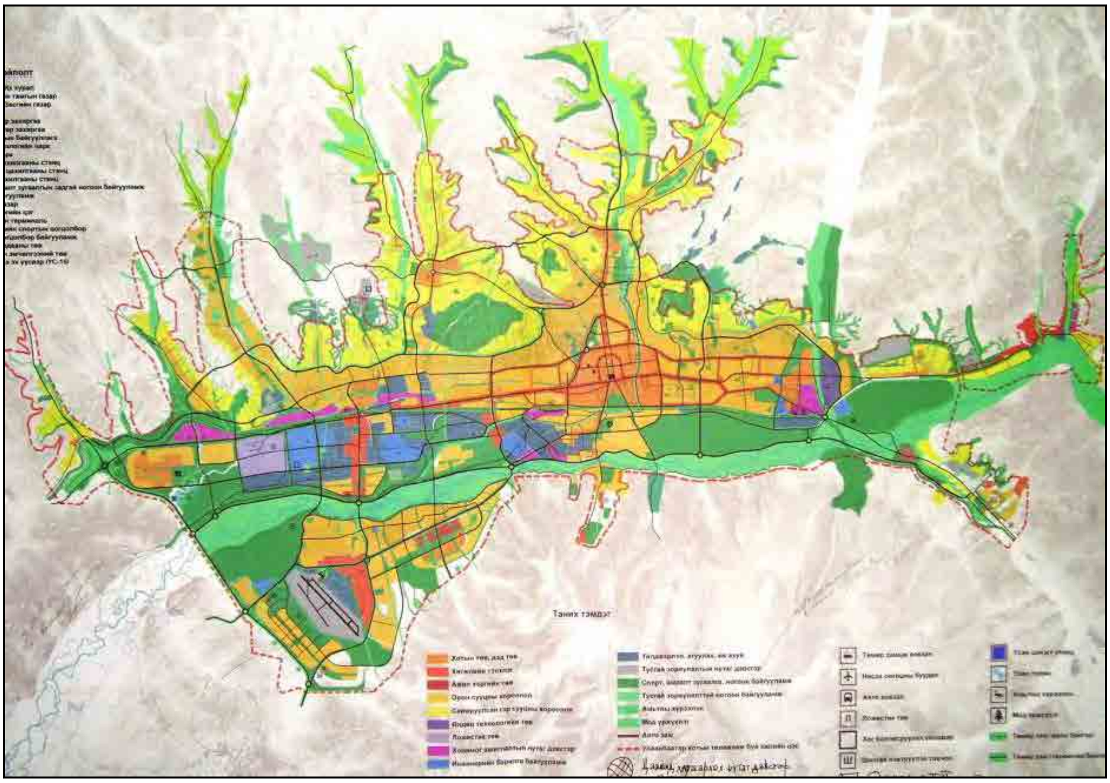
(b) Land Use Plan

Figure 3.1.2 shows the land use plan provided in the UB M/P 2030. To conceptualize the alleviation of traffic congestion and decentralization by new city center and satellite cities, Ulaanbaatar City is divided into eight (8) centers and six (6) sub-centers such as residential, commercial and government facilities, aiming to alleviate excessive concentration of daily shoppers at commercial centers.

The land use plan is to keep the existing industrial area in the western area of Ulaanbaatar City, to move factories consuming a large amount of water to the northern area of the city, and to allocate hi-technology industries in the eastern city. The mixed area of industry and residence (pink color zone) is only 20% in 2020, but will be expanded to 70% in 2030. The existing residential area (thin yellow color zone) located at the northern area of the city consists of 30% of apartments and 70% of gel houses in 2020, but the shares of apartment and gel house will be lead to 70% and 30%, respectively in 2030.

The outline of the land use plan is almost similar to the JICA M/P of 2007; and no new development plan is added. The land use plan and the population distribution are almost based on the JICA M/P, and there are only a few differences in each zone.

The urban development plan largely concerned with the traffic demand of the Ajilchin Flyover Construction Project is a development program of large-scaled new town in the southwestern area of the city. The population frame in the new town plan is reduced to 170,000 persons from the 200,000 persons of the JICA M/P. The development plan for the central area 160ha of the new town has already been approved by the government, and construction has started.



Source: Department of Roads, Ulaanbaatar City, 2012 (under revision by the Government)

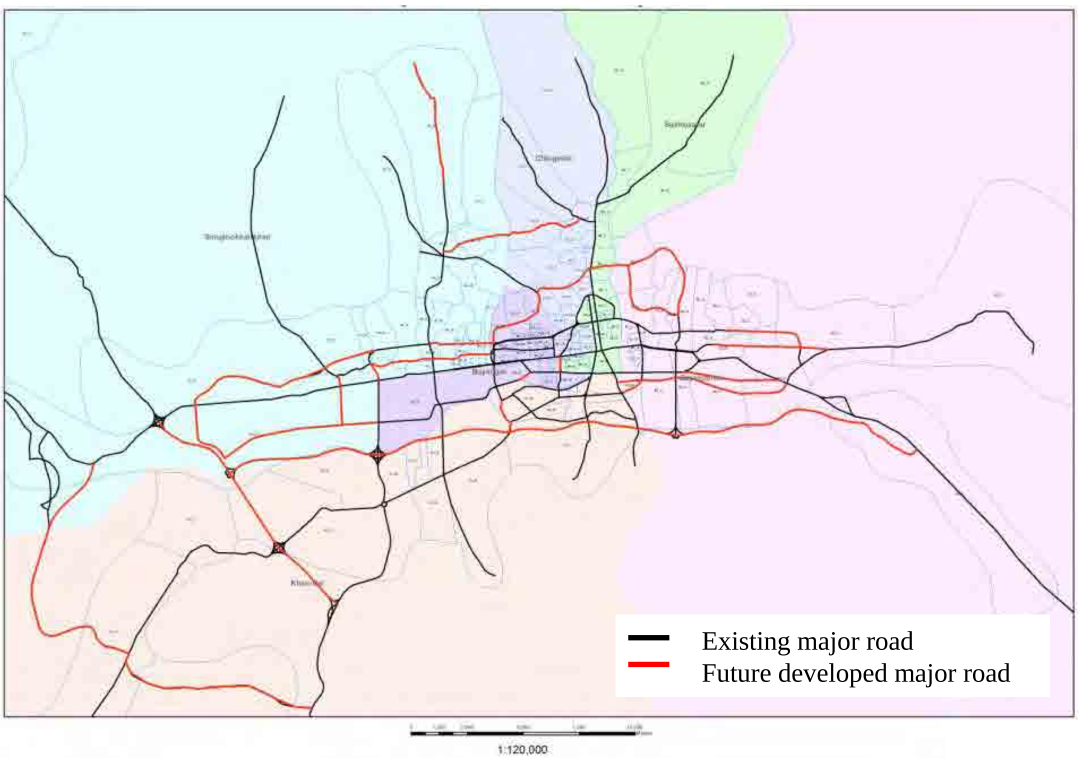
Figure 3.1.2 Land Use Plan in the UB M/P

c) Road and Public Transport Infrastructure Plan

The road infrastructure programs in the UB M/P are proposed as below (see Figure 3.1.3). Among the program, three programs i through iii are scheduled to be completed by 2016.

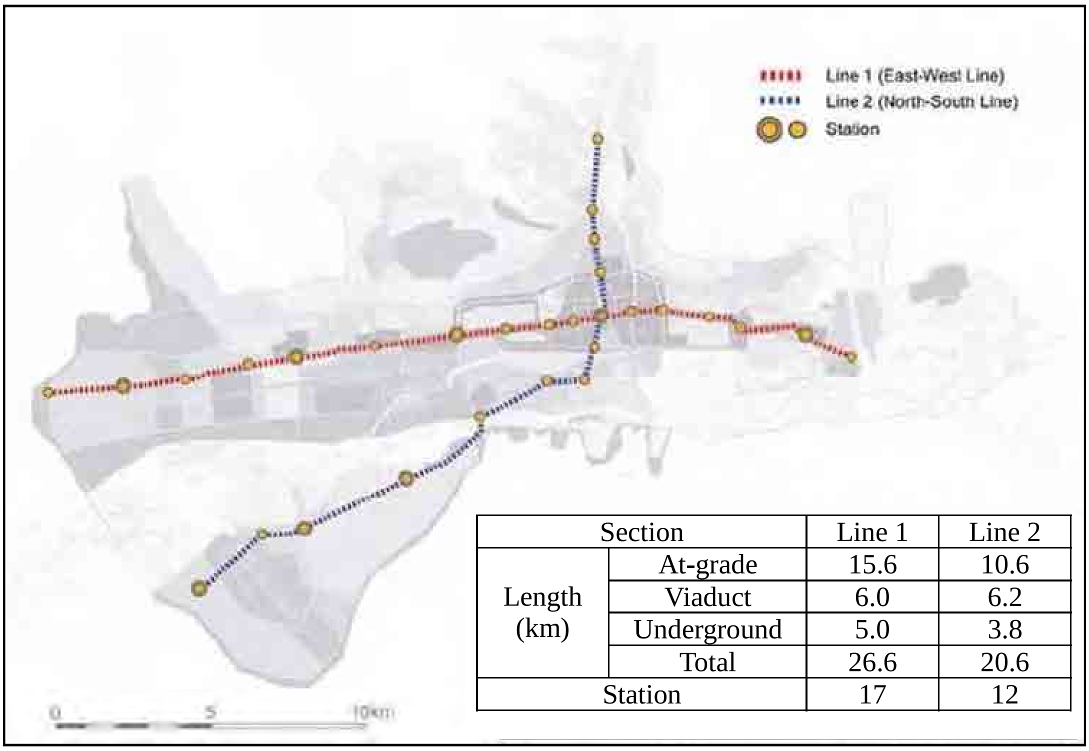
i. Construction plan of two (2) east-west arterial roads pararell to Peace Avenue in the north-south direction;
ii. Construction plan of an inner ring road and an outer ring road in the central city;
iii. Construction plan of three (3) north-south arterial access roads between the east-west arterial roads;
iv. Construction plan of an expressway along the eastern city fringe; and
v. Construction plan of an east-west sub-expressway in the southern city.

One of two east - west arterial road mentioned above “i” has indicated the route connectiong the Power Plant Road and Narny Road going through Ajilchin Fly-over.On the other hand, the present public transport service depends on the city public bus and trolley bus. In the UB M/P, to alleviate vehicle traffic congestion and environmental influence due to exhaust gas, introduction of MRT system (Metro) into the central area and BRT system in east-west and north-south directions is planned along with operational improvement of existing trolley bus system (see Figure 3.1.4).



Source: Department of Roads, Ulaanbaatar City, 2012

Figure 3.1.3 Future Road Network Plan for Ulaanbaatar City in 2030



Section		Line 1	Line 2
Length (km)	At-grade	15.6	10.6
	Viaduct	6.0	6.2
	Underground	5.0	3.8
	Total	26.6	20.6
Station		17	12

Source: JICA: The Study on City Master Plan and Urban Development Program of Ulaanbaatar City (UBMPS), 2009

Figure 3.1.4 Public Transport Service Plan for Ulaanbaatar City in 2030

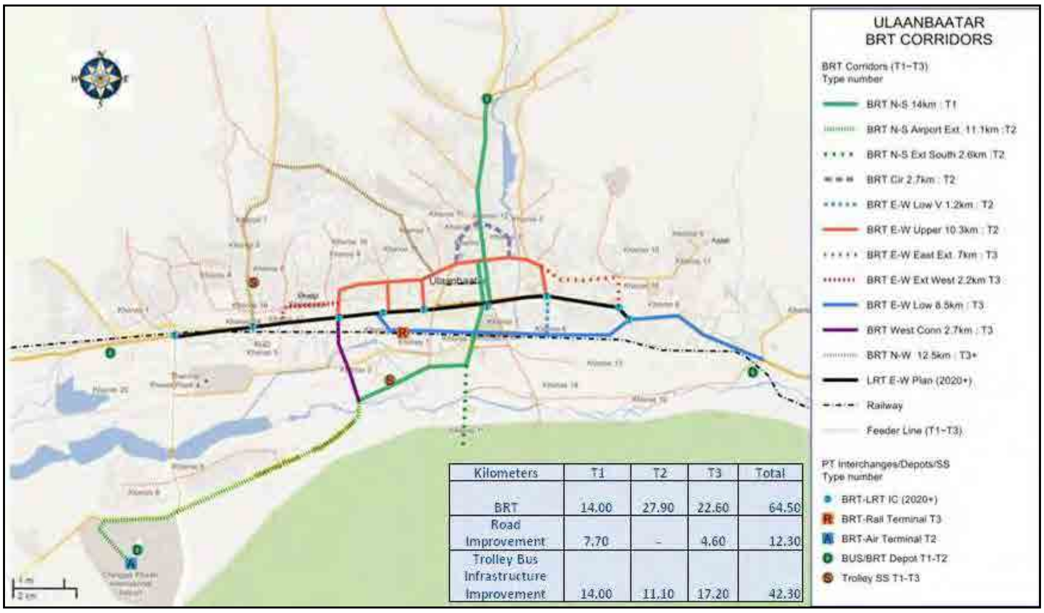
(2) Ulaanbaatar Urban Transport Development Project (ADB BRT Project)

i) Plan Overview

The Ulaanbaatar Urban Transport Development Project (hereinafter referred to as the “ADB BRT Project”) is a feasibility study financed by ADB under its long-term investment program (Multi-Tranche Financing Facility: MFF) based on the financial loan of 88.0 million USD in 2013 and 88.0 million USD in 2015. The detailed design of the project is to be started in 2013. The project consists of (1) the BRT system plan (BRT corridor design, station design, bus terminal design in gel area and BRT operation plan); (2) the road improvement plan (road and bridge improvement, BRT Corridor improvement and trolley bus improvement); (3) the traffic management plan (intersection improvement, road safety improvement and traffic circulation); and (4) the parking operation and NMT plan (CBD parking control, parking control along the BRT route and the NMT plan).

ii) BRT Operation Network Plan

The BRT operation network plan is shown in Figure 3.1.5. The BRT operation network is composed of five (5) routes such as the east-west routes centering on Peace Avenue and the three (3) north-south routes centering on Sukhbaatar-Chinggis Avenue though the CBD area (including the airport southern extension route) and other north-east route.



Kilometers	T1	T2	T3	Total
BRT	14.00	27.90	22.60	64.50
Road Improvement	7.70	-	4.60	12.30
Trolley Bus Infrastructure Improvement	14.00	11.10	17.20	42.30

Source: ADB ULAANBAATAR SUSTAINABLE URBAN TRANSPORT DEVELOPMENT PROJECTS, 2012

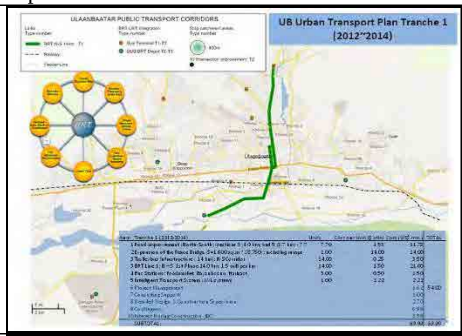
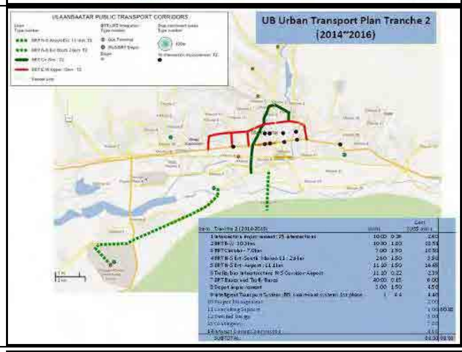
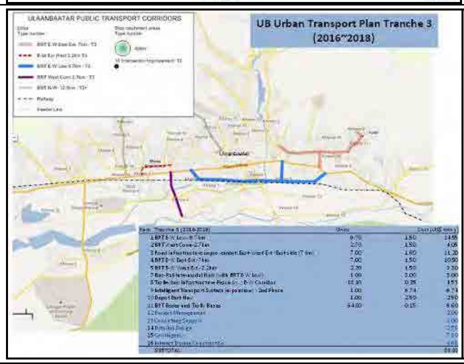
Figure 3.1.5 Ulaanbaatar Urban Transport Development Project (ADB BRT Project)
(Tranche 1-3: 2012-2019)

iii) Implementation Plan of the BRT System

The BRT system will be implemented in three (3) stages: the First Stage (T1) in 2012-2014; the Second Stage (T2) in 2014-2016; and the Third Stage (T3) in 2016-2018 (see Table 3.1.2). The BRT route largely concerned with the traffic demand of the Ajilchin Bridge Construction Project is 14km long north-south route via Chinggis Avenue in the First Stage (T1 in 2012-2014) and the extension route from the airport to southern newtown in the Second Stage (T2 in2014-2016). Of the total traffic demand volume for the Ajilchin Flyover, it is predicted that the trips generated from the airport and southwestern new town will be diverted to the BRT public transport mode.

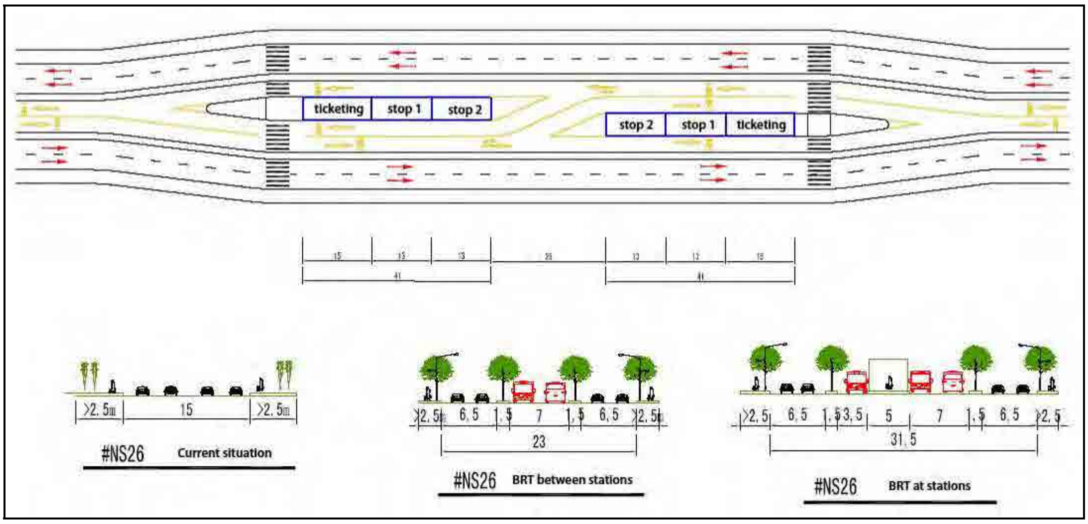
As for the current operation of trolley bus system, the north-south route BRT located on the northern side of Peace Avenue has been terminated. It is required to re-furbish trolley buses and to improve operation schedule in accordance with the commencement of the BRT system and the Metro system. In addition, it is planned to provide pedestrian crossing facilities and to introduce Non-Motorized Transport (NMT) such as walking and/or bicycle.

Table 3.1.2 Operation Plan of Ulaanbaatar BRT System in 2030 (Tranche 1-3: 2012-2019)

Operation Stage of BRT System	Operation Route
BRT System:Tranche 1 (2012~2014) 1) N-S Route:14km	
BRT System: Tranche 2 (2014-2016) 1) Ring Route: 7km 2) E-W Upper Route: 10.3km 3) N-S Airport Extension Route: 11.1km 4) N-S Extension South Route: 2.6km	
BRT System: Tranche 3 (2016-2018) 1) E-W Low Route: 9.7km 2) E-W East Extension Route: 7km 3) E-W Extension West: 2.2km 4) West Connection Route: 2.7km	
LRT (Metro) System: Long-Term Plan 1) LRT (Metro) E-W Route	

iv) Typical Cross-Section of BRT Station

The typical cross-section of the BRT system on Chinggis Avenue which is adjacent to the route of the Ajilchin Flyover Construction Project is shown in Figure 3.1.6. At the marginal section of the road, the existing 4-lane road (carriageway 15m + sidewalk 5m = 20m) will be widened to 6-lane road (carriageway 23m + sidewalk 5m = 28m). On the other hand, in front of the station, the existing road will be widened to 36m in whole section.



Source: ADB ULAANBAATAR SUSTAINABLE URBAN TRANSPORT DEVELOPMENT PROJECTS, 2012

Figure 3.1.6 Ulaanbaatar Urban Transport Development Project (ADB BRT Project)
(Tranche 1-3: 2012-2019)

3.2 FUTURE SOCIO-ECONOMIC FRAME IN ULAANBAATAR CITY

(1) Future Population in Ulaanbaatar City

The future population forecast projected in the JICA M/P are based on the predicted values from the NSO-UNFPA (National Statistics Office, United Nations Population Fund) and the UBMP–2020 (Existing Ulaanbaatar M/P targeting the year 2020) as shown in Table 3.2.1. The average annual growth rate of population in the central 6 districts of Ulaanbaatar City was presumed at 4% until 2010 by reducing the average annual growth rate of 4.2% in 2000-2005, and the JICA M/P projected the future average annual growth rates from 2008 to 2030, as shown in Table 3.2.1, gradually decreasing from 4.2% in 2001-2005 to 2.0% in 2020-2025, and to keep this level in 2026-2030. Based on the above formulation, the future population of Ulaanbaatar City in 2010, 2020 and 2030 was projected at 1.107 million, 1.438 million and 1.739 million respectively (see Table 3.2.1 and Figure 3.2.1).

Through the comparison between the past record of population and the population projection of the JICA M/P for 2005-2010, it was observed that the JICA M/P predicted population of 1.107 million persons (average annual growth rate: 4.0%) is almost close to 1.09 million persons (ditto 3.7%), although the population decreased once in 2009 due to the economic crisis of Lehman Shock.

As for the future population framework after modification by the Urban Development Department of the Ulaanbaatar Municipal Government, the future population of Ulaanbaatar City (6 districts) was projected at 1.051 million persons (ditto 3.0%) in 2010, 1.236 million persons (ditto 1.6%) in 2020 and 1.400 million persons (ditto 1.3%) in 2030. The future traffic demand in the Study for the Ajilchin Flyover Construction Project will adopt the future population framework adjusted by the Urban Development Department of the Ulaanbaatar Municipal Government.

Table 3.2.1 Future Population Forecasts for Ulaanbaatar City (6 districts) until 2030 (JICA M/P)

Classification		2005	2010	2015	2020	2025	2030
JICA M/P	Central UB (6 Districts) (x 1,000)	909.0	1,107.2	1,250.6	1,437.8	1,585.5	1,739.1
	Ave. Annual Growth Rate (%)	4.2	4.0	3.2	2.3	2.0	2.0
Past Record (2005-2010)	Central UB (6 Districts) (x 1,000)	909.0	1,089.9	-	-	-	-
	Ave. Annual Growth Rate (%)	4.2	3.7	-	-	-	-
Ulaanbaatar M/P	Central UB (6 Districts) (x 1,000)	909.0	1,051.4	*1,138.2	1,235.6	*1,318.0	1,400.4
	Ave. Annual Growth Rate (%)	-	*3.0	-	*1.6	-	*1.3

Source: JICA: The Study on City Master Plan and Urban Development Program of Ulaanbaatar City (UBMPS), 2009
MONGOLIAN STATISTICAL YEARBOOK, 2002-2010
Note: * Calculation based on the UB set value

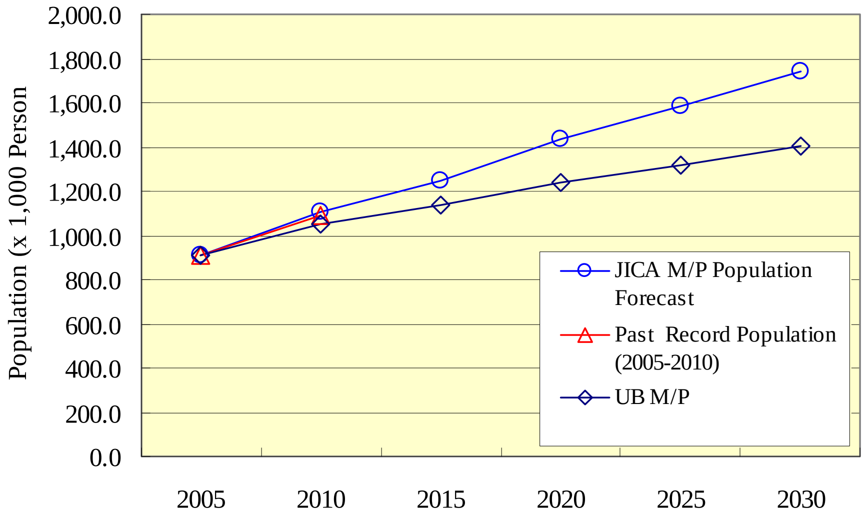


Figure 3.2.1 Future Population Forecasts for Ulaanbaatar City (6 districts) until 2030 (JICA M/P)

(2) Future Gross Regional Domestic Production (RGDP) in Ulaanbaatar City

In the JICA M/P, the average growth rates of GDP in Mongolia and GRDP in Ulaanbaatar from 2008 through 2030 were formulated based on the IMF annual report and the annual statistics book of Mongolia as shown in Table 3.2.2.

The JICA M/P projected 8.3% GDP growth rate for Mongolia and 7.0% GRDP growth rate in Ulaanbaatar City for 2008-2010 following the growth rate in the recent years. For the period of 2011-2015, the mining industry will continuously contribute to the GDP growth of Mongolia, and the GRDP growth rate of Ulaanbaatar City will increase due to development of urban economy. The growth rate of Ulaanbaatar City will exceed that of the entire Mongolia. Therefore, the JICA M/P projected 7.0% GDP growth rate for Mongolia and 7.5% GRDP growth rate for Ulaanbaatar City. The GDP and GRDP growth rates will follow the same trend as in 2015-2020. For the period 2020-2030, the growth rates of Mongolia and Ulaanbaatar City will slow down due to the decrease in population growth and maturing of the economy; however, it is presumed that the growth rates of Ulaanbaatar City and Ulaanbaatar City will follow the stream of stable growth rate. In this context, it was projected that the GDP growth rate of Mongolia is 6.4% and the GRDP growth rate of Ulaanbaatar City is 6.8%. The growth rate of Ulaanbaatar City will still be higher than that of Mongolia because of concentration of population and industries in the city.

The actual achievement of GDP and GRDP in 2008-2010 resulted in a certain deviation from the predicted rate due to the negative growth of -1.3% caused by economic factors such as economic depression by the sudden rise of domestic inflation in 2009 and the economic crisis (Lehman Shock). Although the average growth rate of GRDP decreased from 16.7% to 6.9%, the influence to the GRDP of Ulaanbaatar City was less than the influence to the GDP of Mongolia and the GDP in Mongolia and GRDP in Ulaanbaatar City were high at 6.1% and 12% respectively.

Based on the foregoing, the economy of Mongolia will further stabilize with the increase of revenue from the large-scale development of such mineral resources as coal and the rise of prices, and thus the economic growth rate equal to the GDP and GRDP projected in the JICA M/P is expected.

Table 3.2.2 Assumed Growth Rates of Mongolia's GDP
and Ulaanbaatar's GRDP

Period	GDP in Mongolia	GRDP in Ulaanbaatar City
2008-2010	8.3%	7.0%
2011-2015	7.0%	7.5%
2015-2020	7.0%	7.5%
2020-2030	6.4%	6.8%

Source: JICA: The Study on City Master Plan and Urban Development Program of Ulaanbaatar City (UBMPS), 2009

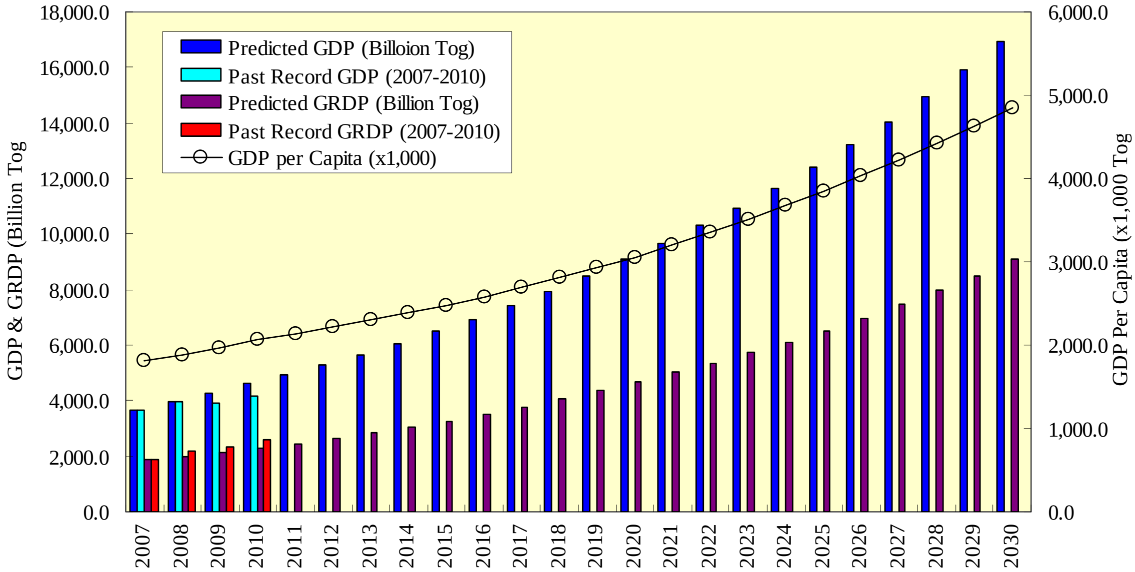


Figure 3.2.2 Assumed Growth Rates of Mongolia's GDP and Ulaanbaatar's GRDP

3.3 CURRENT TRAFFIC CONDITION AND CHARACTERISTICS IN THE STUDY AREA

(1) Result of Traffic Count Survey

The daily vehicle traffic flow condition in the study area in 2012 is shown in Figure 3.3.1. High traffic volumes (two-way, 16-hours) were observed at Chinggis Avenue and the Peace Bridge of Chinggis Avenue with 69,000-62,000 vehicles and 57,000 vehicles respectively. On the other hand, traffic volumes at Energy Street, Ajilchin Street and Narny Road which connect with the western, southern and central parts of the city were 19,000, 44,000 and 38,000 vehicles respectively. With regard to Dund Gol Street which runs in parallel with the railway and the Dund River and used as a detour for the Chinggis Avenue in the east-west direction, the traffic volume was approximately 14,000 vehicles (see Table 3.3.1).

As to the difference of traffic volume between weekdays and holidays, the holiday traffic volume at Peace Avenue, Chinggis Avenue and Narny Road shows about 20-30% decrease in comparison with weekdays. On the other hand, the traffic volume of Energy Street and Dund Gol Street shows about 40-50% of decrease, which reflects that these roads accommodate commuter traffics on weekdays.

The ratio between 16-hour volume and 24-hour traffic volume based on the result of the 24-hour traffic volume counting survey at Ajilchin Street, Narny Road and Chinggis Avenue are 90.7%, 92.2% and 87.8%, respectively on weekdays and 91.1%, 93.1% and 86.5%, respectively on holidays. Based on the ratio of 16-hour volume to 24-hour traffic volume, the highest daily traffic volume of about 75,000-67,000 vehicles is seen at Peace Avenue and the second highest daily traffic volume of 62,000 vehicles is observed at Peace Bridge on Chinggis Avenue. Daily traffic volumes on Energy Street, Ajilchin Street and Narny Road are about 21,000, 49,000 and 41,000 vehicles, respectively (see Figure 3.3.1).

Since the east-west railway in the study area has only two bridges, i.e. the Peace Bridge in the east area and the Gurvaljin Bridge in the west area (at present, the Narny Bridge at the midpoint of these bridges is under construction), the two-way daily traffic volumes reach 62,000 and 49,000 vehicles, respectively. Obviously these two bridges are the bottlenecks from the analysis result of congestion degree (ratio between traffic capacity of 12,000 veh./day[1] and actual daily traffic volume) at 1.30 and 1.01, respectively. Especially, two-way daily traffic volume at the Sapporo roundabout on Peace Avenue intersecting with Ajilchin Street is 75,000 vehicles, and the congestion degree reaches 1.05 indicating capacity over. It was observed that this situation brings the spillback effect from the starting point of the Sapporo roundabout to the succeeding intersections in the peak periods.

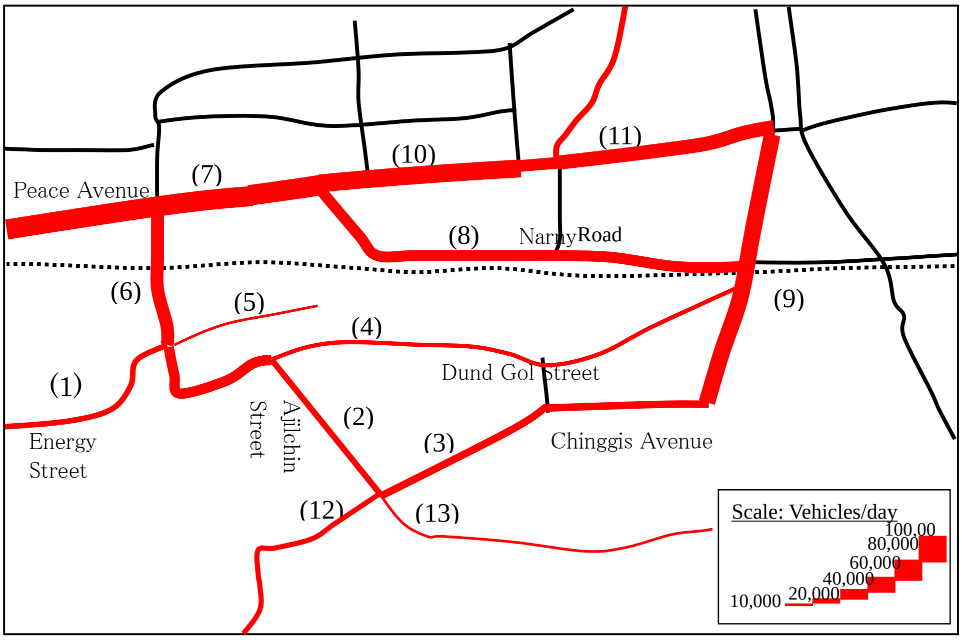


Figure 3.3.1 Current Daily Vehicle Traffic Flow Condition

[1] Road Capacity of 12,000 veh/day is the capacity of Class -1 road of Categoly 4 stipulated in Article 5 of Road Structure Ordinance, Japan, 2004.

Table 3.3.1 Sixteen (16) -Hour Traffic Volume and Daily Traffic Volume
in the Road Network in 2012

Traffic Counting Point	**Existing Traffic Volume in 2012 (Vehicles)**			
	Weekday		**Holiday (Sunday)**	
	16-Hours	**24-Hours**	**16-Hours**	**24-Hours**
(1) Energy Street	19,492	21,100	11,794	12,900
(2) Ajilchin Street	19,876	22,600	12,643	14,600
(3) Chinggis Avenue	24,908	28,356*	20,628	23,861*
(4) Dond Gol Street	14,601	16,600	6,044	7,000
(5) West Industrial Road	3,940	4,300	893	980
(6) Gurvaljin Bridge	44,135	48,673*	28,260	30,990*
(7) Peace Avenue	69,530	75,400	60,059	64,500
(8) Narny Road	37,579	40,757*	32,089	34,457*
(9) Peace Bridge	57,363	62,200	47,800	51,300
(10) Peace Avenue	61,653	66,900	49,847	53,500
(11) Peace Avenue	48,373	52,500	36,416	39,100
(12) Teberchit Street	16,863	19,200	15,405	17,800
(13) Zaisan Street	7,176	8,200	377	440

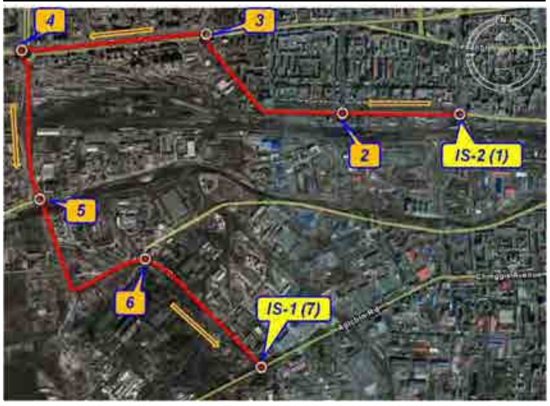
Source: JICA: Ajilchin Br. Study, 2012
Note: * Actual counting volume, the others are calculated volumes based on the factor of 16 hrs/24 hrs.

