Chapter 7 Road and Pavement for Priority Projects

Chapter 7 Road and Pavement for Priority Projects

7.1 Assessment of Road Condition

7.1.1 Road Condition Survey

As a first step in assessing the condition of the Karabutak ~ Kzyl Orda border road section and the Atyrau ~ Mahambet road section, the Study Team collected existing data available at Kazdornii and Actdor. This information was then updated and supplemented by the results of site surveys and investigations carried out by the Study Team. Existing and new data were then analyzed to assess roads and culverts.

(1) Site Surveys and Laboratory Tests

The following site investigations were undertaken by the Study Team:

(a) Visual inspection and geometric structure survey.
(b) Roughness survey.
(c) Pavement Deflection measurement.
(d) Test pits and undisturbed sampling.
(e) California bearing ration test and other tests.

(2) Review and Analysis of data

The results of site surveys were put into chart form as shown in Appendix II-5 "Road Condition Chart". The road condition charts contain the following information;

(a) Kilometer stations, according to kilometer posts.
(b) Width of carriage ways and shoulders.
(c) Pavement structure composition.
(d) Embankment slope and height at edge.
(e) Roughness measurements.
(f) Defects noted during road surface visual inspection.
(g) Pavement structure deflection measurements and estimated strength.
(h) Overall pavement quality evaluation.

The analysis of collected data is presented below according to the following headlines.

(a) Climatic Conditions, and Soil Types and Strength
(b) Geometric Characteristics
(c) Pavement Condition
(d) Condition of Culverts

7.1.2 Climatic Conditions, and Soil Types and Strength

The climate influence the road pavement conditions. The influencing factors are the extent and frequency of temperature variations, the difference between maximum and minimum temperatures, precipitation and evaporation, wind direction and strength, depth of snow cover, and depth of frost penetration.

The studied roads are located in a continental arid zone having high rate of evaporation, low rainfall and higher spread of frost penetration. Tables 1 ~ 10 of Appendix II-8 show meteorological condition for the Karabutak, Irgiz and Atyrau regions.

The result of the test pits survey indicates that the subgrade along the priority projects roads consists of fine sand and light loam. The average soil deformation modulus is 85 Mpa (Mega Pascal) for the Karabutak road section and 65 Mpa for the Atyrau road section.

Existing soil types and strength measured are shown in Table 7.1.1.

Table 7.1.1 : Existing Soil Types and Strengths

No.	Location (km)	Subgrade Soil Type	Deformation Modulus (Mpa)		CBR		Internal Friction Angle (°)
			Soil	Base	Soil	Base	
Karabutak ~ Kzyl Orda border Road Section							
1	991 + 800	Fine sand	100	140	10	12	38
2	1036 + 500	Fine sand	100	150	10	12	38
3	1069 + 000	Dune sand	75	120	8	12	33
4	1098 + 900	Dune sand	75	130	8	12	33
5	1129 + 500	Fine sand	100	155	10	12	38
6	1191 + 250	Light loam	65	110	4	10	29
Atyrau ~ Mahambet Road Section							
1	48 + 010	Light loam	65	70	6	6	29

Data Source : JICA study, 1996

7.1.3 Geometric Characteristics

(1) Embankment Height

In the Karabutak ~ Kzyl Orda border road section, the embankment height measured at the edge of the shoulder. It ranges from about 0.0m to 4.0m, and average is some 0.75m.

In the Atyrau ~ Mahambet road section, the embankment height measured at the edge of the shoulder. It ranges from about 0.0m to 3.5m, and average is some 0.87m excluding the following sections which were built too low and which were covered with water by the flood inundation in 1993 and 1994,

km 43.00 ~ 43.15,	km 48.40 ~ 48.42,	km 56.50 ~ 56.62
km 61.35 ~ 61.50,	km 67.80 ~ 67.93,	km 69.10 ~ 69.30
km 71.20 ~ 71.50,	km 73.80 ~ 73.95,	km 74.70 ~ 74.90
km 78.80 ~ 78.95		

Table 7.1.2 (1) and Table 7.1.2 (2) show average embankment height along the road. Details are shown in Appendix II-5, "Road Condition Chart".

