JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF TRADE AND INDUSTRY
ROAD DEPARTMENT OF
MINISTRY OF INFRASTRUCTURE DEVELOPMENT
MONGOLIA

# BASIC DESIGN STUDY REPORT ON THE PROJECT FOR ROAD CONSTRUCTION UTILIZING ROCK ASPHALT IN MONGOLIA

FEBRUARY 1995



PACIFIC CONSULTANTS INTERNATIONAL
JAPAN OVERSEAS CONSULTANTS CO., LTD.

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## PREFACE

In response to a request from the Government of Mongolia, the Government of Japan decided to conduct a basic deign study on the Project for Road Construction Utilizing Rock Asphalt in Mongolia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Mongolia a study team headed by Mr. Takashi INADERA, Deputy Director of the Research and Information Division, Economic Affairs Bureau, Ministry of Construction and constituted by members of Pacific Consultants International from September 21st to October 12th, 1994.

The team held discussions with the officials concerned of the Government of Mongolia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Mongolia in order to discuss a draft report from November 20th to November 27th,1994 and as the result, the present report was finalized.

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

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

February 1995

Kimio FUJITA
President
Japan International Cooperation Agency

February 1995

Mr. Kimio FUJITA
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Road Construction Utilizing Rock Asphalt in Mongolia.

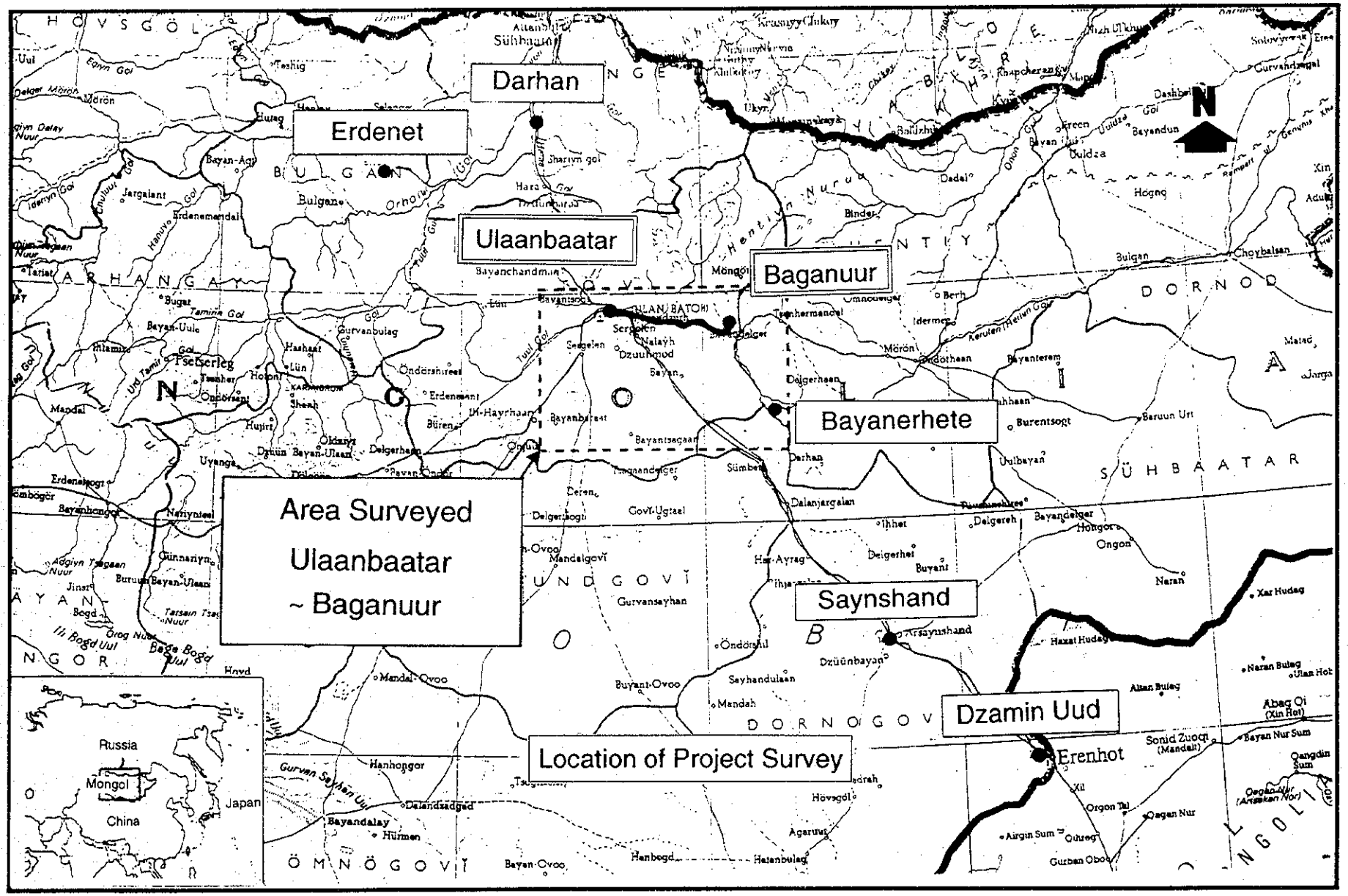
This study was conducted by Pacific Consultants International and Japan Overseas Consultants Co.,LTD, under a contract to JICA, during the period of September 12th, 1994 to February 28th, 1995. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Mongolia, and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and Ministry of Construction. We would also like to express our gratitude to the officials concerned of the Ministry of Trade and Industry, Road Department of the Ministry of Infrastructure Development, and the JOCV Mongolia office and the Embassy of Japan in Mongolia for their cooperation and assistance throughout field survey.

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

Very truly yours,

Hiroyuki ENDO
Project Manager,
Basic Design Study Team on the Project
for Road Construction Utilizing
Rock Asphalt in Mongolia
Pacific Consultants International
Japan Overseas Consultants Co,.LTD


Darhan
Erdenet
Ulaanbaatar
Baganuur
Bayanerhete
Saynshand
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Area Surveyed
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Location of Project Survey
Russia
Mongol
China
Japan
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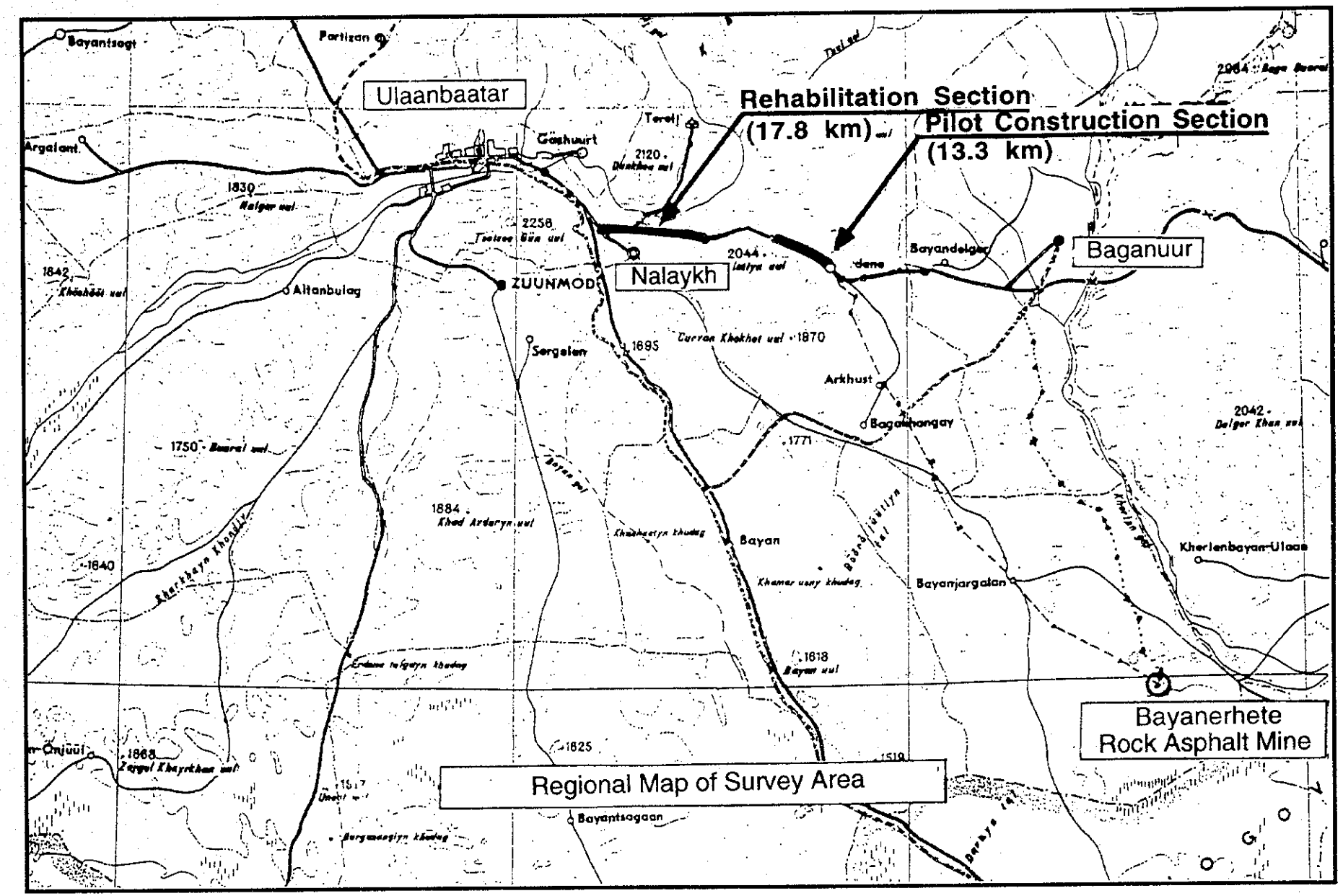
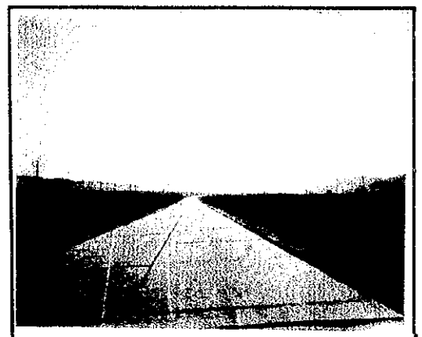
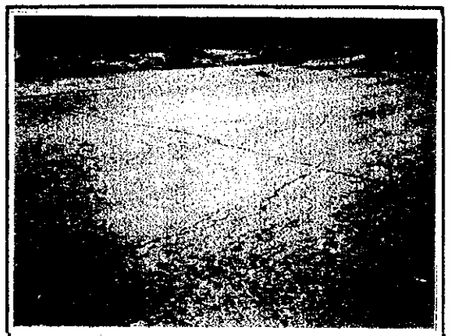
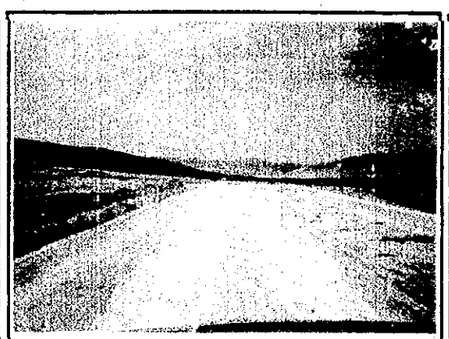

Ulaanbaatar
Rehabilitation Section
(17.8 km)
Pilot Construction Section
(13.3 km)
Nalaykh
Baganuur
Bayanerhete
Rock Asphalt Mine
Regional Map of Survey Area
ZUUNMOD
Altanbulag
Sergelen
Arkhust
Bayan
Bayanjargalan
Kherlenbayan-Ulaan
Bayantsagaan
Bayantsogt
Partizan
Argalant
Tarel
Baganhangay



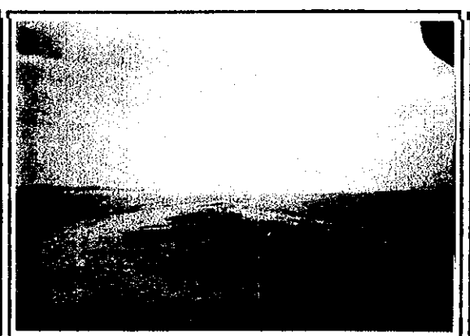
The road from the inspection station east of Ulaanbaatar to Nalaykh was made with Chinese assistance and paved with cement - concrete. There is much damage, especially in the joints.



Rock Asphalt test paving has been conducted from the fork to Terelj over the last 4 years. About 50 damaged spots were located (vertical and horizontal cracks, alligator cracks, potholes, etc.).