(2) Result of Travel Time Survey

i) Survey Overview

The peripheral roads around the project site of Ajilchin Bridge were selected as the survey routes for the travel time survey to obtain the current travel speed condition affecting traffic congestion mitigation in the study area (see Figure 3.3.2). The survey was carried out by round trip travel in the morning and evening peak hours and midday off-peak hour. The survey items were time of passing checkpoints, major stopping causes, and frequency.

Route of Western Narny St.-Southern Ajilchin St.



Route of Eastern Narny St.-Southern Ajilchin

Figure 3.3.2 Survey Route for Travel Time Survey

ii) Travel Time Distribution

a) Route of Western Narny Road-Southern Ajilchin Street

In the counterclockwise direction from Western Narny Road to Southern Ajilchin Street, travel time in the morning peak period and the midday period are almost same at 24.8 to 24.9 minutes (average travel speed, about 16km/h). On the other hand, travel time in the evening peak period is double at 45.5 minutes (average travel speed, about 9km/h), which means traffic congestion caused by the perceived bottlenecks at the three-leg intersection (No. 3 point in the Figure) on Peace Avenue with Narny Road and the Sapporo Roundabout (No. 4 point in the Figure) on Peace Avenue with Ajilchin Street.

For the clockwise direction from Southern Ajilchin Street to Western Narny Road, the travel times during the morning peak period and the evening peak period are not much different at 26.6 to 23.8 minutes (average travel speed, 15-17km/h), indicating partial traffic congestion. In the midday period, the travel time is 17.9 minutes (average travel speed, about 22km/h), indicating no traffic congestion.

Table 3.3.2 Travel Time by Peak Period and Average Travel Speed

Route	Morning Peak Period (8:00-10:00)		Midday Period (12:00-14:00)		Evening Peak Period (18:00-20:00)	
	Travel Time (Min.)	Average Travel Speed (km/h)	Travel Time (Min.)	Average Travel Speed (km/h)	Travel Time (Min.)	Average Travel Speed (km/h)
Western Narny Road- Southern Ajilchin Street (6.72km)	24.8	16.3	24.9	16.4	45.5	8.9
Southern Ajilchin Street-Western Narny Road (6.57km)	26.6	14.8	17.9	22.0	23.8	16.6

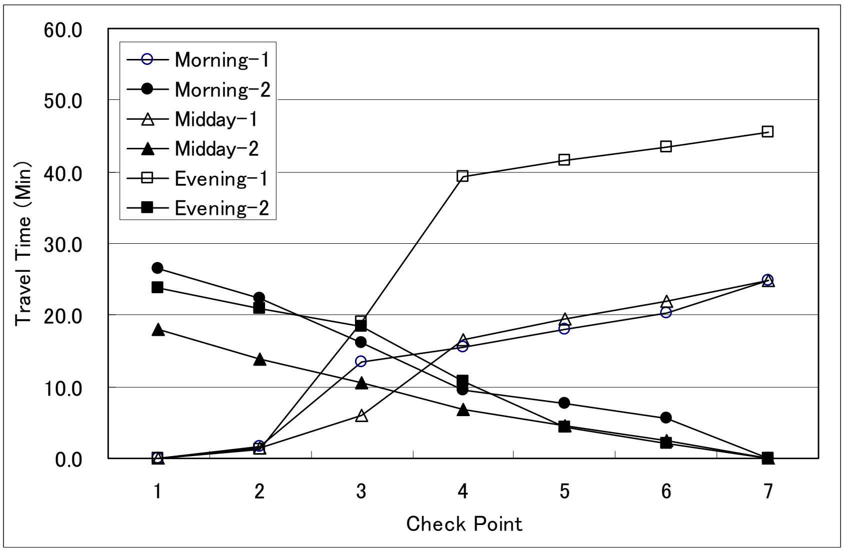


Figure 3.3.3 Travel Time and Distance Diagram

b) Route of Eastern Narny Road-Southern Ajilchin Street

In the clockwise direction from Eastern Narny Road to Southern Ajilchin Street, the travel time in the midday from morning peak period is 25.3-22.2 minutes (average travel speed, 13-15km/h), indicating a slight traffic congestion. However, the travel time in the evening peak period is 33.0 minutes (average travel speed, 10km/h), showing a serious traffic congestion.

On the other hand, for the counterclockwise direction from Southern Ajilchin Street to Eastern Narny Road, the travel times of morning peak period and the midday period are 44.8 to 53.0 minutes (average travel speed, 7-8km/h), showing chronic traffic congestion. In the evening peak period, the travel time is reduced by half at 24.6 minutes (average travel time, 14km/h) in comparison with the morning peak period, indicating minor traffic congestion. It was observed that these traffic congestions are caused by the bottlenecks of signalized intersection on the Peace Avenue with the Ajilchin Street in the neighborhood of Peace Bridge.

Table 3.3.3 Travel Time by Peak Period and Average Travel Speed

Route	**Morning Peak Period (8:00-10:00)**		**Midday Period (12:00-14:00)**		**Evening Peak Period (18:00-20:00)**	
	Travel Time (Min.)	**Average Travel Speed (km/h)**	**Travel Time (Min.)**	**Average Travel Speed (km/h)**	**Travel Time (Min.)**	**Average Travel Speed (km/h)**
Eastern Narny Road-Southern Ajilchin Street (5.37km)	25.3	12.8	22.2	14.5	33.0	9.8
Southern Ajilchin Street-Eastern Narny Road (4.77km)	44.8	7.7	53.0	6.5	24.6	14.1

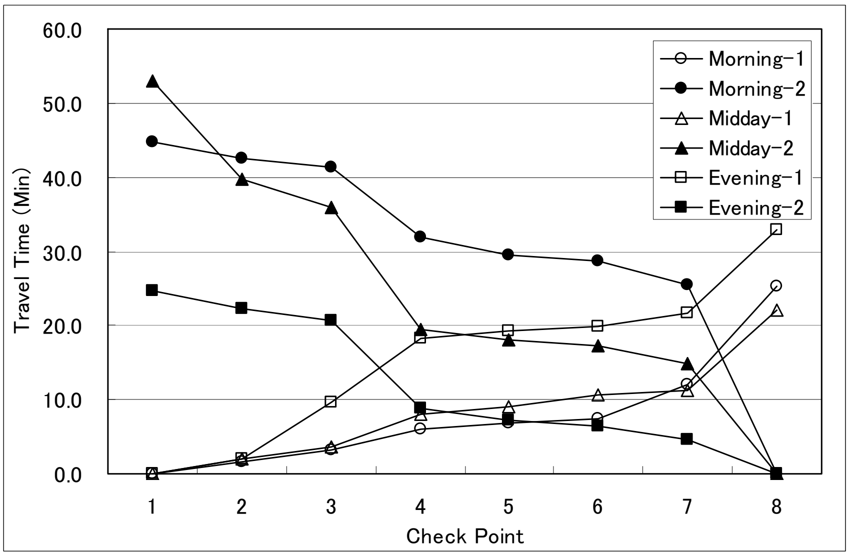


Figure 3.3.4 Travel Time and Distance Diagram

iii) Average Travel Speed by Segment and Major Stopping Causes

Distribution of average travel speed by segment in the periods of morning peak (8:00-10:00), midday (12:00-14:00) and evening peak (18:00-20:00) is shown in Figure 3.3.5.

In the morning peak period, the segments of Chinggis Avenue and Narny Road were identified as heavily congested areas in terms of travel speed of 10km/h or less. Most stoppages were the result of intersection waiting time by the concentration of commuter traffic and the spill-back effect due to the bottleneck at the signalized intersections. Obviously, the intersection of Peace Bridge with Narny Road, the three-leg intersection cranking to the right from southern Peace Bridge and four-leg signalized intersection on the Chinggis Avenue with Ajilchin Street are recognized as bottlenecks.

Traffic congestion is almost alleviated in the midday period, indicating travel speed at 20km/h-40km/h; however, traffic congestion still remains around the intersection of Peace Bridge and Narny Road on the Chinggis Avenue in the same manner as the morning peak period with average travel speed of less than 10km/h. The major stoppages are resulting from the spill-back effect due to the bottlenecks of signalized intersection. The bottlenecks are therefore limited to the intersection of Peace Bridge with Narny Road, the three-leg intersection and the four-leg signalized intersection on the Chinggis Avenue with Ajilchin Street in the same manner as the morning peak period.

In the evening peak period, the Sapporo roundabout on Peace Avenue, the west entrance of Narny Road with the Peace Avenue and the intersection of the Peace Bridge and Narny Road on the Chinggis Avenue in the same manner as the morning peak and midday periods were identified as heavily congested area, indicating travel speeds of 10km/h or less. The major stoppages are resulting from the spill-back effect due to the bottlenecks of signalized intersection. The bottlenecks are the Sapporo roundabout and the intersection of Peace Bridge with Narny Road.

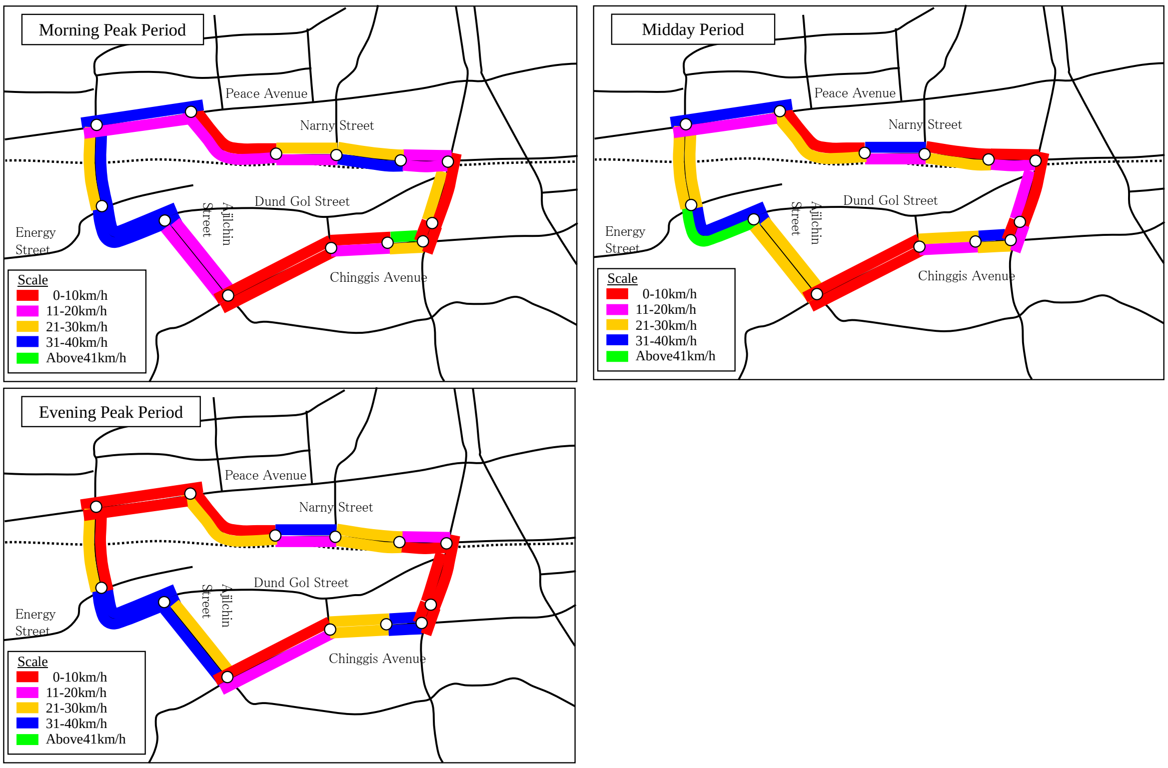


Figure 3.3.5 Distribution of Average Travel Speed by Segment

(3) Analysis of Traffic Bottleneck in the Study Area

i) Identification of Bottleneck for Factors of Traffic Congestion

As shown by the analysis of the traffic count survey, the existing Gurvaljin Bridge and the Peace Bridge will be the bottlenecks of traffic congestion due to the concentration of traffic between western/southern city and central city in the peak periods. In addition, as shown by the analysis of the travel time survey, it was observed that the roads located in these existing bridges will be the bottleneck segments of traffic congestion judging from the situation of excess traffic capacity of existing roads, because the average travel speed is remarkably low. The locations and segments of traffic bottleneck that becomes the factors of traffic congestion in the study area are shown in Figure 3.3.6.

ii) Factors causing Traffic Congestion and Necessity of Ajilchin Bridge Construction

The factors causing traffic congestion in the study area are pointed out as below:

- Insufficient traffic capacity of major intersections
- Concentration of traffic to the limited number of existing bridges over the east-west railway (Gurvaljin Bridge and the Peace Bridge)

Especially, since the bridges on the east-west railway in the study area are only the Peace Bridge in the east area and the Gurvaljin Bridge in the west area, these bridges are bottlenecks causing traffic congestion by the traffic concentration. In this context, it is assumed that the construction of Ajilchin Bridge on the east-west railway is highly required to avoid the traffic bottleneck on the Gurvaljin Bridge and the Peace Avenue.

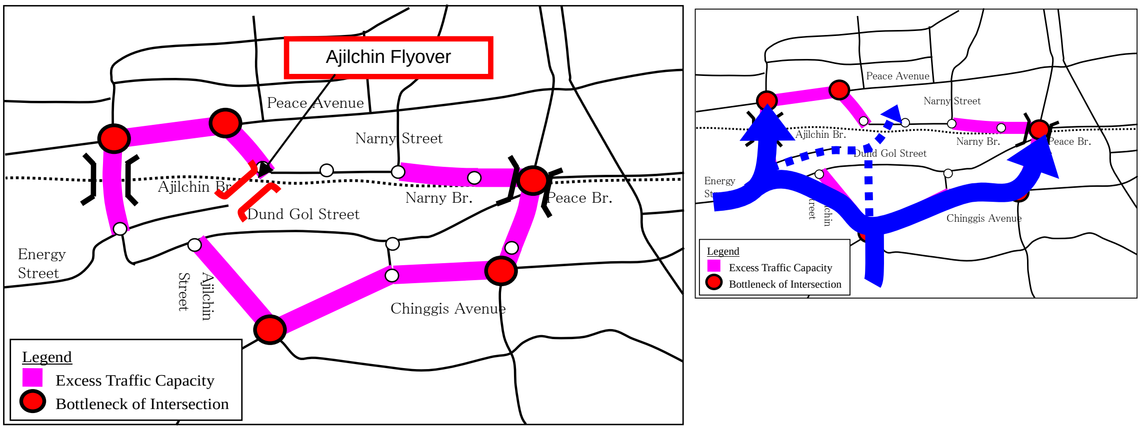


Figure 3.3.6 Bottlenecks and Segments with Excessive Traffic and Change of Traffic Flow

(4) Verification for Construction Effect of Ajilchin Bridge

The distribution of daily average travel speed by segment after the construction of Ajilchin Bridge as the results of the existing traffic assignment simulation on the basis of existing vehicle OD survey is shown in Figure 3.3.7 and Figure 3.3.8.

By comparison of the existing travel speed in the morning/evening peak periods obtained through the travel time survey and the traffic assignment simulation, the construction effect of Ajilchin Bridge is as summarized below.

- With construction of Ajilchin Bridge, average travel speeds are increased at; Peace Avenue (+7%), Ajilchin Street (+11~21%), Chinggis Avenue (+3~7%) and Narny Road (+6%), which will induce significant alleviation of traffic congestion in these roads.
- Especially, average travel speed of Ajilchin Street (from Gurvaljin Bridge connecting to Chinggis Avenue) is drastically increased. It means diversion of traffics from western part of Ulaanbaatar City to Ajilchin Bridge will duly contribute to alleviation of traffic congestion at Gurvaljin Bridge and Chinggis Avenue.

Based on the above aspects, construction of Ajilchin Bridge has significant effect of alleviation of current traffic congestion.

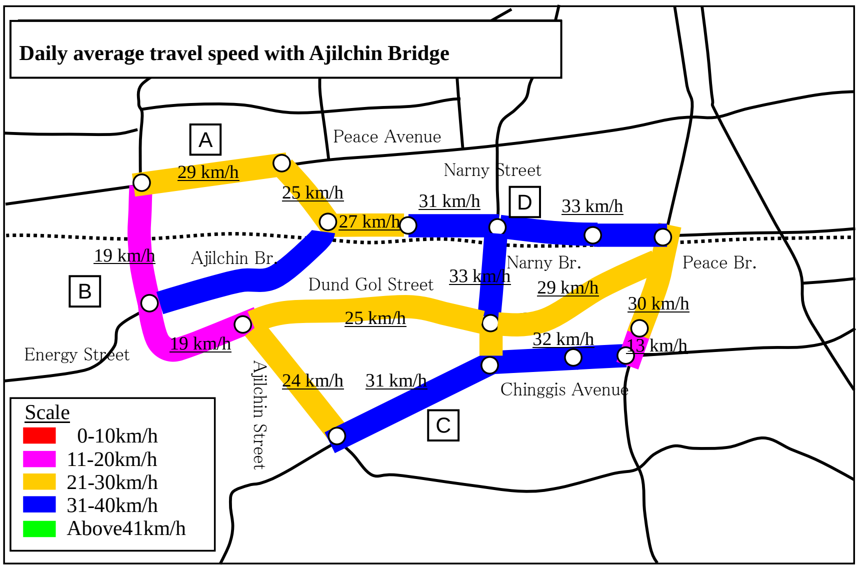


Figure 3.3.7 Distribution of Daily Average Travel Speed by Existing Traffic Assignment Simulation (after construction of Ajilchin Bridge)

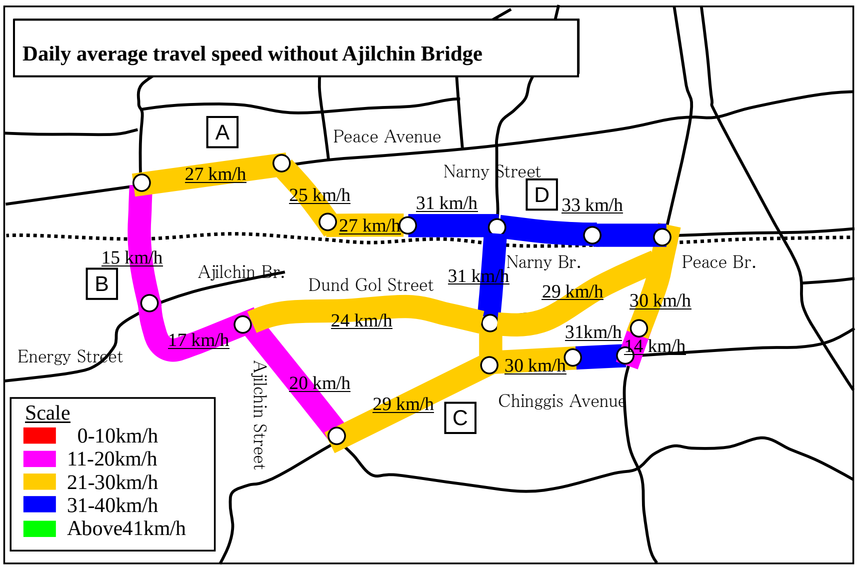


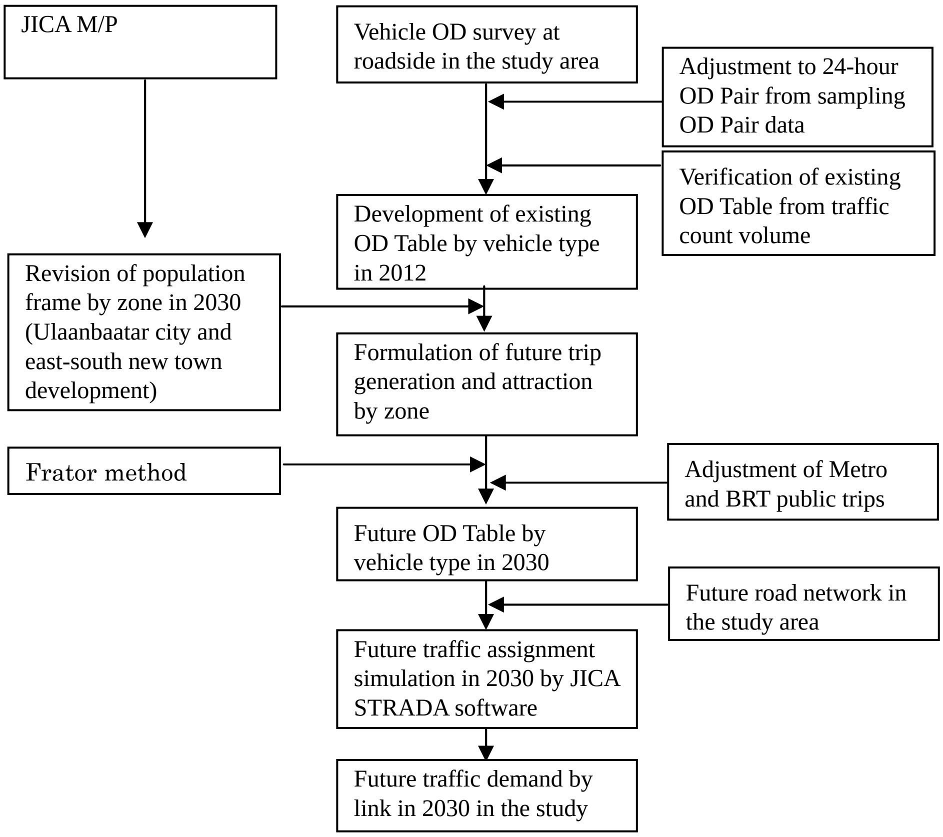
Figure 3.3.8 Distribution of Daily Average Travel Speed by Existing Traffic Assignment Simulation (before construction of Ajilchin Bridge)

It must be noted that average travel speed in Figure 3.3.7 and Figure 3.3.8 are simulation output of JICA STRADA, and waiting time at traffic signals is not taken into account. Accordingly, these figures of average travel speed shall be used only for comparison of two (2) cases, i.e. with Ajilchin Bridge and without Ajilchin Bridge, and thus do not give exact travel speed.

3.4 FUTURE TRAFFIC DEMAND FORECAST

(1) Method of Future Traffic Demand Forecast

The future traffic demand forecast of the Ajilchin Bridge in the study area was carried out based on the flow chart shown in Figure 3.4.1. The task of traffic demand forecast is presented as below.



Note: OD Survey is an interview survey to clarify origin and destination with purpose of trip

Figure 3.4.1 Flow Chart of Future Traffic Demand Forecast in the Study Area

i) Development of Existing OD Table in 2012

Based on the result of sampling OD data of the vehicle OD survey at nine (9) locations in the study area for the Ajilchin Bridge construction, the existing OD Table by vehicle type in 2012 was formulated. The existing and future road network and zoning was generally uniformed with the report of JICA M/P in 2007. However, the traffic assignment simulation was carried out based on the sixteen (16) zones (dividing only 3 zones around Ajilchin Bridge into smaller zones) in the study area of Ajilchin Bridge construction and eight (8) integrated zones in the outside study area (outside 9 locations of vehicle OD survey) of Ajilchin Bridge construction (see Figure 3.4.2).

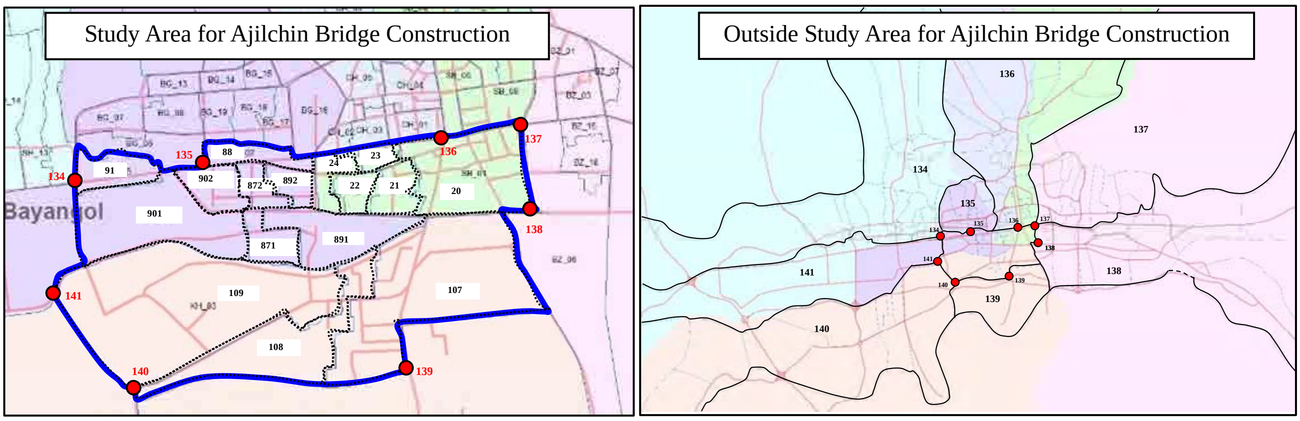


Figure 3.4.2 Existing Road Network in 2012 and Traffic Zones

ii) Development of Future OD Table in 2030

The future OD Table by vehicle type in 2030 was formulated from the existing OD Table with the process of combined future zonal population of the Ulaanbaatar City in the JICA M/P. As to the future population framework, the zonal future generation and attraction volumes in 2030 resulted in a decrease of 80.5%, because the future population in the UB M/P was brought down at 1,400,000 from the 1,740,000 in the JICA M/P. Furthermore, with regard to the development program of the southwestern city (large-scaled new town), the zonal future generation and attraction volumes in related development area also resulted in a decrease of 85.0%, since the population frame in the new town plan was reduced from 200,000 of the JICA M/P by 170,000.

In this study, diverted trips to the public transport mode such as Metro and BRT system in the city was equated with the OD trips of public transport in the future vehicle OD Table; therefore, the traffic assignment in 2030 without the zonal generation and attraction trips of public transport mode was carried out.

iii) Future Traffic Assignment

Based on the future OD Table in 2020 and 2030, the future traffic assignment was carried out on the future road network, in both cases of “with” and “without” the Ajilchin Bridge construction, through the simulation model of JICA STRADA software.

(2) Future Traffic Demand

The future traffic demand (daily two-way traffic volume) at the major locations in 2020 and 2030 in both cases of “with” and “without” the Ajilchin Bridge construction is shown in Table 3.4.1 and Figure 3.4.3. The OD Pair desire line and traffic volume flow map are shown in Figure 3.4.4 (1)(2) and Figure 3.4.5 (1)(4).

i) Future Traffic Demand in 2020

The future traffic demand in 2020 at the Ajilchin Bridge was estimated at 26,600 vehicle/two-way day. By comparison between the future traffic demand by links "with the Ajilchin Bridge" and "without the Ajilchin Bridge," the impact situation to the surrounding roads is pointed out as below:

- The traffic load at the Gurvaljin Bridge of the Ajilchin Street will be reduced at approximately 19%.
- At the same time, the traffic load at the Peace Avenue and the Chinggis Avenue where there are existing competitive routes with the Ajilchin Bridge will be reduced at approximately 18% and 14% respectively, in segments of significant change.
- On the other hand, the in-and-out traffic to the Narny Road will be increased, and the traffic load is increased at approximately 22%, in segments of significant change.

ii) Future Traffic Demand in 2030

The future traffic demand in 2030 at the Ajilchin Bridge was estimated at 57,600 vehicle/two-way day. By comparison between the future traffic demands by links "with the Ajilchin Bridge" and "without the Ajilchin Bridge," the impact situation to the surrounding roads is pointed out as below:

- The traffic load at the Gurvaljin Bridge of the Ajilchin Street will be reduced at approximately 34%.
- At the same time, the traffic load at the Peace Avenue and the Chinggis Avenue where there are existing competitive routes with the Ajilchin Bridge will be reduced at approximately 48% and 19% respectively, in segments of significant change.
- On the other hand, the in-and-out traffic to the Narny Road will be increased, and the traffic load is increased at approximately 39%, in segments of significant change.
-

Table 3.4.1 Future Traffic Demand (Daily Two-Way Traffic Volume) in 2020/2030 in the Future Road Network

Location	**Daily Two-Way Traffic Volume (Vehicle)**			
	In 2020		**In 2030**	
	With	**Without**	**With**	**Without**
(1)	26,600	-	57,000	-
(2)	21,000	22,700	24,200	29,700
(3)	31,600	24,600	52,300	31,800
(4)	54,600	67,000	51,300	98,800
(5)	50,300	62,300	76,000	115,700
(6)	35,600	35,600	99,300	99,300
(7)	55,200	52,900	103.900	100,800
(8)	22,100	21,900	45,300	47,400
(9)	6,900	8,500	13,100	15,500
(10)	22,600	28,600	46,200	50,200
(11)	26,700	21,200	49,200	44,600

Location	Daily Two-Way Traffic Volume (Vehicle)			
	In 2020		In 2030	
	With	Without	With	Without
(12)	44,300	46,600	70,300	72,400
(13)	11,800	23,000	25,300	24,800
(14)	33,400	31,600	64,100	62,900
(15)	30,000	34,400	53,300	63,400
(16)	29,900	37,100	55,300	67,900
(17)	25,500	28.000	40.000	40,200

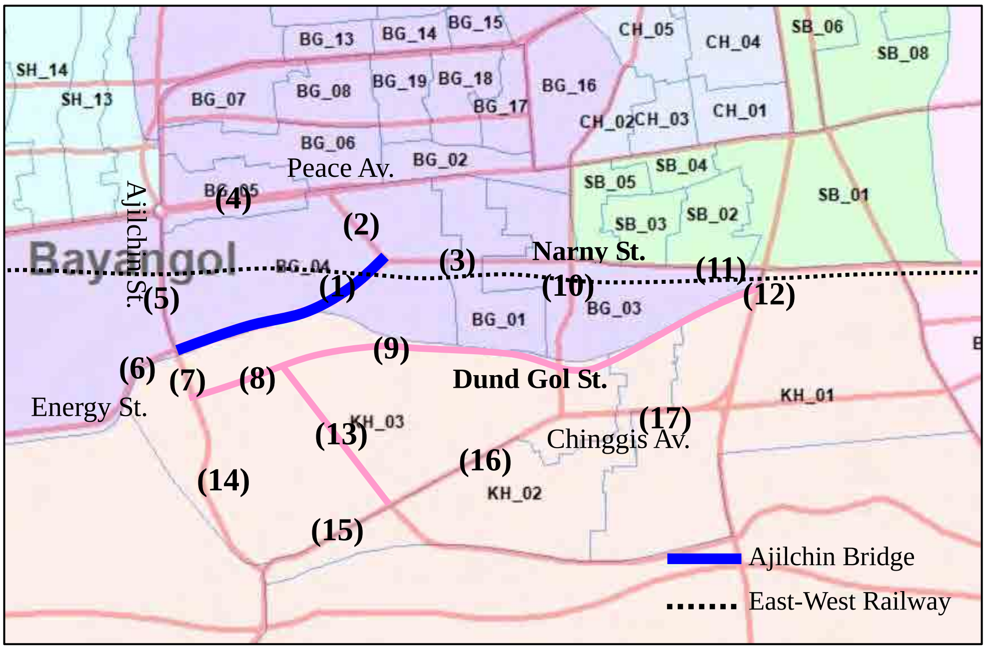


Figure 3.4.3 Location of Future Traffic Dead in Future Road Network

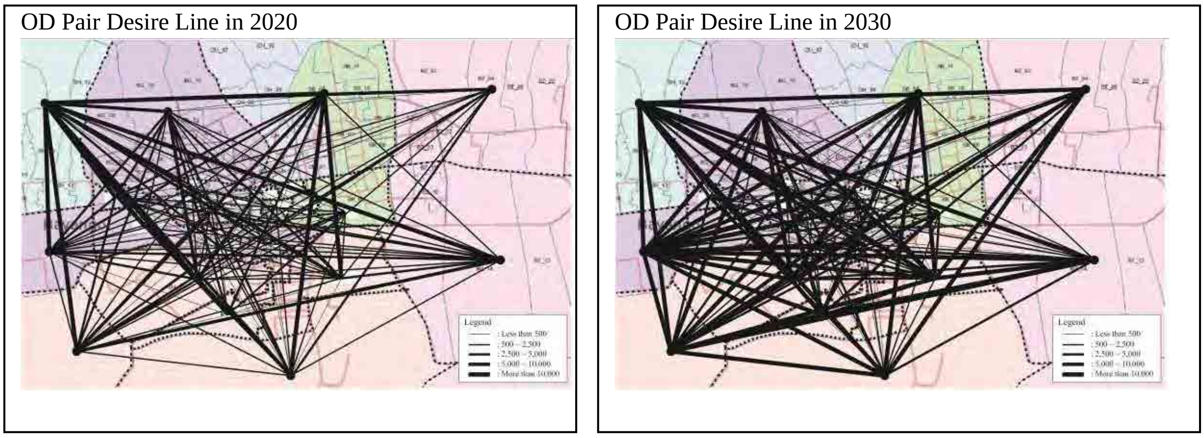
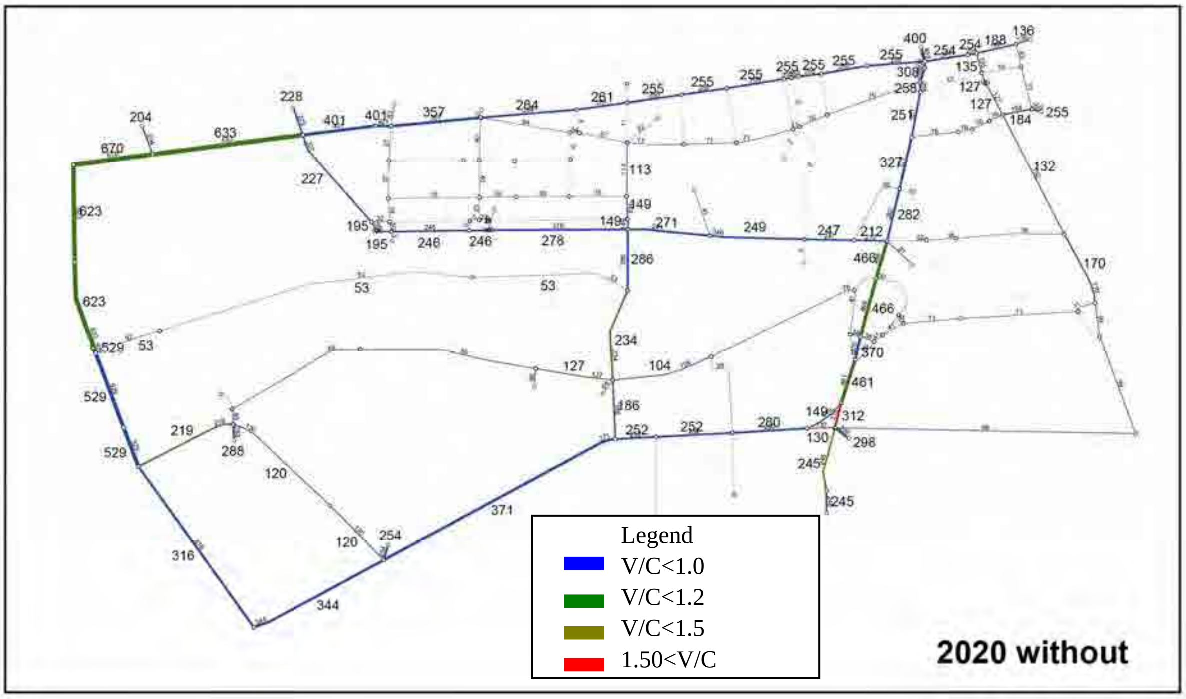