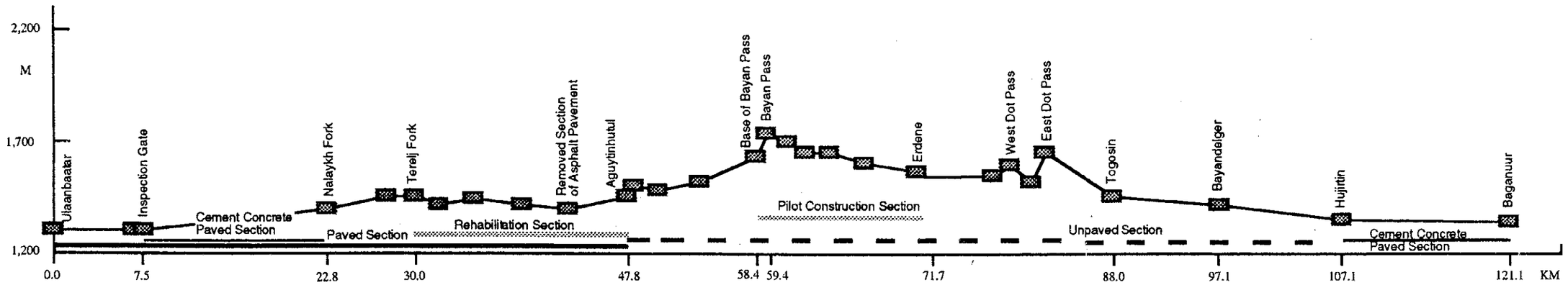


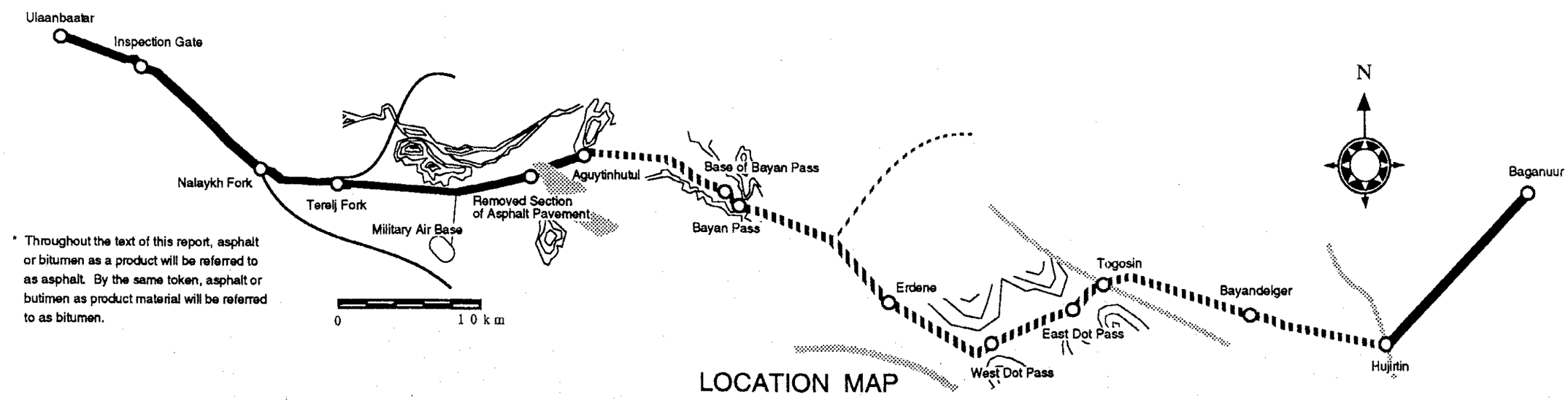
East of the section which completed paving construction in Sept., 1994, the Mongolian government is conducting earth works up to Erdene.



From Erdene to Hujirtin river one finds several dirt roads meandering through the Mogolian steppe. Some spots seem to have been filled with crushed rock at one time

The 18 km section before Baganuur were paved with asphalt * by the USSR. Joint construction is very poor.




* Throughout the text of this report, asphalt or bitumen as a product will be referred to as asphalt. By the same token, asphalt or butimen as product material will be referred to as bitumen.

# SUMMARY

# SUMMARY

Mongolia became independent with the aid of the former Soviet Union in 1921, and continued close relations for many years. Under Soviet economic assistance, Mongolia joined COMECON and developed its economy by specializing in ranching and mining. The former formed 20 % of the GNP in 1991, and the latter 34 % the same year. Mongolia's domestic transport depends heavily upon rail and highway transport. Road transport accounted for 78.7 % of cargo transportation and 98.7 % of passenger traffic in 1991, so is obviously a major element in Mongolian transportation. Major roads were, as of 1993, 11,248 km national roads, 38,042 km local roads, and 150,000 km other roads. Most of these are undeveloped dirt roads which account for 97.8 % of all roads and 75.7 % national roads in Mongolia. The percentage of paved roads is 10.6 % of national roads (1,191 km) and 0.3 % of local roads (112 km); overall percentage is a very low 0.7 %.

In 1991, a master plan for the development of roads in Mongolia was drawn up with the aid of the former Soviet Union which called for pavement of 4,000 km of national roads by the year 2000 and 9,000 km of local roads by 2010. However in 1990 the Soviet Union, which had supported all economic development until then, ceased all economic aid. Due to the ensuing economic crisis in the USSR, severe shortages of oil, machinery, spare parts and household goods all of which had been imported, dealt a serious blow to the daily life of Mongolians (not to mention Mongolian industry) and the nation fell into deep economic crisis. Mongolia is faced with the need to develop its road system and improve the flow of goods if it is to ease into a market economy and therefore bring growth to its industries. However, just as all other industries, the construction industry; which also depended heavily on the Soviet Union and eastern Europe for equipment, materials, and financial assistance; has been practically unable to build new roads or maintain older ones.

In 1993, Mongolia filed a request to the Japanese government for grant aid cooperation for the procurement of equipment needed to accomplish that country's road construction and equipment development plan. In response, the Japanese government sent a project survey team to review Mongolia's road development plan and investigate the situation in September 1993. As a result, the need for a pilot construction program was recognized, and a conclusion was reached that not only equipment but also road construction be included as objectives of the request contents, which were therefore adjusted accordingly. Based on the request from the Mongolian government, the Japanese government made the decision to conduct a survey for the basic plan. JICA sent to Mongolia study team from September 21st to October 12th, 1994. The team held discussions with the officials concerned of the Government of Mongolia, and

conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Mongolia in order to discuss a draft report from November 20th to November 27th, 1994.

The contests of the request from the Mongolian government are as follows:

- Rehabilitation by rock asphalt of 16 km section of road previously constructed by Mongolian authorities.
- Pilot construction of new road section (15 km) with rock asphalt.
- Procurement of equipment for rock asphalt excavation (diesel excavator, rock drill, etc.)
- Procurement of equipment for road construction (back-hoe-type excavator, bulldozer, water lorry, roller, etc.)

The survey team discussed and confirmed the background of the request and its contents, the location of the project, its execution and operative system with the road department. Also, a site survey of the project site between Ulaanbaatar and Baganuur was conducted in which natural conditions were also observed through topographical and geological surveys. In addition, materials on social economic indices, land use, etc. were collected. Upon examination and review of discussion, confirmation, site surveys, and collected materials in Mongolia, the appropriateness of the request was confirmed, basic plan arranged and basic design study report compiled. The following effects are anticipated of the project:

(1) By using domestically produced rock asphalt, dependence upon imported bitumen as pavement material will decrease. By using rock asphalt, volume of bitumen used can be decreased by about 60 %.

(2) The use of rock asphalt and the establishment of its paving technology, mechanization of road construction, repair technology, and the transfer of the above technologies will serve as a model case for Mongolia in the future.

(3) By increasing the safety and service level of the Ulaanbaatar - Baganuur road, as a transport route, movement of goods will be conducted more effectively. At present, traffic volume is 150 to 200 vehicles a day, but coal transport from Baganuur and consumer goods transport from the capital will benefit from improvements.

The number of people who will benefit is estimated at 320,000, or 15 % of Mongolia's population of 2.2 million (290,000 people in Ulaanbaatar, or roughly half the population of 580,000; 20,000 in Baganuur; 10,000 people en route).

(4) As a result of paving improvements, average driving speed will raise from 20 km/h to 50 km/h. This will reduce transport time, save fuel and reduce number of breakdowns along the route, therefore conducing ameliorating effects to the economy and society in general.

(5) In the case of unpaved roads, drivers take liberty to drive where they please, thus bringing about destruction of the steppe environment. By paving the road, vehicles will drive on the main road, thereby preserving and improving the steppe.

The executing agency of this project will be the Road Department of Ministry of Infrastructure Development. The Road Department will also be responsible for maintenance.

The results of the basic design are summarized as follows:

(1) Outline of Project (Construction)

1) Rehabilitation Section and Types

Section concerned: approx. 17.8 km, from Terelj fork to Aguytinhutul.

Contents:

(1) Pavement of 600 m totally damaged section of road.

(2) Repair of small-scale damage (potholes, cracks, etc.) approx. 50 locations

(3) Overlay of relatively continuous areas of damage. (a total 7,000 $m^2$ area had been selected on the basis of problems in maneuverability)

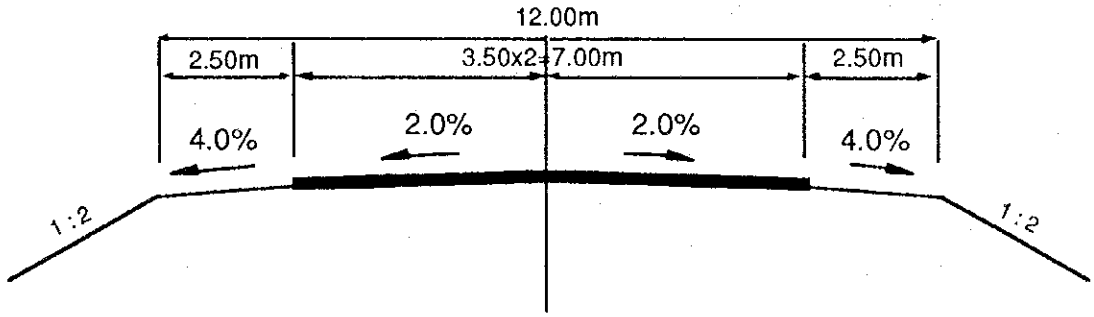
2) New Pilot Construction and Implementation

Section concerned: From entrance to Bayan pass to Erdene (approx. 13.3 km)

Composition of the typical cross section:

The composition of road width is planned as follows:

- No. of lanes : 2
- Lane width : 3.5 m
- Crossfall (lane) : 2 %
- Crossfall (shoulder) : 4.0 %
- Shoulder width : 2.5 m




(2) Outline of Equipment

1) Provision of equipment for rock asphalt excavation (diesel excavator, screw-type drill, etc.).

2) Provision of road construction equipment (back-hoe type excavator, bulldozer, water lorry, compacting roller, etc.).

Considering that rock asphalt excavation takes place in winter and road construction in summer, certain pieces of equipment will be used on both sites to increase efficiency. Regarding spare parts, necessary parts for the two-year span of the project as well as foreseeably necessary parts for maintenance over a period of two years after the completion of the project (when equipment is handed over to Mongolian authorities) will be provided.

Remarks) both: use for rock asphalt quarry and road construction
rock: use for rock asphalt quarry
road : use for road construction

| No. | Model | Spec. | Nos. | Remarks |
|---|---|---|---|---|
| (1) | Bulldozer with ripper | 32 tons | 1 | both |
| (2) | Bulldozer with ripper | 21 tons | 2 | road |
| (3) | Bulldozer | 15 tons | 1 | road |
| (4) | Back hoe | 1.4 $m^3$ | 1 | both |
| (5) | Back hoe | 0.6 $m^3$ | 6 | both |
| (6) | Motor grader | 3.7 m | 2 | road |
| (7) | Tire roller | 10 tons | 2 | road |
| (8) | Vibration roller | 10 tons | 1 | road |
| (9) | Macadam roller | 10 tons | 2 | road |
| (10) | Asphalt finisher | 2.4-4.5 m | 1 | road |

| No. | Model | Spec. | Nos. | Remarks |
|---|---|---|---|---|
| (11) | Tractor shovel | 2.1m$^3$ | 2 | both |
| (12) | Tractor shovel | 1.2m$^3$ | 2 | both |
| (13) | Crawler drilling machine | pneumatic 180 kg | 1 | both |
| (14) | Air compressor | 17m$^3$/min. | 1 | both |
| (15) | Large-scale breaker | hydraulic 1,300 kg | 1 | both |
| (16) | Dump truck | 11 tons | 28 | both |
| (17) | Water lorry | 6,000 litter | 2 | road |
| (18) | Fuel lorry | 6,000 litter | 2 | both |
| (19) | Truck with crane | 8 ton/2.9 tons | 1 | both |
| (20) | Truck crane | 25 tons | 1 | both |
| (21) | Trailer | 25 tons | 1 | both |
| (22) | Crusher plant | 90 tons/hr | 1 | road |
| (23) | Crusher plant | 30 tons/hr | 1 | rock |
| (24) | Asphalt plant | 30 tons/hr | 1 | road |
| (25) | Electric generator | 200 KVA | 3 | both |
| (26) | Electric generator | 45 KVA | 5 | both |
| (27) | Vehicle for carrying explosives | 1 ton 4 wheel drive | 1 | rock |
| (28) | On-site concrete mixer | 0.5m$^3$ | 1 | road |
| (29) | Vibration compactor | 110 kg | 2 | road |
| (30) | Vibration compactor | 90 kg | 4 | road |
| (31) | Hand breaker | 30 kg | 4 | road |
| (32) | Air compressor | 7m$^3$/min. | 1 | road |
| (33) | Tire chain | for wheel equipment | 42 | both |
| (34) | Small equipment for pavement construction | | 2 | road |
| (35) | Mobile work shop | | 2 | both |
| (36) | Asphalt sprayer | 25-30 litter/min. | 2 | road |
| (37) | CBR, asphalt testing equipment | | 1 set | road |
| (38) | Radio communication equipment | 30w, 5w | 1 set | both |
| (39) | Spare parts | | 1 set | |

The project must be conducted under the assumption that after the Japanese side has completed construction, Mongolia will have developed organizational capability and system to execute the same type of construction on its own. Therefore we propose that the Mongolian government recognize the importance of the following points and endeavor to improve its system.

- Personnel selected as recipients of technology transfer training should be chosen in regards to their future potential.

- A maintenance responsibility system for provided equipment must be established as soon as possible.

- Regarding equipment provided by Japan and roads constructed by Japan, Road Department must put aside a certain amount as a regular budget for maintenance to ensure continued use.

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# List of Abbreviations

## A. Authorities and Agencies

| | |
|---|---|
| ADB | Asian Development Bank |
| COMECON | Council for Mutual Economic Assistance |
| JICA | Japan International Cooperation Agency |
| MTI | Ministry of Trade and Industry |
| MID | Ministry of Infrastructure Development |
| NDB | National Development Board |
| RD | Road Department |

## B. Other Abbreviations

| | |
|---|---|
| $ | Dollar |
| 4WD | 4 - Wheel Drive |
| CBR | California Bearing Ratio |
| GDP | Gross Domestic Product |
| GM | (Muddy) Silty Gravel |
| GNP | Gross National Product |
| H | Height |
| HP | Horse Power |
| kl | kilolitre |
| km | kilometre |
| $km^2$ or sq.km | Square kilometre |
| km/hr | Kilometre per hour |
| KVA | Kilovolt-ampere |
| kw | kilowatt |
| m | metre |
| $m^2$ | Square metre |
| $m^3$ or cu.m | cubic metre |
| min. | minute |
| mm | Millimetre |
| n.a. | not available |
| Nos | Numbers |
| % | Per cent |

| | |
|---|---|
| Ø | Diametre |
| PCU | Passenger Car Unit |
| PMMS | Pavement Maintenance Management System |
| SM | Silty Sand |
| t | Ton |
| t/h | Ton per hour |
| t/m2 | Ton per square metre |
| TA | Equivalent Thickness to Asphalt Mixture |
| Tg | Tugrik |
| US | the United States of America |
| Veh. | Vehicles |
| VpD or VPD | Vehicles Per Day |
| W | Width |
| ¥ | Yen |

# CHAPTER 1 BACKGROUND OF PROJECT

# Chapter 1 Background of Project

## 1-1 Background of Project

Since its independence in 1921, Mongolia continued very close relations with the former USSR for several decades. Mongolia's economy depended heavily on the Soviet Union's financial assistance; thus disastrous effects came about with the end of Soviet financial aid in 1990. Since that year the country's GDP has suffered minus growth, affecting domestic industries and citizens' quality of life in all aspects.

To combat this situation, the Mongolian government met with the World Bank to formulate a new three-year plan (1993 ~ 1995). The fields of development emphasized in this plan are transportation infrastructure, revitalization of manufacturing industries by use of domestic resources, revitalization of agricultural and pastoral industries, and development of mining industries. The central theme in each of these fields is emphasis on self-reliance and avoidance of excessive reliance on foreign aid.

Development of domestic industries depends upon the productive activity of trade flow and raising up an effective export industry. However, road and rail networks within Mongolia at present are not sufficiently developed as effective means of transport to move Mongolia's agricultural or industrial products to and from the capital and other regions.

Mongolia's domestic transport depends heavily upon rail and highway transport systems, but roads carry the greater burden. In 1991, roads carried 78.7 % of domestic cargo traffic and 98.7 % of passenger traffic. However, only 10.6 % of national routes are paved, and 0.7 % of all routes combined.

As a result, sections of highway which can be used safely year-round are extremely limited and road development is an urgent matter. Since Mongolia had almost completely depended upon the Soviet Union and other east European nations in this matter, including the import of machinery, asphalt, etc. Therefore the construction of new roads and maintenance of existing ones have become difficult after the cutoff of Soviet aid in 1990.

Under these circumstances, the Mongolian government has requested Japan for the procurement of equipment to be used in development and construction of major routes within the country which would be constructed utilizing local rock asphalt.

## 1-2 Outline of Request and Main Components

As mentioned previously, the Mongolian government, as represented by the Road Department of the Ministry of Infrastructure Development, has requested Japan for the procurement of equipment to be used for rock asphalt, procured locally, in the construction and development of the main national route, specifically between Ulaanbaatar and Baganuur.

The request consists of the four following points:

(1) Rehabilitation of previously paved route with rock asphalt
(16 km section of route between Nalaykh and Erdene previously constructed by Mongolian authorities)

(2) Pilot construction of newly paved route using rock asphalt
(15 km section between Nalaykh and Baganuur)

(3) Procurement of equipment for quarrying of rock asphalt (see table 1-1)
(Diesel excavator, Screw-type drilling machine, etc.)

(4) Procurement of road construction equipment (see table 1-2)
(Back-hoe type excavator, bulldozer, water lorry, tire roller, etc.)

The contents of points (3) and (4) are as follows:

**Table 1-1 Equipment for Rock Asphalt Excavation**

| No. | Equipment | | Quantity |
|---|---|---|---|
| 1. | Diesel Excavator | 1 - 1.5 $m^3$ | 2 |
| 2. | Screw-type Drilling Machine | | 1 |
| 3. | Bulldozer with Ripper | 21 tons | 2 |
| 4. | Dump Truck | 10 tons | 8 |
| 5. | Truck | 1.5 tons | 1 |
| 6. | Jeep | 4WD | 2 |
| 7. | Micro-bus | | 1 |
| 8. | Water Pump | 2 $m^3$/min. at 60 m head | 5 |
| 9. | Diesel Generator | 300 kw | 2 |
| 10. | Stone Crusher | 100 tons | 1 |
| 11. | Stone Screen | 100 tons | 1 |
| 12. | Wheel Loader | 1.5 $m^3$ | 2 |
| 13. | Welding Equipment | electric type | 1 |
| 14. | Chain Block | 1.5 tons | 2 |
| 15. | Spare Parts | 15 % | |

**Table 1-2 Road Construction Equipment**

| No. | Name | | Quantity |
|---|---|---|---|
| 1. | Bulldozer with Ripper | 32 tons | 1 |
| 2. | Bulldozer with Ripper | 21 tons | 1 |
| 3. | Bulldozer | 15 tons | 1 |
| 4. | Back-hoe | 0.6 $m^3$ | 1 |
| 5. | Motor Grader | 3.1 m | 1 |
| 6. | Tire Roller | 10 tons | 1 |
| 7. | Vibration Roller | 10 tons | 1 |
| 8. | Macadam Roller | 10 tons | 1 |
| 9. | Asphalt Finisher | 2.4 m - 4.5 m | 1 |
| 10. | Asphalt Sprayer | 4 tons | 1 |
| 11. | Tractor Shovel | 1.2 cu.m | 1 |
| 12. | Tractor Shovel | 2.1 cu.m | 2 |
| 13. | Air Compressor | 7.5 cu.m/min. | 1 |
| 14. | Dump Trailer | 25 tons | 5 |
| 15. | Dump Truck | 11 tons | 4 |
| 16. | Water Lorry | 6 kl | 1 |
| 17. | Fuel Lorry | | 1 |
| 18. | Cargo Truck with Crane | 8 tons | 1 |
| 19. | Truck Crane | 25 tons | 1 |
| 20. | Trailer | 25 tons | 1 |
| 21. | Crusher Plant | 120 t/hr | 1 |
| 22. | Generator | 37/45 KVA | 1 |
| 23. | Concrete Mixer | 0.5 cu.m | 1 |
| 24. | Plate Compactor | 80 - 100 kg | 4 |
| 25. | Hand Breaker | 30 kg | 4 |
| 26. | Tire Chain | | 20 |
| 27. | Implement | | 2 |
| 28. | Work Shop | 8 tons | 1 |
| 29. | Spare Parts | 20 % | |

## 1-3 Projects and Programs of Other Donor

Technical aid projects having to do with roads are shown below:

(1) New Zealand: Inventory and Maintenance Management System for Highway Bridges

An inventory of bridges was carried out and maintenance manual compiled over a period of two months. Report delivered on July 16, 1994. This report discusses the importance of taking inventory and keeping up with maintenance,

also methods of survey and manual-making. Emergency repairs or bridge replacement are not discussed.

(2) Sweden: Training Program

A training program being conducted since 1993. Every year two trainees participate in a 45-day training session conducted at the Swedish National Road Administration.

(3) World Bank: Urban Transport Sub-project

Mongolian Transport Rehabilitation Project

Focusing on technical assistance for urban public transportation and support in areas of passenger transport operation.

Contents of Project: Training in the areas of maintenance, economics, investment planning, transportation network development, and traffic systems in urban public transportation. At present, consultants are being selected.

(4) ADB: Road Master Plan and Feasibility Study

This study began as an overhaul of the Soviet-formulated master plan, but due to the lack of basic data on traffic volume and the presence of data pre-dating the economic reformation, a workable data base was unobtainable. Therefore, an entirely new master plan, including design standards, was formulated.

- The plan was constructed for a 20-year period as a medium-length term plan.

  The entire road network as planned entailed 5,362 km of roads at a cost of approximately 427 million US dollars.

- 24 sections of road with high priority status were reviewed and specified as basic objectives.

  The total length of these are 3,898 km at a cost of 322 million US dollars.

- The sections of highest priority according to the master plan are as follows:

| | | |
|---|---|---|
| Dahan - Erdene | : | 180 km |
| Nalaykh - Saynshand | : | 440 km |
| Nalaykh - Baganuur | : | 100 km |
| Total | : | 720 km |

- Collecting of new basic data, formulating presuppositive evaluations for master plan (based on social economics at present, traffic volume, design standards, cost, etc.)

- Importance and/or prioritization of considering international road project.

  Asian Highway, Tumen River Project, Silk Route, etc.

# CHAPTER 2 OUTLINE OF PROJECT

# Chapter 2 Outline of Project

## 2-1 Objectives of Project

The objectives of this project are:

To use Mongolian - produced rock asphalt,
To use provided equipment for the actual road construction,
To transfer technical skills in use and maintenance of equipment as well as construction and quality control technology,
To contribute to the development of Mongolia.

## 2-2 Study and Examination on the Request

Based upon the present situation regarding the area of concerned project and results of site examination, the survey team and representatives of the Mongolian government reached accord on contents of request as expressed in the following four points:

(1) Road rehabilitation of damaged areas using rock asphalt previously paved by Mongolian authorities between Nalaykh and Aguytinhutul

(2) Pilot construction of new paved road with rock asphalt between Bayan Pass and Erdene

(3) Procurement of rock asphalt quarry equipment: diesel excavator, screw-type drilling machine, etc.

(4) Procurement of road construction equipment: back-hoe excavator, bulldozer, water lorry, compacting roller, etc.

The following points need to be reviewed in consideration of the contents of the request from the Mongolian government.

(1) Is rock asphalt a sustainable resource?

(2) Is rock asphalt a feasible material for use in road construction?

(3) What are the problems, if any, in using rock asphalt as a paving material at present?

(4) What areas need improvement in regards to construction management and quality control?

(5) What cautionary points need to be observed in the transfer of technology?

(6) All the above points considered, what is the necessary sphere of construction and equipment required?

Results of examination of these points are presented below.

### 2-2-1 Rock Asphalt Resources in Mongolia

The Bayanerhete rock asphalt quarry is located 120 km south-southeast of Baganuur in an undulating steppe region characteristic of Mongolia.

The Ministry of Energy, Mining, and Geology has compiled reports on Bayanerhete based upon surveys conducted since 1985:

- First Preparatory Survey Report (1986)
- Second Preparatory Survey Report (1987)
- Report on Feasibility Study for Quarry Development (1987)
- Detail Plan for Open Mining (1988)
- Completed Survey Report (1988)

Upon reviewing the above reports, the following results were obtained:

Geological boring tests were conducted in grill formation at a pitch of 50 m, for a total of 166 bores.

Rock asphalt was found in multiple layers, the nearest to the surface being 60 cm below, while the deepest was found as far down as 60 m. The layers themselves were found to range in thicknesses between 0.5 and 7.0 meters. The volume of subsurface rock asphalt is estimated at 1,988,000 tons.

- In shallow areas 67,200 tons
- In deep areas 1,913,600 tons

The thicknesses of the more shallow layers were thin (1.2 to 1.3 m), and asphalt content ratio low (generally 7 to 14 %).