Figure 3.4.4 OD Pair Desire Line in 2020/2030



Figur 3.4.5(1) Daily Draffic Demand in 2020 (WithCase)

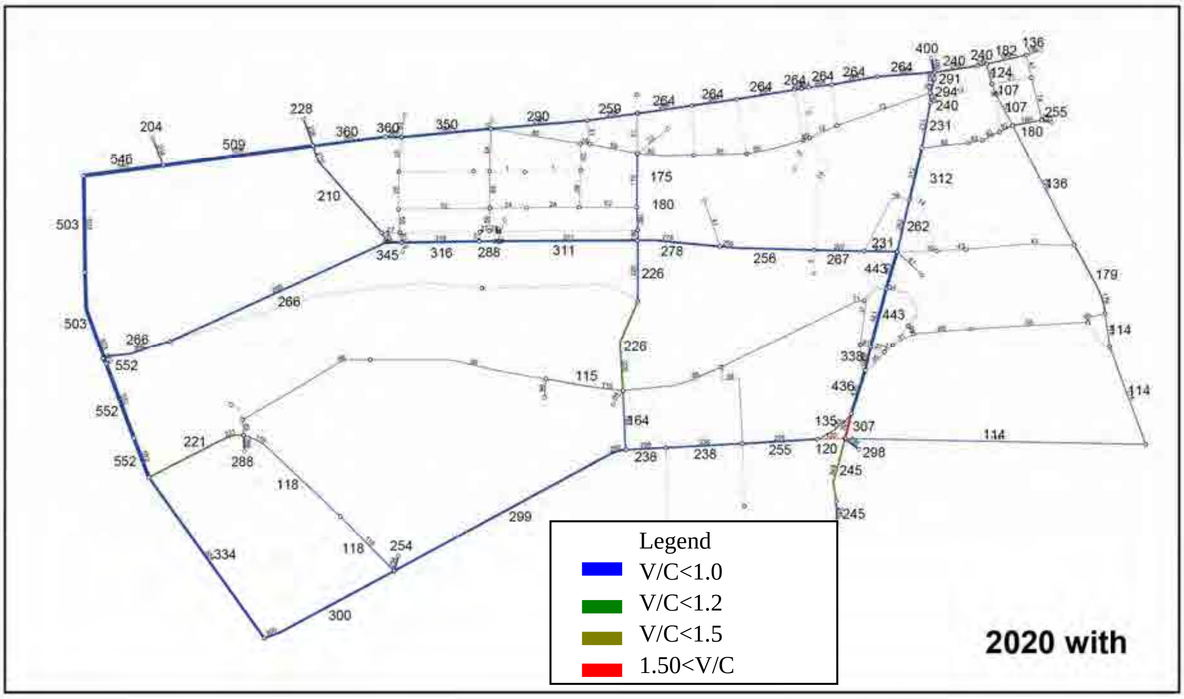


Figure 3.4.5(2) Daily Draffic Demand in 2020(WithoutCase)

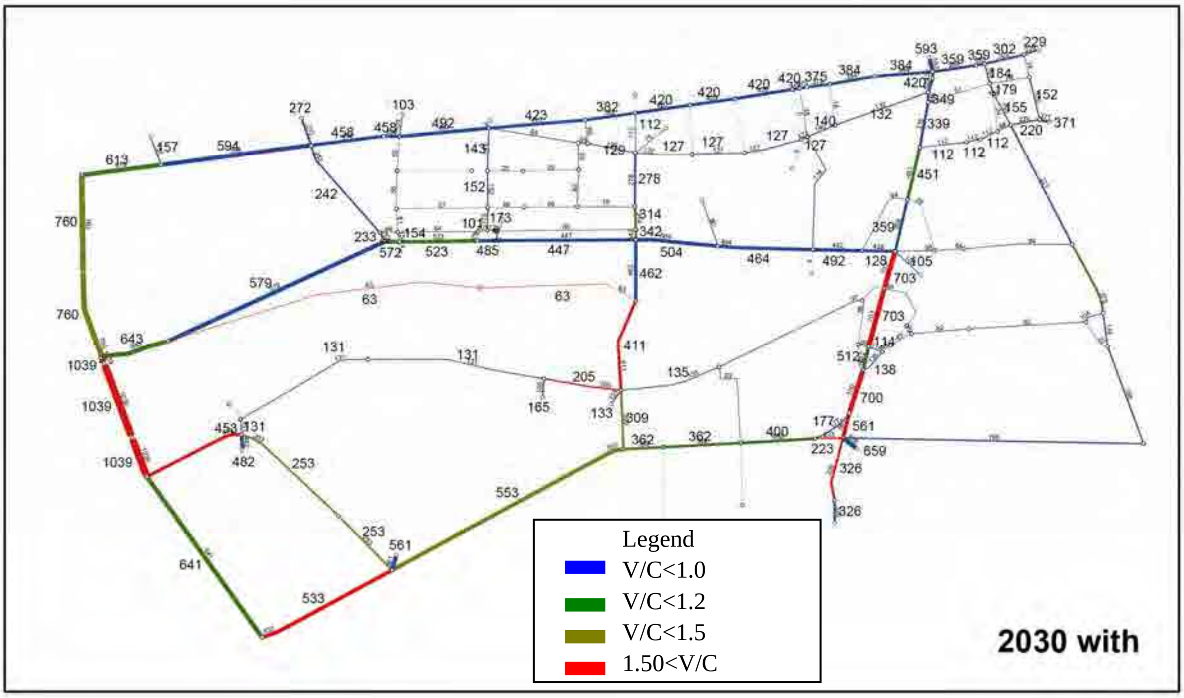


Figure 3.4.5(3) Daily Draffic Demand in 2030 (WithCase)

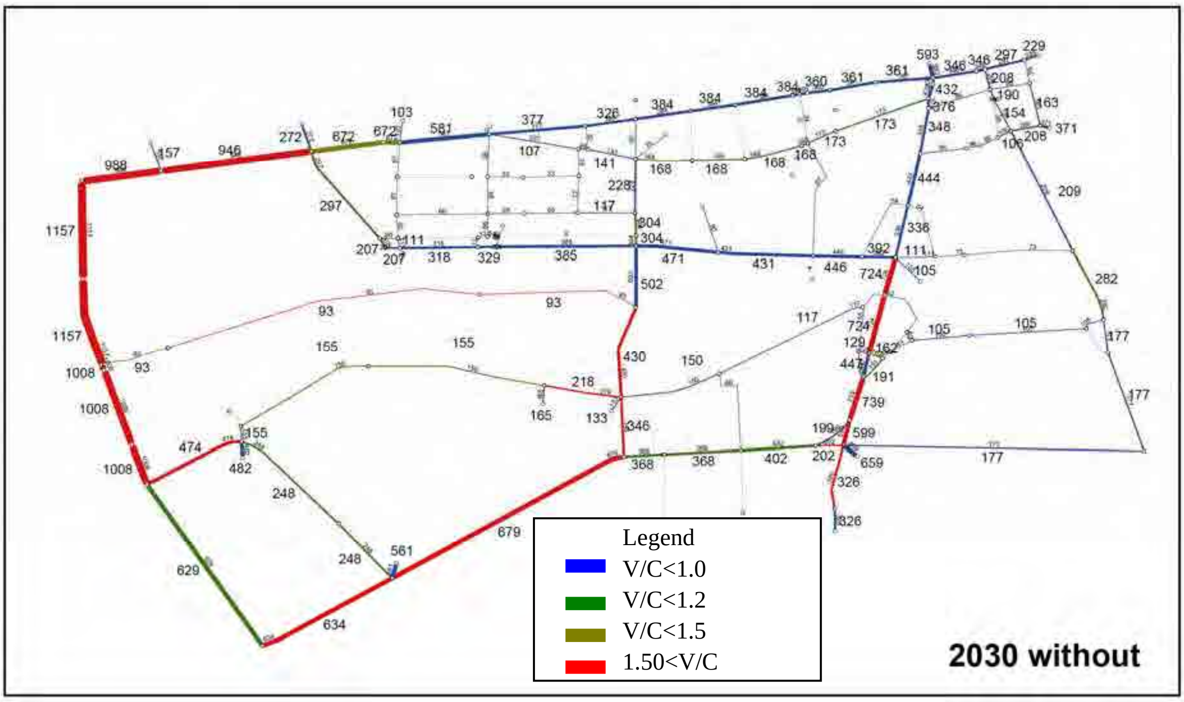


Figure 3.4.5(4) Daily Draffic Demand in 2030 (WithoutCase)

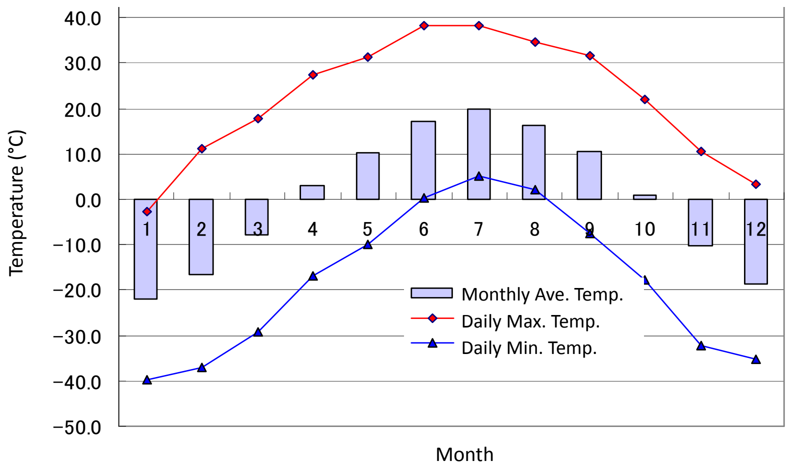
CHAPTER 4

NATURAL CONDITIONS

4.1 CLIMATE

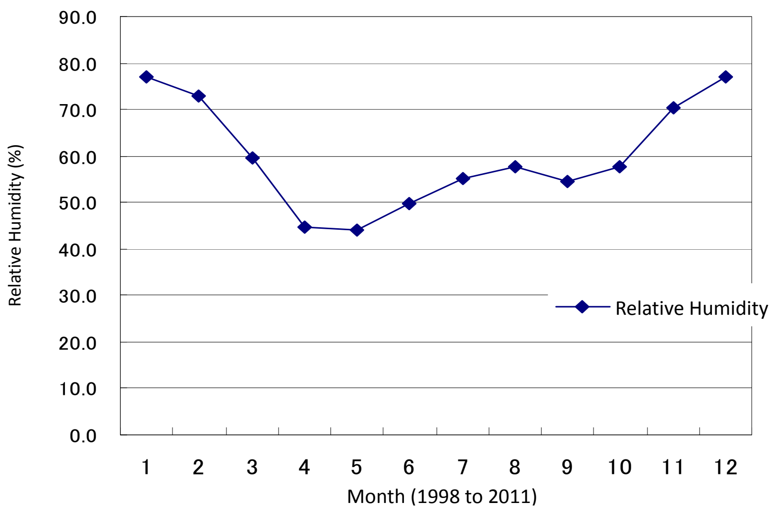
(1) Temperature and Humidity

Ulaanbaatar City has a continental climate, which is characterized by a cold climate from October to April with an average temperature of about 0°C or below (daily lowest temperature in January is -40°C) and a long spell of hot summer (daily highest temperature is 40°C) from May to September. Furthermore, daily temperature fluctuation reaches as high as 30°C to 40°C. Humidity exceeds 70% in winter season from November to February, and is less than 60% in March through October.



Source: JICA Survey Team

Figure 4.1.1 Temperature Data (1998-2011: Ulaanbaatar Station)

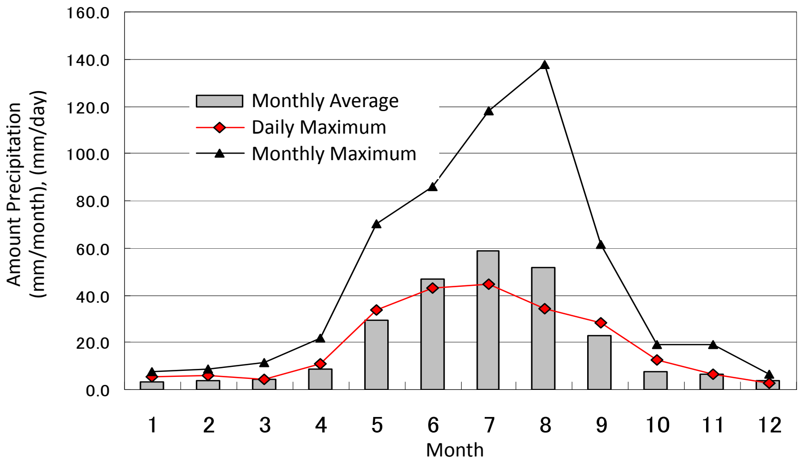


Source: JICA Survey Team

Figure 4.1.2 Humidity Data (1998-2011: Ulaanbaatar Station)

(2) Precipitation

According to meteorological data for the past 14 years (1998 to 2011), the annual average precipitation is 247.8 mm/year. As for monthly precipitation, they have comparatively large amounts of rain from May to September with the maximum monthly average precipitation occurring in July at 58.6 mm/month. The maximum monthly precipitation amount in the past 14 years is 137.7 mm/month in August 2000. Focusing on daily precipitation amounts, the maximum amount is 44.8 mm/day in July 2009.

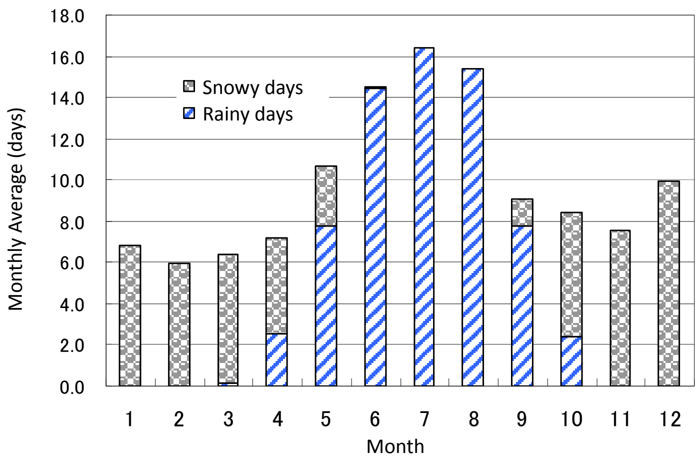


Source: JICA Survey Team

Figure 4.1.3 Precipitation Data (1998-2011: Ulaanbaatar Station)

(3) Number of Days with Rainfall and Snowfall

There is snowfall but no rainfall from October through April, and the number of days with snowfall is approximately 6-8 days a month. The number of days with rainfall from May through September, when the construction work is scheduled, is 10-16 days a month.

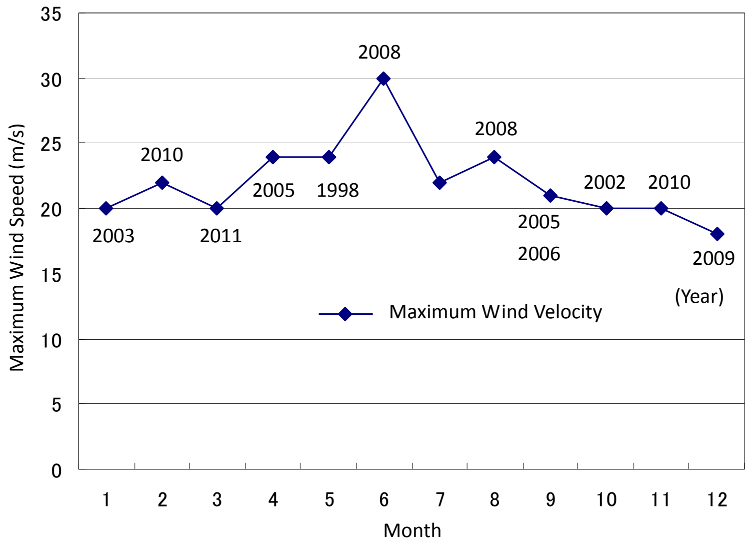


Source: JICA Survey Team

Figure 4.1.4 Number of Days with Rainfall and Snowfall (1998-2011: Ulaanbaatar Station)

(4) Wind Velocity

Figure 4.1.5 shows the monthly maximum wind velocity data. The maximum value is V=30m/s (June 2008), but values from V=20m/s to 25m/s are recorded throughout the year.



Source: JICA Survey Team

Figure 4.1.5 Monthly Maximum Wind Speed Data (1998-2011 : Ulaanbaatar Station)

4.2 TOPOGRAPHIC AND GEOLOGICAL CONDITION

(1) General

Ulaanbaatar City stretches about 5km long north to south and about 30km long east to west, and the altitude is around 1,300m. On the southern part of the city, the Tuul River runs from east to west along the foot of Bogdkhan Mountain Conservation Area. There is a series of virtually bare mountains and hills on the northern part of the city. The Selbe River (of which downstream is called as the Dund Gol River) flows into the Tuul River from the south slope in the northern part of the city. The Project site is located on the lowland consisting of diluvium terrace deposit and alluvial river sediments.

As for the geological condition of Ulaanbaatar City, the mountain area consists of sandstone and shale of the Carboniferous period in the Paleozoic era and the Cretaceous period in the Mesozoic era and, in particular, granite of the Jurassic period in the Mesozoic era is distributed on the south mountains.

Quaternary diluvium is distributed as terrace deposit, and alluvium sediment is distributed in the vicinity of river. Figure 4.2.1 shows the geological segmentation of Ulaanbaatar City.

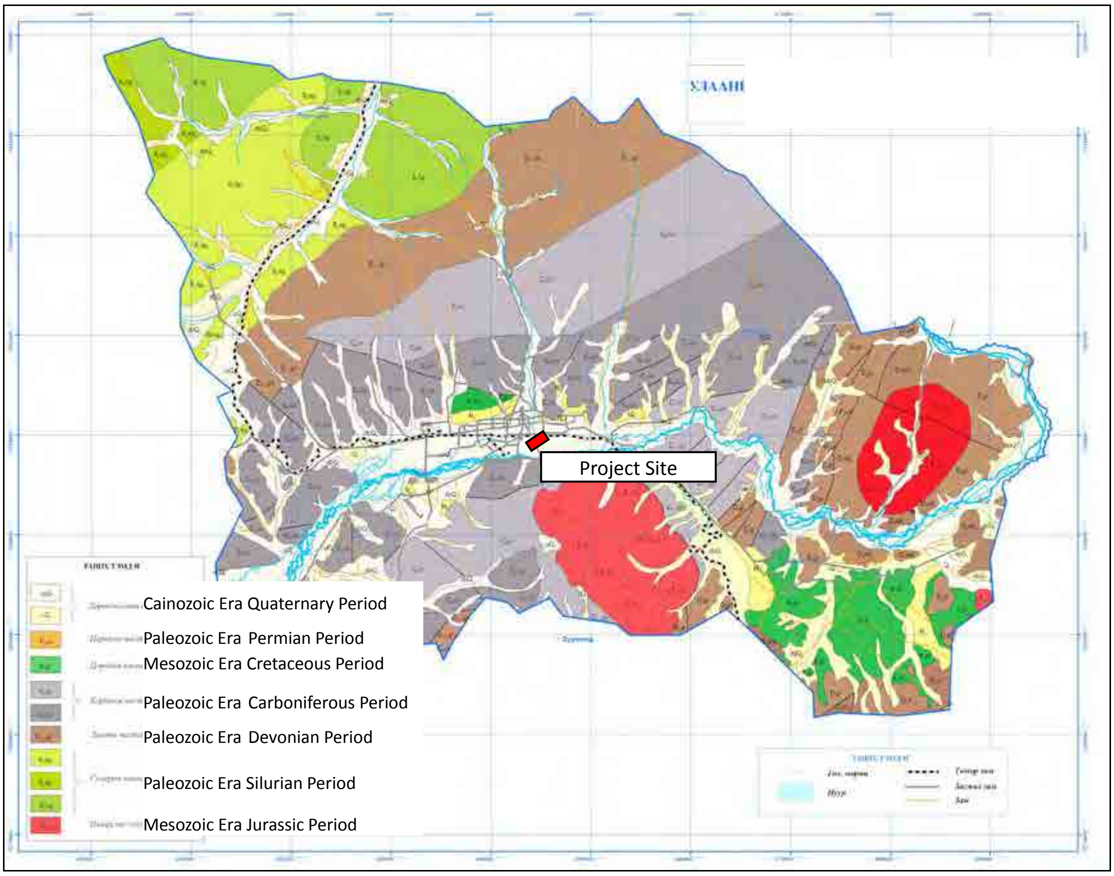


Figure 4.2.1 Geological Segmentation Diagram of Ulaanbaatar City

(2) Soil Property at the Project Site

The Project site belongs to the Bayanggol District No. 4. This area becomes a line of which the east end starts at Narny Road in front of Ulaanbaatar Station, going across the railway, passing West Industry Road along the Dund Gol River (the Selbe River) and reaching Ajilchin Street.

The geological formation of the Project site is classified as Diluvium and Alluvium of Quaternary Period in Cenozoic mainly consisting of loose sand, clayey gravel and sand with boulder (maximum diameter of 75mm).

(3) Field Test Results

At the site, (a) boring investigation with Standard Penetration Test (SPT), (b) test-pit digging for CBR test, and (c) field permeability test were carried out. Each test point is indicated in the figure below.

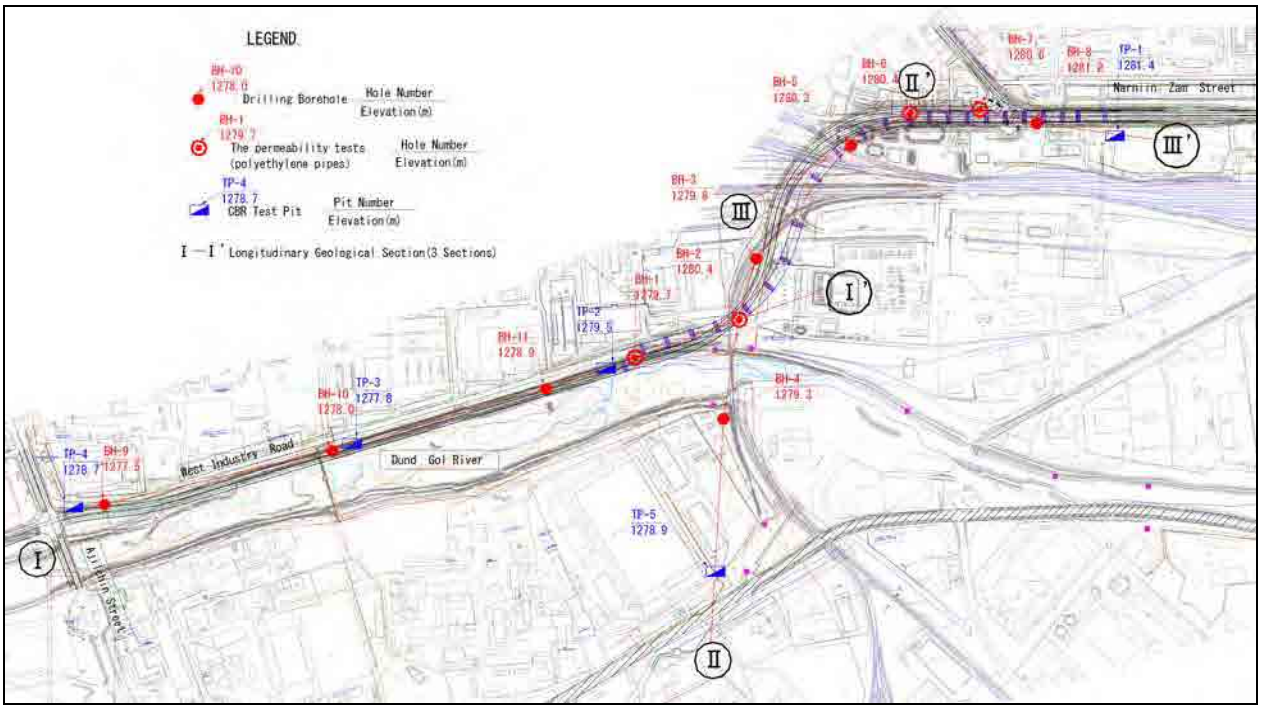


Figure 4.2.2 Field Test Location Map

The machine boring accompanied with SPT were carried out at 11 points in total: five (5) points at the flyover section, four (4) points at West Industry Road, one (1) point at South Road opposite side of the Dund Gol River, and one (1) point at Narny Road. As for CBR Tests test-pit digging and material sampling were carried out at five (5) locations in total: three (3) locations at West Industry Road, one (1) location at South Road opposite side of the Dund Gol River, and one (1) location at Narny Road.

Table 4.2.1 Details of Field Tests

Items	Positions	Ground Elevation (m)	Depth (m)	Laboratory Test
Machine Boring with SPT	BH-1	1,279.7	19.0	Specific gravity of soil particle, unit weight, Atterberg limit, particle size and natural water content
	BH-2	1,280.4	18.0	
	BH-3	1,279.8	12.0	
	BH-4	1,279.3	19.0	
	BH-5	1,280.3	16.0	
	BH-6	1,280.4	16.0	
	BH-7	1,280.6	12.0	
	BH-8	1,281.2	14.0	
	BH-9	1,277.5	12.0	
	BH-10	1,278.0	14.0	
	BH-11	1,278.9	13.0	
CBR Test (sampled from test-pit)	TP-1	1,281.4	2.0	Unit weight, particle size, natural water content, compaction test, and immersion CBR test
	TP-2	1,279.5	2.1	
	TP-3	1,277.8	2.0	
	TP-4	1,278.7	2.0	
	TP-5	1,278.9	2.0	
Field Permeability Test (Unsteady Method)	BH-1	1,279.7	3.0	
	BH-2	1,280.4	3.0	
	BH-6	1,280.4	3.0	
	BH-7	1,280.6	3.0	

As a result of boring investigation at 11 locations in the Project site, embankment consisting of a gravel layer with clay and sand exist with 1 - 2m thick. Especially, the top layer of embankment up to one meter deep from the surface is loose. Relatively dense sand and gravel bearing boulders underlies with 4 – 8m thick. Groundwater level is stably observed at around 3.2 – 4.5m below existing ground surface (approx. elevation of 1,275m). No permafrost soil was observed in the Project site.

As for particle size, particles exceeding 4.75mm reached 50% or more by weight and the layer consist of comparatively large-sized particles. Low natural water content in the range of 3 to 17% was observed. The CBR values show a high level of more than 17% at all five points.

Furthermore, field permeability test (an unsteady method) was conducted at four points in total; two points at West Industry Road (along the Dund Gol River) and two points at the railway site maintenance road were implemented. The permeability coefficient of gravel layer was 1.8×10^{-3} to 2.7×10^{-3} cm/sec.

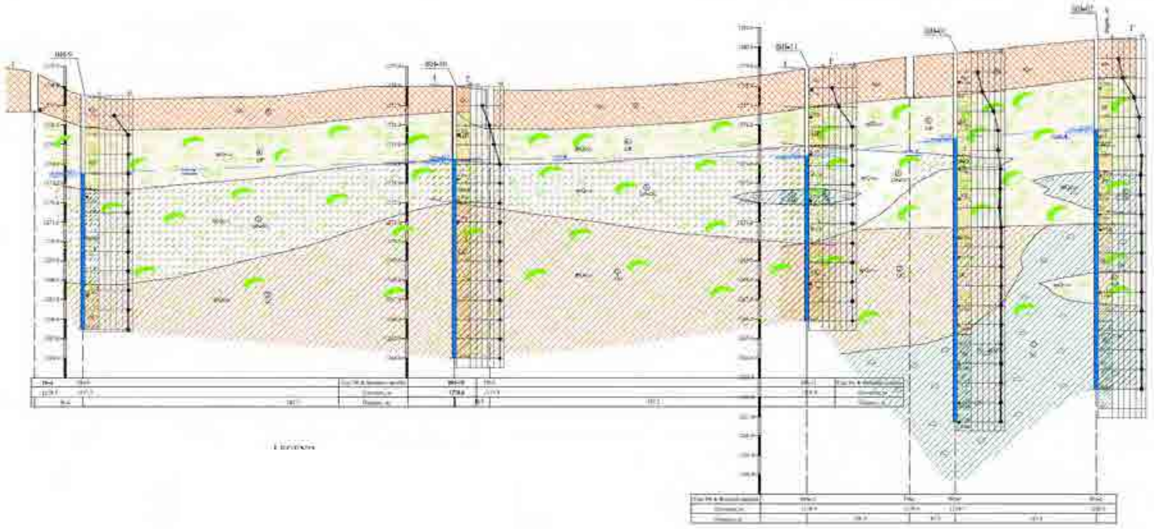


Figure 4.2.3 Geological Section I - I’

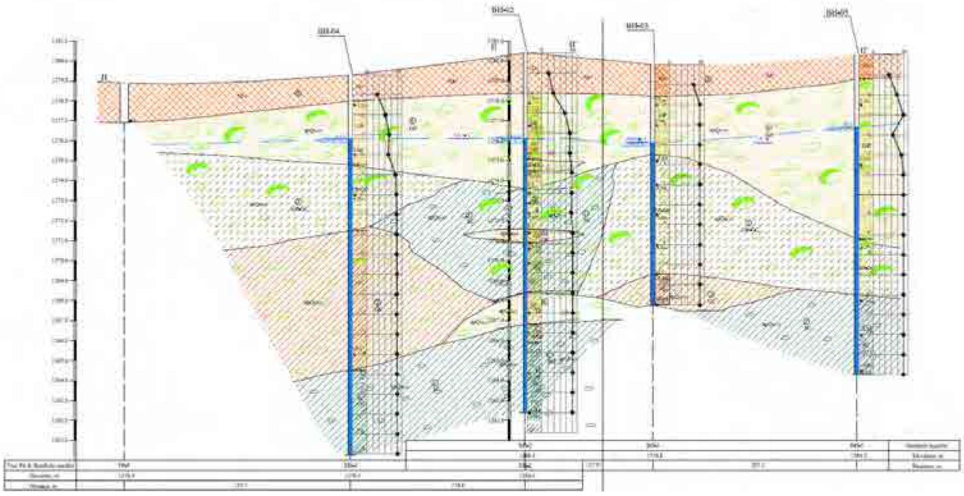


Figure 4.2.4 Geological Section II - II’

Figure 4.2.5 Geological Section III - III’

4.3 TOPOGRAPHIC SURVEY

Topographic survey was conducted for basic design of this project. The scope of topographic survey is described in Figure 4.3.1. In order to study the alternative routes (East-West route and South-North route, refer to Section 5), the scope of the survey covers the south route of Dund River. Centerline survey and cross sectional survey were conducted only for the east-west route based on the result of alternative route comparison. The content of survey conducted is shown in Table 4.3.1.

Table 4.3.1 Contents of Topographic Survey

No	Item	Unit	Quantity
1.	Control point survey (Temporary BM inst./ Differential leveling)	Location	7
2,	Plane survey (Preparation plan, Scale:1/500)	m^2	550,000
3.	Centerline survey / Profile leveling	km	2.7
4.	Cross sectional survey (Width:50m@20m)	Cross Section	121

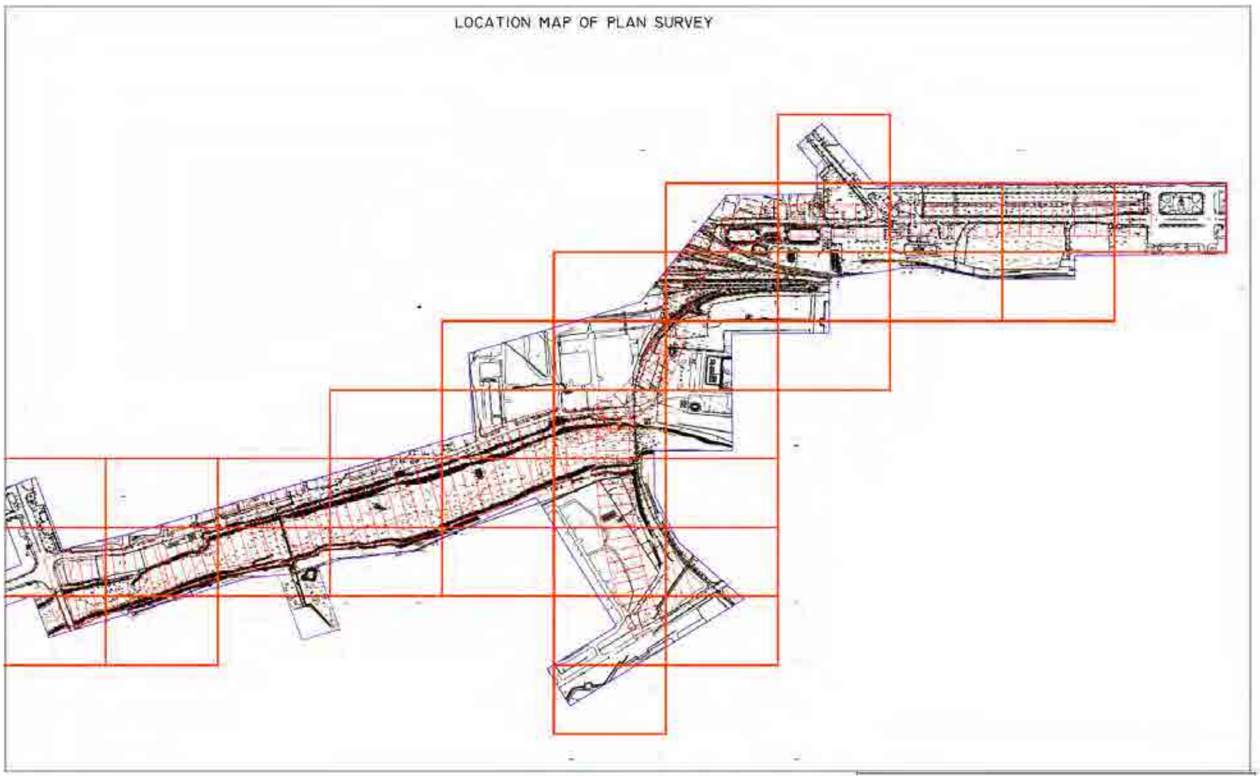


Figure 4.3.1 Scope of Topographic Survey

CHAPTER 5

ROUTE SELECTION FOR AJILCHIN FLYOVER

5.1 NECESSITY OF AJILCHIN FLYOVER

Among the four (4) routes in the north-south direction crossing the railway running through the central part of Ulaanbaatar City, only two (2) routes are provided with existing flyovers; namely, the Peace Bridge (62,200 vehicles/day) and the Gurvaljin Bridge (48,673 vehicles/day).

Table 5.1.1 Traffic Volume of Existing Railway Flyover

(Unit: vehicles/day)

Year	2012	2020	2030
Peace Bridge	62,200	46,600	72,400
Gurvaljin Bridge	48,673	62,300	115,700
Narny Bridge	--	28,600	50,200
Total	110,873	137,500	238,300

Though the traffics may be dispersed after completion of Narny Bridge under Japan's Grant Aid, the traffic volume is estimated to greatly exceed the traffic capacity of each bridge (48,000 vehicles/day) by 2030. Furthermore, due to limited accessibility for the railway crossing, the neighboring arterial roads such as Peace Avenue, Ajilchin Street and Chinggis Avenue will be congested and the average travel speed at peak hours may decrease below 10 km/h. In addition, the section from the west side of the junction between Narny Road and Peace Avenue to the Sapporo Roundabout (the intersection with Ajilchin Street) suffers from congestion (75,400 vehicles/day) since no arterial road is available in the east-west direction to complement Peace Avenue, resulting in a bottleneck by traffic accessing to the city center.