At present, mining is conducted close to the surface; at 4 to 5 meters, with only a small amount of stripped soil. The surface of mined area is 100 x 400 m; open mining. The production record over the past four years has been at a maximum of 3,000 to 4,000 tons/year and the four-year total at about 10,000 tons. The following equipment has been used for excavation and transporting of rock asphalt, and soil stripping:

| | | | |
|---|---|---|---|
| - | Drill | 1 | diameter 140 mm |
| - | Dump truck | 4 | 5 tons |
| - | Excavator | 1 | 1.0 $m^3$ (rental) |
| - | Bulldozer | 1 | 139HP (rental) |
| - | Dump truck | 2 | 10 ~ 12 tons (rental) |

This equipment has mostly been rented from construction companies in Ulaanbaatar, but due to shortage of equipment, availability is not always guaranteed. Apart from such occasional setbacks can be added shortages of fuel and/or lubricants for machinery and dynamite for the mining itself. Due to a lack of budget, excavation has not been conducted since 1993.

Other layers of rock asphalt in deep areas have been confirmed from a depth of 14 m. Survey results estimate an excavatable volume at 900,000 tons. The asphalt content of this layer is higher than those of shallow areas. The earth layer covering this deep layer entails a stripping thickness of 30 m with an estimated overburden ratio of about 7. However, there is an aquifer layer at about 15 m below the surface.

Excavation of the rock asphalt takes place in two stages; soil stripping takes place in the summer months (May to September), while excavation of the rock itself is best conducted between December 20 and February 20 when solidification from sub-freezing temperatures contributes to greater ease in explosives and excavatory labor.

Excavated rock asphalt was taken to the asphalt plant stockyard in Nalaykh in preparation for construction of the following year. The distance between the quarry and asphalt plant is 180 km over an unimproved dirt road, taking 5 ~ 6 hours in transport one way. A portion of the road passes through a marshy area, so transporting is conducted only in the winter months when frozen.

Besides Bayanerhete, with which this project is concerned, rock asphalt was also found in the Zunbayan oil fields 20 km from Saynshand near the Chinese border thirty years ago. Out of the 800,000 tons which were confirmed, 30,000 tons have been used experimentally. The existence of rock asphalt has also been confirmed in Hujirt and Bogd in Ovorhangay Province and Harnor in Dornod Province, but volume has not been surveyed.

In conclusion, it can be said that the requested construction volume goal of paving 8 km of road per year which would entail a necessary 4,000 tons of rock asphalt per year, would be attainable by using the 50,000 remaining tons of rock asphalt from the shallow layers. Deeper layers would also (disregarding excavation expenses) yield a sufficient amount of the necessary rock asphalt.

## 2-2-2 Rock Asphalt Test-Paving Conducted in Mongolia

Research and Production Corporation "Autozam" confirmed the existence of rock asphalt in Bayanerhete based on information from the Geology Research Laboratory in 1985 and sent staff from Kazakhstan in 1988 to research the use of rock asphalt. Excavation commenced in 1990 and, as mentioned previously, rock asphalt was used in test-paving over a length of 17.8 km beginning from the Terelj fork. The test-paving section is shown below.

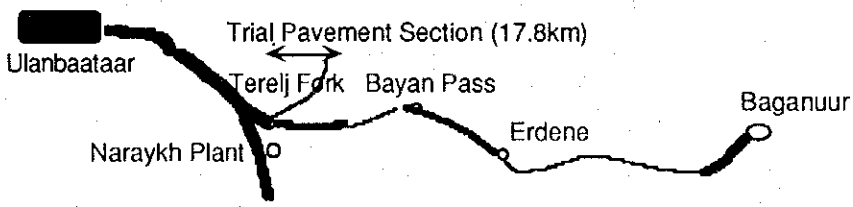



**Fig. 2-1 Location of Test - Paving Section**

The present manufacturing method of rock asphalt mix is to first heat up regular crushed rock, add approximately 30 % unheated rock asphalt into mixer where the heated aggregates will melt the rock asphalt as the mixer crushes to powder; finally, a small percentage of heat-melted raw bitumen is added. In all, one batch of 600 kg is mixed in 90 seconds. Implementation consists of a regular direct-heating plant installed with a rock asphalt weight-measuring device. The number of workers at the asphalt plant is 8 or 9, including bulldozer operators. The mix is carried to the site in a dump truck and applied to the paving surface in the same manner as regular asphalt mixes, that is, spread over with a finisher and compacted with a roller. Aging machinery and inadequate construction skills, causing uneven quality in the finished product, are points in need of improvement, although the material itself is adequate as a pavement. With application of Japanese technology, improvements can be made which would enable the reduction of foreign asphalt imports; a move which would also reduce expenditures.

## 2-2-3 Problems in Utilizing Rock Asphalt as Road-Paving Material

a. Efficiency of Plant

Research and Production Corporation "Autozam" presently owns and operates the Nalaykh test plant (one plant at 30 t/hour). However, it has been in use for 6 to 7 years, is lacking in parts, and maintenance is insufficient. One more plant is presently under construction, but due to the lack of parts operation can not be anticipated in the near future.

b. Quality Control in Use of Rock Asphalt

Rock asphalt which has been brought in from the quarry has been crushed, then moved to the belt conveyer hopper by bulldozer; therefore the mingling of some dirt and sand is unavoidable. Rock asphalt containing 7 % to 15 % pure bitumen is roughly divided into two groups, depending on the level of bitumen content as judged on sight. This method has caused problems in the quality control in content mixing. Also, rock asphalt which has been quarried and carried to the stockyard in winter, being left outside, sticks back together in the summer months, making it necessary to re separate.

c. Equipment for Quality Management

At present, Research and Production Corporation "Autozam" has the following facilities for testing soil quality and asphalt:

- Hand Auger Boring Test
- Grading Analysis
- Compaction Test
- Physical Test (specific gravity, water content, grain size accumulative curve)
- Test for Impurities
- Penetration Test (asphalt)
- Sieve Analysis Test
- Marshall Testing Apparatus (to be used for measuring asphalt mixtures, but apparently not in use)

There are no facilities or equipment for testing CBR, which is the basis of pavement design. Therefore, the survey team took soil samples (approximately 25 kg each) from four representative spots, brought them back to Japan and conducted soil tests. As a result of the test, the following CBR was obtained.

**Table 2-1 CBR Test Results**

| | Damaged section | Bayan Pass | ErdeneWest3.3k | Erdene East 2.0k |
|---|---|---|---|---|
| Gravel | 35 | 43 | 40 | 44 |
| Sand | 36 | 23 | 36 | 28 |
| Silt | 22 | 27 | 21 | 24 |
| Clay | 7 | 7 | 3 | 4 |
| Definition | SM | GM | GM | GM |
| Swelling Ratio | 0.036 | 1.507 | 0.458 | 0.532 |
| Water Contents | 9.1 | 9.3 | 9.4 | 10.0 |
| Average CBR | 5.4 | 13.4 | 61.3 | 30.1 |

d. Aging of Presently Available Road Construction Equipment

Road construction equipment presently used by Research and Production Corporation "Autozam" for test paving is shown below: (Almost all are from the former Soviet Union)

**Table 2-2 Presently Available Road Construction Equipment at "Autozam"**

| | | |
|---|---|---|
| Grader | 1 | 124HP |
| Bulldozer | 2 | 130HP |
| Excavator | 2 | 0.5 $m^3$ 0.25 $m^3$ |
| Vibrating Roller | 2 | 8 ton (both steel rollers) |
| Tire Roller | 1 | 15 ton |
| Bulldozer | 1 | 75HP |
| Asphalt Finisher | 1 | 3.5 m |
| Asphalt Finisher | 1 | Mongolian made, simplified model |
| Dump Truck | 8 | 5 ton (10 ton and 12 ton available by rent) |
| Miscellaneous | 6 | Truck, crane, asphalt sprayer, automobile |

It was explained that using the above equipment, paving of 500 m per month (7-meter wide, 2-lane road) was possible, but due to lack of materials, this year has remained at 2 km. In addition to the aging of the equipment, there are almost no possibilities for repair.

e. Shortage of Facilities for Maintenance and Repair of Equipment

There are no facilities such as workshops, etc., for maintenance or repairs, so all such work must be conducted on site or wherever parked. Previously, equipment was carried to a repair shop in Ulaanbaatar when necessary, but this shop's capacity has fallen somewhat, making it necessary to conduct equipment repair on the field.

Due to these conditions, even relatively new vehicles are sometimes seen out of service.

f. Damage of Previously Paved Surfaces

The standard layer components of the 17.8 km stretch of road which has been chosen as candidate for rehabilitation are as follows:

- Surface layer: Heat-and-mix type rock asphalt, 3 cm

- Binder layer: Heat-and-mix type rock asphalt, 4 cm
- Base course: Gravel 10 to 20 cm (depending on situation of roadbed)

Cracks, potholes, and bumps were observed by sight and a test drive to give an evaluation of the pavement condition. As of the survey of October 5 there were 50 potholes, etc., which require attention. The prime coat over the base course and tack coat between the binder layer and surface layer had not been applied due to lack of materials. Putting a thin layer of pavement over a soiled surface at low temperatures is bound to bring about loss of surface pavement, and most likely the cause of potholes.

In the past, when Mongolian authorities have filled in potholes or other damaged areas, an overlay would be conducted without painting a tack coat in the process. Evidently, there is a problem in construction methods. In the proposed project area, which is the region surrounding Ulaanbaatar, winter low temperatures go below -40 °C. In such conditions, shrinkage cracks in asphalt would be practically unavoidable. This phenomenon is especially seen in Chinese asphalt mixtures which have high paraffin content. Cracks at regular intervals which cross the road and vertical cracks down the center of the road can be judged as cracks caused by shrinkage from freezing. Also, alligator cracks found in certain areas are thought to be caused by lack of supporting strength below the pavement.

Regarding damage due to frost heave (which was not observed by team members in Mongolia), there is seen no particular consideration in preventing any such problem on any layer over the entire section. A 600 m section of cutaway on both sides of the road which is presumed to have been damaged by frost heave was an issue of the preliminary survey. As a result of this survey, it was found that due to the excavation of 5 to 7 meters, permafrost which had been below the surface now is affected by warming of spring temperatures, which caused the exposed permafrost area to melt and water to seep into the roadbed, therefore bringing about the damage. Interviewing authorities involved, it was found that the rising up of pavement associated with frost heave was not observed. It was said that a part of the pavement which had been paved in the autumn was damaged in the following spring.

g. Issues Concerning Construction of New Roads

Road construction from the Terelj fork to Bayan pass is being done by the Nalaykh Road Construction Company, which has completed 18 km of paving to Aguytinhutul (order amount: 40,000,000 Tg; period of construction: 1985 ~ 1995). This company's quality of work and efficiency is poor. Construction from Bayan pass to Erdene is carried out by Tug Province Road Construction and Repair Company,

which owns a large number of equipment and is highly capable. Dirt roads in Mongolia are made of rock litter from eroded rock, somewhat like gravel or crushed rock. Grassy surfaces are removed, and this material is laid as roadbed fill material. Interviewing revealed that about 10 cm of base course material (river gravel from near the capital) was spread over the road and then compacted with a roller, but the actual process was not observed. The asphalt finisher being used has not produced good results, and a hand rake is applied afterwards, but this is also not well done. Tack coating is not applied. Insufficient operating skills and aging of equipment are two major issues.

### 2-2-4 Points Needing Improvement Regarding Construction Management and Quality Control

a. Plant

It is nearly impossible to supply repair parts from Japan for equipment that was imported from the former Soviet Union. In order to carry out construction efficiently in the short summer season, and to transfer pavement technology to Mongolia's concerned parties, it is believed to be most beneficial economically to provide an entirely new facility. The Mongolian authorities have also submitted an additional request for a new plant.

b. Methods of Rock Asphalt Use

It is necessary to ameliorate the presently employed storage facilities which store rock asphalt of varying bitumen content together. For example, it may be necessary to make smaller divisions of storage within the stock area, or conversely, to figure out a way to use different types of rock asphalt together to make a uniform content. Therefore, it can be said that a device for measuring bitumen content need be procured. The maximum mixing volume of rock asphalt in a given asphalt mixture depends upon fabricated grain size and heating temperature. Heating of rock asphalt which contains about 20 % bitumen needs a specialized dryer and is economically unwise. When mixing unheated rock asphalt with heated aggregates 20 % to 30 % content is the limit due to the upper limits of heatable temperature. The results of analyzing bitumen content of samples brought back to Japan show that a 22 % mixture ratio is the most appropriate. At this ratio, the appropriate amount of raw bitumen to add would be 2.2 %. The maximum diameter of rock asphalt to be sent to the plant would be 20 mm.

Reference: An example of a plant in Japan using defunct paving materials as recycled aggregates: Aggregates of grain size smaller than 40 mm tend to have dirt mixed in,

so are used as base course material; those above 40 mm are crushed in a roll crusher and impeller - crusher to under 20 mm and sifted for uniformity. After measuring these aggregates, they are heated and put into a mixer with recycled oil. The bitumen content of the recycled aggregates is low at 5 to 7 %, but in the heated aggregates method, the material flows from the burner side so that the included bitumen will not burn.

c. Equipment for Quality Control

In order to introduce the type of test used presently in Japan for quality control, it is advisable that in consideration of the term of project execution, that laboratory management and operation, as well as technology transfer be conducted by the Japanese side.

d. Maintenance and Repair of Equipment

At present, with almost no facility for repair, procurement of a mobile workshop as requested by the Mongolian authorities to enable moderate repairs on site which would efficiently mobile work shops, is a must.

### 2-2-5 Points of Caution Regarding Transfer of Technology

a. This project is concerned with providing road construction equipment to Mongolia and actually implementing it in the intended construction itself, while transferring technological skills in equipment use, maintenance, construction, and management.

In order to carry out these objectives, operation and management of rock asphalt quarrying, asphalt plant operation procurement of high quality asphalt mixes, and paving will be necessary for the overall operation.

b. This project is to be carried out under the condition that, following completion of construction by the Japanese team, Mongolian authorities will be able to conduct further projects independently. Therefore it is necessary to add and confirm the following items with the Mongolian side upon explanation of the draft report.

- Personnel selected as recipients of technology transfer training should be chosen in regards to their future potential.
- A maintenance responsibility system for provided equipment must be established as soon as possible.

- Regarding equipment provided by Japan and roads constructed by Japan, the road department must put aside a certain amount as a regular budget for maintenance to ensure continued use.

### 2-2-6 Summary of Examination Results

a. Section to be Rehabilitated and Types

Section concerned: 17.8 km, between Terelj fork and Aguytinhutul.

Contents:

(1) Paving of totally damaged section 600 m in length.
(2) Small scale repairs in approx. 50 locations (potholes, cracks, etc.)

(3) Overlay of relatively continuous sections of damaged spots. (7,000 square meters) Overlay is limited to areas presently inadequate for driving.

b. New Pilot Section and Its Construction

Section concerned: 13.3 km, from base of Bayan pass to Erdene .

Reasons for selection:

(1) The concerned section of road is one of the three top priority roads specified by the ADB, and is under construction by the Road Department.

(2) This section lies between Nalaykh and Baganuur, two cities with relatively high traffic levels between them, therefore of utmost priority.

(3) Road design has been completed and preparation work has begun, but due to lack of budget and capability of the part of the contractor, completion of pavement is uncertain.

(4) The 37 km section east of Erdene is the object of ADB's feasibility study.

c. Equipment Necessary for Excavation of Rock Asphalt

Equipment to be provided will be selected upon the basis of results of calculation of yearly construction volume based upon results of above examination as well as equipment and number necessary according to type of construction together with a re-examination of working conditions and requested equipment. Results of re-examination will be presented below.

d. Equipment Necessary for Road Construction

Just as in the case of equipment for rock asphalt excavation, provided equipment will be selected upon re-examination of requested equipment. Results of re-examination will be presented below.

## 2-2-7 Additional Items Agreed with the Mongolian Government:

a. Executing authority and management office for construction equipment:

Road Department of Ministry of Infrastructure Development.

b. Scope of Japan's Implementation:

Sections in which local contractors have already commenced construction will become the responsibility of the Japanese construction contractor. This will entail all parts from drainage structures and subgrade to upper paved surfaces. (Pipe culverts which have been prepared for six locations will be moved by the concerned Mongolian party).

c. Completion of Pavement Utilizing Local Rock Asphalt:

Completion of pavement utilizing local rock asphalt, that is, making use of domestic resources, is the prime objective as stated by the Mongolian government.

d. Volume of Subsurface Rock Asphalt:

The volume of subsurface rock asphalt has been confirmed, but economically excavatable volume has not been examined. The project at hand will make use of shallower layers of asphalt. Economic feasibility will be studied in the case of utilizing deeper layers in the future.

e. Re-examination of Requested Equipment Based on Final Confirmation and End Results:

Based on the items listed above, requested equipment will be re-examined and equipment to be provided will be selected.

### 2-2-8 Propriety of the Co-operative Project

Based upon examination of the study this project has been judged to be acceptable as a grant project from Japan. Its effectiveness and practicality, and the ability of the Mongolian government to execute it deem it to be compatible with the Japanese grant system. Therefore, on the assumption that grant co-operation from Japan will be applicable, we will proceed to examine the outline of the project and prepare the basic plan.

## 2-3 Project Description

The purpose of this project is to provide the following equipment as part of the solution for improving the poor situation of roads suffering from insufficient materials and equipment, unrealized construction technology, and the low level of management and operation skills as analyzed by reviewing the results of this survey report.

(1) Raising levels of construction technology of local contractors and improving standards of management and operation within the executing agency through construction of new paved road with rock asphalt between Bayan pass and Erdene.

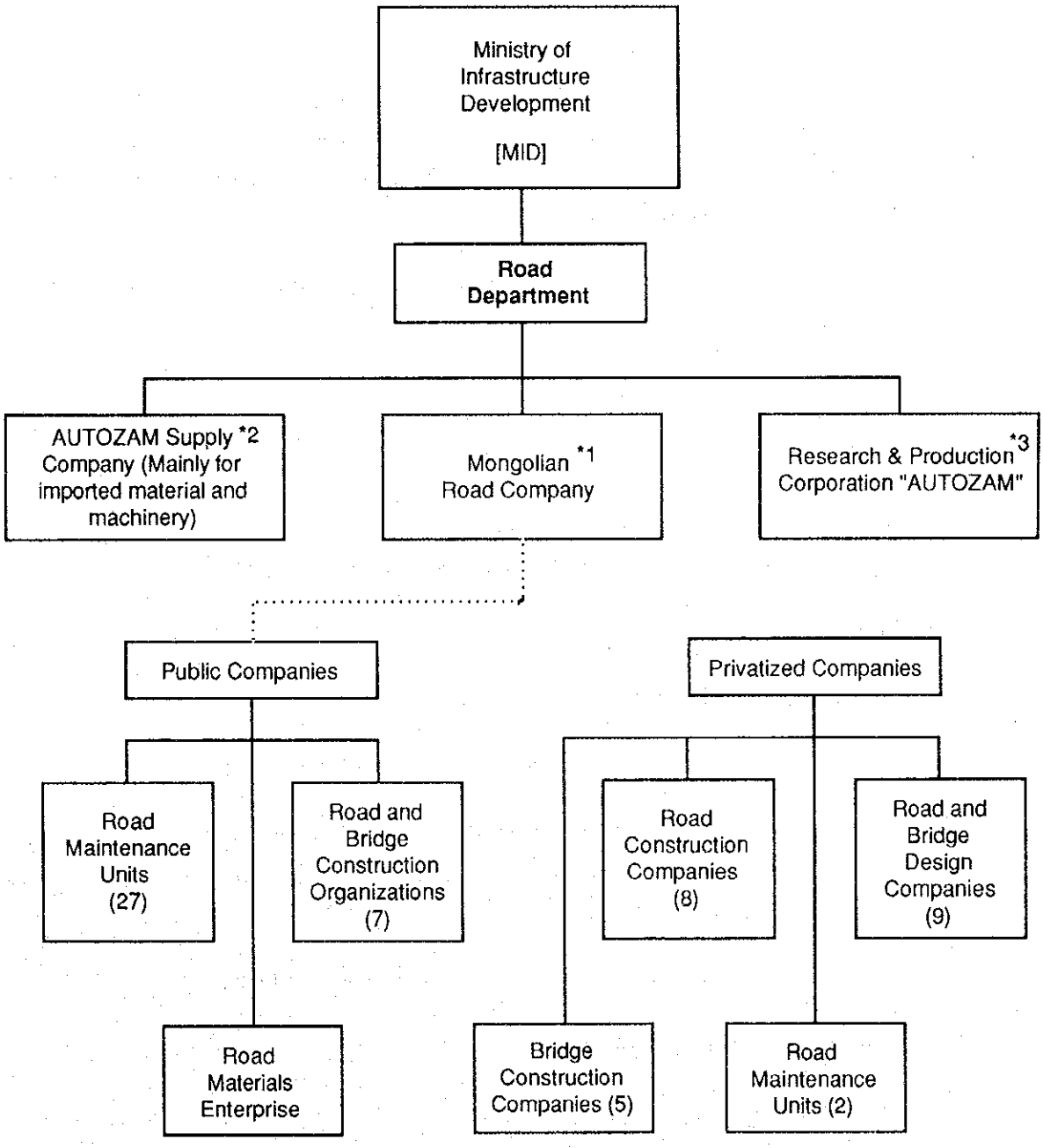
(2) Repairing of damage spots in pavement with rock asphalt using provided equipment, in the Mongolian - constructed section of road between Terelj fork and Aguytinhutul.

(3) Diesel excavator, rock drill (screw-type), etc., as equipment necessary for rock asphalt excavation.

(4) Back-hoe type excavator, bulldozer, water lorry, compacting roller, etc., as road construction equipment.

## 2-3-1 Executing Agency and Operational Structure

a. Below is a diagram of the executing agency, Ministry of Infrastructure Development (MID), Road Department.




( ) indicates number of companies.

**Fig. 2-2 Organizations of MID and Road Department**

*1) Mongolian Road Company (founded January 1992)

Staff: 50 members

Construction of roads and bridges, ordering for repair work, supervision. Mongolian Road Company has 25 public companies under it, with contracts with other privatized firms.

| | |
|---|---|
| 1992 | 300 million Tg |
| 1993, budget 2 billion Tg | 1.4 billion Tg |
| 1994, budget 2.8 billion Tg | 1.5 billion Tg (includes 20 % repair work) |
| 1995, budget 4 billion Tg | |

Construction within the city of Ulaanbaatar is managed directly by the city and out of the scope of work of Mongolian Road Company.

*2) Autozam Supply Company

Staff: 40 members

Import and sale of materials and equipment
Budget: 200 million Tg + managing expenses 1.5 million Tg (1993)

Product handled:

Bitumen: 1993, 4,000 tons

1994, 3,600 tons; made use of World Banks' loan

Imported asphalt from Russia at US$80 ton, and sold with total 26.5 % tax (15 % customs tax and 10 % trade tax, etc.); plus handling charge.

Equipment and parts are imported when profitable.

*3) Research and Production Corporation "Autozam"

Staff: 120 members

Researchers, technicians: 40
Laborers (plant, rock asphalt quarry): 60
Clerical/Management: 20

A research agency chiefly involved with research for practical uses of rock asphalt; and Production of design standards. This owns experimental plant in Nalaykh.

b. Capability of Mongolian Side after Project Completion:

Capability of Mongolian side regarding effective use of equipment and proper maintenance of constructed road after completion of the project is sufficient. The Road Department will be in charge of equipment supplied within the project. A new plan to create a technical servicing and overhauling system for road equipment and machinery is underway.

As for maintenance of constructed road, it will be responsibility of local maintenance unite.

### 2-3-2 Budget

Road department has access to 13 % of oil sales as a part of its budget. For 1994, new construction costs are budgeted at 5.7 million $, maintenance costs at 2 million $, equipment purchase at 0.4 million $; over 200 % more than the previous year. This implies that the projected maintenance expenses for equipment to be provided by the project will be sufficiently covered.

### 2-3-3 Location and Condition of Project Site

a. Natural Conditions

The northwest of Mongolia is a mountainous region rich in rivers and lakes, while the southeast is famous for the Gobi Desert; a barren area of sand and gravel. Average elevation of the entire country is 1,580 m; making it a highlands nation. The climate is typical of a landlocked country.

The project area includes Ulaanbaatar and Baganuur in eastern Mongolia. Natural characteristics are described as follows:

- Elevation from 1,300 to 1,800 meters; undulating grassy plains and hillocks.
- Typical of a continental inland area, great differences in temperature; particularly cold in winter (below -40 °C).
- Due to winter conditions, construction work is only possible from middle of April to middle of October. Earthworks sometimes continues until late of November before the ground becomes frozen.

- Yearly average precipitation is about 400 mm; even in winter, snow fall is few. According to July 1991 data from the Meteorology Research Center, monthly precipitation in winter is from 2 to 7 mm, but 92.7 mm in August.

- Winds and sandstorms are prevalent from April to June.

b. Overview of Transportation Infrastructure

(1) Railroads

The main railroad line in Mongolia stretches 1,111 km from Sukhe-baatar at the northern border, through the capital, and south to Zamyn-Uud at the Chinese border. 8 east-west lines make up the remainder of the rail system, bringing the total rail mileage to 1,813 km. There is one line which goes through Nalaykh on its way to the coal-mining town Baganuur, roughly corresponding to the present project area. Its main purpose is to carry about 3.7 million tons of brown coal from Baganuur to the power plant in Ulaanbaatar.

(2) Air Transport

At present, the only international airport is in Ulaanbaatar, being served by Mongolia Airlines, Chinese Airlines, and Aeroflot. Domestic flights serve 17 airports throughout the country, Ulaanbaatar as the hub. The only airport in the project area is a military airport in Nalaykh.