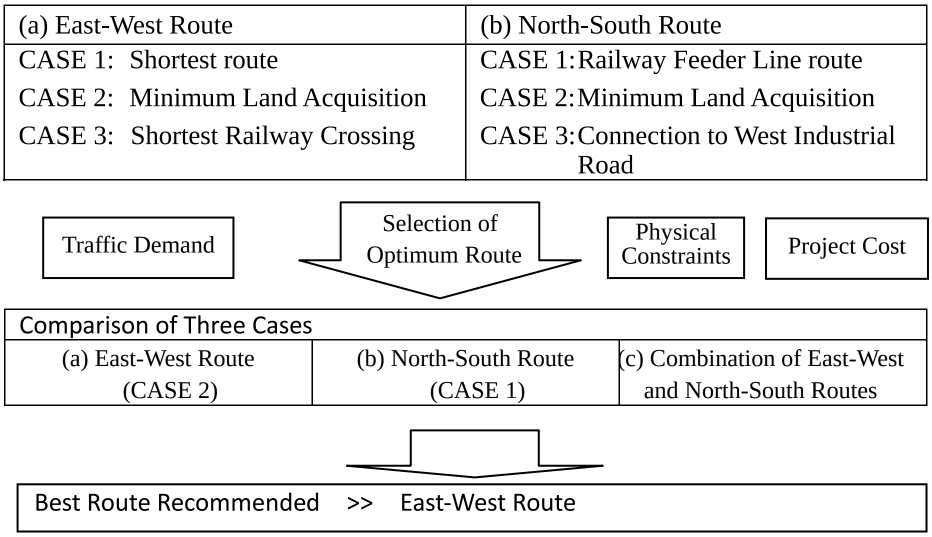
On the other hand, Narny Bridge is about 3km away from Gurvaljin Bridge, and the proposed location of the Ajilchin Flyover is almost at the middle of the these bridges. Accordingly, in appreciation of traffic dispersion from Peace Avenue, prospective Ajilchin Flyover will contribute to improvement of the north-south network crossing the railway and reduction of traffic volume at the section from the junction of Peace Avenue and Narny Road to Sapporo Roundabout by 48% in 2030.

In the future, a major east-west direction trunk road parallel to the Peace Avenue, which is proposed in the Urban Development Master Plan 2030, will be formulated after completion of Ajilchin Flyover, and thus it is expected to reduce the traffic load at Peace Avenue and strengthen the road network in the east-west direction. Therefore, construction of Ajilchin Flyover at the proposed location is highly required for the road network in the future.

5.2 STUDY OF BRIDGING ROUTE

(1) Outline of Bridging Route Comparison

As described in Chapter 3 Traffic Planning, the possible alternative routes of Ajilchin Flyover are: (a) the East-West route, and (b) the North-South route. Based on the traffic characteristics mentioned above, comparison of the two routes is as diagrammatically shown in the figure below in order to decide the best route.



Note: The approximate cost of the above cases, including the effect of price increase and exchange fluctuation based on the construction cost of Narny Bridge (a Grant Aid Project), is estimated.

Figure 5.2.1 Flow Chart of Decision on Bridge Route and Project Area

The results of comparative study are shown in the following pages. In conclusion, the East-West Route (CASE 2: Minimum land acquisition) shall be prioritized as the best possible option for the construction work in the aspects of traffic safety, project feasibility and environmental issues.

(2) Comparison of East-West Route

(Confidential)

(3) Comparison of the North-South Route

(Confidential)

(4) Comparison between East-West Route, North-South Route and Combined Case

(Confidential)

5.3 PROJECT SCOPE DESCRIPTION

As mentioned in the previous chapter, since the superiority of the East-West Route has been verified, the project scope is defined as follows.

(1) Starting/Ending Points of Project

Starting Point: At the intersection between Ajilchin Street and West Industrial Road

Ending Point: Intersection of Narny Road in front of Ulaanbaatar Railway Station

(2) Flyover: From Narny Road to West Industrial Road

(3) Access Road

North Side: Since the 4-lane widening of Narny Road is ongoing, the area of access road for Ajilchin Flyover shall be adjusted to the widening plan.

South Side: The west side from the railway feeder line to Power Plant No. 3 to the intersection with Ajilchin Street

(4) Dund River Crossing Bridge

It is rather difficult for the initially requested location of the Dund River Bridge to connect to the new flyover due to several constraints. Furthermore, since the area is densely occupied by railway feeder lines, factories and gers, land acquisition for the access road to a Dund River crossing bridge will encounter serious difficulties. On the other hand, the existing Dund River crossing bridge is, as mentioned in Paragraph 2.4, scheduled to have 4-lane widening and rehabilitation by the fund of Ulaanbaatar City, which means whole section of Ajilchin Street will be improved to 4-lane.

Figure 5.3.1 shows an alternative location of the Dund River crossing bridge. However, there are few merits in the construction of a new Dund River crossing bridge at the alternative location as described below:

(i) The benefit is limited to only certain users in the relevant area.

(ii) Additional installation of intersection to the arterial road induces decline of mobility.

(iii) Land acquisition for access road is difficult at the property of newly constructed factories.

Accordingly, the Project scope shall be limited to the following aspects excluding construction of new Dund River crossing bridge.

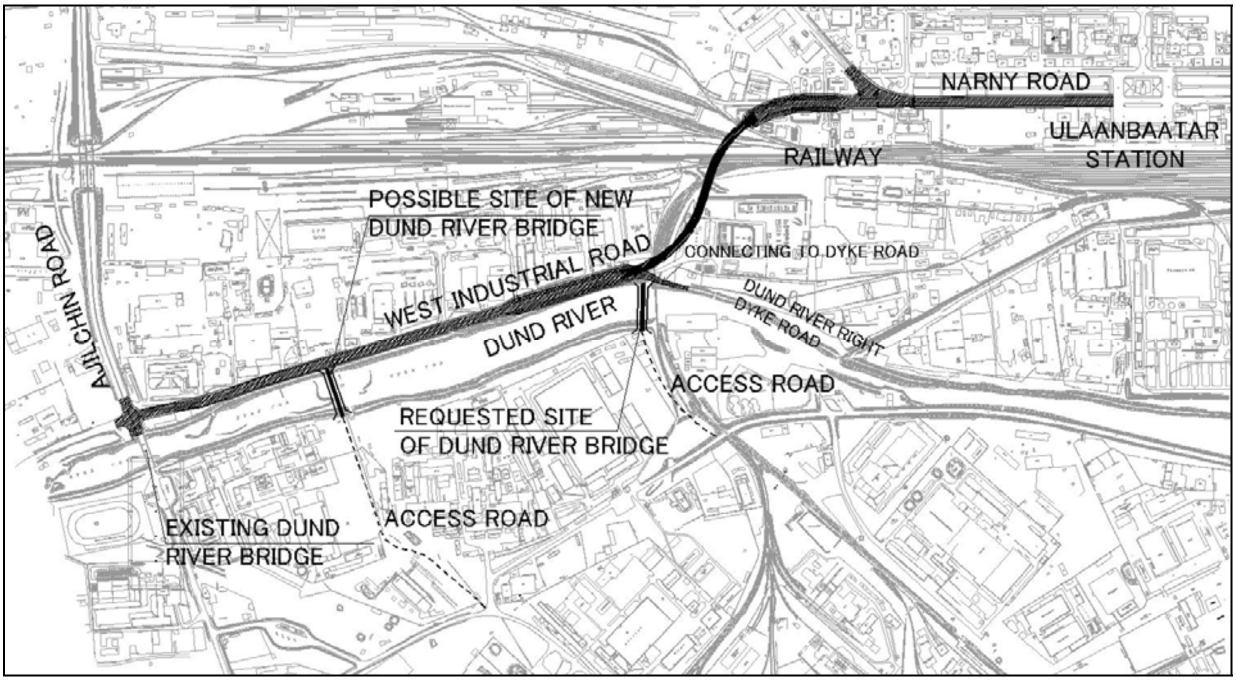


Figure 5.3.1 Candidate Site for Dund River Bridge

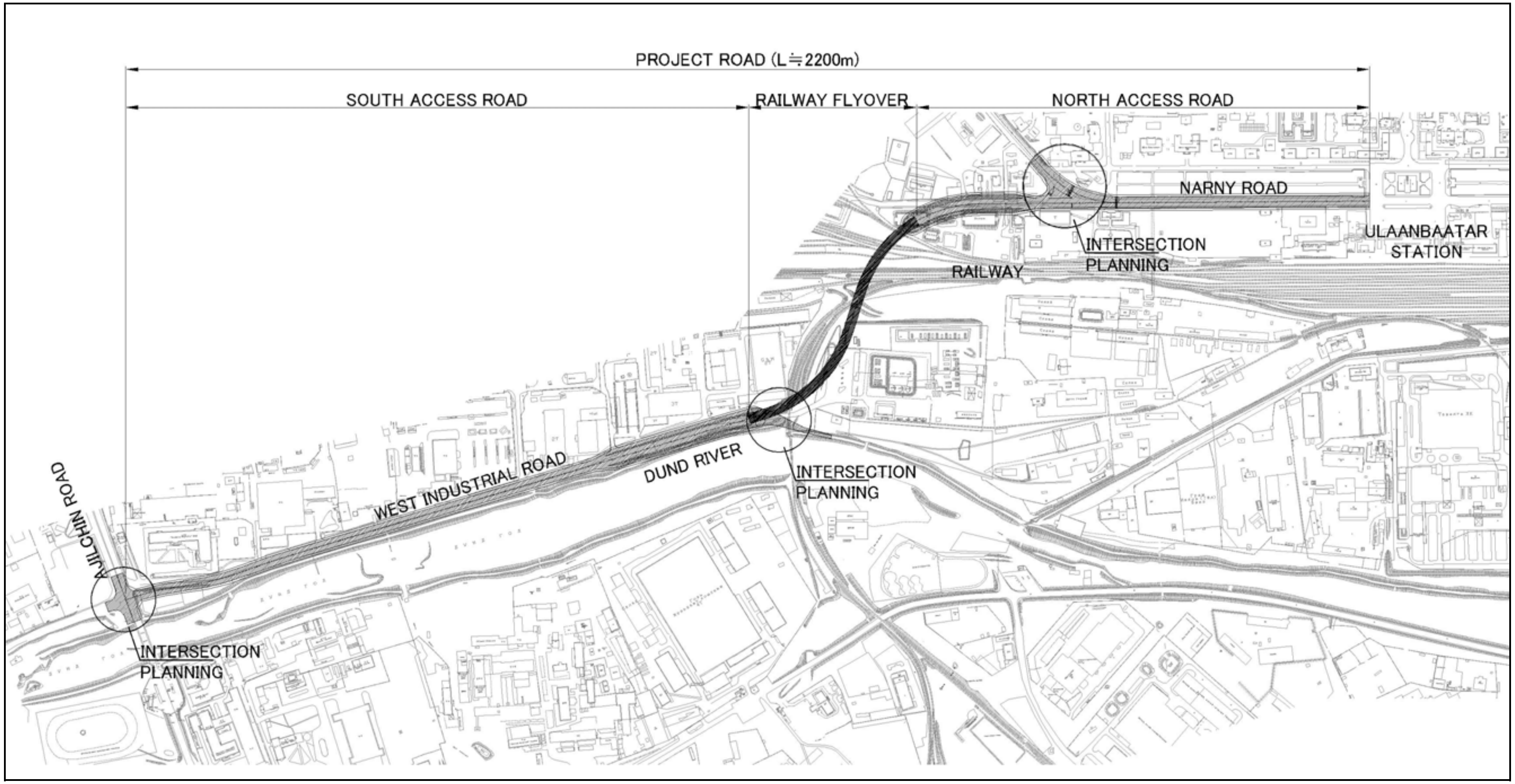


Figure 5.3.2 Project Area

CHAPTER 6

UTILITY SURVEY

6.1 EXISTING UTILITIES

There are various utilities installed both above and under the ground in the Project site. Although the Construction and Urban Development Department of Ulaanbaatar City manages the utility information as CAD data which consist of utility line with topographic data and type and spec of Usability, there is still certain possibility of unknown underground utilities in the Project site since all information are not managed in totality. Therefore, the relevant data was obtained from each utility administrator, and the Survey Team updated the utility information map in the Project site. The utility types and administrators are as indicated in Table 6.1.1.

Table 6.1.1 Utilities and Administrators

Type	Details	Administrator	Remarks
Hot-water pipe	Pipe, Manhole	Ulaanbaatar Heating Distribution Network Company; Housing and communal service authority in Ulaanbaatar City	
Water supply	Pipe, Manhole	The Water Supply and Sewerage Authority	
Sewage line	Pipe, Manhole	The Water Supply and Sewerage Authority	
Electricity	High voltage: Electric power cable (In the air/Underground), Pylon	Ulaanbaatar Electricity Distribution Network Company; Energy Authority	
	Low voltage: Electric power cable (In the air/Underground)		
Communication cable	Cable (Above the ground/Underground), Pit	ICT Network Company	
CATV	Main line, Sub-cable, Pit	ICT Network Company	Not included in this project.
Gas station	Pipe, Pit	Ministry of Mineral Resources and Energy	
Drainage	Pipe, Manhole	Water Facility Public Corporation	
Ulaanbaatar Railway	Railway Track	Ulaanbaatar Railway (UBTZ)	
	Electricity, Communication, etc.		

The outline of utilities in each section considered to be affected by the Project is summarized below.

(1) West Side Access Road

Table 6.1.2 Utility Outline of West Side Access Road

Type	Specifications	Remarks
Hot-water Pipe	Above the ground: φ350mm (Materials are steel pipes and guard pipes.)	They cross the road for this project near STA. 0+440.
Water Supply	Steel Pipe φ100mm to φ200mm etc.	Most of them are built along the roads for this project.
Sewage Line	Plastic Pipe φ600mm, φ200mm, etc. Cement Pipe φ500mm, φ400mm, etc.	Some are installed along the roads for this project; others are installed across roads and rivers. There are main pipes (collecting pipes) and branch pipes which connect buildings to the main pipes.
Electricity	Buried: Approx. φ50mm	Both high and low voltage lines are buried in the ground. Some are installed along the roads for this project; others are installed between buildings.
	Above the ground: Low voltage line	Low voltage lines are installed along the roads for this project.
Communication Cable	φ100mm, φ150mm, etc.	Some are installed along the roads for this project; others are installed across the roads.

(2) Bridge Section

i) Between A1 and P2

Table 6.1.3 Utility Outline between A1 and P2

Type	Specifications	Remarks
Sewage line	Plastic pipe φ600mm	Going through the north side of the A1 abutment to the P1 pier, sewage lines go across horizontally in the ground between P1 and P2 piers. Relocation may be required depending on the construction method of the piers.
Electricity	Buried: Approx. φ50mm	They are buried on the north side of the A1 abutment to the P1 pier. Relocation is required since there may be interference with the planned location for the P2 pier and the A1 abutments.
	Above the ground: High voltage line	High voltage lines are planned to be installed on the southern side of the P2 piers.
Communication Cable	Approx. φ150mm	They are installed on the north side of the A1 abutments to the P1 pier.

ii) Between P2 and P5 Piers

Table 6.1.4 Utility Outline between P2 and P5

Type	Specifications	Remarks
Hot-water Pipe	Buried: Steel Pipe φ200mm	They run between the P2 and P3 piers in the ground.
Water Supply	Steel Pipe φ50mm to φ100mm etc.	They are installed on the eastern side of the P3 to P5 piers.
Electricity	Buried: High voltage line (Pipe diameter is unknown.)	Power cables of railways are installed along the railway spur to the third thermal plant. Though high voltage lines are planned to be installed on the eastern side of the P2 to P5 piers, relocation is required to avoid the bridges.
	Above the ground: Low voltage line	Low voltage lines are installed. Relocation is required due to interference with the bridge.
Communication Cable	Approx. φ150mm	Almost all are built along the bridge between the P3 and P5 piers. Relocation is required due to interference with the piers.

iii) Between P6 and P8 Piers

Table 6.1.5 Utility Outline between P6 and P8

Type	Specifications	Remarks
Hot-water Pipe	Above the ground: Specifications are unknown.	Since there is interference with the P8 pier, relocation is required. Additionally, the P9 pier may require relocation depending on the construction method.
Water Supply	Steel pipe φ500mm	Since there is interference with the P7 pier, relocation is required.

(3) East Side Access Road

Table 6.1.6 Utility Outline between P9 and A2

Type	Specifications	Remarks
Hot-water Pipe	Buried: Steel Pipe φ1000mm, φ800mm, φ40mm etc.	The φ300m pipe is installed horizontally along the bridge in the ground or on the ground. Since there is interference with the piers, relocation is required. Additionally, the φ1000mm pipe goes underground around the P17 pier, and the φ40mm pipe goes underground around the A2 abutment.
	Above the ground: φ300mm (Steel pipes with concrete Box)	The φ300m pipe is installed horizontally along the bridge in the ground or on the ground. Relocation is required due to interference with the piers.
Water Supply	Steel Pipe φ500mm	They are installed horizontally along the bridges. As there is interference with the piers, relocation is required.
Sewage Line	Corrugated Pipe φ1,200mm	Under construction in the ground of the green belt of Narny road.

6.2 RESULTS OF TRIAL EXCAVATION

The test pits were dug as per the updated utility information map in order to confirm actual installation conditions of utilities in the Project site. Firstly, ten areas (D-1 to D-10) were set in the Project area and preliminary exploration of underground utilities was conducted using sonar test.

Secondly, the 19 locations of test pits were selected on the basis of preliminary exploration, and exact installation conditions of the existing underground utilities was visually confirmed. The results of trial excavation are summarized in Table 6.2.1 and the following pages. Detailed utility location is shown in Annex: Drawings.

Table 6.2.1 Outline of Trial Excavation Results

Test Area	Pit No	Confirmed Utility	Remarks
D-1	P-1	Power cable x 1 Communication cable x 7	
	P-2	Heating pipe (Not included in the utility information map.)	
D-2	P-3	Communication cable x 8, φ13cm to 17cm	
D-3	P-4	Power cable x 2, φ5cm	(Not included in the utility information map.)
	P-6	Power cable x 1, φ5cm Communication cable x 1, φ15cm	
	P-7	Power cable x 3, φ5cm	(Some are not included in the utility information map.)
D-4	P-8	Power cable x 1, φ5cm	
	P-9	Power cable x 3, φ4cm to 5cm	
D-5	P-10	Concrete Box 70cm x 70cm Communication cable x 1, φ12cm Power cable x 1, φ5cm	There is a possibility they are not used at the same time. (Power cable is not included in the utility information map.)
	P-20	None	
D-6	P-11	None	
D-7	P-18	Power cable x 1	
D-8	P-12	Water supply x 2, φ13cm	
	P-13	Communication cable x 2, φ13cm	
D-9	P-17	None	
	P-19	Power cable x 1	
D-10	P-14	Heating pipe x 1 Power cable x 1, φ1cm	
	P-15	Power cable x 2, φ5cm to 10cm	
	P-16	Heating pipe x 1	

Figure 6.2.1 Overall View of Test Trench Location

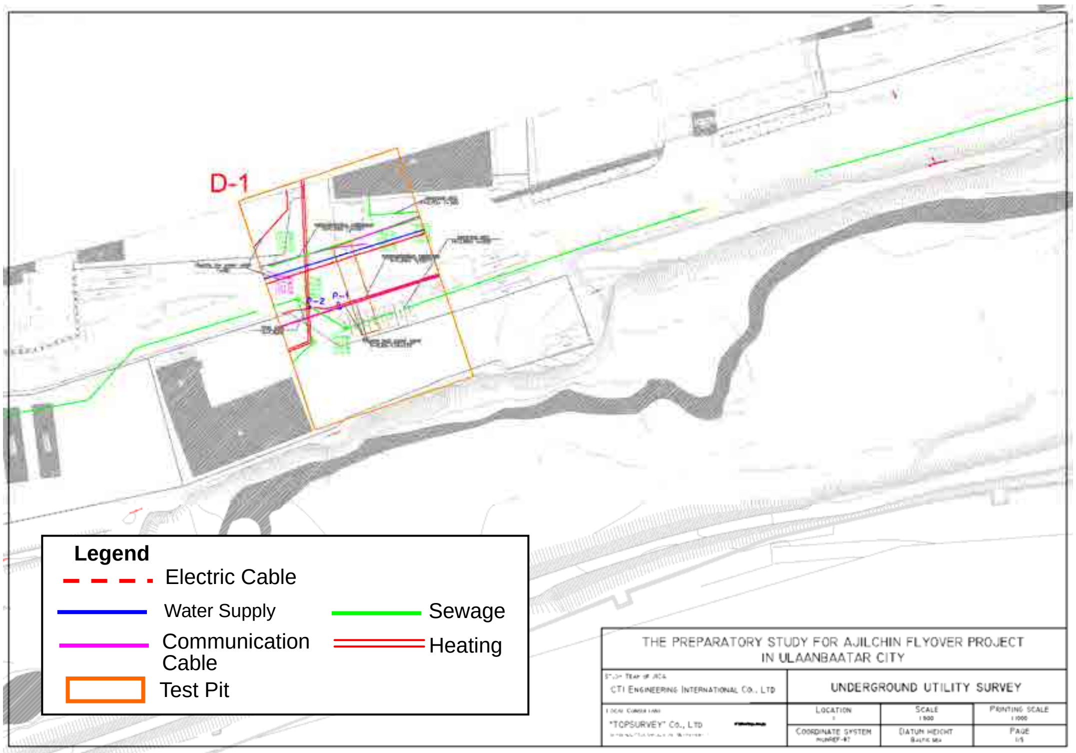


Figure 6.2.2(1) Detailed Figure of Test Trench Location (D-1)

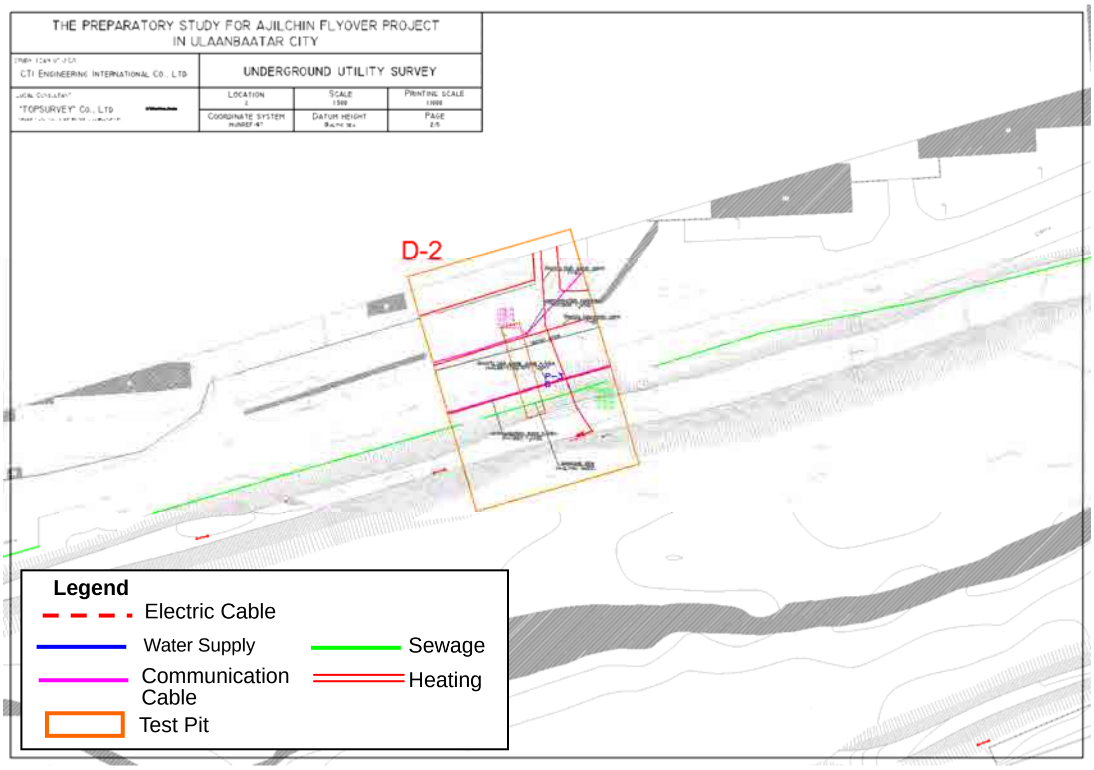


Figure 6.2.2(2) Detailed Figure of Test Trench Location (D-2)

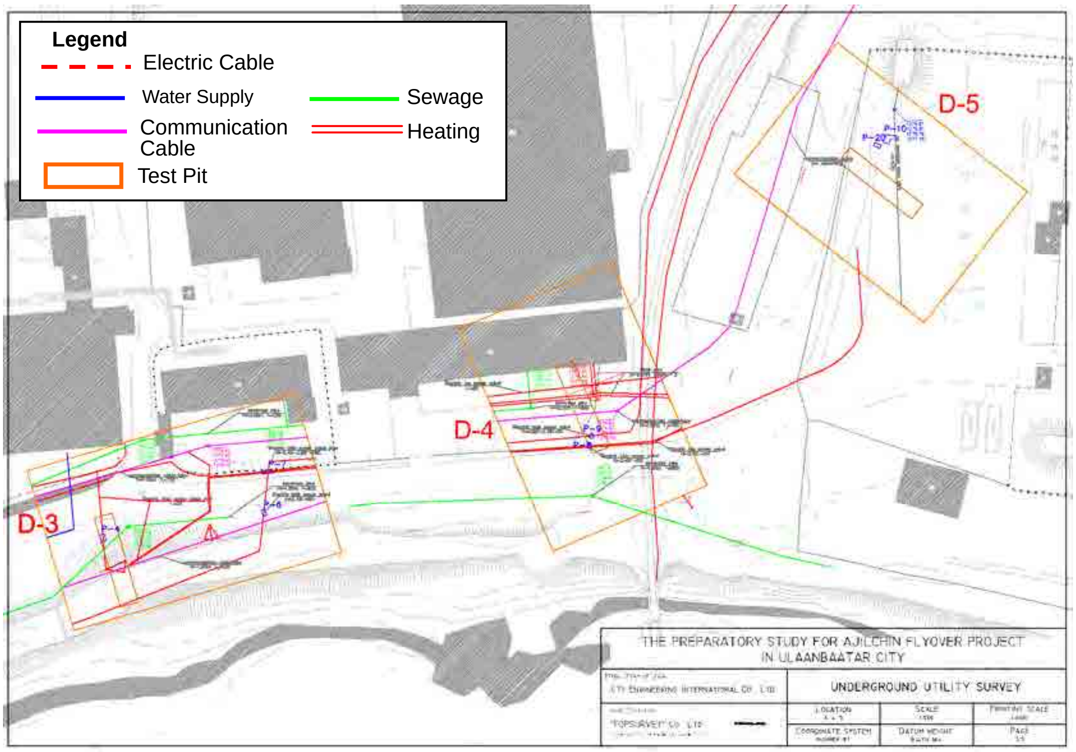


Figure 6.2.2(3) Detailed Figure of Test Trench Location (D-3 to D-5)

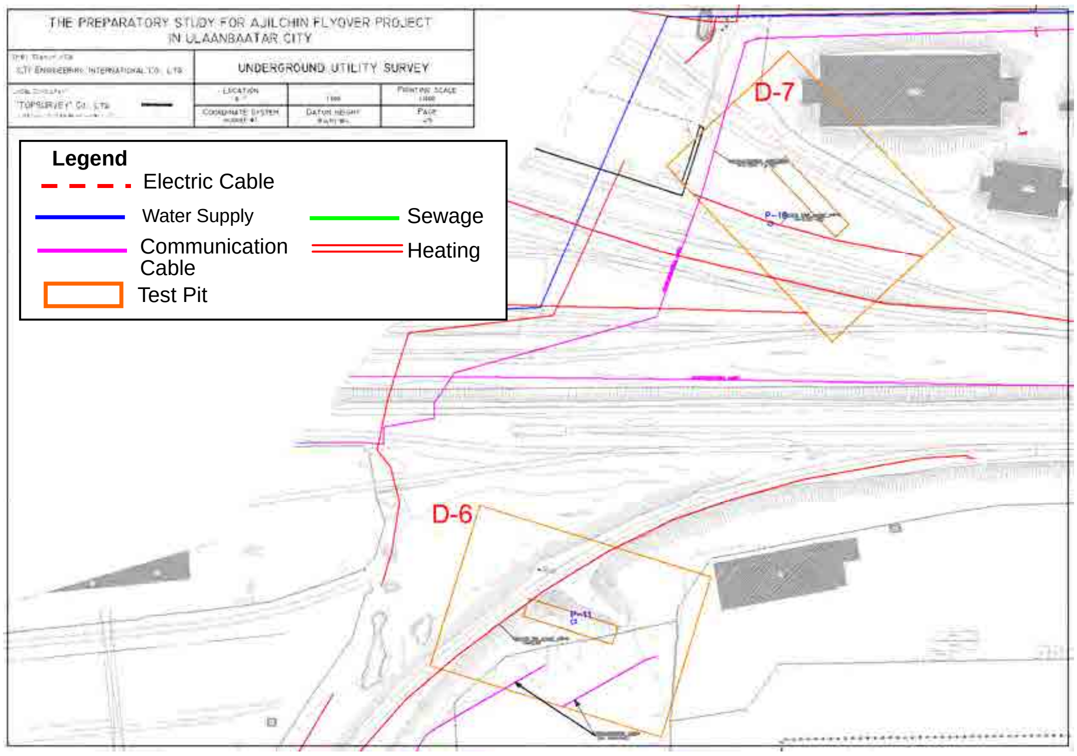


Figure 6.2.2(4) Detailed Figure of Test Trench Location (D-6 to D-7)

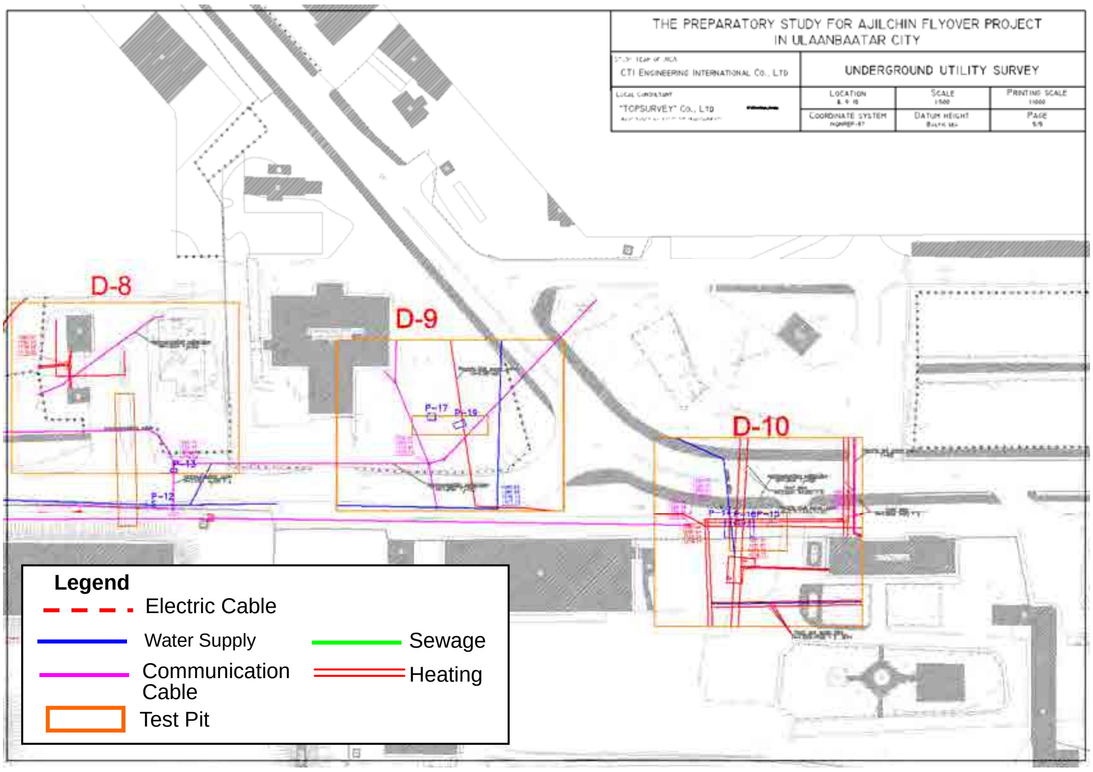


Figure 6.2.2(5) Detailed Figure of Test Trench Location (D-8 to D-10)

6.3 FUTURE UTILITY PLAN

Installation of high voltage electric power cables/pylons and sewerage pipes has been in progress since 2012. Though double-tracking of railway is allegedly scheduled, specific plan and schedule are not yet fixed. The following is a summary of information pertinent to the future utility plan.

Table 6.3.1 Future Utility Plan

Type	Details	Progress	Remarks
Electricity	High voltage electric power cable and pylons	Under construction	With the support of the World Bank, a new substation will be built and high voltage electric power cables (35kV) and pylon for high voltage (H-26m) will be installed.
		Construction will begin in 2012.	Branch electricity distribution from the high voltage electric power cable described above to the newly built railway staff quarters (Golden Park). (Underground buried cable; GL-0.7-1.0m). The construction will be done in 2012 by the fund of Ulaanbaatar City.
Sewage line	Sewage pipe	Under construction	Sewage pipes of approx. φ1 m will be installed horizontally through Narny Road intersection on the terminal side of this project.
Railway	Track	Concept only. Timing of implementation and the detailed plan have not been decided.	There is a plan to increase the track of the main line from one to three; however, the timing and detailed widening area has not been decided.

6.4 UTILITY RELOCATION PLAN

(1) West Industrial Road

i) Underground Utilities

In the West Industrial Road, parking space and/or median strip with sufficient width will be installed between the existing road and the new road. Therefore, existing underground utilities below the carriage way of prospective new road shall be relocated to the space of parking space and/or median strip.

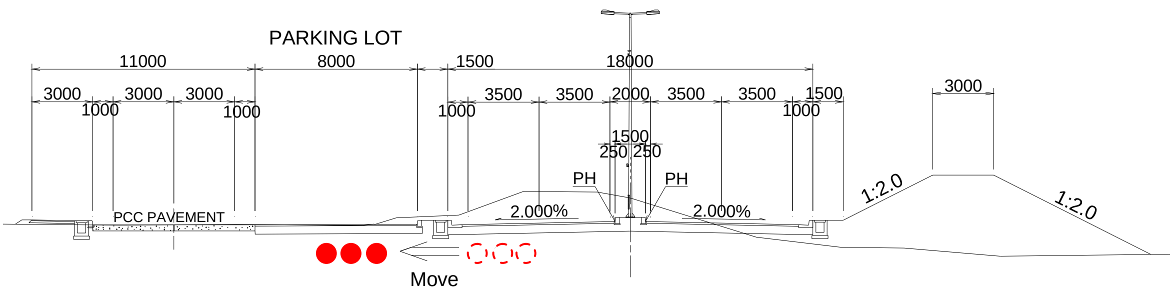


Figure 6.4.1 Relocation Image of Utilities of West Industrial Road

ii) Hot-water Pipe

Near STA. 0+440, hot-water pipes (φ350) go across the proposed road of the Project. These pipes encroach into the road construction gauge, and thus need to be relocated prior to implementation of the Project.

Figure 6.4.2 Hot-water Pipes around STA. 0+440

(2) Railway Flyover Section

There are many utilities which may interfere to substructure/foundation work of the piers and abutments. Besides, even no interference to the permanent structures, some utilities will interfere to such temporary work as excavation and diversion/coffering. Therefore, these utilities need to be relocated to an area where interference to the bridge construction work can be eliminated.

(3) Narny Road Area

Underground utilities below the carriageway should be relocated to below the side walk to secure prospective maintenance. Utilities crossing the roads should be protected by overlying layer with adequate thickness (0.8 m or more) to withstand the traffic load.

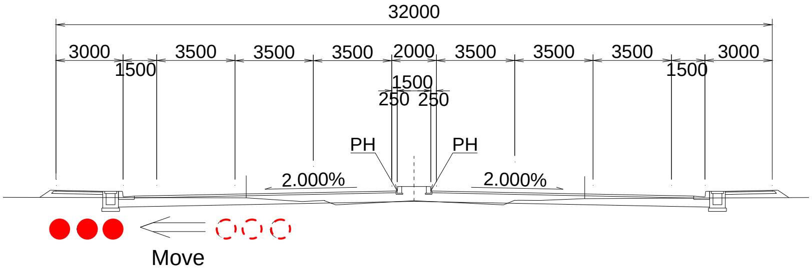


Figure 6.4.3 Relocation Image of Utilities on Narny Road

Hot-water pipes (φ300) connected from Narny Road to the premises of railways may interfere to foundation of the bridge near STA1 +500, and thus proper relocation is required

In addition to above, hot-water main pipes (φ800x2, φ1,000x2) are installed below Narny Road. Since relocation of these main hot-water pipes are difficult, locations of abutment and piers were soundly determined so that large-scale relocation of main pipes could be eliminated.

Figure 6.4.4 Hot-Water Pipe around STA. 1+500

(4) Relocation Plan

As the result of utility survey and subsequent discussion with related utility administration offices, following relocation works have been identified to be necessary for smooth implementation of the Project. Underground utilities will be relocated principally to outside of carriage way such as under the sidewalk for easy maintenance.

Existing utilities can be classified as:

- Utilities possible to relocate prior to land acquisition; and
- Utilities possible to commence relocation work without land acquisition.

Cost for relocation has been estimated as follows through objective-wise discussion with concerned agencies as well as mutual confirmation in WG and JCC meetings. (Route for relocation shall be referred to drawings enclosed in ANNEX)

Table 6.4.1 Utility Relocation Plan

(Confidential)

(Confidential)

(Confidential)

6.5 NECESSARY PROCEDURES FOR RELOCATION OF UTILITIES

Relocation of utilities for any project in Ulaanbaatar City is conducted according to the following procedures after approval of project implementation. Relocation work and its management are conducted under the responsibility of Ulaanbaatar City.

STEP-1 Technological Facility Department in Ulaanbaatar City asks administration offices of the objective utilities for specific design and cost estimate for required relocation.

STEP-2 Each administration office of the utilities orders specific design to the consultant.

STEP-3 Following design by the consultant, specific design and relocation cost are submitted to Ulaanbaatar City.

STEP- Ulaanbaatar City approves the budget for relocation.

STEP-5 Ulaanbaatar City orders the relocation work.

In "The Project for Construction of Railway Fly-Over in Ulaanbaatar City (2009 to 2012)", delay of some utility relocation work seriously affected the construction schedule of the flyover. Accordingly, the following points shall be duly considered for implementation of the Project:

1) Project Implementation Unit (PIU) shall be organized prior to commencement of detailed engineering design for the Project.

   Organizing PIU was expected when the detailed design of "The Project for Construction of Railway Fly-Over in Ulaanbaatar City" (hereinafter referred to as Narny Bridge) had started. As a result, however, PIU was organized at the start of construction work. Although Ulaanbaatar City took the initiative for the relocation work, the work was not completed prior to commencement of the construction work for Narny Bridge. Based on this experience, it is important to ensure organizing PIU prior to commencement of detailed engineering design.

2) The staff members of Engineering Facility Department in Ulaanbaatar City must participate in PIU as a key staff.

   In order to coordinate the schedule of detailed engineering design and construction of the flyover with the schedule of utility relocation in terms of design and site work, staff members of the Engineering Facility Department in Ulaanbaatar City shall be assigned as a key staff of PIU until at least the early stage of the construction work. Since there was not satisfactory coordination was not satisfactory, between PIU and the Engineering Facility Department in Ulaanbaatar City in Narny Bridge project, it took much time to solve the problems pertinent to utility relocation.

3) Strengthening Management on Utility Relocation Work

   In the construction of Narny Bridge, it was revealed that many underground utilities supposed to “must have been relocated” had not been relocated by Ulaanbaatar City. It was not confirmed whether or not the relocation work had been processed appropriately based on the contract by Ulaanbaatar City since the staff who was in charge of the transaction had already been shifted to another department. Therefore, the key staff of the Engineering Facility Department of Ulaanbaatar City who may be dispatched to the prospective PIU is required to be involved in whole process of relocation works to secure ultimate completion of the relocation work with unwavering responsibility.

4) Allocation of Discretionary Reserve

   Since the record and management of existing underground utilities is not perfect, it is difficult to know the entire situation even if a detailed survey is conducted. Therefore, it is crucial to cope with newly discovered underground utilities during the construction in a flexible manner. In this sense, it is recommended to allocate contingency budget for relocation works urgently required to secure construction schedule of the Ajilchin Flyover.

Detailed design of utility relocation and the budgetary allocation should be done during detailed engineering design of the Ajilchin Flyover. Relocation work should be completed prior to hand over of the Project site to the Contactor.

The relocation schedule should be adjusted so that the latest utility information after relocation work could be provided to the contractor and the consultant in charge of supervising the construction work.

CHAPTER 7

DESIGN OF FLYOVER AND ACCESS ROAD

7.1 BASIC POLICIES

(1) Basic Policies of Bridge Plan

i) Constraints by Climate Conditions

Due to the harsh climate conditions in temperatures lower than minus 40°C during midwinter, main construction work using concrete and asphalt cannot be conducted from October to March of the next year (6 months). Therefore, bridge plan minimizing work periods by utilizing factory and precast products are prioritized.

ii) Procurement Conditions of Materials and Equipment

Transportation of materials and equipment procured from a foreign country is limited to the use of railway and roads. Especially, since large-sized materials and equipment require transport by railway from China, the size of the material and equipment should meet these conditions.

iii) Bridge Erection above Railway Track

Structure types of bridge and the construction methods minimizing impact on railway operations are to be selected since the Project will cross the railways which are the most important lifeline of logistics in Mongolia.

iv) Construction adjacent to Railway Track

So as not to affect the railway operation, proper countermeasure is required for construction including foundation work adjacent to the railway track. The policy is that large-sized excavation should not be adopted for foundation works adjacent to the tracks. Additionally, since there is a future plan to increase from one to three multiline tracks, the location of the piers is designed to secure sufficient space for future installation of additional main tracks.

v) Construction in Urban Area with Heavy Traffics

Since the Project site is located in urbanized area, there are many underground utilities. Especially, the impact on hot-water pipes and high voltage lines should be minimized and pier locations should be considered to minimize the impact of utility relocation. So as to minimize the social impact due to traffic congestion induced by the construction work, the construction method with the shortest construction period and the minimum traffic control is prioritized. Besides, when piers are constructed in Narny Road, their shape and locations should be considered to fully ensure the visibility to the road users (drivers/pedestrians).

vi) Quality Control

Supply of re-bar and concrete becomes extremely tight from spring through summer when whole construction works are intensively concentrated in Ulaanbaatar City. Additionally, the quality of fresh concrete obtained in the market is quite fluctuating, and some concrete plants could not operate due to unstable power supply during the past construction works.

Since rapid temperature changes require proper modification of construction schedule, the severe natural environment also makes quality management of concrete works more difficult. Therefore, it is important to fully enhance the management system to ensure reliable quality by using steel structure or precast products.

(2) Basic Policies of Road Plan

i) Crossing Conditions of Roads and Railways

The following construction gauges should be ensured at the crossing points of roads and railways in the interchange according to Mongolian standards. The flyover section is designed to have a height of 6.9 meters from the track to correspond to the future electrification plan of railways.

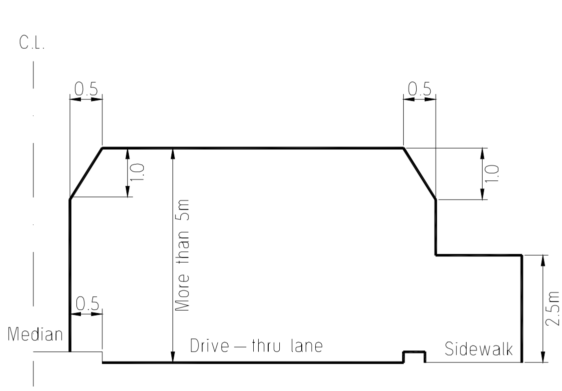


Figure 7.1.1(a) Construction Gauges of Road Crossing

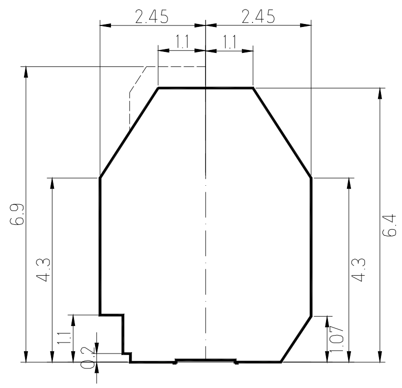


Figure 7.1.1(b) Construction Gauges of Railway Crossing

ii) Longitudinal Grade

Among the main roads having steep grades in the city, the road grade in sections with steep grades and many traffic accidents are Sansar Tunnel: 6.4%, and Chingunjav Street: 5.8%. Relatively steep grades in the other sections are Khusgol Street, the vicinity of Geser Temple: 5.1%, Southern area of Ikh Toyruu East Cross Road Intersection: 5.0%, Ard Ayush Avenue: 4.9%, Amarsanaa Street: 4.0%, Gurvaljin Bridge: 4.0%, and Peace Bridge: 3.3%, which means accident probability increases when the grade exceeds 5.0%. Considering the fact that the approach road is close to the intersection in this Project, the maximum longitudinal grade is designed to be I_{max}=4.5% or less.

iii) Countermeasures to Traffic Congestion in West Industry Road

Many plants stand in a row along the West Industry Road, which is an access road located on the west side of the flyover, and large-sized vehicles frequently come in and out of those plants. Merging of these vehicles with through traffic of the flyover will induce traffic congestions, and thus the existing West Industry Road shall remain as a service road, and the main road connecting the flyover shall be designed to be on the outside of the service road. (Existing parking space is maintained.)

Figure 7.1.2(a) Improvement Plan of West Industry Road

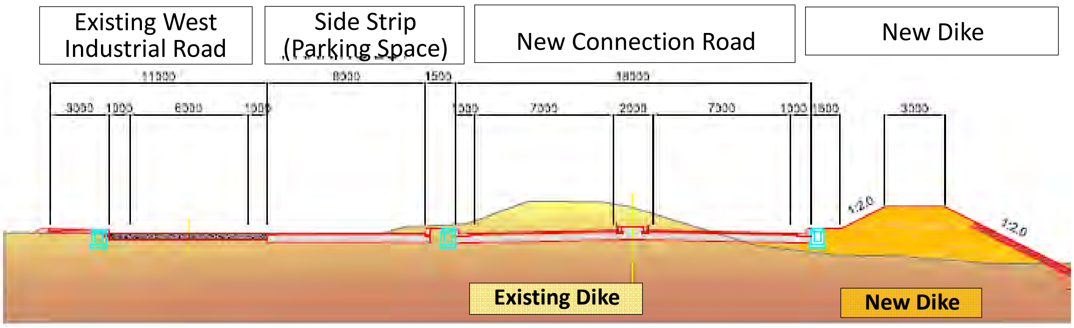


Figure 7.1.2(b) Typical Cross Section of West Industry Road

7.2 ROAD PLAN

(1) Target Year and Design Traffic Volume

Target year and traffic volume are as follows:

Target Year: 2030 (Compatible with UB M/P)

Design Traffic Volume: 57,000 vehicles (Based on the results of traffic demand forecast)

(2) Design Vehicles

Since there is no specific standard/guideline for road design in terms width and axle distance of vehicles, the following semi-trailer is used as object vehicles for road design:

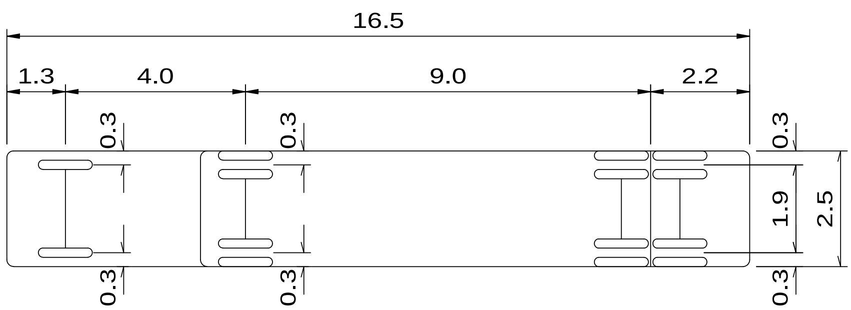


Figure 7.3.1 Design Vehicle (Semi-trailer)

(3) Geometric Criteria

i) Comparison of Road Planning Conditions

As for road planning conditions, comparison was made among the Mongolian standards (BNBD 32-01-04, 32-01-07), American standards (AASHTO) and Japanese standards (Government Order on Road Design Standards). In principle, road plan/design shall comply with Japanese standards with reference to such standards as follows:

- Lane width: as per Mongolian standard
- Shoulder width: as per Japanese standard since Mongolian standard does not stipulate width of shoulder and/or median strip to be applied in urbanized area with severe constraints of land availability.
- Horizontal alignment: as per both Mongolian and Japanese standards. Super-elevation in a curve section is max. 4% in accordance with AASHTO "Urban Arterial Road" considering freezing of carriageway in winter season.

Table 7.2.1 Comparison of Geometric Criteria for Main Road

Item		To be applied	Mongolian standard	AASHTO	Japanese standard
Road standard		2nd Main Road(32-01-07) Main Road (32-01-04)	2nd Main Road(32-01-07) Main Road (32-01-04)	Urban Arterials	Class 4 1st grade
Design Speed V (km/h)		60	60 (120 or 100)	50 - 100	60 (50 or 40)
Lane Width (m)		3.5m	3.5m	3.0-3.6m	3.25m (special area 3.5m)
Median Zone (Marginal Strip) (m)		2.0 (0.25)	5.0, min0.0	1.2	1.0 (0.25)
Shoulder Width	General Section (m)	1.0	2 - 2.5, 3.5	0.6	0.5
	Bridge Section (m)	0.5	-	1.8-2.4	0.5
Minimum Curve Radius R (m)		200m	150m	135	150m(Minimum)
Maximum Super-elevation (%)		4%	5%	-	6%
Minimum Radius without Super-elevation (m)		2000 (Standard Grade 2%)	1500	877	2000
Minimum Horizontal Curve Length (m)		100(θ<7:700/θ)	-	-	100(θ<7:700/θ)
Easement Curve	Curve Length (m)	50	40	33	50
	Minimum Parameter	90	-	-	90
	Minimum Radius without Clothoid Curve (m)	500	-	213	500
Maximum Longitudinal Grade		4.5%	7.0%	-	6% (snow/cold region)
Vertical Curve	Crest (m)	1400	1600	K=11	1400
	Sag (m)	1000	900	K=18	1000

Table 7.2.2 Comparison of Geometric Criteria for On/Off Ramp

Item		To be applied	AASHTO	Japanese standard	Remarks
Road standard		Class B	CASE-1 B	Class B	
Design Speed V (km/h)		V=40km/h	30-50	V=40km/h	
Lane Width (m)		3.25	5.5 (pavement width)	3.25	
Shoulder Width		0.75m（Internal side） 1.5m（External side）	0.6-1.2m（Internal side） 2.4-3.0m（External side）	0.75m（Internal side） 1.5m（External side）	
Minimum Curve Radius R (m)		50m(Minimum)	47m	50m(Minimum)	
Maximum Super-elevation (%)		4.0%	4%	6%	
Minimum Radius without Super-elevation (m)		800	441	800	
Minimum Horizontal Curve Length (m)		70	—	70	
Easement Curve	Curve Length (m)	35	22	35	
	Minimum Parameter	35	—	35	
	Minimum Radius without Clothoid Curve (m)	140	95	140	
Maximum Longitudinal Grade		4.5%	—	6% (snow/cold region)	
Easement Curve	Crest (m)	450	K=4.0	450	
	Sag (m)	450	K=9.0	450	

ii) Design Conditions of Road

As for geometric criteria, the design conditions suitable for the Project are set as follows after comparing the standards in Mongolia (BNBD 32-01-04, 32-01-07), American standards (AASHTO) and Japanese standards (Government Order on Road Design Standards).

Table 7.2.3 Geometric Criteria to be applied for the Project

Item		**Main Road**	**ON-OFF Ramp**	**Remarks**
Road Standard		**2nd Main Road (32-01-07)** **Main Road (32-01-04)**	**—**	
Design Speed V (km/h)		60	40	
Lane Width (m)		3.5	3.25	
Median Zone (Marginal Strip) (m)		2.0 (0.25)	—	
Shoulder Width	General Section (m)	1.0	—	
	Bridge Section (m)	0.50	1.50 (External Side) 0.75 (Internal Side)	
Minimum Curve Radius R (m)		200	160	
Maximum Super-elevation (%)		4%	4%	
Minimum Radius without Super-elevation (m)		2000 (Standard Grade 2%)	800	
Minimum Horizontal Curve Length (m)		100 (θ<7:700/θ)	70	
Easement Curve	Curve Length (m)	35	35	
	Minimum Parameter	90	35	
	Minimum Radius without Clothoid Curve (m)	500	140	
Maximum Longitudinal Grade		4.5%	4.5%	
Vertical Curve	Crest (m)	1400	450 (Minimum Value)	
	Sag (m)	1000	450 (Minimum Value)	

(4) Typical Cross Section

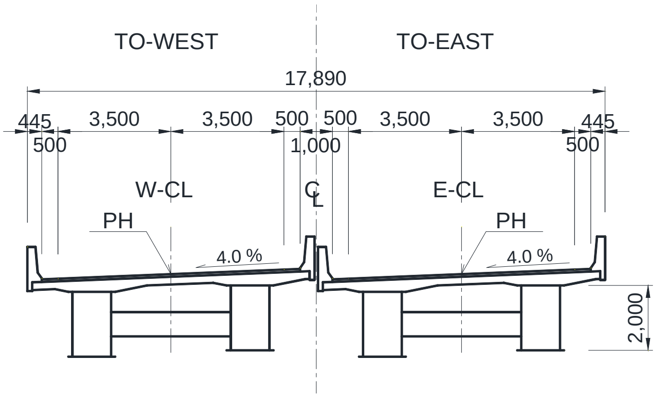


Figure 7.2.2(1) Typical Cross Section of General Bridge Section

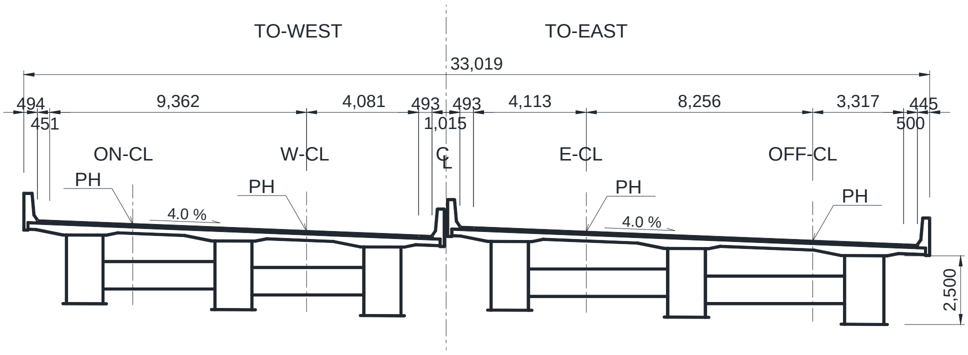


Figure 7.2.2(2) Typical Cross Section of Widening Bridge Section

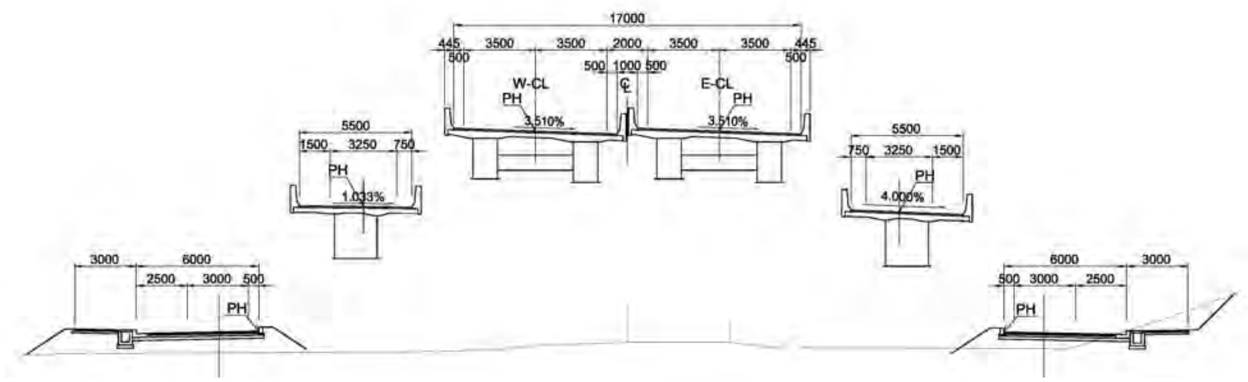


Figure 7.2.2(3) Typical Cross Section of ON-OFF Ramp Section

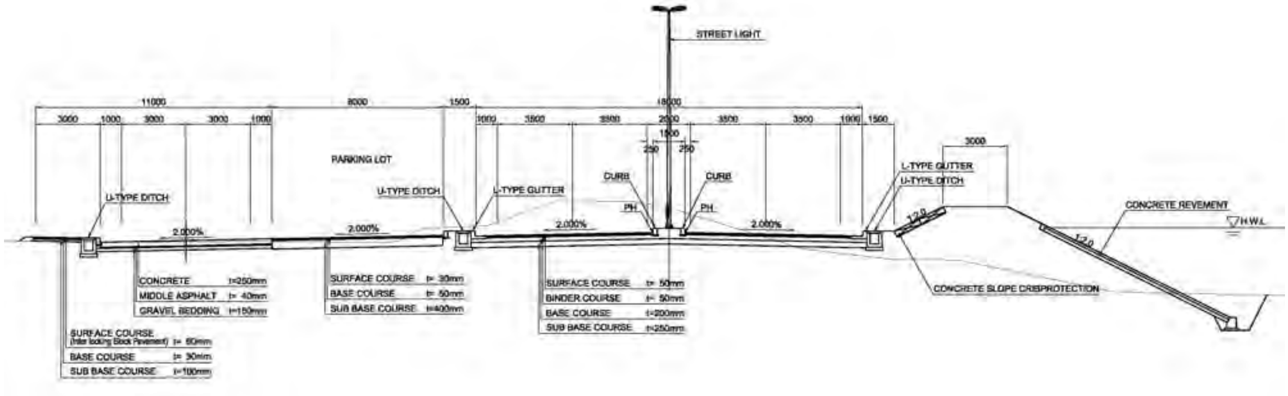


Figure 7.2.2(4) Typical Cross Section Parallel to West Industry Road

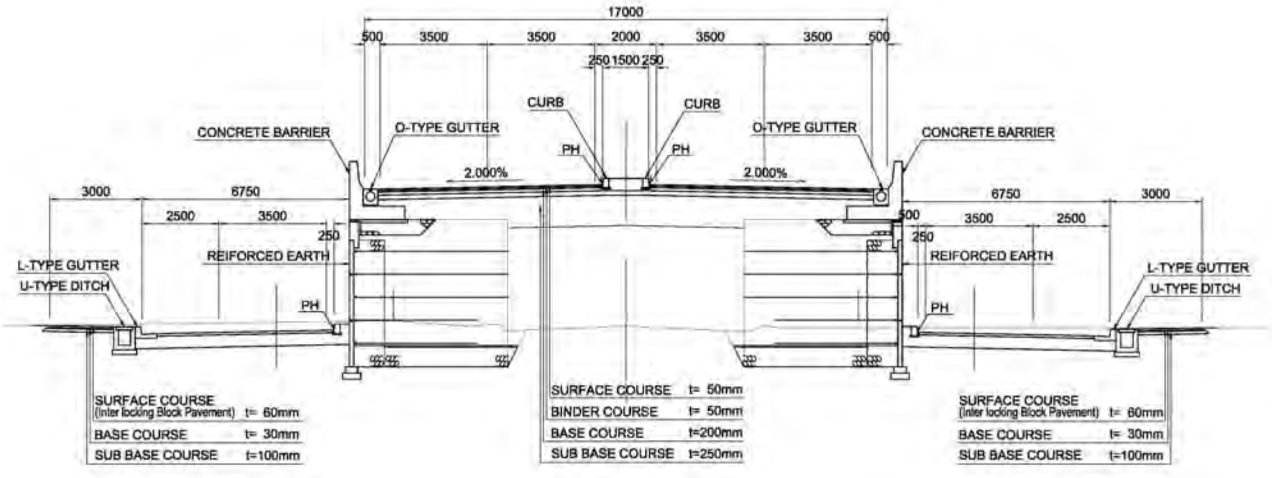


Figure 7.2.2(5) Typical Cross Section of Approach Road in Narny Road

(5) Intersection Plan in Narny Road

At the west end of Narny Road to be crossed by the Ajilchin Flyover, traffic volume is currently 40,000 vehicles/day or more. After completion of the Project, much more vehicles are expected to flow into this intersection. So the type of intersection shall be designed to accommodate the future traffic. The estimated traffic flow at the intersection after the construction of Ajilchin Flyover is as shown below.

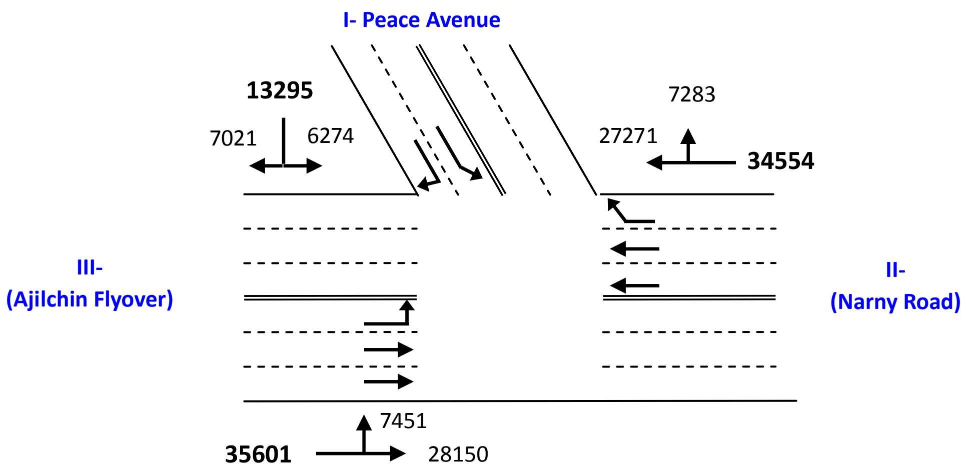


Figure 7.2.3 Estimated Traffic Volume (PCU/day) in 2030 at Narny Road Intersection

Intersection types of the Ajilchin flyover approach road and Narny Road will be either at-grade intersection or grade separation. At-grade intersection may induce congestion resulting in bottleneck. The followings are summary of "Saturation Index of Intersection" calculated for two cases of the at-grade intersection and the grade separation.

Table 7.2.4 Saturation Index of Intersections

Flowing Point		**Peace Avenue**		**Narny Road**		**Ajilchin Bridge**			
		Left Turn	**Right Turn**	**Through**	**Right Turn**	**Left Turn**	**Through**		
Number of Traffic Lanes		1	1	2	1	1	2		
Basic Value of Saturation Flow Rate		**2,000**	**2,000**	**4,000**	**2,000**	**2,000**	**4,000**	Saturation degree of signal phase	Saturation Index of intersection
Traffic Volume		**470**	**530**	**2,050**	**550**	**560**	**2,110**		
Flow Ratio		0.235	0.265	0.513	0.275	0.280	0.528		
Necessary Phase Ratio for At-grade 1 2 3	1Φ			0.513	0.275		0.528	0.528	1.073
	2Φ		0.265		0.275	0.280	0.528	0.280	
	3Φ	0.235	0.265		0.275			0.265	
Necessary Phase Ratio for Grade Separation 1 2	1Φ		0.265		0.275	0.280		0.280	0.515
	2Φ	0.235	0.265		0.275			0.235	
	3Φ								

Source: JICA Survey Team

In case of grade separation, the construction cost will increase due to additional 228m section of flyover, on/off ramps and corresponding land acquisition. However, detailed comparison in diverse aspects illustrated below reveals that grade separation is more superior than at-grade intersection for intersection of Narny Road and Peace Avenue.

Table 7.2.5 Intersection Structure Comparison of Narny Road

(Confidential)

(6) Plan for Other Intersections

i) Intersection with Ajilchin Street

The intersection of Ajilchin Street and West Industry Road is designed as follows:

a) It is on the premise that the Dund River Bridge is widened to four (4) traffic lanes by Ulaanbaatar City.
b) Since the Power Plant Road has two traffic lanes, the intersection shall be improved by installing a left-turn lane.
c) Since the Power Plant Road needs to be widened to four (4) lanes in the future, full-scale improvement such as grade separation and channelization shall be conducted at the timing of widening. Accordingly, improvement of the Power Plant Road shall be excluded from the Project scope.

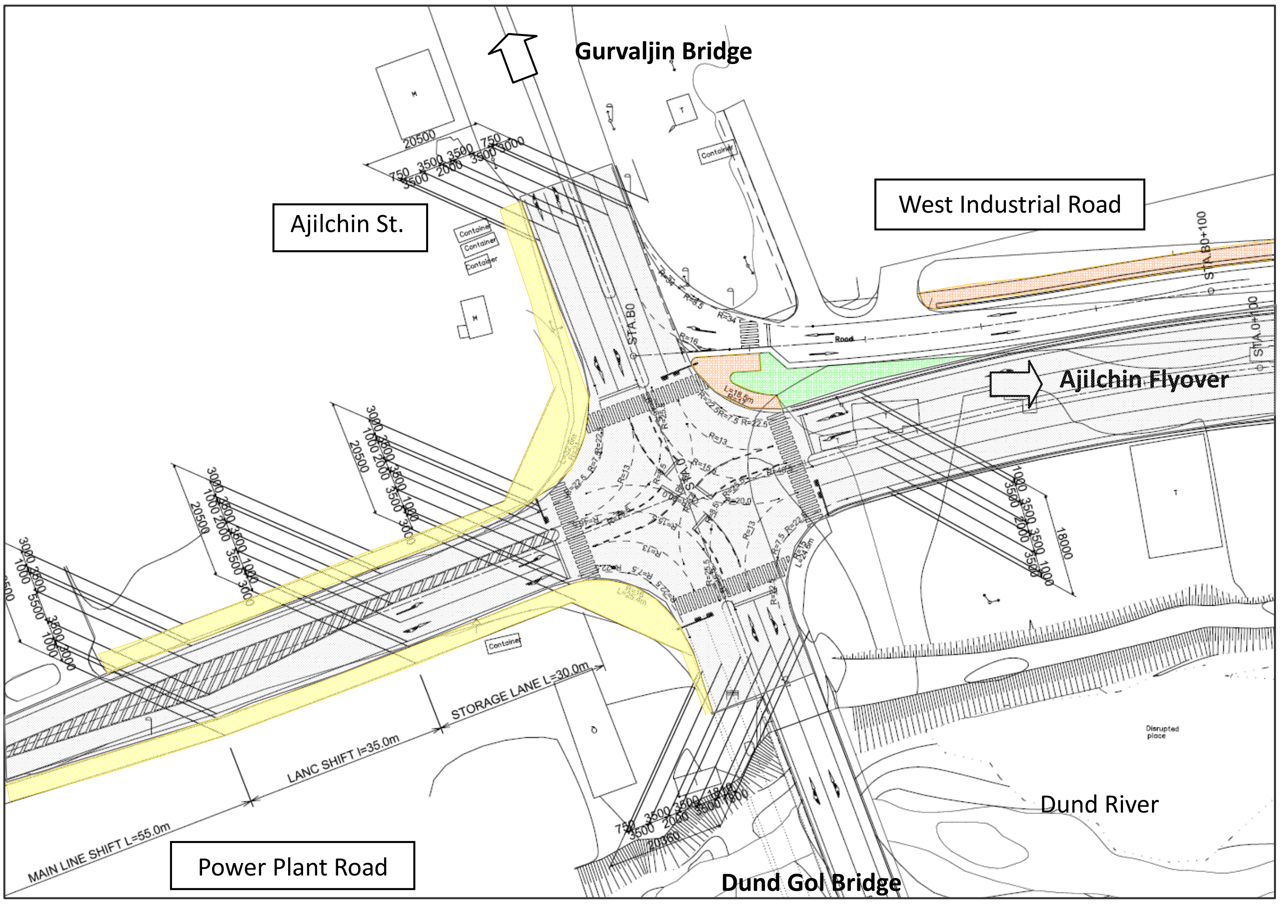


Figure 7.2.4 Plan of Intersection with Ajilchin Road

ii) Intersection of West Industry Road

Grade separation is applied the existing West Industry Road and the project road. At-grade crossing is adopted for West Industry Road and the existing railway feeder line. The Project will cover the limited section up to merging with existing access road.

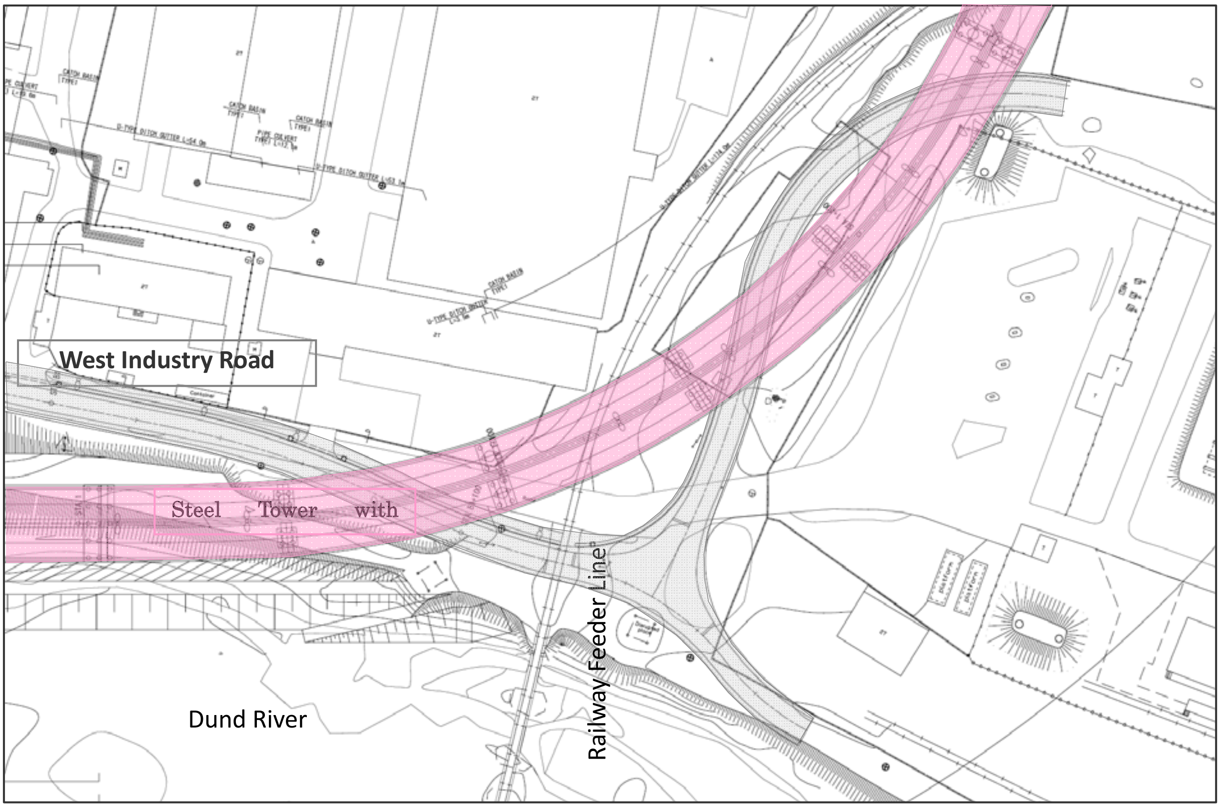


Figure 7.2.5 Plan of Intersection with Existing West Industry Road

(7) Pavement Design

Asphalt concrete pavement is adopted for the Project considering durability and the projected traffic volume. The design of asphalt concrete pavement is based on the "Guidance for Design and Construction of Pavement as revised in 2006" issued by the Japan Road Association.