(3) Water Transport

As a landlocked country, there is no sea transport. Generally, precipitation is minimal and rivers are few throughout the country. At the capital's high elevation, the Haraa river does not carry enough water to merit any sort of transportation. There are also no large rivers along the project route.

(4) Roads

In the same manner as other Mongolian industries, road construction machinery, bitumen, etc. were mostly available via import in the form of Soviet aid, upon which Mongolia depended. However, with rising costs, the slowdown of import activity has been extremely detrimental to the productivity of the construction industry. For example, the price of bitumen rose 5.4 times between 1990 and 1992. One major public construction company with an asphalt plant produced 15,000 tons in 1992, 27,000 tons in 1993, but only was able to produce 4,000 tons in 1994 due to inflationary prices, and paving construction could hardly be carried out. As one way out of this situation,

Research and Production Corporation "Autozam", a subsidiary of the Road Department is conducting research and test construction for the use of rock asphalt, which is found abundantly in Mongolia. The main road between the capital and Baganuur was chosen as a test section for the practical use of rock asphalt.

1) Ulaanbaatar ~ Nalaykh (30 km)

The road to Nalaykh is a 2-lane 7 meter-wide paved road crossing a hilly area. The section from the inspection gate outside the capital to Nalaykh was paved with cement concrete by Chinese aid. In the asphalt paved section there are a large number of vertical and horizontal cracks, and in the cement concrete section there is much damage in joint areas. In 1994, the first snow fell on September 8, and by October there were already days in which afternoon temperatures went below freezing.

2) Nalaykh to Erdene (44 km)

6 km from the fork at Nalaykh is the fork to Terelj. Over this distance maintenance is not good, but it is an asphalt road navigatable at 80 km/hour. The 18 km from this fork to Aguytinhutul is paved with rock asphalt; a two-lane road completed by Nalaykh Road Construction Repair Company under the auspices of the Mongolian Road Company. Although construction began in 1990, pavement work only progressed 16 km in 4 years, and only 2 km were paved in 1994. This section is the object of a rehabilitation project. Over the first 11 km, potholes and other areas requiring repair were counted at 33. Damage in the eastern section is especially prominent. Areas needing repair in this section are more numerous than in other areas paved by ordinary asphalt .

Due to the fact that rock asphalt was not excavated over the winter of 1993, such pavement construction was only possible up to Sept. 5, 1994; after that ordinary asphalt were used in paving. This paving ended on Sept. 27.

Because of cold weather conditions there are 600 m of unpaved road in this section. Underground water seeps down the slopes and both sides, forming puddles in the ditches on both sides. This is a section which was completely damaged in the period between autumn 1991 and spring 1992, not by frost heave, but rather due to the loss of supporting strength resulting from the melting of water frozen in the roadbed. At present, the

surface layer has been removed to allow the roadbed to dry sufficiently before repairing (2 years is expected for drying).

25 km between Aguytinhutul and Erdene consists of gravel and dirt roads, but a new road design has been completed. In this direction there are about 10 different roads meandering and intersecting one another. It is difficult to know which is the main route at first, but it is the one with gravel. Up to Bayan pass concrete pipe culverts are being laid one every two kilometers. At the same time, earthwork (removal of surface soil, approx. 1 m of embankment) is also being conducted. Since there is no control point, alignment is evidently conducted in a straight line.

In one location, a 10-meter bridge has been completed. At Bayan pass, cutaway work is progressing for a new road designed in a straight line, departing from the original road which follows the natural curves of the mountain. The cutaway soil is apparently being used as embankment materials at a site east of here. Fill-in material of domestic origin is supposedly being applied, but there is no evidence of application of base course to cover it. According to plan, however, 15 cm of base course is expected.

3) Erdene - Bayandelger (20 km)

The basic plan for the road between Erdene and Bayandelger has been completed. The gravel road between West Dot pass and East Dot pass is almost unmaintained. A total of 17 km of road on both sides of both passes is totally undeveloped, with many dirt roads. In the steppe, any place a car goes becomes a road, therefore these roads follow the natural flow of the land. At the 88 km point, one crosses Togoshin River (approx. 10 m wide); crossable by car. A 65 m length bridge is planned at the most stable point in the river.

4) Bayandelger ~ Baganuur (24 km)

Bayandelger is a small village located atop a hill more than 2 km north of the road. 10 km after this point is much the same type of undeveloped road as mentioned above. For 14 km past that point is an asphalt concrete 2-lane road built with Soviet aid. It is more or less in good condition except for several unrepaired horizontal and vertical cracks encountered near the entrance of Baganuur.

5) City of Baganuur

Baganuur was founded as a satellite city of Ulaanbaatar in 1978, and is administered by the same. It is a coal mining town producing 4 million tons of coal a year, 90 % of which is sent to the capital by rail and the remainder by road.

- Population 17,000 Number of households 4,000.
  No. of automobiles 450.
  No. of horses 33,000.

- Projected population by 2000: 45,000.

- The mayor of Baganuur expresses hope that the city will become a center of transportation for eastern Mongolia and is considering a coal processing chemical plant, installation of a power plant, leather processing industries.

## 2-3-4 Maintenance Plan

a. Road Maintenance

Regarding maintenance system for repair of pavement damage and wear, the Mongolian Road Company contracts public and private firms based on the budget of the Road Department. Problems involve the lack of the record of the roads, including a data bank of such results, shortage of budget, unavailability of materials and equipment, etc. Road maintenance cost takes up one-half to one-third of normal new construction or repaving costs per area. However, frequency of needed repair or area involved is greatly affected by conditions. Pavement life span can be 10 to 50 years, according to design. Japanese design is generally geared to a life span of ten years. As mentioned earlier, the Road Department allots one-third of the budget for new construction to repairs.

In order to conduct maintenance of pavement effectively on a limited budget, the pavement maintenance management system (PMMS) is recommended. It is strongly recommended that technological assistance be conducted in this field in the future.

Speaking short-term, the systemization of a road maintenance vehicle carrying materials, a small roller, and workers is necessary. The Mongolian side is also highly interested in this.

Speaking solely in terms of this pilot construction section, repair expenses are unnecessary for the first two years after construction. 2 % of construction expense each year for the following 5 years, and an average of 5 % up to 10 years should be allotted afterwards.

b. Equipment Maintenance

(1) Maintenance System

Maintenance - related work in regards to construction equipment is left up to the manager in charge at the respective firms, but due to a shortage of repair shops and other on-site facilities, maintenance methods rely on visual inspection and a few other simple routine checkups such as oil inspection, etc. Periodical maintenance, repair by disassembling, etc., which require special facilities, had to be conducted at the repair shop in Ulaanbaatar. However, since this shop no longer has its former capability, in the meantime equipment must be maintained repaired on site. The Road Department is planning for use of a mobile workshop to be procured by this project to provide on-site maintenance services as an important link to strengthen equipment maintenance capability.

As far as a specific method for equipment maintenance is concerned, the keeping of a vehicle log book (as is presently the case) will remain the base, including records of operation, fuel consumption, maintenance, etc., all necessary from the viewpoint of vehicle status quo. All records should be updated and arranged. By doing so, the operating characteristics, refueling periods, and breakdown tendencies of each equipment can be grasped. This data can then be used by the mobile workshop service to greatly reduce the number of breakdowns. In order to realize these equipment management methods, a maintenance team can be organized as shown below. For the time being, maintenance and repairs cannot be expected from the workshop, so it is recommended that in addition to the standard maintenance machinery and tools, the function of the workshop can be substituted by mobile workshop with crane for heavy repair work in the following way:

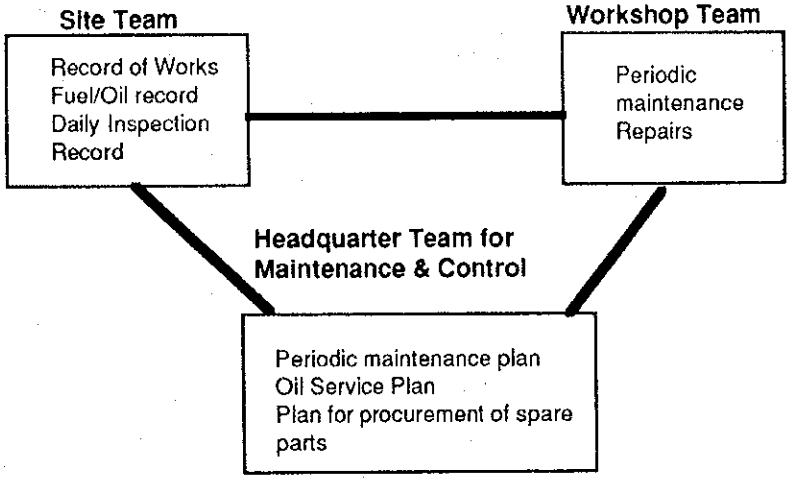



**Fig. 2-3 Maintenance System**

(2) Expenses for Maintenance of Equipment

As mentioned earlier, road construction is carried out by contract by the Mongolian Road Company with public and/or private firms. Therefore, provided equipment will be used in construction lent to concerned contractors. Operating costs such as operators' fee, fuel costs, etc. will be covered by the construction company, but it is important that the Road Department, which is responsible for management of the equipment, procure expenses for maintenance and repair.

Regarding maintenance and repair expenses, the data of Ministry of Construction, Japan was consulted. There are some differences according to type of equipment, but the yearly average maintenance repair expenses throughout depreciation period being calculated at a few percent of equipment cost, the average yearly expenditures for regular servicing and on-site repair costs are estimated at US$ 952,000.

## 2-4 Technical Co-operation

This project entails the provision of equipment to Mongolia to promote self-sufficiency in road management. However, in consideration of the conditions under which that country has conducted road management, it will also involve the actual use of equipment by the Japanese side while transferring technical knowledge and skills in pavement repair and new road construction. However, even in the case that trainees be limited to construction technology, the two-year term of the project would not be sufficient to train one to the point of being truly skilled. Furthermore,

construction goes hand in hand with design, the latter also being indispensable to the future of Mongolia's progress; but the transfer of design methodology is not included in this project. As a solution, the sending of engineers to Japan for training, or the dispatching of specialists may be very helpful. Also, possibilities of placing an in-house consultant in the road department should be considered.

# CHAPTER 3 BASIC DESIGN

# Chapter 3 Basic Design

## 3-1 Design Policy

Basic planning particularly takes the following points into consideration.

(1) In conducting basic planning for the pilot construction section, construction methods, materials and equipment will be selected on the basis of efficiency in construction time and reduction of construction and maintenance costs.

(2) Regarding road design, Mongolian road design will basically be adhered to. Furthermore, survey results obtained by survey team will be used for the design of pavement structures.

(3) Construction planning will be conducted in full consideration of winter limitations.

(4) In areas of large cutaway, sufficient consideration will be made for drainage facilities necessary to prevent complications due to freezing effects of the subgrade.

(5) Regarding rehabilitation section of previously paved road, construction equipment and methods should be selected in sufficient consideration of Mongolian construction technology.

(6) In order to boost the local economy as well as transfer technical skills, planning of construction materials and methods which can make use of local manpower and technology should be conducted.

## 3-2 Study and Examination of Design Criteria

### 3-2-1 Road Design

a. Road Class

The present traffic volume of the road between Nalaykh and Baganuur is 100 ~ 150 cars per day. Even if traffic doubles by the year 2000, this would be L traffic level road in Japan. Even so, the Mongolian Government decided in 1991 to classify the roads to Baganuur and to Darhan as class 3 of a 5-class system presently being reviewed, and is proceeding to develop them. Other roads have been classified as class 4 or 5. In compliance with the previously settled policies of the Mongolian

government, the road will be designed according to class 3 traffic volume standards.

b. Geometrical Design Standards to be Applied:

Geometrical design standards adopted by the Mongolian authorities are shown below.

**Table 3-1 Geometrical Design Standards to be Applied**

| Item | Unit | Standard |
|---|---|---|
| Road Class | | III |
| Terrain | | Flat, Rolling and Mountain |
| VpD | Veh./day | 2,000 - 6,000 |
| Design Traffic Volume | PCU/day | 1,000 - 3,000 |
| Design Speed | km/hr | 100, 80, 50 |
| Lane Width | m | 2 x 3.5 m |
| Shoulder Width | m | 2.5 |
| Median Width | m | n.a. |
| Crossfall of Pavement | % | 2 |
| Crossfall of Shoulder | % | 4.0 |
| Max. Super elevation | % | 10 |
| Min. Radius Curve | m | 100 |
| Max. Gradient | % | 5 |

c. Typical Cross Section

Composition of road width is planned as below from the standards shown above:

- Number of lanes: 2
- Lane width: 3.5 m
- Crossfall of pavement: 2 %
- Crossfall of shoulder: 4.0 %
- Shoulder width: 2.5 m

Although even by the year 2000, design volume of road concerned would only merit treatment of L traffic level road in Japan (width of 5.5 to 6.0 m), as stated previously Mongolian authorities have already planned and designed for 7.0 m width. The finished paved road between Baganuur and Aguytinhutul is also 7 meters in width.