The summary of the required structure number (SN) is given in Table 7.2.6, and the proposed configuration of pavement is illustrated in Figure 7.2.6. On the other hand, the pavement on bridge deck slab shall be Asphalt Pavement with 80mm thickness.

Table 7.2.6 Design CBR and Paving Thickness Design Conditions

	Design CBR[1)]	**Projected Traffic[2)]**	**Required SN (T_A)**
Narny Road	12	1,500 vehicles/day (C Traffic)	23.0 cm
West Industrial Road	12	1,500 vehicles/day (C Traffic)	23.0 cm

1) Design CBR : based on laboratory CBR test

2) 10 years design life from 2020 with 8% of heavy vehicle mixture

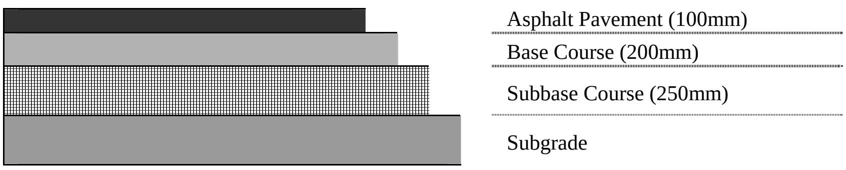


Figure 7.2.6 Configuration of Pavement

(8) Road Drainage System

Storm water on road surface in Project area should be drained to the existing channels and rivers. In Narny Road, the end of drainage system is connected to existing drainage connecting Peace Avenue. Meanwhile, the storm water on West Industry Road and west access road is discharged to the Dund River. Surface water discharge of flyover in northern and southern sides of the railway is designed to drainage along Narny Road and West Industrial Road, respectively.

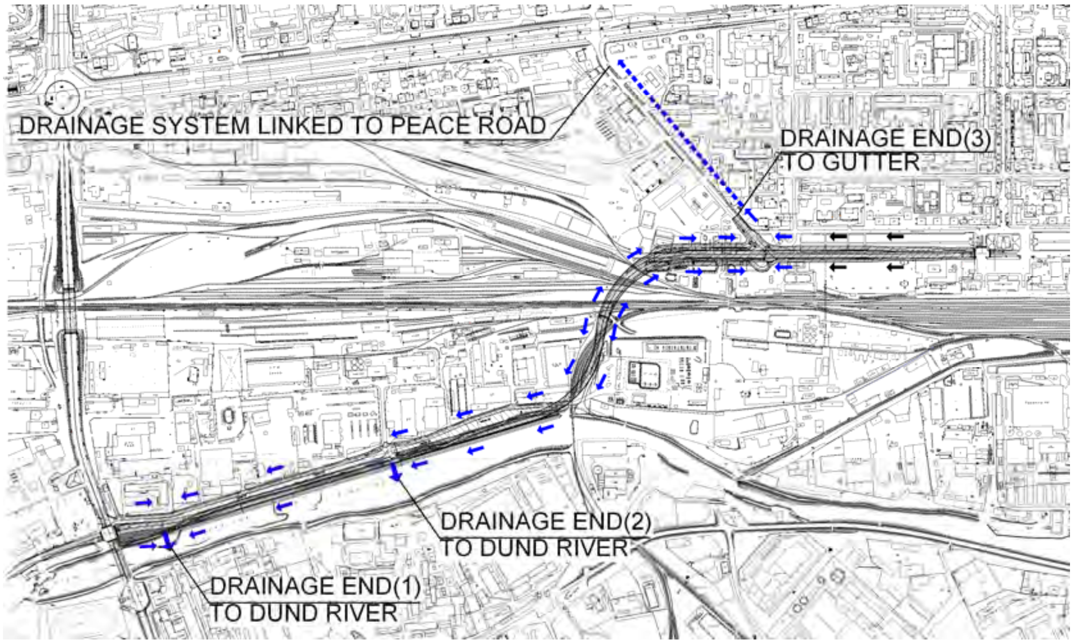


Figure 7.2.7 Drainage Distribution Diagram of the Project Area

(9) Hydraulic Conditions of Dund River and River Dike Design

New access road is planned to be constructed at the south side of the West Industry Road with the removal of the existing river dike at the right bank of Dund River and the construction of a new river dike along the new access load. Dike improvement work is ongoing in the upper stream of Dund River up to Engels Street, and will be extended to downstream after 2013. For design of the dike in this study, the design discharge is set forth to be 346m^3/sec (100-year probability) to calculate the high-water level of Dund River. Dike height in the river section is designed as the high-water level plus 0.8m as allowance height.

Table 7.2.7 High Water Level of Dund River

STA. No.	0+120	0+220	0+320	0+400	0+500	0+600	0+700	0+800	0+900
H.W.L.	1278.4	1277.9	1278.6	1279	1279	1278.7	1278.5	1279.5	1279.7
Dund River	←Downstream (Ajilchin Street) ←			←		←			(Upper Stream)

Note: These values are calculated by uniform flow calculation of Manning Formula. (Average river grade: 0.3%)

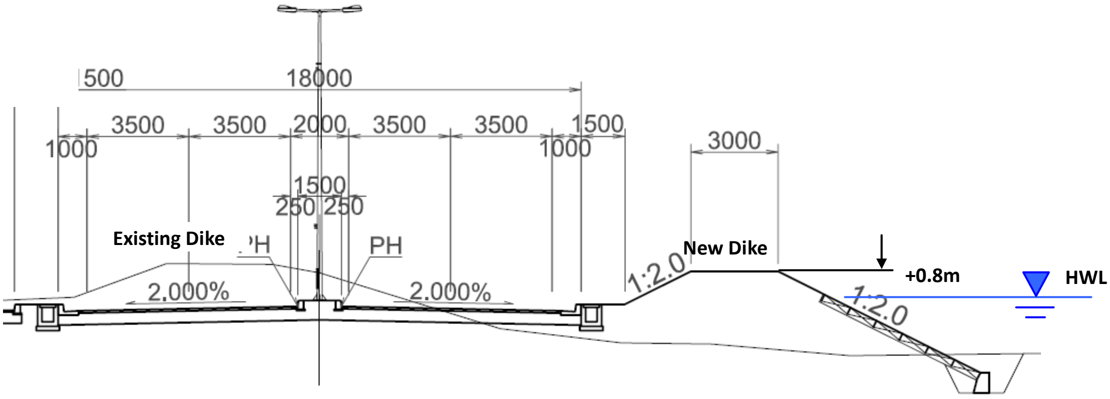


Figure 7.2.8 Typical Cross Section at Right Bank of Dund River

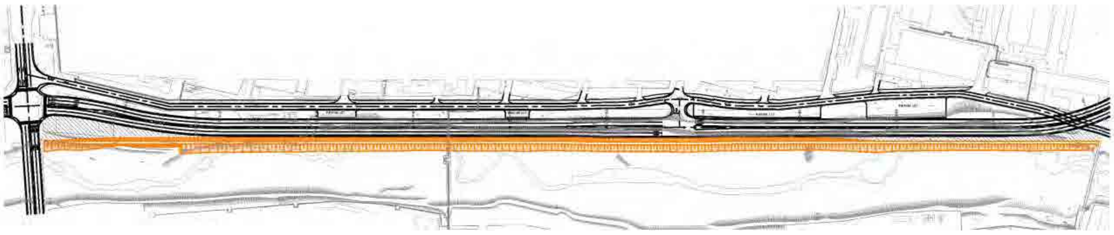


Figure 7.2.9 Construction Area of River Dike at Right Bank of Dund River

With respect to climate change to Mongolia, there will be no significant influence to river dike planning due to the following reasons.

- Survey result of Mongolia Assessment Report on Climate Change (UNEP, 2009) states that precipitation in the summer season has been decreasing since 1940. Other predictions, though with certain deviation in simulation conditions, show increment of precipitation in the summer season will be limited to 0～4%.
- Long-term climate change scenario for 2051-2081 of ci:grasp (Global and Regional Adaptation Support Platform) operated by Giz and PIK (Potsdam Institute for Climate Impact Research) predicts there will not be significant change in precipitation in the summer season.
- The design discharge has been calculated by Mongolian Meteorological Agency on the basis of recent flash flood analysis, and is adopted for design and construction of dike improvement work ongoing at upstream side.
- In case the precipitation increased in 4%, the increased high water level which is estimated as 0.3m in maximum at this river section, shall be lower than allowance height (0.8m).

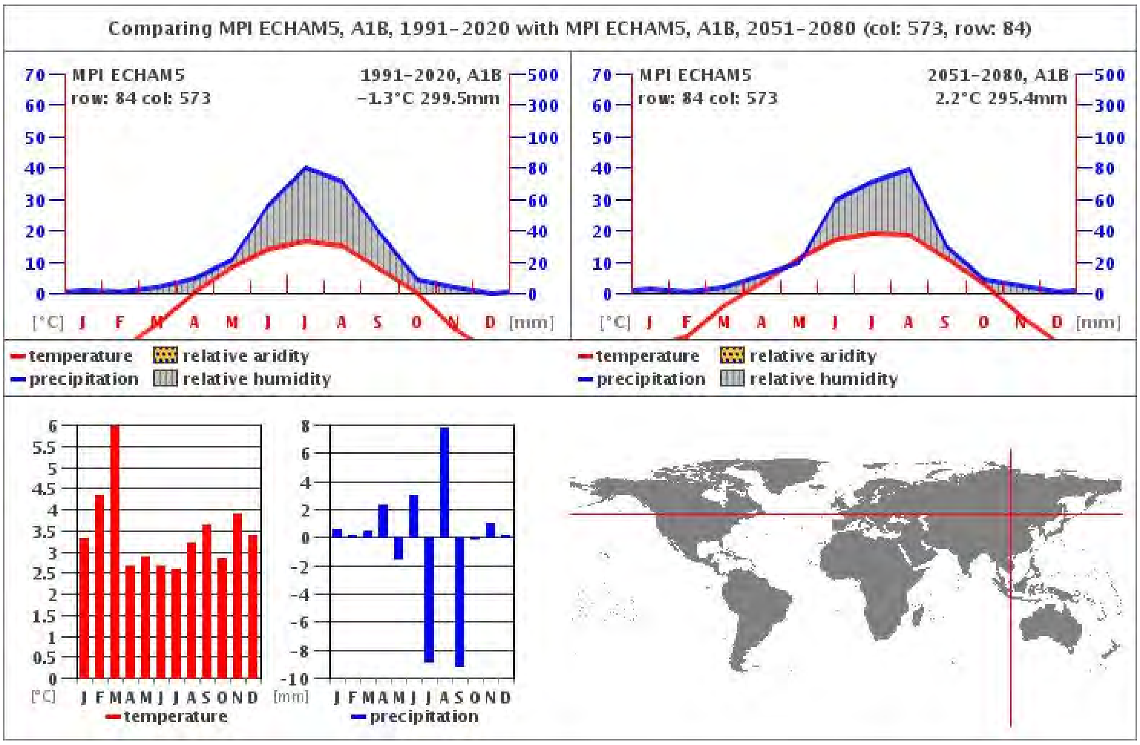


Figure 7.2.10 Prediction of Climate Change near Ulaanbaatar City by ci:grasp

(10) Safety Measure on Skidding Accident in Winter

In October through April in Ulaanbaatar City where the temperature drops below 0°C, traffic accidents tend to happen due to freezing of road surface. Accordingly, the following consideration and safety measures on skidding were proposed for road planning which requires the alignment with sharp horizontal curve (R=200m) and rather steep vertical slope (i=4.5%).

i) Road alignment

The road alignment is planned to be the combined grade of 6% or less without overlap of sharp curve and steep vertical slope in order to minimize driving operations such as steering and braking to follow the road alignment.

ii) Consideration for Low Speed Urban Street

Maximum super-elevation is controlled in 4% to prevent from sideslip at low speed driving.

iii) Physical Countermeasure against the Skidding

Anti-skid pavement is adopted as the most practical and sustainable measure to prevent skidding accident at sharp curve and long vertical slope. The Anti-skid pavement is applied to a bridge section with sharp horizontal curve (R=200m), and approach road with steep vertical slope (i=4.5%). The total area of the Anti-skid pavement for the Project is estimated as 13,800 m^2 in total. More advanced technology on anti-freezing of road surface such as “Road Heating” is also possible to introduced as presented in Table 7.2.8. However, there is no experience of the road heating in Mongolian and the anti-skid pavement has been already demonstrated at the Narny Bridge that can secure the road safety in winter season with lower cost. Thus the road would not be applied for the Project.

Table 7.2.8 Comparison of Countermeasure for Prevention Slipping Accident

(Confidential)

(11) Traffic Control Facility

Traffic Control Center in Ulaanbaatar City was established in 2010 with assistance by Korea, and are enhancing its facility and system with municipal budget. As per coordination with the Traffic Control Center, the Project plans to install the following equipment which is fully compatible with the existing system, as an additional part of ITS in Ulaanbaatar City.

Table 7.2.9 ITS Equipment to be installed in the Project

	Equipment to be installed	Objective	Quantity	Remark
1	Closed Circuit Television Camera (CCTV)	Real time monitoring at traffic control center on traffic situation of intersections	2	1 set for each intersection
2	Video Display System (VDS)	Video recording of traffic situation	2	1 set for each direction
3	Enforcement Machine for Speeding (EMFS)	Enforcement for speeding	2	1 set for each direction

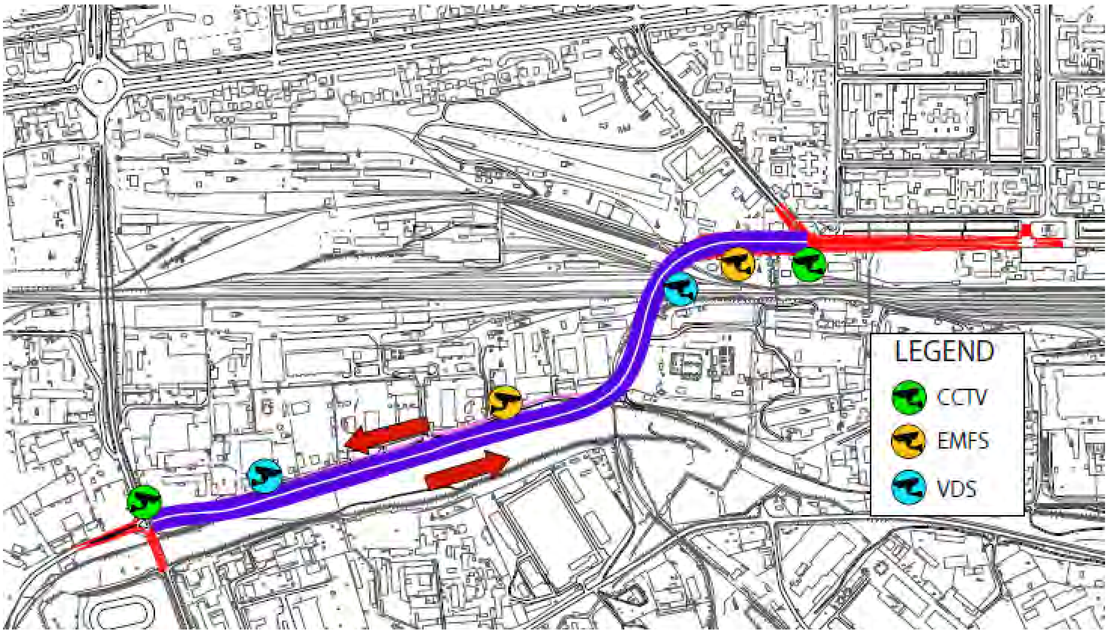


Figure 7.2.11 Proposed Location for Installation of ITS Equipment

7.3 BRIDGE PLAN

(1) Major Point to be discussed in Bridge Plan

With reference to the basic policies for the bridge planning described in 7.1(1), the issues to which special care shall be paid are summarized below. The plan should take into consideration diverse conditions unique to Mongolia

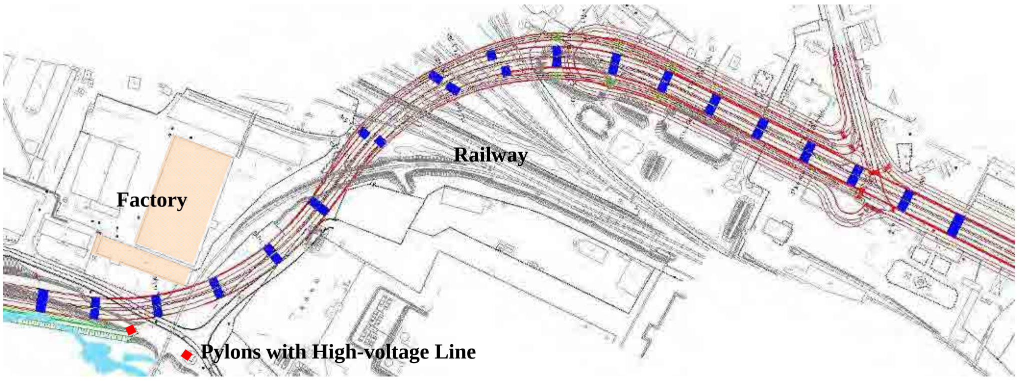
Table 7.3.1 Notes regarding Bridge Plan

	(1) Span Arrangement	(2) Superstructure Type	(3) Substructure Type	(4) Foundation Type
i) Climate Condition	Make span length selection plan that can correspond to the expansion and contraction caused by temperature changes.	Consider restriction of construction period for comparison of concrete bridges and steel bridges. Select materials that can endure -40 degrees Celsius temperature.	Minimize concrete consumption and shorten the construction period.	Consider frost penetration depth when selecting the foundation bearing stratum. Prioritize precast piles to secure quality and shorten the construction period.
ii) Condition of Transportatio n		Be fully aware of shape and dimensions of factory products.		
iii) Girder Erection above Railway Track		Select a construction method and a bridge type that will not hinder railway operations.		
iv) Construction adjacent to Railway Track	Plan span length to enable construction of piers in the railway premises.		Plan a structure that reduces work in the railway premises and use of large-sized heavy equipment.	Select a construction method that digging and foundation work will not affect the rail track.
v) Construction in the urban area with heavy traffic	Make span length long enough to secure visibility at intersections or on the street.	Need to select a construction method that enables construction on narrow construction yards. Prioritize construction method that minimizes impact on traffic control.	Minimize the construction period so as to keep influences by traffic control to a minimum. Select a structure type that ensures visibility at intersections and on the street.	Make a plan that will minimize relocating construction by considering impact on utility.
vi) Underground utility	Plan pier locations that minimize relocation of utility.			Design the foundation size as small as possible to minimize the relocation of underground utility.
vii) Quality control		Prioritize quality by making use of factory products. Select highly durable types that enable the reduction of maintenance costs.	Minimize cross-section of concrete members to minimize risk on construction sites.	

(2) Features of Bridge Location

Location of the bridge construction is classified to 1) railway flyover section and 2) Nary Road section. Features of each section are stated as below.

Table 7.3.2 Characteristics of Bridge Location

	Railway Flyover Section	Narny Road Section
Plan		
Characteristics	• Road alignment is a curve with radius of 200m. • Train operation is about 30 services/day. • As for the feeder line, a freight train travels 2 times a day for supplying coal to No. 3 Thermal Plant and over 10 times a day for transporting materials to other factories along the other railway line irregularly. • Factory building is close to the bridge. Consideration on construction plan shall be given. • Pylons for high-voltage line are under construction. • Ground condition is relatively good, but loose sedimentary layers exist in the railway premises and near Dund River.	• Road alignment is straight. • Traffic volume is over 40,000 cars per day. • In addition to the railway related facilities, commercial and public facilities are situated to the road, and many people utilize the road. • Traffic control is required when implementing construction. • Utility (hot-water pipes with φ1000 and φ800) that is difficult to be relocated is located. • Ground condition is relatively good.

(3) Railway Crossing Condition

Vertical clearance at the railway crossing shall be H=6.9m (future electrification is envisioned), and horizontal clearance from center of railway track to permanent structure such as piers and abutments shall be L=3.5m.

It is supposed that operation of the international passenger trains will not be adjusted for construction work of the Project, but work hours can be secured by adjusting operation of other trains such as cargo and container. Approximately 20 trains per day are operated on feeder lines, and it was confirmed based on discussion with Ulaanbaatar Railway that more than 6 hours per day would be secured for girder erection during construction.

(4) Span Arrangement

i) Each Lane Separated Structure

Each lane (to East and to West) separated structure is proposed for the Project due to reasons described below.

The width is broad; in case of integrated structure, 700mm or more elevation gap will be created in the transverse direction, and the longitudinal gradient will become excessively steep, which may cause traffic accidents such as slippage in the winter.

By separating each lane, the scale of each structure becomes small, which enables to simplify stress transferring mechanism and minimize the dimension of structures.

ii) Determination of Abutment Position

The proposed location of Ajilchin bridge has been highly Urbanized. The planned bridge will be easy for residents to access, and has many occasions of visual contact by residents and drivers. Thus, structures with high retaining walls or girders is not suitable for the proposed bridge from a viewpoint of landscaping and aesthetics. Also, the bearing on abutment should be of a height around 2.5m high from the existing ground surface to facilitate routine inspection and maintenance. Boundary fence will be installed in front of abutment to eliminate unnecessary access of pedestrians.

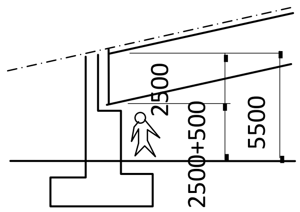


Figure 7.3.1 Image of Abutment Position

iii) Pier Allocation

Each pier position was determined considering the following matters.

P1-P4: Allocation was decided so that piers would not affect railway feeder lines bound for the No. 3 Thermal Power Plant.

P5-P8: Piers were positioned so as not to hinder railway tracks because the bridge will stride over the railway main line where there are many feeder lines going to the switchyard in the railway premises. (P6/P7/P8)

P9-P11: Piers were positioned avoiding the access road used to the railway premises.

P12-P16: Piers were located in places with adequate visibility to the intersection with Narny Road. Allocation of P15 and P16 were decided where relocation of hot-water pipe main line (φ1000, φ800) can be avoided.

iv) Span Arrangement and Bridge Length

The span length selection plan complying with above conditions is indicated in the figure below. Total bridge length is 828m based on the span arrangement.

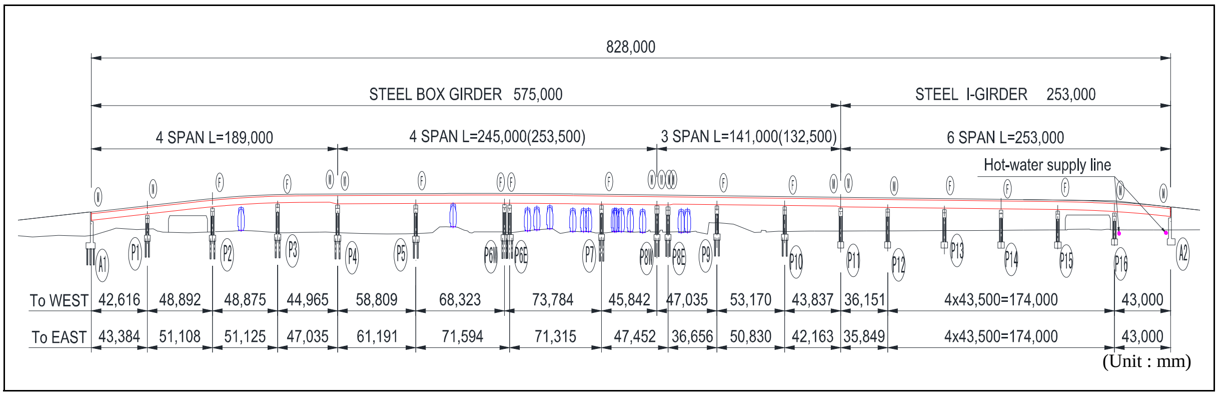


Figure 7.3.2 Bridge Span Arrangement

v) Criteria for Bridge Length

This bridge is 828m long with S-shaped horizontal alignment. Full length of bridge cannot be designed as a continuous structure, and thus shall be divided into four (4) structural elements. The length of each structural element (=bridge) was decided as follows.

-No. 1 Bridge (A1 to P4)-

The structure is continuous girder type with advantages of economical efficiency, maintenance ability, and drivability. A1 abutment is positioned at STA1+005 to secure sufficient visibility at the railway crossing, to minimize influence on the existing utilities during construction due to a large-scale footing, and to reduce the feeling of pressure in front of the building. Continuous girder section ends before the S-shape curve (P5) and extends to P4 pier considering the span length selection of No. 2 Bridge. Consequently, total length of No. 1 Bridge is 189m in center distance.

-No. 2 Bridge (P4 to P8)-

P8 pier position was decided to be where the ramp bridge is installed. To install a ramp bridge, P8 position is to be a jointed section so as to separate the structure. As the result, the length of No. 2 Bridge became 245m (central distance). As for the jointed section on P8, although it is in the railway premises, it was judged that maintenance problems would be small because the joint section cannot be avoided for installing the ramp and the railway premises have relatively sufficient space for maintenance work.

-No. 3 Bridge (P8 to P11)-

The position of P11 was decided to be in the place where the R200m curve section ends. The curve section and the straight section shall be structurally separated to make the superstructure cost at the straight section small. As the result, the length of No. 3 Bridge became 141m (central distance).

-No. 4 Bridge (P11 to A2)-

This will be a straight section, so the structure would be continuous girder type which has advantage in economic efficiency, maintenance ability, and drivability. The A2 abutment position was set so as not to require relocation of trunk line of heating pipe (φ1000 and φ800), reducing expenses for relocation and problems with future maintenance. As the result, it became as STA1+833, and the length of the No. 4 Bridge became 253m.

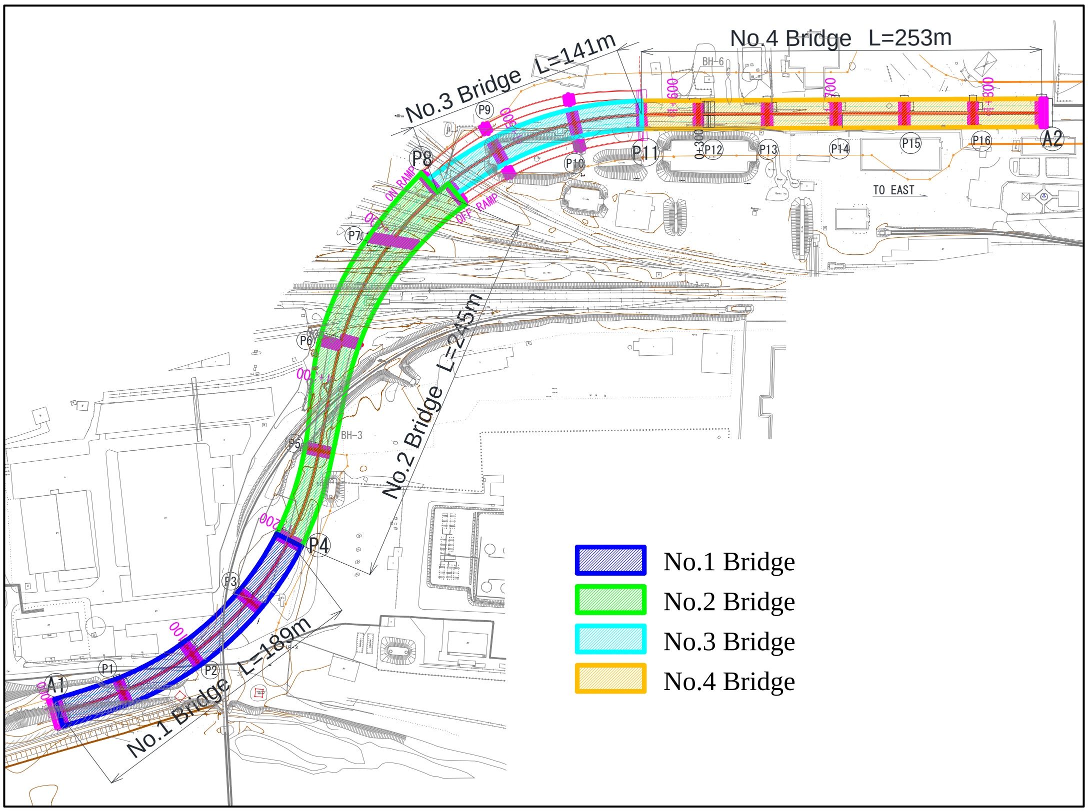


Figure 7.3.3 Bridge Partition

(5) Selecting Superstructure Type

i) Flyover Section

Twin steel box-girder bridge (Triple steel box girder for the flyover section on the main line) is adopted for the flyover section superstructure due to reasons below. (See Table 7.3.4 for details.)

- The flyover section has a curved section with radius of 200m, and its maximum span length is 73m. Therefore, selection of a box girder type with high torsional stiffness shall be required.
- Concrete construction cannot be implemented during the winter period (October to April), and securing quality is difficult. Select steel girders that can be produced at a factory and ensure high quality.
- Select a twin steel box girder bridge that is structurally sound because it can correspond to ramp width expansion and with or without negative reaction.
- The flyover section has a restriction of girder height (2.5m max.) because of the road longitudinal gradient and for securing railway construction gauges. Increase the number of girders (from 2 to 3 steel boxes) to cope with this restriction.

ii) Narny Road Section (Side Span)

Steel I girder bridge is incorporated in the superstructure of the Narny Road section due to the reasons below. (See Table 7.3.5 for details.)

- Select steel girders because this road is in the urban area with heavy traffic, construction yard is small, it is important to shorten the construction period to prevent traffic congestion caused by the construction, and steel girders are economical.
- Select a Steel I girder bridge based on reasons that the road alignment is straight and the maximum span length is about 43m.
- Select a continuous girder type that has advantages such as drivability, small impact (noise) on neighboring environment, and small risk of bridge collapse due to earthquake.

iii) Selection of Slab Type

The condition of the damaged concrete slabs of the existing bridges in Ulaanbaatar City is serious. The damage has been created by structural issues, quality control issues during construction, and overloaded vehicles. A steel-concrete composite deck slab will be used in this project due to the above issues and the following reasons. (See Table 7.3.6 for details.)

- Support for concreting is not required for working above the railway and the existing roads, and construction period can be shortened.
- Steel part is fabricated in factory, so it is easy to secure high quality and high durability.
- Risk of accident by falling concrete in the future and necessity of repair work are small.

iv) Selection of Corrosion Protection Method

As for the materials used for the bridge superstructure, corrosion protection using fluorine resin coating is usually applied to “welded structural rolled steel.” Steel materials called “welded structural weather resistant rolled steel” contain appropriate amounts of alloys to form a dense layer of rust on the surface through repeated exposure to the wet and dry in the atmosphere. This dense rust serves to protect the underlying steel surface. Therefore, this uncoated material can impede the progress of rust. Comparison between 2 materials is described below, and it was decided to use “Rolled Steel for Welded Structure + Coating” for this project.

Table 7.3.3 Comparison of Corrosion Protection

	Rolled Steel for Welded Structure + Coating (SM490+C5 Coating)	**Atmospheric Corrosion Resistant Rolled Steel for Welded Structure (SMA490)**
Image		
Anticorrosion	Corrosion of steel hardly occurs in the dry climate of Mongolia, and the anticorrosion property is high. Therefore, corrosion should not be an issue.	It takes time until stable rust is formed, and there is a possibility that the forming range of stable rust may become uneven.
Landscape	A color for coating that fits the landscape of the urban area can be selected, so the beauty of the landscape can be preserved.	The color has an image of rust and may not fit well to the urban landscape in many cases. In the early stage after being placed in service, rusty fluid may leach causing part of the pier to become brown. In general, the color goes well with the natural colors in the mountain area.
Economical Efficiency	Prices of steel + coating in Japan are equivalent to or higher by several percent compared to the weather resistant steel.	Costs in Japan are a little lower compared to coating specification.
Maintenance Ability	Steel girders need to be repainted regularly, but repainting will not be required for 30 years or so by applying a heavy-duty coating (C5 type).	It is possible that anti-freezing agents for road surface including NaCl causes corrosion of the steel members if no coating is applied.
Evaluation	Considering climate conditions in Mongolia, the past performance of steel bridges, high anticorrosion properties of coatings, and landscape of the urban areas, adopting this type is desirable. Recommended	Taking into account of physical appearance, this type can not be recommended to the Project which is located in Urban Area. Life cycle cost can be reduced in countries with high humidity and a great deal of precipitation, but the effect is possibly small in Mongolia. Not Recommended

Table 7.3.4 Comparison of Superstructure Types at Flyover Section (between A1 and P11)

(Confidential)

Table 7.3.5 Comparison of Superstructure Types at Narny Road (between P11 and A2)

(Confidential)

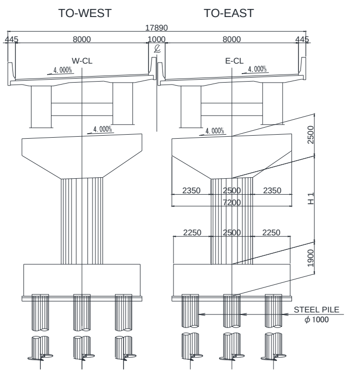
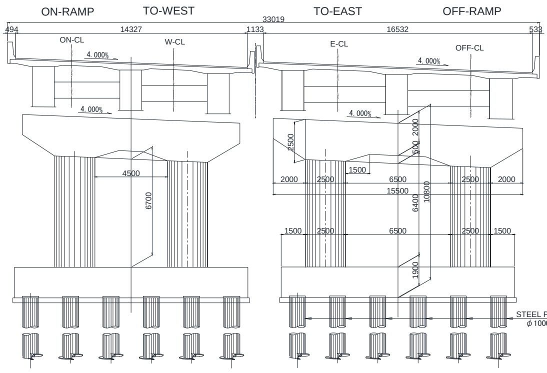
Table7.3.6　Comparison of Deck Slab Type

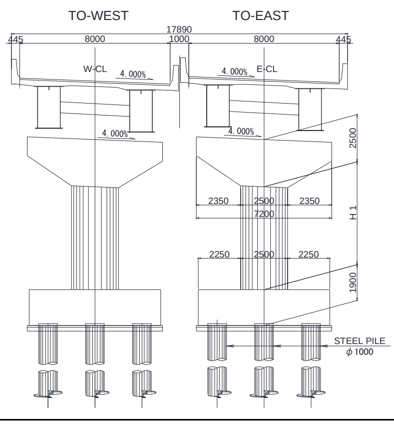
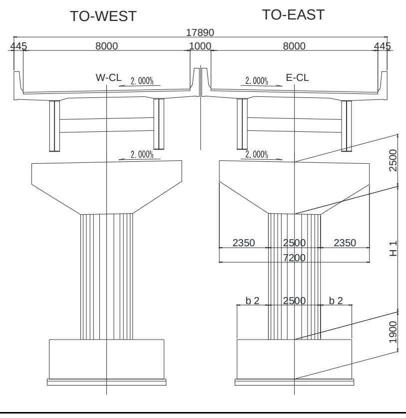
(Confidential)

(6) Types of Pier

In the railway premises, the structure becomes complicated including S-shape curves and ramp widening sections. The substructure type should be selected to correspond to the complicated structure. Also, construction space is limited, and constructing a large-scale footing is difficult. Therefore, pile foundations will be used in the railway premises.