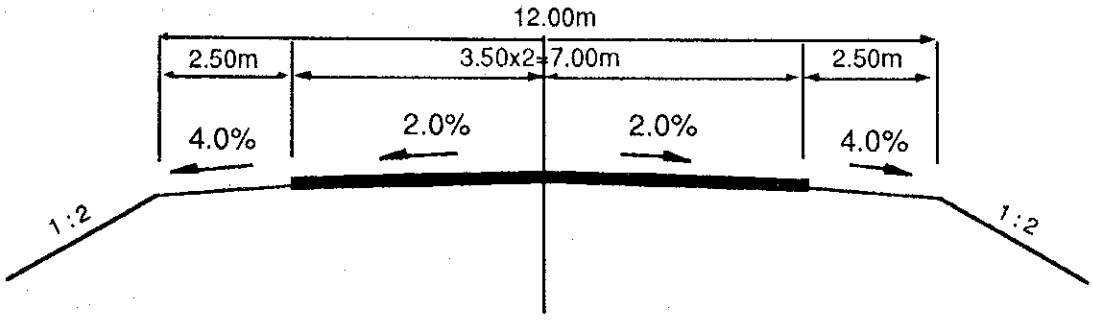



**Fig. 3-1 Typical Cross Section**

d. Design CBR of Subgrade

ADB has measured support strength with a cone penetrometer, and sets the design CBR at 7. Throughout the project area, the color and/or grain size differs on the surface, but vertically speaking, nothing is observed as such below 1 meter in depth. Results of the submerged CBR test of the subgrade which was collected on the last survey are shown in the Table 2-1 (page 2-6). As data, it is rather uneven, but considering that the maximum CBR in Japanese pavement standards is 20, the design CBR is presupposed at 12, with the exception of large cutaway areas.

e. Frost Heave Prevention

Upon visiting Mr. N. Shalk, staff member of Science Academy, Geographical laboratory, the following facts were confirmed:

- In Nalaykh there is a permafrost layer 2 to 3 meters below the surface, but there is no permafrost layer in Baganuur.
- Intermediate points of the project area have not been researched, but it is anticipated that there will exist layers of permafrost in certain areas.
- Even when a permafrost layer is present, there are cases when frost heave does not occur due to soil quality and/or subterranean water volume.

In the course of this project, seeing that there are possibilities that in sections of large cutaways the permafrost layer will be affected and excess melting of water will occur, and that along this section of road silt content is greater than other sections, subgrade replacement will be conducted for areas with a freezing depth of 1.2 m. However, due to the slight rainfall

in Mongolia, consideration of subgrade replacement except in case of deep cutaway on both sides is not necessary.

- Freezing Index

  According to the survey by ADB, Ulaanbaatar's figure is 2718; according to meteorological data on Ulaanbaatar obtained in Japan (Economic Statistics of Mongolia 1986) the figure is placed at 3270, so we will assume a median figure 3000.

- Freezing Depth

  According to calculations, freezing depth from the road surface is as follows:

  3 x (square root of Freezing Index) = 160 cm

  when the index exceeds 500, 70 % is taken, coming to 112 cm.

- Replacement of Subgrade

  When there is sufficient exchange of water content in the subgrade, replace amount of subgrade corresponding freezing depth stated above after subtracting pavement thickness. Pavement of a frost heave preventing nature is obtained by using gravel with high water-passing qualities containing at least 5 % passing of a 0.074 mm sieve.

### 3-2-2 Construction Equipment

Road development in Mongolia is conducted with old equipment from the former Soviet Union and eastern Europe; however, due to the lack of even this type of equipment, a great deal of labor is still conducted by manpower. Furthermore, there is a lack of skilled operators and servicing mechanics and with the departure of former USSR engineers, servicing facilities have been practically abandoned. Therefore, provided equipment should be selected on the basis of applicability to the present operators and mechanics and what they are accustomed to using. For example, use of highly technological electronic equipment which would be unserviceable in Mongolia should be avoided.

The following items are considered as criteria for equipment to be used on the construction site:

In Mongolia, where winter temperatures reach -40 °C, equipment faces severe conditions and equipment especially designed for such an extreme climate becomes necessary. Such equipment tends to have very complicated structure and thus ends up being quite expensive. Furthermore, it requires a high level of technical skill to maintain and spare parts are, again, quite expensive. Therefore, considering that road construction equipment would chiefly be operated in summer months, there is no need to go out of the way to procure winter-proof machinery. As for equipment to be used in the rock asphalt quarry in winter, with considerations being made regarding operating time of day, method of equipment storage (warehouse, etc.), proper selection of oil, sufficient warming up, etc., adjustments for northern area standard in Japan can be simplified and local servicing capabilities will suffice.

For reference's sake, the Zamyn-Uud Railroad Project is handling the equipment in winter by making minor changes in the execution such as enlargement in battery, etc., and paying close attention to fuel and oil management. Selection of equipment will also be conducted in consideration of equipment which would be implementable in either road construction or rock asphalt quarry.

Most of the road maintenance equipment will be of small or medium size. However, we recommend that large-scale equipment to be selected be kept at a minimum and workable combinations with intermediate-size equipment be chosen. As far as maintenance equipment is concerned, a mobile workshop (which will serve as a replacement for the repair shop in Ulaanbaatar which can no longer handle heavy repair to a sufficient degree) should be supplied with general servicing tools as well as a crane for heavy servicing in order to efficiently fulfill the function of a servicing shop.

## 3-3 Basic Plan

### 3-3-1 Road Design

Comparing the design of the pilot construction section which the survey team received from the Road Department and the survey results conducted on site during the previous visit, there were a number of locations in which the height of the embankment was several meters different in the profile; so in the basic plan the longitudinal design was reset in the profile.

Setting criteria: Avoiding high embankments or cutaways, basic goal of 1 m fill-in. Furthermore, cutaway is acceptable only in the case of mountain passes.

As a result, the number of longitudinal curves has increased over the Mongolian plan, but since these survey results are from every 100 meters, we strongly suggest that in the detailed plan the survey be conducted every 25 meters. Regarding the Bayan pass route, we compared and examined the original plan by the Mongolian government which is a straight line calling for large cutaway areas and a construction plan in which the new route basically follows the old route on its way to the pass and finally adopted the straight course for its driving facility. Space for a climbing lane is kept because a grade of about 6% continues for 1200 meters.

Pipe culverts will be the main additional structures. We are considering pipe culverts of D 1.0 m for the basic plan in the same locations as were drawn in the Mongolian plan. Furthermore, overburden depth and reinforcement methods will follow standards of the Japanese Ministry of Construction.

Judging from the situation of the site, guardrails, lighting, and other safety features are not included in the plan. However, a center line and side lines are recommendable, so they have been included in the plan. At present, center lines are not included in road plans outside of the capital, so this will be an object of discussion for Mongolian authorities.

### 3-3-2 Pavement Design

The survey team took samples of subgrade soil collected along the project route (results shown in Table 2-1) and obtained a design CBR of 12. In this case, following the Japanese Manual for Asphalt Pavement (Asphalt Hoso Yoko), is as shown below. Furthermore, in the case that design CBR exceeds 12, the figure is not given, so these have been obtained by calculation.

**Table 3-2 Pavement Thickness to Required**

| | | | | | |
|---|---|---|---|---|---|
| L traffic | CBR=12 | Required TA=10 | Required H=18 | Surface=5 | Base course=16 |
| A traffic | CBR=12 | Required TA=13 | Required H=21 | Surface=5 | Base course=25 |

According to the Manual, 5 cm per layer is sufficient, but as stated in chapter 3, 3-2, Mongolian authorities have classified this route as a class 3 road; pavement thickness 4 cm + 3 cm (double layer). In respect to the Mongolian method, this project will conduct a single layer finish of 6 cm. The reasons for

single instead of double layer are consideration of the thick lift method for cold weather and unavailability of tack coating material. A single layer of 7 cm becomes too difficult to implement, so we have brought thickness down to the maximum single-layer thickness of 6 cm. One problem is that it loses some flatness. In this case, the necessary thickness of crusher-run rock subsurface (the equivalent conversion coefficient 0.33) for L-traffic is 12 cm, for A-traffic is 22 cm. Considering the amount of traffic volume growth by the year 2000, single layer finish of 12 cm is applied.

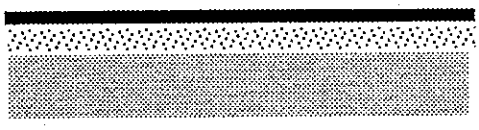



**Fig. 3-2 Pavement Structure**

### 3-3-3 Pilot Construction Project

The only facilities are an asphalt plant and a crusher plant, which will be discussed later. Regarding plant location, maximum transportation distance of asphalt mixtures considering cold weather would be 60 km (2 hours). As shown below, the Nalaykh plant is not at an economically feasible location in relation to the pilot construction section. For the time construction is conducted by Japan, it will be at Erdene. In the future it will be convenient for a plant to be located in Baganuur for construction east of Erdene:

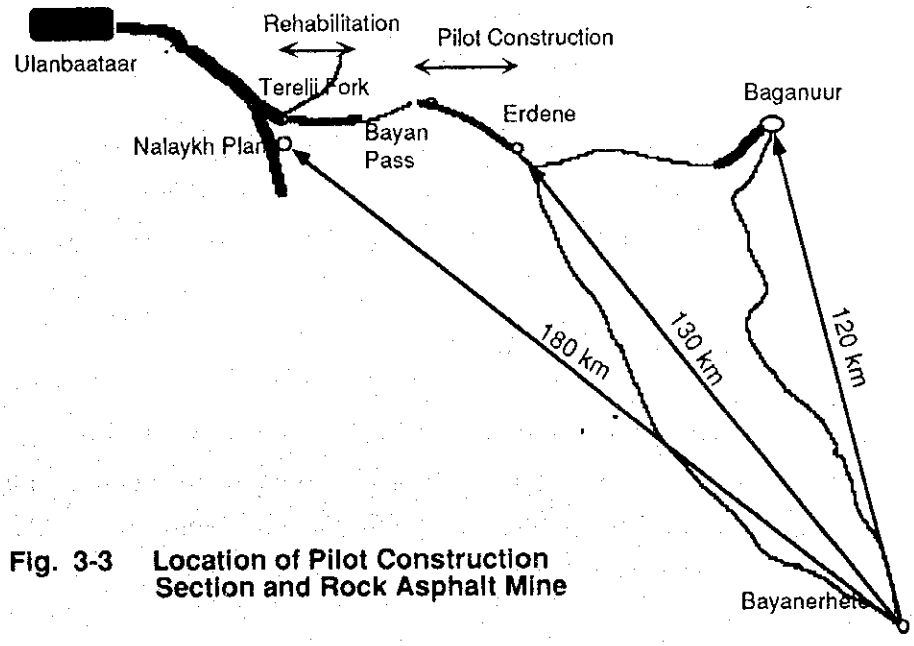



**Fig. 3-3 Location of Pilot Construction Section and Rock Asphalt Mine**

### 3-3-4 Plan for Rock Asphalt Excavating Equipment

Rock asphalt is excavated between December and February when the temperature falls to -40 °C. Work will take place at daytime and equipment will also be used in road construction, so the standard winter-proof specification will be set at -25 °C, with the following conditions included:

- Extra-large batteries to ensure efficiency in starting.
- For the convenience of operator, attachment of heated cabin.

1) Back-hoe 1.5 $m^3$

Rock asphalt is obtained from quarry by excavating with the aid of explosives, breaking down with large breaker. A back-hoe 1.5 $m^3$ would be more appropriate, considering the carrying of quarried rock, .

2) Crawler drilling machine, pneumatic 180 kg

Rock asphalt needs to be excavated from the quarry area with the aid of explosives. We have chosen the suggested Crawler drilling machine for ripping work with the aid of explosives

3) Air Compressor 17 $m^3$/min.

An air compressor of 17 $m^3$/min. is to be use in combination with an 180 kg class Crawler drilling machine.

4) Large breaker 1,300 kg

Rock asphalt needs to be excavated from the quarry area with the aid of explosives , we have chosen the suggested large breaker (1,300 kg class) for ripping work with the aid of explosives. To be used to aid excavation work.

5) Bulldozer with ripper 32 tons

Rock asphalt needs to be excavated from the quarry area with the aid of explosives, we have chosen the suggested Bulldozer with ripper (32-ton class) for ripping work with the aid of explosives. To be used to aid excavation work.

For excavation of overburden, great dozing force is necessary for work efficiency in clearing of blasting face; therefore a 32-ton class bulldozer is used. A machine with tilt-dozer whose blade is appropriate for dozing is chosen.

6) Dump Truck 11 tons

Considering shared use of transport of rock asphalt and overburden as well as road construction materials, an 11-ton class truck was chosen.

7) Tractor Shovel 2.1 $m^3$

A 2.1 $m^3$ class tractor shovel will be used to accompany the 11-ton dump truck.

8) Tractor Shovel 1.2 $m^3$

Considering efficiency of shoveling crushed rock into the hopper at crusher plant, and the fact that 2.5 m is standard hopper width, a 2.2 ~ 2.4 m wide bucket is appropriate. Bucket will be 1.2 $m^3$ class.