Table 7.3.7 Selection of Substructure Type

Section	**In the Railway Premises (Flyover Section)**	
	P1 to P5	**P6 to P8**
Type	Cylindrical Pier (with Beam)	Rigid Frame Pier
Cross-sectional View		
Reason for Selection	Curvature radius is R=200, so cylindrical pier is used as a pier shape because cylindrical piers can evenly resist loads in all directions.	This section requires widening the width for installing a ramp. Construction is implemented in the railway premises, so construction needs to fit in a narrow space. Width requires 15m or more, so the rigid frame pier is used for this section.

Section	**In the railway premises (Flyover Section)**	**Narny Road**
	P9 to P10	**P11 to P16**
Type	Cylindrical Pier	Cylindrical Pier
Cross-sectional View		
Reason for Selection	Curvature radius of this section is R=200 in the same way as A1 to P5, so cylindrical pier is used as a pier shape because cylindrical pier can evenly resist loads in all directions.	Horizontal alignment on Narny Road is straight. Supporting layer is confirmed in shallow position. Different from the railway premises, restriction of construction space is small. Therefore, economically efficient spread foundation + cylindrical pier are used for this section. Depth of spread foundation should be 4m taking into account freezing and thawing of the ground in winter.

(7) Selection of Foundation Type

i) Flyover Section

Select a construction type based on the following criteria. Influence of excavation work for foundation on railway track (feeder lines to the switchyard) should be minimized. Construction period in the railway premises should be shortened. Influence on train operation should be minimized. Based on the fact that the ground is mainly gravelly soil mixed with cobblestones, the following 3 construction methods were studied and compared.

(1) Rotary penetration steel pipe pile

(2) Cast in place concrete pile

(3) Spread foundation

As the result, it was decided to use the “rotary penetration steel pipe pile” method because the method is economical and has excellent construction performance as well as having shown good results with the Narny Bridge.

Table 7.3.8 Comparison of Foundation Type at Flyover Section (A1 to P10)

(Confidential)

ii) Narny Road Section

At the Narny Road section, construction should be conducted while the existing traffic is maintained, so the excavating range for the foundation work is limited. When the land acquisition for constructing the service road beside the bridge is completed, sufficient space can be kept for controlling the existing traffic. Based on the conditions above, foundation types were compared, and the spread foundation was selected for economical and construction performance reasons.

Table 7.3.9 Comparison of Foundation Types at Narny Road Section

(Confidential)

7.4 BASIC DESIGN OF BRIDGE

In this study, outline designing is implemented based on the design standards below. Allowable stress design method is used considering uncertainty of material properties.

(1) Design Condition

i) Design Standards for Reference

a) Specifications for Highway Bridges (Japan Road Association, March 2012)

b) Planning of Auto Road Bridge and Pipe Culvert (32-02-03, 2005)

c) Norm and Regulation for Design of Facility in Earthquake Region (22.01.01*/2006) Ministry of Construction and Urban Development)

ii) List of Design Conditions

Planned Location				Narny Road to West Industry Road, in Ulaanbaatar City
Bridge Length				828 m
Standard Road Width				8.0 m
Horizontal Alignment				A=100 ~ R=200 ~ A=100 ~ R=200 ~ A=100 ~ ∞
Design Live Load				B-Live Load in Specifications for Highway Bridge by Japan Road Association (See Figure 7.4.1 and Table 7.4.2)
Thermal Load				-40℃≦T≦40℃
Design Horizontal Seismic Coefficient				Level 1 Earthquake Motion: kh = 0.10 Level 2 Earthquake Motion: kh = 0.50
Superstructure	Type			Up and Down Line Separated Structure (Main Line) Continuous Structure Twin Box Girder Bridge, Continuous Structure Bridge with Minimized Usage of Steel Girder Plates (Ramp Section) Multi-span Continuous Box Girder Bridge
Superstructure	Materials			SM520, SM490Y, SM490, SM400, SS400
Superstructure	Slab Type			Steel-Concrete Composite Deck Slab: Slab thickness is 210 mm to 250 mm.
Superstructure	Bearing Type			Steel bearing
Substructure	Type	Abutment and Pier		Reversed T Type Abutment, Overhang Type Cylindrical Pier, Rigid Frame Pier
Substructure	Type	Foundation		Rotary Penetration Steel Pipe Pile: φ1000, Spread Foundation
Substructure	Materials	Structure	Reinforcing Bar	SD345
Substructure	Materials	Structure	Concrete	σck=24N/mm2
Substructure	Materials	Foundation		SKK490
Substructure	Bearing Stratum			GP-GC Layer
Crossing Condition	Railway Crossing Section			Construction Gauge: H=7.0m Maintain distance from the track center by L=3.5m for permanent structure. (See Figure 7.4.3.)
Crossing Condition	Road Intersection			Construction Gauge: H=5.0m
Guard Fence				Concrete Guard Fence (Japan Guard Fence Installation Outline: SC Type, Florida Type)

iii) Materials

Materials applied to design should conform to the standards below.

Table7.4.1 Specification of Materials used for Basic Design of Bridge

Material	Application	Specification
Concrete	Abutment, Pier, Wall Rail	σck=24 N/mm^2
	Steel-Concrete Composite Deck Slab	σck=30 N/mm^2
Reinforcing Bar		SD345 (JIS)
Steel for Structure	Superstructure	SM520, SM490Y, SM490, SM400, SS400 (JIS)
Steel Pipe for Structure	Rotary Penetration Steel Pipe Pile	SKK490 (JIS)

iv) Live Load

According to Mongolian design standards, the design should be made based on "AK load consisting of biaxial load and uniform load modeling heavy vehicles" or "NK load of 4 axial heavy vehicles modeling large-sized trailers." In association with the recent increase in vehicle size, revision of the design load is planned. As a result of comparing the following 5 loads including the current standards in Mongolia and live load that is planned to be revised (See Figure 7.4.1), it was decided to adopt Japanese B-live load (Figure 7.4.2, Table 7.4.3) which creates the largest bending momentum as a live load for this project.

a) Design Standard in Mongolia (before revision) (AK load or NK load; K=11)
b) Design Standard in Mongolia (after revision) (AK load or NK load; K=15)
c) Specifications for Highway Bridges in Japan (B-live load)
d) USA AASHTO LRFD (HL-93)
e) UK BS ENV 1991-1-1996 (Euro Code, LM-1)

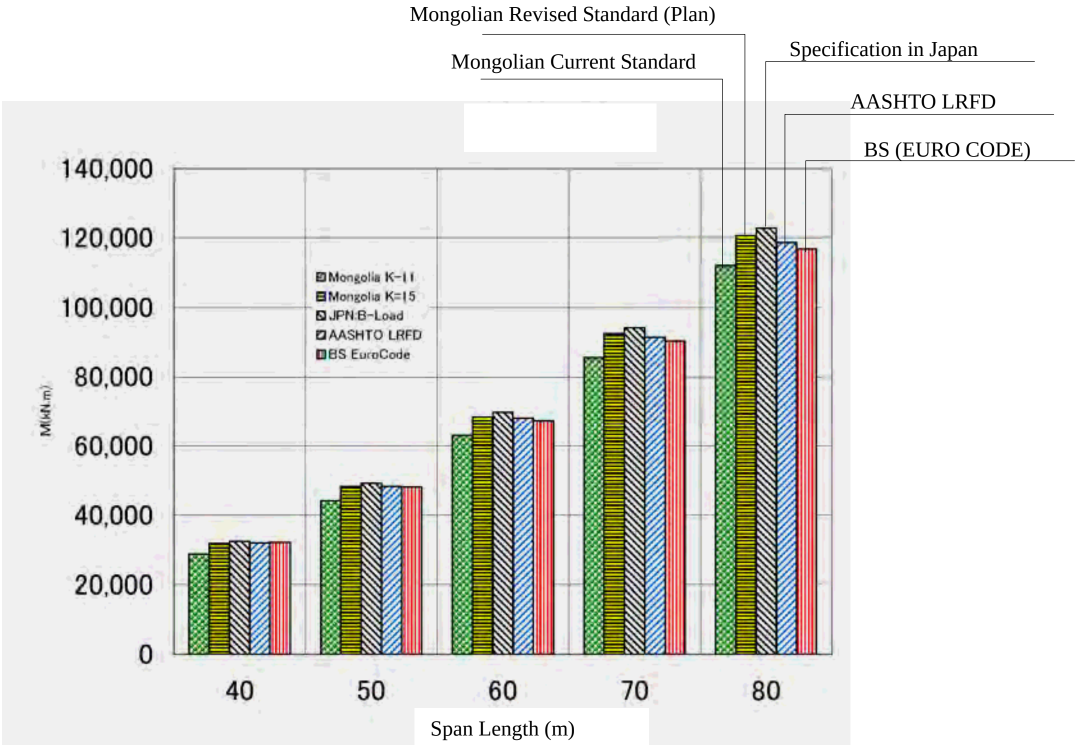


Figure 7.4.1 Comparison of Live Load Influence by Mongolia and Other Countries' Design Standards

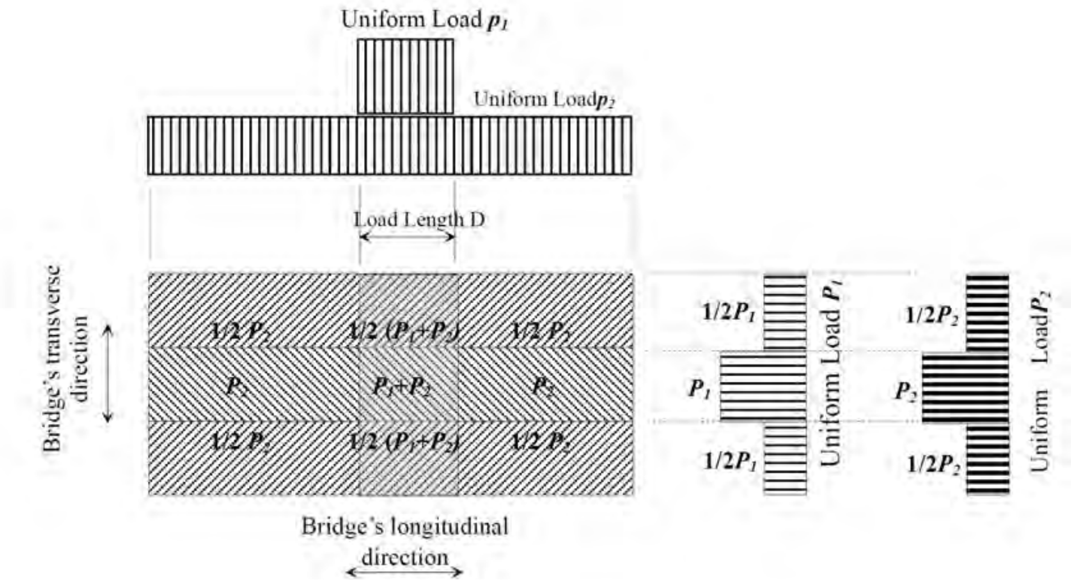


Figure 7.4.2 B-Live Load of Specifications for Highway Bridges in Japan

Table 7.4.2 B-Live Load Prescription of Specifications for Highway Bridges in Japan

Live Load on Main Lanes (Width: 5.5m)						**Live Load on Secondary Lanes**
	Uniform Load p_1		Uniform Load p_2			
Load Length D (m)	Load (kN/m^2)		Load (kN/m^2)			
10	For calculation of bending moment	For calculation of shearing force	L≦80	80<L≦130	130<L	
	10	12	3.5	4.3-0.01L	3.0	50% of live load on main lanes

v) Thermal Load

According to weather data for the past 14 years (1998 to 2011), the lowest temperature/highest temperatures are ±40℃. Also, in the design standard (BNbD32.02.03), the same figure is indicated. Therefore, structure temperature referred to in this project is set to -40°C≦T≦40°C.

vi) Wind Load

Wind load is calculated using the maximum instantaneous wind speed, 30m/s, in Ulaanbaatar for the past 14 years (1998 to 2011).

vii) Soil Properties for Design

Boring investigation was conducted in the actual place to perform various geological investigations. Based on the results of boring, each soil modulus per layer were calculated. Schematic diagrams are shown in Figure 7.4.3. Each soil modulus is shown in Table 7.4.4.

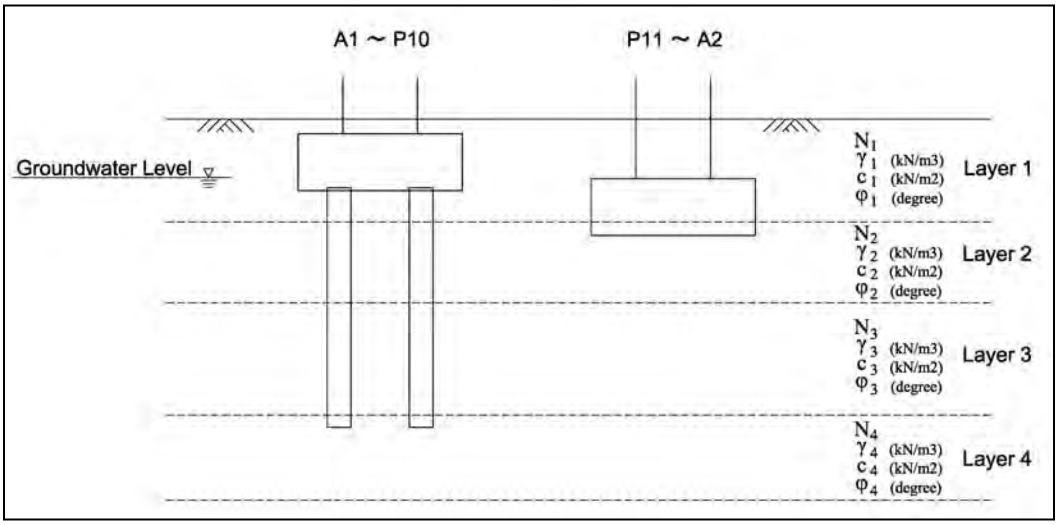


Figure 7.4.3 Schematic Diagram of Each Soil Modulus

Table 7.4.3 Soil Properties per Layer of Boring Point

Boring No.	BH-01	Design Target: Substructure	A1			
Layer	Design N Value	Unit Weight γ (kN/m^3)	Cohesion c (kN/m^2)	Angle of Internal Friction φ (˚)	Deformation Coefficients Eo (kN/m^2)	
					Ordinary Time	During Earthquakes
tO_{IV}	14	19	0	34	39,200	78,400
GP	42	22	0	39	117,600	235,200
GP-GC	50	22	0	39	140,000	280,000
GP-GC	50	21	0	38	140,000	280,000

Boring No.	BH-02	Design Target: Substructure	P1, P2, P3, P4			
Layer	Design N Value	Unit Weight γ (kN/m^3)	Cohesion c (kN/m^2)	Angle of Internal Friction φ (°)	Deformation Coefficients Eo (kN/m^2)	
					Ordinary Time	During Earthquakes
GP	39	22	0	38	109,200	218,400
SC	45	20	0	38	126,000	252,000
GP	50	22	0	38	140,000	280,000

Boring No.	BH-03	Design Target: Substructure	P5, P6			
Layer	Design N Value	Unit Weight γ (kN/m^3)	Cohesion c (kN/m^2)	Angle of Internal Friction φ (˚)	Deformation Coefficients Eo (kN/m^2)	
					Ordinary Time	During Earthquakes
GP	50	21	0	40	140,000	280,000
GP-GC	50	21	0	40	140,000	280,000

Boring No.	BH-05	Design Target: Substructure	P7, P8, P9, Ramp-P1			
Layer	Design N Value	Unit Weight γ (kN/m^3)	Cohesion c (kN/m^2)	Angle of Internal Friction φ (˚)	Deformation Coefficients Eo (kN/m^2)	
					Ordinary Time	During Earthquakes
GP	40	21	0	40	112,000	224,000
GP	40	21	0	40	112,000	224,000
GP	50	21	0	39	140,000	280,000
GP-GC	50	21	0	39	140,000	280,000

Boring No.	BH-06	Design Target: Substructure	P11, P12, P13, Ramp-A2			
Layer	Design N Value	Unit Weight γ (kN/m^3)	Cohesion c (kN/m^2)	Angle of Internal Friction φ (˚)	Deformation Coefficients Eo (kN/m^2)	
					Ordinary Time	During Earthquakes
GC	50	21	0	39	140,000	280,000

Boring No.	BH-08	Design Target: Substructure	A2			
Layer	Design N Value	Unit Weight γ (kN/m^3)	Cohesion c (kN/m^2)	Angle of Internal Friction φ (˚)	Deformation Coefficients Eo (kN/m^2)	
					Ordinary Time	During Earthquakes
GP	50	22	0	39	140,000	280,000

viii)Allowable Stress

a) Steel Product

Allowable stress of steel products is as follows.

Table 7.4.4 Allowable Stress of Steel Products (N/mm^2)

Types of Stress	**SS400 SM400**	**SM490 SKK490**	**SM490Y SM520**	**SD345**
Tension	140	185	210	180
Compression	140	185	210	200
Shear	80	105	120	-

b) Concrete

Allowable stress of reinforced concrete members is as follows.

Table 7.4.5 Allowable Stress of Concrete (N/mm^2)

Types of Stress ＼ σck		21	24	30
Compressive stress	Bending compressive stress	7.0	8.0	10.0
	Axial compressive stress	5.5	6.5	8.5
Shearing stress	Only concrete	0.22	0.23	0.25
	With diagonal tension bar	1.6	1.7	1.9
	Punching shearing stress	0.85	0.90	1.00
Bond stress	Deformed bar	1.4	1.6	1.8

(2) Seismic Design

i) Earthquake Intensity Scale of Project Location

According to the Mongolian seismic design standard, BNbD22.01.01/2006, 6, 7, and 8 are prescribed as the applicable MSK earthquake intensity scale. Ajilchin Flyover construction site is located near the border of MSK 7 to 8 as shown in Figure 7.4.4. Based on the possibility of a magnitude 7 earthquake occurrence (pointed out by a French research institute in 2010), Mongolian Science Academy is reviewing seismic intensity in Ulaanbaatar City.

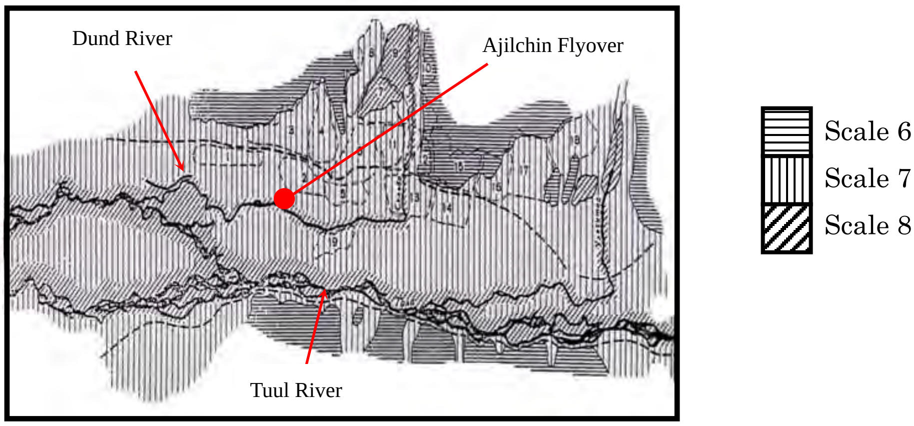


Figure 7.4.4 Map of Earthquake Intensity in Ulaanbaatar City

ii) Earthquake Load used for Seismic Design

According to Mongolian seismic design standard, use the following calculation formula to calculate by replacing earthquake load with static load. (Single Spectrum Calculation Method)

$S_{ik} = K_1 \cdot K_\varphi \cdot Q_k \cdot A \cdot \beta_i \cdot \eta_{ik}$

K_1 : 1.0 for elastic design, 0.12 to 0.35 for recognizing a plastic hinge

K_φ : Coefficient per ground type, Ground Type II (500<Vs<800) = 1.0

Q_k : Mass

A : 0.1g, 0.2g, and 0.4g for standard accelerated velocity set per MSK seismic coefficient 7, 8, and 9 respectively

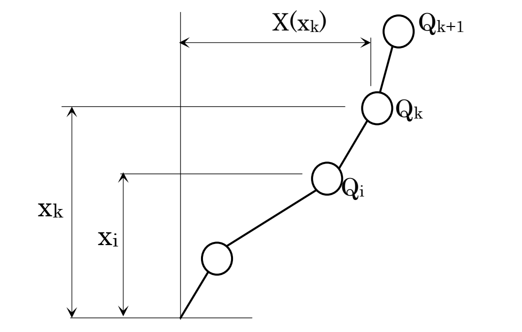


Figure 7.4.5 Explanation Drawing of Analysis Coefficient η

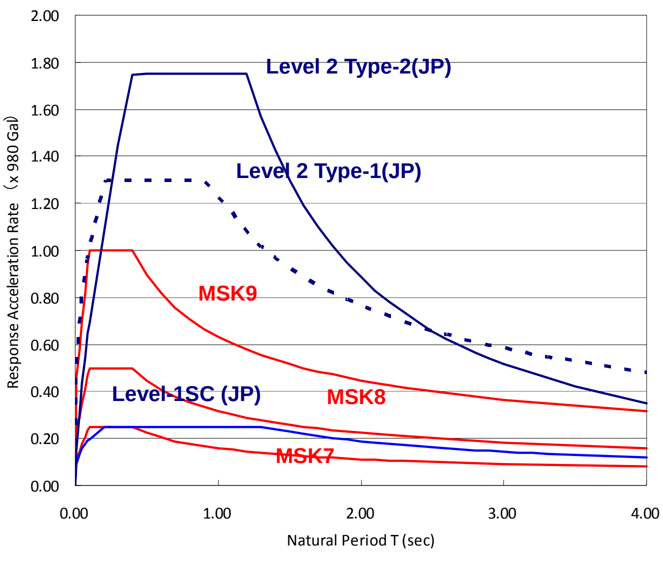
β_i : Acceleration Response Spectrum

Ti 0.1sec	βi = 1+15Ti
0.1sec Ti < 0.4sec	βi = 2.5
0.4sec Ti	β = 2.5 (0.4 / Ti)0.5

η_{ik} : Analysis Coefficient

$\eta_{ik}=X_i(x_k) \cdot \Sigma(Q_j \cdot X_i(x_j)) / \Sigma(Q_j \cdot X_i^2(x_j))$

Response spectrum by an earthquake can be calculated using K_1(=1.0), K_φ(=1.0: Ground Type II), A, and β_i. In seismic design in Japan, response spectrum used for design structures within elastic range (Applied to Seismic Coefficient Method) and response spectrum used for design allowing localized damage that can be recovered in a short period are given (Level-1, Level-2).



Note: SC: Seismic Coefficient Method, Regional Factor for JP=1.0
Source: JICA Fact-Finding Team

Figure 7.4.6 Comparison of Response Spectrum
(Source: JICA Fact-Finding Team)

Figure 7.4.6 shows a comparison between response spectrum for Type II Ground in Mongolia and Japan. With MSK7 (bridge construction site in Ulaanbaatar under prevailing regulations), an earthquake load smaller than that of Japanese seismic coefficient method is given. With MSK8 and MSK9, an earthquake load is larger than the Japanese seismic coefficient method but the response acceleration rate is 2/3 and 1/2 of Level 2 Type 1 in Japanese specification. The bridge's own natural period T is approximately 0.5 to 1.0 second. When applying the Mongolian standard, MSk7 to MSK9, its acceleration rate becomes approximately 0.2g to 1.0g.

iii) Earthquake Motion in Mongolia under Consideration

At present, the "Earthquake Disaster Prevention Ability Improvement Project in Ulaanbaatar City" is studying earthquake motion based on the following 2 scenarios.

- Scenario I: Results by Hustai Fault
- Scenario II: More serious result caused by Emeelt Fault and Gunjiin Fault

As for the response acceleration applied to design, as shown in Figure 7.4.7, newly studied scenario type earthquake motion becomes approximately double of acceleration in the existing design guidelines. In discussion with the Ulaanbaatar City Road Bureau, it was decided to apply MSK8 of the current guideline based on the following matters; the recurrence interval of MSK8 that is prescribed in the existing standard is approximately 475 years; the bridge's own natural period is approximately 1.0 second; acceleration will be the biggest with Scenario-I (influenced by the Hustai Fault) but the recurrence interval with this scenario is not clear. According to trial analysis, quantity of reinforcing bar of piers increases 70% in weight of which cost would be equivalent to one (1) percent of the total construction cost in case the Senario-1 is adopted. This additional amount can be covered by contingency cost of the Project.

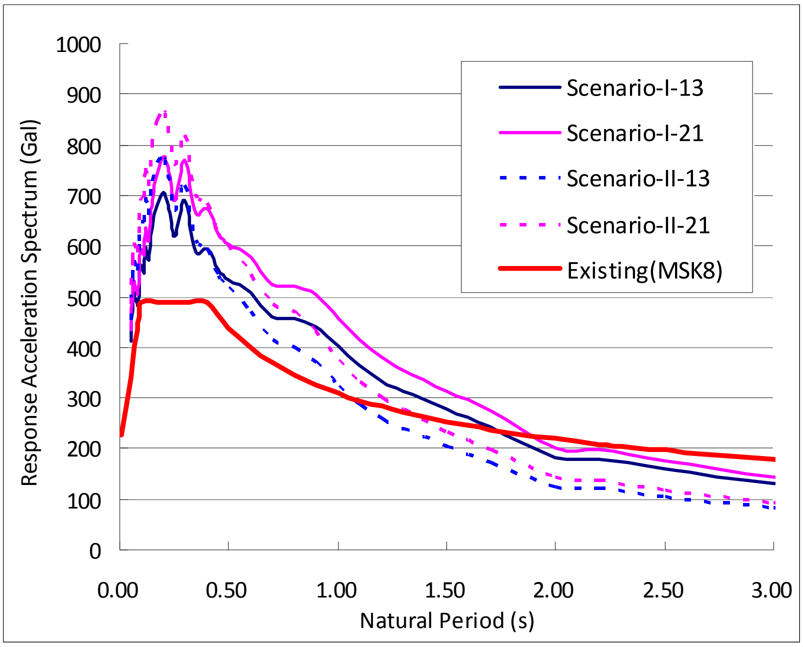


Figure 7.4.7 Comparison of Response Acceleration Spectrum of Scenario Earthquake Motion and the Current Guideline

iv) Seismic Design Policy for the Project

For seismic design of this bridge, based on the above reviews i) and ii), the following seismic design policy is adopted considering 2 levels of earthquake motion, which are Level 1 earthquake motion and Level 2 earthquake motion, in accordance with the method in the Specifications of Highway Bridges by the Japanese Road Association.

a) Time-proven Japanese seismic design method is used.
b) As for earthquake motion (Level 1) with high probability of occurrence during service period, the design should be made based on the Japanese seismic coefficient method (elastic design), and apply a design horizontal seismic coefficient Kh=0.10.
c) Earthquake intensity based on the Mongolian seismic design standard should be MSK8, which is handled as earthquake motion of Japanese seismic design Level 2 to allow deformation of bridge piers and piles to the nonlinear range.

Level 1 earthquake motion mentioned above is a medium-scale earthquake. The probability of such an earthquake motion affecting the structure once or twice during its service period is high. Against Level 1 earthquake motion, the structure is designed to behave within the elastic limit when subjected to a horizontal seismic coefficient of 0.1 (static horizontal load of 0.1 times of structure weight). Level 2 earthquake motion has low probability of occurrence and is very strong. Against Level 2 earthquake motion (design horizontal seismic coefficient 0.5), the structure would be damaged to a certain extent, but it should be designed to allow plastic deformation of the structure to the extent that a large-scale fall will not cause extensive damage to its surroundings but not to the extent that it exceeds the ultimate lateral strength.

v) Unseating Prevention System

In accordance with “ Specifications for Highway Bridges Part-V Seismic Deign” (Japan Road Association, 2012), bridge unseating prevention system was examined. Basic ideas of selecting the bridge unseating prevention system are indicated in Figure 7.4.8.

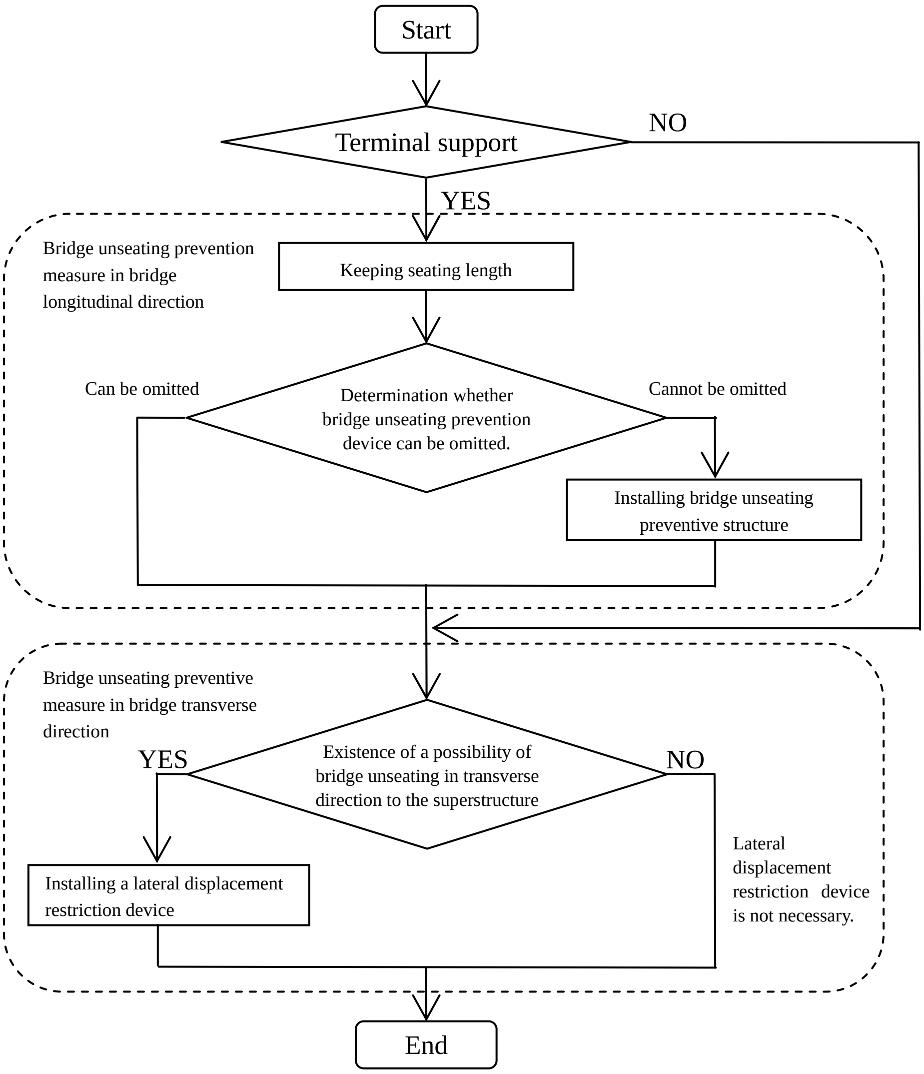


Figure 7.4.8 Flow chart for Examination of Bridge Unseating Prevention System

According to the above examination, it was concluded that bridge unseating preventive devices in the longitudinal direction are required but the lateral displacement restriction devices in the transverse direction are not required since each bridge has 3 or more spans and less chances that all bearings would be destroyed and the superstructure's response displacement become excessive are expected.

The bridge unseating preventive device to be installed should be a type to connect the superstructure to the substructure or to connect the superstructures using PC cables. Installation example of the bridge unseating preventive device is indicated in Figure 7.4.9.

Table 7.4.6 Study Result of Bridge Unseating Preventive System

Place to be Installed			Seating Length			Bridge Unseating Preventive Device	
			Check	S_E	S_{ER}	Necessity	Structure Type*
A1-P4	WEST	A1	○	1.35	0.910	○	TYPE A
		P4	○	1.35	0.922	○	TYPE B
	EAST	A1	○	1.35	0.914	○	TYPE A
		P4	○	1.35	0.932	○	TYPE B
P4-P8	WEST	P4	○	1.35	0.991	○	TYPE B
		P8W	○	1.35	0.935	○	TYPE C
	EAST	P4	○	1.35	1.003	○	TYPE B
		P8E	○	1.35	0.921	○	TYPE C
P8-P11	WEST	P8W	○	1.35	0.932	○	TYPE C
		P11	○	1.35	0.916	○	TYPE B
	EAST	P8E	○	1.35	0.880	○	TYPE C
		P11	○	1.35	0.908	○	TYPE B
P11-A2	WEST	P11	○	1.35	0.877	○	TYPE B
		A2	○	1.35	0.912	○	TYPE A
	EAST	P11	○	1.35	0.876	○	TYPE B
		A2	○	1.35	0.912	○	TYPE A
ON RAMP	WEST	P8W	○	1.35	0.944	○	TYPE C
		ON-P1	-	-	-	-	-
		ON-P2	-	-	-	-	-
		ON-A2	○	1.35	0.924	○	TYPE A
OFF RAMP	EAST	P8E	○	1.35	0.871	○	TYPE C
		OFF-P1	-	-	-	-	-
		OFF-P2	-	-	-	-	-
		OFF-A2	○	1.35	0.899	○	TYPE A

* Refer to TYPE A, TYPE B, and TYPE C in Figure 7.4.9 for the structure type.

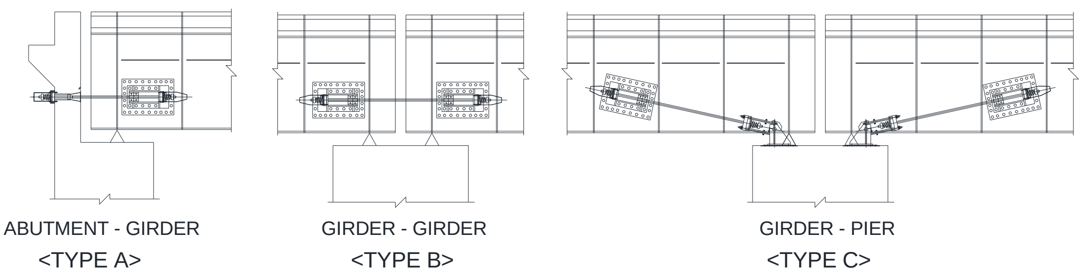


Figure 7.4.9 Installation Example of Bridge Unseating Preventive Structure

(3) Superstructure Design Results

i) Superstructure Reaction Force

A list of superstructure reaction force is shown below.

※ [grey box] Grey shaded columns are substructures subject to check.

No. 1 Bridge		TO-WEST					TO-EAST				
		A1	P1	P2(F)	P3(F)	P4	A1	P1	P2(F)	P3(F)	P4
Reaction force of dead load	G1	929.4	3115.8	2832.6	3120.6	818.1	936.5	3209.4	2981.0	3274.1	842.6
	G2	1019.4	2988.8	2827.1	3149.1	1272.2	1035.8	3122.0	2986.3	3321.5	1348.5
	Total	1948.8	6104.5	5659.7	6269.7	2090.3	1972.3	6331.4	5967.3	6595.6	2191.1
Live load	G1	832.8	1575.6	1552.5	1578.0	773.7	838.7	1603.6	1594.3	1621.8	783.9
	G2	898.2	1553.6	1546.2	1581.5	1005.2	906.7	1582.5	1581.0	1618.1	1027.2

No. 2 Bridge		TO-WEST					TO-EAST				
		P4	P5(F)	P6(F)	P7(F)	P8	P4	P5(F)	P6(F)	P7(F)	P8
Reaction force of dead load	G1	944.4	5590.2	4331.8	5494.6	1310.1	1023.6	5281.1	4121.3	5330.1	1341.5
	G2			4786.8	3614.5	1143.6			4238.8	4736.2	1176.5
	G3	2097.6	4887.1	5498.3	5145.9	1029.8	2333.2	5498.8	5232.7	4848.9	1015.6
	Total	3042.1	10477.3	14616.9	14254.9	3483.5	3356.9	10779.9	13592.7	14915.2	3533.6
Live load	G1	805.3	2308.8	1729.4	2540.7	1092.9	812.0	2069.3	1599.3	2381.6	1131.2
	G2			1554.7	2663.9	818.2			1327.9	2694.2	858.0
	G3	1218.3	1933.4	2072.2	2338.4	881.0	1260.2	1951.5	2014.0	2205.2	900.4

No. 3 Bridge		TO-WEST				TO-EAST			
		P8	P9(F)	P10(F)	P11	P8	P9(F)	P10(F)	P11
Reaction force of dead load	G1	1344.1	3385.1	3201.6	1167.8	890.6	2907.6	3134.5	1093.1
	G2	843.4	3316.5	3196.6	841.0	689.3	2844.7	3132.2	797.6
	Total	2187.4	6701.6	6398.2	2008.8	1579.9	5752.3	6266.8	1890.7
Live load	G1	1026.0	1617.9	1582.3	968.8	894.4	1503.1	1546.0	945.3
	G2	784.1	1613.1	1589.7	789.6	743.2	1495.8	1553.7	777.1

No.4 Bridge		TO-WEST						
		P11(M)	P12(M)	P13(F)	P14(F)	P15(F)	P16(M)	A2(M)
Reaction force of dead load	G1	819.5	2545.5	2473.3	2511.2	2411.3	2771.6	985.3
	G2	750.7	2469.5	2452.3	2477.0	2382.8	2737.9	973.5
	Total	1570.1	5015.0	4925.6	4988.2	4794.1	5509.6	1958.8
Live load	G1	830.0	1487.2	1513.2	1536.3	1514.5	1548.4	868.0
	G2	795.2	1477.1	1514.1	1535.1	1514.3	1548.5	867.9
		TO-EAST						
		P11(M)	P12(M)	P13(F)	P14(F)	P15(F)	P16(M)	A2(M)
Reaction force of dead load	G1	799.9	2503.1	2445.7	2480.2	2380.4	2739.4	973.1
	G2	750.0	2490.8	2484.8	2508.1	2411.0	2772.8	984.8
	Total	1549.9	4993.9	4930.5	4988.3	4791.4	5512.1	1957.9
Live load	G1	827.6	1484.5	1513.2	1536.4	1513.5	1548.0	867.7
	G2	792.7	1474.9	1514.2	1536.2	1514.0	1547.9	867.7

Ramp		TO-WEST (ON)				TO-EAST (OFF)			
		P8	**P1(F)**	**P2(F)**	**A2**	**P8**	**P1(F)**	**P2(F)**	**A2**
Reaction force of dead load	G1	1336.3	2632.4	2488.0	984.4	685.0	2113.0	2328.9	859.3
	G2	454.8	3211.7	3003.4	644.8	470.3	2186.3	2435.3	531.1
	Total	1791.1	5844.0	5491.3	1629.3	1155.3	4299.2	4764.2	1390.5
Live load	G1	874.4	1111.1	1097.2	733.6	655.9	1016.9	1054.3	694.8
	G2	511.5	1266.4	1232.4	552.9	498.1	1040.5	1086.3	522.9

ii) List of Superstructure Design Results

The table below shows cross-sectional compositions and stress intensity in places where the cross-sectional force becomes maximum on each bridge (in the center of span and on the middle supporting point) taking To EAST side as an example.

a) No. 1 Bridge (EAST)

G1	**Section No.**		**Center of 1st Span**	**Pier No. 1**		**Center of 2nd Span**	**Pier No. 2**		**Center of 3rd Span**	**Pier No. 3**		**Center of 4th Span**
	Material		**SM490Y**	**SM490Y**		**SM490Y**	**SM490Y**		**SM490Y**	**SM490Y**		**SM490Y**
DIMENSION	Upper Flg.	W	1450	1450		1450	1450		1450	1450		1450
		t	21	28		19	26		19	30		22
	Left Web.	H	1979	1972	1972	1981	1974	1974	1981	1970	1970	1978
		t	10	14		10	13		10	15		10
	Right Web.	H	1979	1972	1972	1981	1974	1974	1981	1970	1970	1978
		t	10	14		10	13		10	15		10
	Lower Flg.	W	1450	1450		1450	1450		1450	1450		1450
		t	18	28		14	27		14	30		20
STRESS	Upper Flg.	σ	-172	209	209	-158	205	205	-152	204	204	-180
	Lower Flg.	σ	199	-209	-209	185	-201	-201	179	-204	-204	203
	Web	τ	15	61	64	17	66	65	17	58	64	16
		Synthesis	0.88	1.11	1.13	0.77	1.10	1.09	0.72	1.04	1.08	0.91
G2	Section No.		Center of 1st Span	Pier No. 1		Center of 2nd Span	Pier No. 2		Center of 3rd Span	Pier No. 3		Center of 4th Span
	Material		SM490Y	SM490Y		SM490Y	SM490Y		SM490Y	SM490Y		SM490Y
DIMENSION	Upper Flg.	W	1450	1450		1450	1450		1450	1450		1450
		t	22	31		21	29		20	34		26
	Left Web.	H	1978	1969	1969	1979	1971	1971	1980	1966	1966	1977
		t	10	14		10	14		10	15		11
	Right Web.	H	1978	1969	1969	1979	1971	1971	1980	1966	1966	1977
		t	10	14		10	14		10	15		11
	Lower Flg.	W	1450	1450		1450	1450		1450	1450		1450
		t	20	31		18	29		16	34		26
STRESS	Upper Flg.	σ	-174	206	206	-164	204	204	-166	207	207	-188
	Lower Flg.	σ	195	-206	-206	187	-204	-204	189	-207	-207	201
	Web	τ	15	61	64	17	64	62	18	59	66	15
		Synthesis	0.84	1.08	1.1	0.78	1.09	1.08	0.8	1.07	1.12	0.88

PIER △ △ △

b) No. 2 Bridge (EAST)

Girder	Part	Item		Center of 5th Span	Pier No.5		Center of 6th Span	Pier No.6		Center of 7th Span	Pier No.7		Center of 8th Span
G1	**Section No.**			**Center of 5th Span**	**Pier No.5**		**Center of 6th Span**	**Pier No.6**		**Center of 7th Span**	**Pier No.7**		**Center of 8th Span**
G1	**Material**			**SM490Y**	**SM520-H/ SM490Y**		**SM490Y**	**SM520-H/ SM490Y**		**SM490Y**	**SM520-H/ SM490Y**		**SM490Y**
DIMENSION	Upper Flg.	W		1450	1450		1450	1450		1450	1450		1450
DIMENSION	Upper Flg.	t		26	58		23	45		21	52		20
DIMENSION	Left Web.	H		2445	2387	2387	2456	2411	2411	2456	2396	2396	2464
DIMENSION	Left Web.	t		12	17		12	14		12	20		12
DIMENSION	Right Web.	H		2445	2387	2387	2456	2411	2411	2456	2396	2396	2464
DIMENSION	Right Web.	t		12	17		12	14		12	20		12
DIMENSION	Lower Flg.	W		1450	1450		1450	1450		1450	1450		1450
DIMENSION	Lower Flg.	t		29	55		21	44		40	52		16
STRESS	Upper Flg.	σ		-185	200	200	-184	206	206	-203	210	209	-169
STRESS	Lower Flg.	σ		185	-207	-207	203	-208	-208	193	-210	-209	196
STRESS	Web	τ		19	69	60	15	55	68	25	72	59	17
STRESS	Web	Synthesis		0.76	1.13	1.06	0.92	1.06	1.15	0.92	1.16	1.09	0.86
G2	Section No.							Pier No. 6		Center of 7th Span	Pier No.7		Center of 8th Span
G2	Material							SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y
DIMENSION	Upper Flg.	W						1450		1450	1450		1450
DIMENSION	Upper Flg.	t						50		27	44		18
DIMENSION	Left Web.	H						2400	2400	2441	2412	2412	2467
DIMENSION	Left Web.	t						15		12	20		12
DIMENSION	Right Web.	H						2400	2400	2441	2412	2412	2467
DIMENSION	Right Web.	t						15		12	20		12
DIMENSION	Lower Flg.	W						1450		1450	1450		1450
DIMENSION	Lower Flg.	t						50		32	44		15
STRESS	Upper Flg.	σ						194	194	-193	194	194	-151
STRESS	Lower Flg.	σ						-194	-194	185	-194	-194	170
STRESS	Web	τ						50	63	25	59	72	23
STRESS	Web	Synthesis						0.91	1.00	0.85	0.96	1.05	0.67
G3	Section No.			Center of 5th Span	Pier No. 5		Center of 6th Span	Pier No. 6		Center of 7th Span	Pier No. 7		Center of 8th Span
G3	Material			SM490Y/ SM520-H	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y	SM490Y		SM490Y
DIMENSION	Upper Flg.	W		1450	1450		1450	1450		1450	1450		1450
DIMENSION	Upper Flg.	t		38	57		22	49		19	40		18
DIMENSION	Left Web.	H		2413	2386	2386	2459	2402	2402	2455	2421	2421	2468
DIMENSION	Left Web.	t		12	17		12	17		12	19		12
DIMENSION	Right Web.	H		2413	2386	2386	2459	2402	2402	2455	2421	2421	2468
DIMENSION	Right Web.	t		12	17		12	17		12	19		12
DIMENSION	Lower Flg.	W		1450	1450		1450	1450		1450	1450		1450
DIMENSION	Lower Flg.	t		49	57		19	49		22	39		14
STRESS	Upper Flg.	σ		-207	208	208	-180	208	208	-177	194	196	-143
STRESS	Lower Flg.	σ		183	-208	-208	204	-208	-208	191	-197	-199	159
STRESS	Web	τ		20	68	63	15	57	72	27	57	77	18
STRESS	Web	Synthesis		0.94	1.13	1.10	0.92	1.06	1.16	0.84	0.97	1.13	0.57
PIER					Δ			Δ			Δ		

c) No. 3 Bridge (EAST)

G1	**Section No**		**Center of 9th Span**	**Pier No. 9**		**Center of 10th Span**	**Pier No. 10**		**Center of 11th Span**
	Material		**SM490Y**	**SM490Y**		**SM490Y**	**SM490Y**		**SM490Y**
DIMENSION	Upper Flg.	W	1450	1450		1450	1450		1450
		t	17	22		19	26		19
	Left Web.	H	2183	2178	2178	2181	2174	2174	2181
		t	11	13		11	13		11
	Right Web.	H	2183	2178	2178	2181	2174	2174	2181
		t	11	13		11	13		11
	Lower Flg.	W	1450	1450		1450	1450		1450
		t	10	25		15	27		15
STRESS	Upper Flg.	σ	-140	205	205	-159	206	206	-162
	Lower Flg.	σ	175	-192	-192	193	-202	-202	187
	Web	τ	15	56	62	15	63	62	13
		Synthesis	0.69	1.03	1.06	0.83	1.08	1.08	0.78
G2	**Section No**		**Center of 9th Span**	**Pier No. 9**		**Center of 10th Span**	**Pier No. 10**		**Center of 11th Span**
	Material		**SM490Y**	**SM490Y**		**SM490Y**	**SM490Y**		**SM490Y**
DIMENSION	Upper Flg.	W	1450	1450		1450	1450		1450
		t	16	21		18	25		18
	Left Web.	H	2184	2179	2179	2182	2175	2175	2182
		t	11	13		11	13		11
	Right Web.	H	2184	2179	2179	2182	2175	2175	2182
		t	11	13		11	13		11
	Lower Flg.	W	1450	1450		1450	1450		1450
		t	14	23		15	25		15
STRESS	Upper Flg.	σ	-125	194	194	-145	198	198	-147
	Lower Flg.	σ	133	-185	-185	172	-198	-198	166
	Web	τ	14	54	61	14	62	61	12
		Synthesis	0.40	0.93	0.96	0.66	1.02	1.01	0.61
PIER				Δ			Δ		

d) No. 4 Bridge (EAST)

G1	Section No		Center of 12th Span	Pier No. 12		Center of 13th Span	Pier No. 13		Center of 14th Span	Pier No. 14		Center of 15th Span	Pier No. 15		Center of 16th Span	Pier No. 16		Center of 17th Span
	Material		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM520-H/ SM490Y
DIMENSION	Upper Flg.	W	530	530		530	530		530	530		530	530		530	530		530
		t	39	44		29	45		29	47		31	43		27	51		49
	Web.	H	2361	2356	2356	2371	2355	2355	2371	2353	2353	2369	2357	2357	2373	2349	2349	2351
		t	12	16		12	16		12	16		12	16		12	18		12
	Lower Flg.	W	530	530		530	530		530	530		530	530		530	530		530
		t	39	57		29	58		29	60		30	55		26	66		49
STRESS	Upper Flg.	σ	-209	210	210	-203	208	208	-206	208	208	-205	207	207	-203	210	210	-208
	Lower Flg.	σ	209	-182	-182	203	-181	-181	206	-181	-181	208	-182	-182	207	-182	-182	208
	Web	τ	14	60	59	14	59	59	14	60	60	14	59	58	15	54	59	15
		Synthesis	0.70	1.18	1.18	0.91	1.15	1.16	0.93	1.16	1.16	0.95	1.15	1.14	0.94	1.13	1.16	0.92
G2	Section No		Center of 12th Span	Pier No. 12		Center of 13th Span	Pier No. 13		Center of 14th Span	Pier No. 14		Center of 15th Span	Pier No. 15		Center of 16th Span	Pier No. 16		Center of 17th Span
	Material		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM490Y	SM520-H/ SM490Y		SM520-H/ SM490Y
DIMENSION	Upper Flg.	W	530	530		530	530		530	530		530	530		530	530		530
		t	36	44		29	46		29	47		31	43		27	52		49
	Web.	H	2364	2356	2356	2371	2354	2354	2371	2353	2353	2369	2357	2357	2373	2348	2348	2351
		t	12	16		12	16		12	16		12	16		12	18		12
	Lower Flg.	W	530	530		530	530		530	530		530	530		530	530		530
		t	35	57		29	59		29	60		31	56		27	67		49
STRESS	Upper Flg.	σ	-206	208	208	-206	207	207	-206	209	209	-205	209	209	-203	208	208	-209
	Lower Flg.	σ	209	-180	-180	206	-181	-181	206	-183	-183	205	-181	-181	203	-181	-181	209
	Web	τ	15	59	60	14	60	60	14	60	61	14	59	58	15	55	59	15
		Synthesis	0.71	1.16	1.16	0.93	1.16	1.16	0.93	1.17	1.18	0.92	1.17	1.16	0.91	1.12	1.15	0.93
	PIER			△			△			△			△			△		

(4) Substructure Design Results

i) Pier Design

Pier design is calculated based on the conditions indicated in 7.4 (1) (2), and stresses at pier base and beam was checked as shown in Figure 7.4.10.

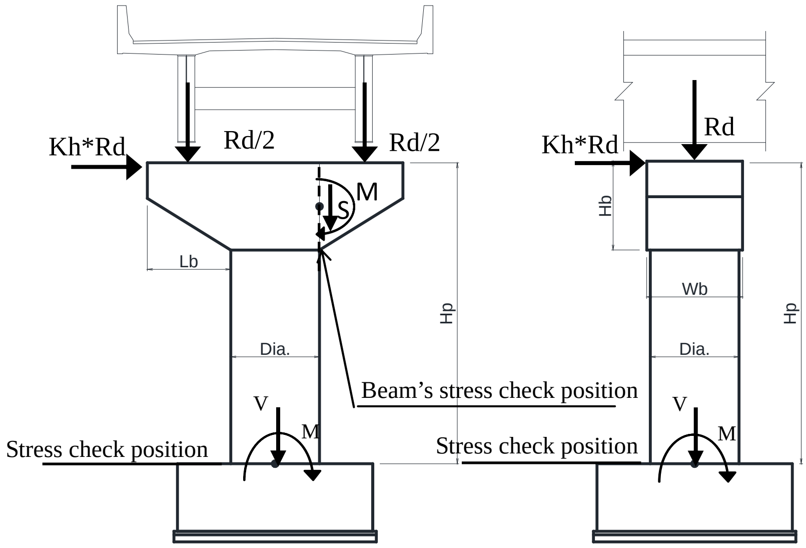


Figure 7.4.10 Stress Check Position of Pier

a) List of Beam Design Results

Group	Target Pier	Lb(m) xWb(m) xHb(m)	Main Reinforcing	Check for Bending Momentum			Check for Shearing	
				Bending Stress Check (When dead load applied)		Corbel Check (When dead load applied)	Average Shearing (Ordinary Time)	Stirrup Volume (Ordinary Time)
				σc < σca (σca = 8.0) (N/mm2)	σs < σsa (σsa = 100) (N/mm2)	Asu > AsuReq (mm2)	τm < τa1 (N/mm2)	Aw > AwReq (mm2) Reinforcing Alignment
Group1	P9W	2.35 x 2.7 x 2.5	D35x 2 levels 34 pieces	2.59	83.8	32524>27289	1.259>0.293 (*1)	3096.8 > 2500.6 D22-4 sets (8 pieces) ctc150
Group2	P5W	2.35 x 3.0 x 2.5※	D38 x 2 levels 42 pieces	3.02	82.7	47880>38939	1.417>0.293 (*1)	4053.6 > 3186.2 D25-4 sets (8 pieces) ctc150
Group3	P4E	2.35 x 3.0 x 2.5	D35 x 2 levels 38 pieces	2.53	81.7	36351>29739	1.345>0.294 (*1)	3096.8 > 3023.7 D22-4 sets (8 pieces) ctc150
Group4	P7W	2.00 x 2.7 x 2.5	D35 x 2 levels 34 pieces	2.79	97.1	32524>32013	0.922>0.290 (*1)	1548.4 > 1421.5 D22-2 sets (4 pieces) ctc150
Group5	P8W	2.50 x 3.0 x 2.5	D32 x 2 levels 34 pieces	2.59	95.6	32524>32013	0.857>0.308 (*1)	1373.4 > 1421.5 D22-2 sets (4 pieces) ctc150
Group6	Ramp-P1W	1.35 x 2.7 x 2.0	D16 x 1 level 34 pieces	0.20	19.8	—	0.012<0.152	—

*1 When τm < τa1, align necessary stirrup volume.

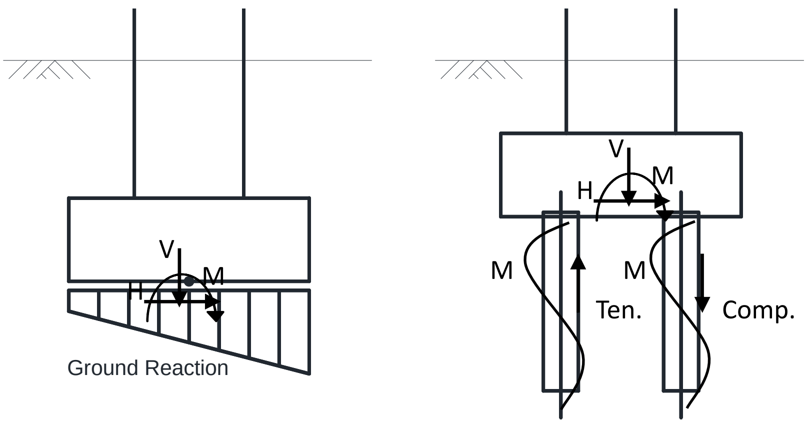
b List of Pier Design Results

Upper: Calculated value; Lower: Allowable value

	Substructure Type	Bearing Condition	Dia. (mm) ×Height(m)	Main Rebar	Level 1 Seismic Design (Stress)		Level 2 Seismic Design (Horizontal Strength)
					Concrete	Rebar	khcW < Pa
					(N/mm^2)	(N/mm^2)	(kN)
P1E	Column with Overhanging beam	M	φ2500×6.1m	D32 n=40	9.25 < 12.0	152.3 < 300	1632 < 2048
SP3E	Column with Overhanging beam	F	φ2500×9.2m	D38 n=78	9.27 < 12.0	134.9 < 300	2884 < 2993
P4E	Column with Overhanging beam	M, M	φ2500×9.2m	D35 n=52	10.33 < 12.0	184.3 < 300	1830 < 1887
P5E	Column with Overhanging beam	F	φ2500×9.6m	D38 n=92	10.50 < 12.0	122.0 < 300	3155 < 3231
P6W	Rigid Frame Pier	F	φ2500×9.3m	D38 n=80	9.33 < 12.0	139.1 < 300	2785 < 2790
P7E	Rigid Frame Pier	F	φ2500×8.9m	D38 n=88	9.43 < 12.0	127.9 < 300	3032 < 3146
P8W	Rigid Frame Pier	M, M	φ2500×8.8m	D32 n=44	8.70 < 12.0	189.2 < 300	1116 < 1334
P9W	Column with Overhanging beam	F	φ2500×8.6m	D35 n=88	8.10 < 12.0	106.5 < 300	2714 < 2844
P11W	Column with Overhanging beam	M, M	φ2500×10.3m	D35 n=48	8.03 < 12.0	147.9 < 300	1334 < 1529
P12W	Column with Overhanging beam	M	φ2500×10.1m	D38 n=48	7.78 < 12.0	117.7 < 300	1690 < 1836
P13W	Column with Overhanging beam	F	φ2500×9.9m	D38 n=52	8.33 < 12.0	133.8 < 300	2431 < 2567
Ramp-P1W	Column with Overhanging beam	F	φ2500×8.2m	D35 n=52	6.30 < 12.0	74.5 < 300	1972 < 2067

ii) Foundation Design

As for designing foundation construction, grouping was made based on the substructure type and bearing conditions; then design calculations were conducted using typical substructure types.



(a) Spread Foundation (b) Pile Foundation

Figure 7.4.11 Design of Foundation

a. List of Pile Foundation Design Results

Upper: Calculated value, Lower : Allowable value

	Height	Length・	Normal Condition				Level 1 Seismic Design				Level 2 Seismic Design		
	(m)	Number・Thickness	Compression (kN)	Tension (kN)	Displacement (mm)	Stress (N/mm2)	Compression (kN)	Tension (kN)	Displacement (mm)	Stress (N/mm2)	Mmax<My (kN・m)	Pmax<PNU (kN)	Yield
A1	11.3	L=5.0m / n=15 / t=14mm	2689 < 4049	1687 > 0	1.89 < 15	100 < 185	3319 < 6073	533 > -847	2.64 < 15	154 < 210	—	—	—
P1E	8.0	L=5.0m / n=4 / t=14mm	2775 < 3951	2676 > 0	0.00 < 15	69 < 185	3763 < 5926	586 > -880	3.34 < 15	188 < 277	1906 < 2406	6026 < 10744	No
P3E	11.1	L=5.5m / n=6 本 / t=14mm	2120 < 4012	2005 > 0	0.00 < 15	53 < 185	3031 < 6018	327 > -951	2.25 < 15	138 < 277	2421 < 2565	5552 < 10709	No
P4E	11.1	L=5.5m / n=4 / t=14mm	2862 < 4012	2740 > 0	0.00 < 15	71 < 185	3921 < 6018	382 > -1007	3.31 < 15	186 < 277	1807 < 2384	6368 < 9777	No
P5E	11.5	L=5.0m / n=6 / t=14mm	2919 < 3839	2805 > 0	0.00 < 15	73 < 185	3987 < 5759	804 > -846	1.87 < 15	154 < 277	2232 < 2371	7201 < 11517	No
P6W	11.2	L=5.5m / n=10 / t=14mm	2141 < 4004	2029 > 0	0.00 < 15	53 < 185	3678 < 6007	494 > -1005	2.28 < 15	165 < 277	2331 < 2560	7046 < 11709	No
P7E	10.8	L=6.5m / n=12 / t=14mm	1872 < 3961	1772 > 0	0.00 < 15	47 < 185	3359 < 5942	285 > -1131	2.60 < 15	161 < 277	2383 < 2625	6902 < 11709	No
P8W	10.7	L=5.0m / n=8 / t=14mm	1814 < 3961	1661 > 0	0.05 < 15	45 < 185	3159 < 5942	317 > -729	3.02 < 15	168 < 277	1740 < 2639	4952 < 9777	No
P9W	10.5	L=5.0m / n=6 / t=14mm	2124 < 3962	2010 > 0	0.00 < 15	53 < 185	2816 < 5942	551 > -729	1.97 < 15	124 < 277	2211 < 2564	5410 < 10744	No
Ramp-P1W(ON)	10.1	L=5.0m / n=4 / t=14mm	2631 < 3951	2509 > 0	0.00 < 15	65 < 185	3274 < 5926	916 > -867	2.09 < 15	137 < 277	2017 < 2441	6142 < 10744	No

b) List of Spread Foundation Design Results

Upper: Calculated value, Lower: Allowable value

	Height	Dimension	Normal Condition				Seismic		
			Falling	Sliding	Ground Reaction	Bearing Capacity	Falling	Sliding	Bearing Capacity
	(m)	(m)	(m)	(－)	(kN/m2)	(kN)	(m)	(－)	(kN/m2)
P11W	12.2	4.5×4.5	0.000 < 0.750	－ > 1.5	474 < 700	9223 < 24050	1.431 < 1.500	5.050 > 1.2	7023 < 11604
P12W	12	4.5×4.5	0.000 < 0.750	－ > 1.5	532 < 700	10393 < 24050	1.298 < 1.500	4.790 > 1.2	8393 < 12766
P13W	11.8	5.0×5.0	0.000 < 0.833	－ > 1.5	449 < 700	10766 < 29720	1.387 < 1.667	4.403 > 1.2	8666 < 15640
A2	11.6	6.0×17.89	0.490 < 1.000	2.833 > 1.5	442 < 700	30490 < 58576	1.415 < 2.000	1.508 > 1.2	26513 < 29147
Ramp-A2W(ON)	11	6.0×6.394	0.444 < 1.000	3.134 > 1.5	426 < 700	10843 < 21655	1.386 < 2.000	1.599 > 1.2	9332 < 11495
Ramp-A2E(OFF)	10.8	5.5×6.390	0.425 < 0.917	2.874 > 1.5	418 < 700	9612 < 18719	1.363 < 1.833	1.504 > 1.2	8217 < 9151

7.5 APPLICATION OF JAPANESE TECHNOLOGY

This project is to construct a portion of the road forming the east-west major road indicated in the Ulaanbaatar City Master Plan of 2030, so its public nature is very high. However, design and construction conditions for building the bridge are very severe, and a high technological level is required. Assumed problems for building the Ajilchin Flyover and Japanese technology to deal with such problems are introduced below.

(1) Construction Adjacent in Railway Premises and a Narrow Space (Rotary Penetration Steel Pipe Method)

Ajilchin Flyover has a road alignment which strides over the railway premises where the railway mainlines and feeder lines are closely laid. Width of the railway premises is 350m in length. Therefore, multiple piers need to be placed in the railway premises, but railway tracks are closely laid and limit space for arranging the piers. Construction space is also very small.

Figure 7.5.1 Construction using Rotary Penetration Steel Pipe Pile

Therefore, the rotary penetration steel pipe pile method must be applied due to the space limitations. The method enables to downsize the structure and conduct construction in a narrow space. Spiral steel plates are attached to the toe of the pile, the pile is penetrated into the ground while the steel pile is rotated (see Figure 7.5.2), and a pile is established. Pile establishment is highly possible even in earth containing boulder

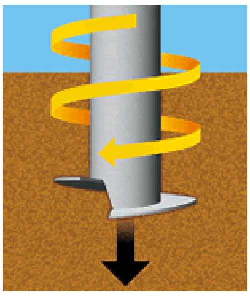


Figure 7.5.2 Image of Rotary Penetration

as is the case with this project site. Typical advantages are described below.

i) Large Bearing Capacity and Small Footing

Due to the effect of the steel plate's essentially widening the bottom end of the pile, approximately 1.5 times more bearing power is obtained compared to the general cast-in-place pile. Therefore, the number of piles can be reduced, and the footing size can be downsized. (See Figure 7.5.3)

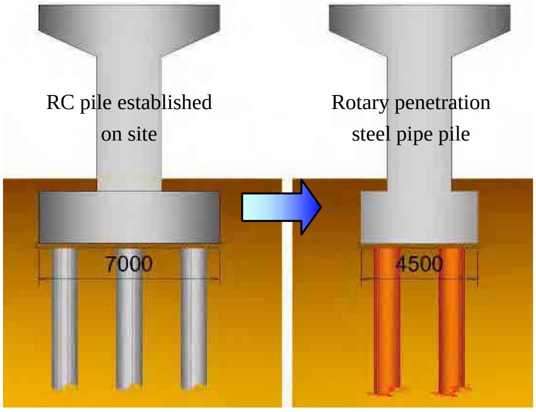


Figure7.5.3 Comparison of Footing Size per Pile Type

ii) Construction Adjacent to Railway Track

This construction will be conducted in the railway premises, and hindering train operations must be avoided. With this method, the rotating pile presses into and penetrates the ground, which can keep down vibration with a small risk of problems such as displacement of the train tracks. When suspending steel pipes, a crane is used. A full swing machine rotates and presses steel pipes into the ground, so there is no danger of steel pipes contacting the trains or falling down due to the crane's rotating movement. Also, no digging is necessary, so there is no risk of loosening the surrounding ground. This method is appropriate for neighboring construction.

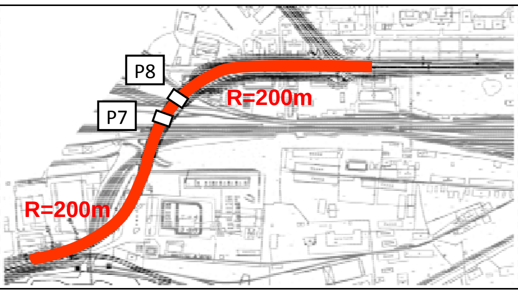
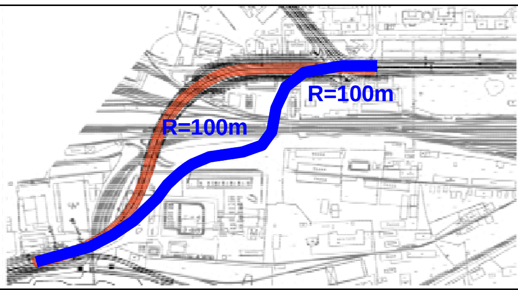
iii) Less Waste Soil

With this method, piles can be established without digging the ground, so the process of disposing of soil after drilling (drilling, transport, treatment) is eliminated, which reduces adverse effects on the environment. Also, space for installing drilling equipment is small. Construction can be conducted on a small site.

iv) Comparison of Rotary Penetration Steel Pipe Pile and Concrete Pile

Provided that rotary penetration steel pipe pile should not be applied and replaced by cast-in-place concrete pile, piling work for P7 and P8 is impossible due to limited working space, and thus alignment of the bridge needs to be modified to secure sufficient working space for installation of cast-in-place concrete pile. In this case, radius of curve is changed from 200m to 100m, which requires design speed to be decreased from 60km/h to 50km/h. Moreover, it will induce serious problem of accidental risk due to freezing of bridge deck.

Table 7.5.1 Comparison of Possible Routes as per Piling Methods

	
Rotary Penetration Steel Pipe Pile	Cast-in-place Concrete Pile

(2) Construction above Rail Tracks and the Existing Roads (Steel-Concrete Composite Deck Slab)

It is planned that the Ajilchin Flyover crosses over existing railway tracks and Narny Road. General RC slab requires construction of work platforms and supports for building the slabs. It requires extra construction space in addition to the construction gauge. Space under the girders is occupied during construction, so it is difficult to conduct safe control without hindering the existing traffic (trains and cars).

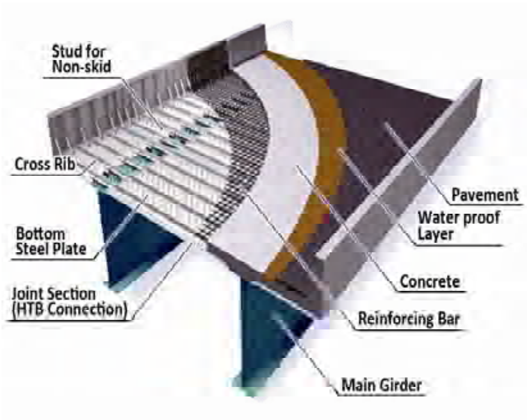


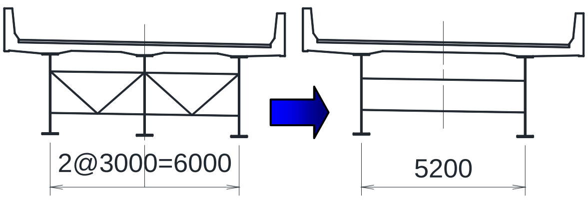
Figure 7.5.4 Image of Composite Deck Slab

The steel-concrete composite deck slab is applicable to those issues, of which technology is used for the Narny Bridge. The advantages of the slab are described below.


Figure 7.5.5 Construction of Composite Deck Slab

i) Formwork and construction of supports are not required.

Bottom steel plate of the composite slab functions as a mold form until concrete hardens, so no mold form is necessary. Also, the bottom steel plate is reinforced by longitudinal ribs, and it is self-sustainable which makes construction of supports unnecessary for building slab. There is no risk of influence on the existing traffic under the girders.



(a) RC Slab (b) Composite Slab

Figure 7.5.6 Difference of Girder Alignment per Slab Type

ii) Widening span of deck slab

Bottom steel plate of the composite slab functions as a structural member bearing sectional force after concrete hardens. It is a composite structure which effectively combines the steel member and concrete in charge of tensile force and compressive force respectively. Its rigidity is high, and the deck slab span can be lengthened, which reduces the number of girders and also contributes to cost reduction.

iii) High Durability

This slab type is a composite structure of steel plates and concrete, so it has high rigidity. Maintenance labor can be saved, and the life cycle cost also can be reduced. Also, the underside is covered with steel plates, so there is no concrete fall down. Thus there is no effect to the railway. When the main girder is launched, it can be used as a reinforcement member.

(a) Underside of Damaged (caved in) RC Slab

(b) Underside of Composite Slab

Figure 7.5.7 Bottom of Slab

(3) Erection Method above Railway Track (Launching Method)

Girders of the Ajilchin Flyover must be installed above the railway in a manner that will not hinder train operation. General construction method is to install a vent (a column temporarily bear a girder), place a girder on the vent, and connect each other. However, no space for installing a vent or placing a crane can be obtained over the railway, so the launching method which assembles the girders in advance next to the railway and slides them over the railway is to be used.

Figure 7.5.8 Erection Method over the Railway Track (Narny Bridge)

The launching method itself has been used for building the Narny Bridge. The method is generally used for places where vents cannot be installed, such as over a railway or road. When launching a girder, the girder stress inverts against ordinary time. This bridge is a curve line bridge, so three-dimensional control is required when launching a girder. High level construction technology is required for this method.