9) Vehicle for Carrying Explosives 1 ton 4WD

A one-ton class truck will be used for carrying explosive materials. A four-wheel drive vehicle is chosen in consideration of uneven terrain.

10) Crusher Plant 30 tons/hour

In order to raise carrying-efficiency levels in carrying rock asphalt from the quarry to plant site, a crusher plant will be placed at the quarry and rock asphalt transported after crushing. This class of plant is necessary to obtain required amount.

11) Electric Generator 200 KVA

Since there are no electric utilities supplied to this site, and to request the local government to supply them would cost an enormous sum, electric generators with sufficient power to operate on-site equipment are necessary.

12) Electric Generator 45 KVA

It is necessary to pitch a camp in the asphalt plant yard. This class of generator will be necessary for electrical needs in the office, accommodations, etc.

13) Mobile Workshop

There will be several tens of pieces of heavy equipment on site including many of which are not mobile. A mobile repair vehicle is necessary for repairs and maintenance. Installed with equipment for repairs and servicing as well as for processing simple parts, it will be four-wheel drive in consideration of the nature of the site. To enable a certain amount of heavy maintenance, including removal and attachment of unit parts, a crane will also be installed.

### 3-3-5 Road Construction Equipment Plan

Work will take place at daytime, so the standard winter-proof specification will be set at -25 °C, with the following conditions included:

- Extra-large batteries to ensure efficiency in starting.
- For the convenience of operator, attachment of heated cabin.

1) Back-hoe 1.5 $m^3$

Subbase materials are obtained from quarry by excavating with the aid of explosives, breaking down with large breaker. A back-hoe 1.5 $m^3$ would be more appropriate, considering the carrying of quarried rock,.

2) Crawler drilling machine, pneumatic 180 kg

Subbase materials needs to be excavated from the quarry area with the aid of explosives, we have chosen the suggested crawler drilling machine for ripping work with the aid of explosives

3) Air Compressor 17 $m^3$/min.

An air compressor of 17 $m^3$/min is to be use in combination with an 180 kg class crawler drilling machine.

4) Large breaker 1,300 kg

Subbase materials need to be excavated from the quarry area with the aid of explosives. We have chosen the suggested large breaker (1,300 kg class) for ripping work with the aid of explosives. To be used to aid excavation work.

5) Bulldozer with ripper 32 tons

Subbase materials need to be excavated from the quarry area with the aid of explosives, we have chosen the suggested bulldozer with ripper (32-ton class) for ripping work with the aid of explosives. To be used to aid excavation work.

Great dozing force is necessary for work efficiency in clearing of blasting face; therefore a 32-ton class bulldozer is used. A machine with tilt-dozer whose blade is appropriate for dozing is chosen.

6) Bulldozer with ripper 21 tons

Along the project route, a portion calls for cutaway excavation in a mountainous stretch, part of which is rocky. We basically recommend a standard of 32-ton class bulldozer for ripping work, but due to the large number of cracks in the rock, a 21-ton bulldozer was chosen for transportation purposes.

7) Bulldozer 15 tons

For covering of cross-structures, etc. under the road, reclaiming and compacting work, a 15 ton class bulldozer is the standard. For transportation purposes, 15-ton class is considered appropriate. For wide application of work, a tilt-dozer attachment is included.

8) Motor Grader 3.7 m

For leveling and spreading materials of pavement construction of planned route, a 3.1 m class motor grader is standard. However the road width in this project is 7 meters (2 lanes x 3.5 m), so 3.7 m class is considered appropriate. At present, Mongolia is also using 3.7 m class. For scarifying work, a scarifier will be attached. For wider applicability, a blade will be attached in front. That being used in Mongolia also is equipped with a front blade.

9) Back-hoe 0.6 $m^3$

For use in rock asphalt excavation, excavation of proposed route cutaway, excavation of material for fill-in areas, we recommend a 0.6 $m^3$ class back-hoe. This is also appropriate for loading onto an 11-ton dump truck.

10) Tire Roller 10 tons

For compacting of pavement construction of planned route, and pavement of asphalt mixtures, a tire roller (8 ~ 20 ton class) is standard

11) Vibration Roller 10 tons

For compaction of embankment in fill-in section of planned route, an over-4-ton class vibration roller is standard. 10 ton class is appropriate for considered construction purposes.

12) Macadam Roller 10 tons

For compacting of pavement construction of planned route, and pavement of asphalt mixtures, Road roller or Macadam roller (10 ~ 12 ton class) is standard .

13) Asphalt Plant 30 tons/hour

Presently, the asphalt plant in Mongolia is not in operation due to lack of parts, and no procurement of new parts is in sight. Judging from volume required of project, this class of plant was selected.

14) Electric Generator 45 KVA

It is necessary to pitch a camp in the asphalt plant yard. This class of generator will be necessary for electrical needs in the office, accommodations, etc.

15) Crusher Plant 90 tons/hour

According to survey, available rock is usable for crushed rock and/or subsurface material. At present a local construction company is excavating such at a site along the road. Crushed rock or subsurface material will be taken as much as possible from project site, with a minimum amount taken from aggregate factories. This class of plant will be necessary for obtaining needed volume.

16) Electric Generator 200 KVA

Since there are no electric utilities supplied to this site, and to request the local government to supply them would cost an enormous sum, electric generators with sufficient power to operate on-site equipment are necessary.

17) Asphalt Finisher 2.4 ~ 4.5 m

For paving of asphalt mixtures in pavement construction of proposed route, a 2.4 m ~ 5.0 m class asphalt finisher is standard. This type is appropriate for the width of the proposed route (3.5 m x 2 lanes).

18) Asphalt Sprayer

For spraying of asphalt emulsion and etc. in implementation of prime coat and tack coat. For efficiency, to be boarded on truck. Capacity of 25-30l/minute in conjunction with other implementations. To be also used for rehabilitation work

19) Tractor Shovel 1.2 $m^3$

Considering efficiency of shoveling crushed rock asphalt material and aggregates into the asphalt plant, and crushed rock into the hopper at crusher plant, and the fact that 2.5 m is standard hopper width, a 2.2 ~ 2.4 m wide bucket is appropriate. Bucket will be 1.2 $m^3$ class.

20) Dump Truck

For transport of sand, aggregates, and asphalt concrete. For transportation efficiency, a 25-ton class dump truck with trailer was reviewed, but considering local road conditions, an 11-ton carrier was chosen. This is about the same size as 5 to 10-ton class trucks being used in Mongolia.

21) Tractor Shovel 2.1 $m^3$

A 2.1 $m^3$ class tractor shovel will be used to accompany with the 11-ton dump truck.

22) Water Lorry 6 kl

For pavement construction of planned route, and water lorry (5.5 ~ 6.5 kl class) is standard.

23) Tank Lorry 6 kl

There will be a number of immobile pieces of equipment in the rock asphalt quarry yard, the subbase materials quarry yard, cutaway and fill-in road sites and pavement sites. Since there is concern regarding availability of fuel locally, this will be used for fuel supply to about 25 pieces of heavy machinery. At an average of about 200 litters per piece, capacity would need to be 5 kilolitres. A capacity of 6 kl was chosen.

24) Truck Crane 25 tons

This class of crane is needed for assembly and/or repair of asphalt and crusher plants as well as for attachment/replacement of heavy equipment.

25) Truck with 2.9 tons Crane 8 tons

A crane-attached truck is needed for transport of concrete culvert pipes, moving concrete mixer and for transport of attachments of crawler type equipment.

26) Trailer 25 tons

This is needed to transport bulldozer and back-hoe to and from rock asphalt and crusher quarries and road sites. 25-ton class is appropriate considering class of machinery to be transported and road condition.

27) On-site Concrete Mixer 0.5 $m^3$

A mobile mixer is needed to mix concrete to be used in laying pipes and in foundations for asphalt and in foundations for asphalt and crushing plants.

28) Vibration Compactor 90 kg, 110 kg

This standard class vibration compactor will be used for compaction of asphalt in repair of pot holes of existing roads.

29) Hand Breaker 30 kg

In repair of existing roads, there is some need to repair from subgrade, in which case this will be used to break asphalt.

30) Air Compressor 7 $m^3$/min.

An air compressor of 7 $m^3$/min is to be use in combination with an 30 kg class Hand Breaker.

31) Tire Chains

For safe maneuvering of roads during winter months when rock asphalt quarry is in operation.

32) Small Equipment for Pavement Construction

Burner, rake, planer, shovel, etc. for asphalt construction.

33) Radio communication equipment

For an effective mutual communication network between sites and between site and office, transmitters will be placed in Nalaykh plant, rock asphalt quarry, and Erdene plant, the transmitter for vehicle in the mobile work shop, and receivers in each camp, crushed rock manufacturing base, etc..

34) CBR testing equipment, asphalt testing equipment

CBR testing equipment which is needed for subbase quality control, and equipment for measuring asphalt content of rock asphalt (necessary for quality control of asphalt mixes) , also measuring and inspection equipment such as a level-testing apparatus to check levelness after completion of paving, core-cutter to inspect density and thickness of pavement, will be included.

35) Mobile Workshop

A four-wheel drive vehicle which can easily operate on site, with equipment for repair and servicing, and processing simple parts. Includes crane for ease in heavy repairs, on-site attachment and removing of unit parts. It will be prepared for rock asphalt excavation equipment, but will

not be at quarry so will be adjusted to emergency repairs of road construction equipment.

36) Spare Parts

Since most equipment found in Mongolia was made in the former Soviet Union, there is some availability of parts, but inventory is scarce, so it is predicted that almost all necessary parts will need to be imported. This would normally take anywhere from 3 to 6 months. To avoid such situations, spare parts should be included with equipment when procured. Furthermore, after the two-year pilot construction by Japanese contractors is completed, equipment will be serviced before being turned over to the Mongolian side, Spare parts will be included upon provision in order to aid maintenance in the following 2 years.

### 3-3-6 Necessary Amount of Equipment

The following points are considered as basic criteria in calculating necessary amount of equipment.

1) Amount necessary for paving 8 km of new road per year.
2) Amount necessary for rehabilitation construction according to project.

**Table 3-3 Necessary Amount of Equipment**

Remarks) both: use for rock asphalt quarry and road construction
rock: use for rock asphalt quarry
road : use for road construction

| No. | Model | Spec. | Nos. | Remarks |
|---|---|---|---|---|
| (1) | Bulldozer with ripper | 32 tons | 1 | both |
| (2) | Bulldozer with ripper | 21 tons | 2 | road |
| (3) | Bulldozer | 15 tons | 1 | road |
| (4) | Back hoe | 1.4m³ | 1 | both |
| (5) | Back hoe | 0.6m | 6 | both |
| (6) | Motor grader | 3.7m | 2 | road |
| (7) | Tire roller | 10 tons | 2 | road |
| (8) | Vibration roller | 10 tons | 1 | road |
| (9) | Macadam roller | 10 tons | 2 | road |
| (10) | Asphalt finisher | 2.4-4.5m | 1 | road |

| No. | Model | Spec. | Nos. | Remarks |
|---|---|---|---|---|
| (11) | Tractor shovel | 2.1m³ | 2 | both |
| (12) | Tractor shovel | 1.2m³ | 2 | both |
| (13) | Crawler drilling machine | pneumatic 180 kg | 1 | both |
| (14) | Air compressor | 17m³/min. | 1 | both |
| (15) | Large breaker | hydraulic 1,300 kg | 1 | both |
| (16) | Dump truck | 11 tons | 28 | both |
| (17) | Water lorry | 6,000 litter | 2 | road |
| (18) | Fuel lorry | 6,000 litter | 2 | both |
| (19) | Truck with crane | 8 tons/2.9 tons | 1 | both |
| (20) | Truck crane | 25 tons | 1 | both |
| (21) | Trailer | 25 tons | 1 | both |
| (22) | Crusher plant | 90 tons/hr | 1 | road |
| (23) | Crusher plant | 30 tons/hr | 1 | rock |
| (24) | Asphalt plant | 30 tons/hr | 1 | road |
| (25) | Electric generator | 200 KVA | 3 | both |
| (26) | Electric generator | 45 KVA | 5 | both |
| (27) | Vehicle for carrying explosives | 1 ton 4 wheel drive | 1 | rock |
| (28) | On-site concrete mixer | 0.5m³ | 1 | road |
| (29) | Vibration compactor | 110 kg | 2 | road |
| (30) | Vibration compactor | 90 kg | 4 | road |
| (31) | Hand breaker | 30 kg | 4 | road |
| (32) | Air compressor | 7m³/min. | 1 | road |
| (33) | Tire chain | for wheel equipment | 42 | both |
| (34) | Small equipment for pavement construction | | 2 | road |
| (35) | Mobile work shop | | 2 | both |
| (36) | Asphalt sprayer | 25-30 litter/min. | 2 | road |
| (37) | CBR, asphalt testing equipment | | 1 set | road |
| (38) | Radio communication equipment | 30w, 5w | 1 set | both |
| (39) | Spare parts | | 1 set | |