Table 7.1.2 (1) : Average Embankment Height on the Karabutak Road Section

Sub section (km)	Embankment Height (m)	Subsection (km)	Embankment Height (m)
965-971	1.9	972-977	0.5
978-1069	0.7	1070-1075	1.1
1076-1088	0.4	1089-1103	1.1
1104-1117	0.6	1118-1126	1.9
1127-1131	0.6	1132-1136	3.2
1137-1151	0.3	1152-1155	1.2
1156-1162	0.6	1163-1166	1.2
1167-1178	0.7	1179-1181	1.0
1182-1190	0.7	1191-1225	1.0
1226-1229	1.0	1230-1232	1.3
1233-1240	1.4	-	-

Data Source : JICA study, 1996

Table 7.1.2 (2) : Average Embankment Height on the Atyrau Road Section

Sub section (km)	Embankment Height (m)	Subsection (km)	Embankment Height (m)
1-71	0.9	72-83	1.4

Data Source : JICA study, 1996

(2) Carriageway and Shoulder

In the Karabutak ~ Kzyl Orda border road section, the existing carriageway width ranges from 5.3m to 9.0m (average is about 7.0m), and shoulder width ranges from 2.0m to 6.0m (average is about 4.0m) in one side.

In the Atyrau ~ Mahambet road section, the existing carriageway width ranges from 5.5m to 10.5m (average is about 6.5m), and shoulder width ranges from 2.1m to 7.7m (average is about 3.5m) in one side.

Table 7.1.3 (1) and Table 7.1.3 (2) show average width of carriageway and shoulder along the road. Details are shown in Appendix II-5, "Road Condition Chart".

Table 7.1.3 (1) : Average Carriageway / Shoulder Width on the Karabutak Road Section

Sub section	Carriageway Width (m)	Shoulder Width (m)	Sub section	Carriageway Width (m)	Shoulder Width (m)
965-971	6.6	1.9	972-977	6.5	4.5
978-1069	6.6	0.7	1070-1075	7.1	4.0
1076-1088	7.7	7.7	1089-1103	7.5	2.9
1104-1117	7.7	6.7	1118-1126	7.0	3.4
1127-1131	7.5	7.0	1132-1136	6.4	3.0
1137-1151	6.7	8.0	1152-1155	7.2	4.4
1156-1162	7.0	0.6	1163-1166	7.0	4.5
1167-1178	7.0	0.7	1179-1181	7.0	5.4
1182-1190	7.0	0.7	1191-1225	7.0	4.5
1226-1229	8.0	1.0	1230-1232	8.0	3.5
1233-1240	7.6	1.4	-	-	-

Data Source : JICA study, 1996

Table 7.1.3 (2) : Average Carriageway / Shoulder width on the Atyrau Road Section

Sub section	Carriageway Width (m)	Shoulder Width (m)	Sub section	Carriageway Width (m)	Shoulder Width (m)
1-71	6.7	3.7	72-83	5.6	2.5

Data Source : JICA study, 1996

7.1.4 Pavement Condition

Pavement characteristics and conditions, including composition, roughness, damages and overall suitability are evaluated as follows.

(1) Pavement Structure

Pavement structure, thickness of layers and material in the Karabutak ~ Kzyl Orda border road section and the Atyrau ~ Mahambet road section were cleared by the test pits survey undertaken by the Study Team.

Table 7.1.4 (1) and Table 7.1.4 (2) show the summarized road pavement composition. Further detail data is provided in Appendix II-5, "Road Condition Chart".

Table 7.1.4 (1) : Pavement Composition on the Karabutak Road Section

Station No. (km)	Base course Thickness (cm)	Surface course Thickness (cm)	Station No. (km)	Base course Thickness (cm)	Surface course Thickness (cm)
985+000	22	4	991+800	26	5
1022+000	15	8	1036+500	8	6
1069+000	8	6	1098+900	18	5
1109+000	12	6	1129+500	12	4
1168+000	-	12	1191+250	-	15
1221+000	-	16	1227+000	24	4

Data Source : JICA study, 1996

Table 7.1.4 (2) : Pavement Composition on the Atyrau Road Section

Station No. (km)	Base course Thickness (cm)	Surface course Thickness (cm)	Station No. (km)	Base course Thickness (cm)	Surface course Thickness (cm)
48+010	4	19	49+000	24	15
58+000	16	4	-	-	-

Data Source : JICA study, 1996

The base course is made primarily by sand and gravel mixture, except for a few section where crushed stone was used. The surface course consisted of "cold black stone" and mixture of gravel, sand, and bitumen.

(2) Roughness Measurements

The Study Team carried out the latest roughness measurement in June, 1996. The results were reported as an average value for every kilometer in Appendix II-3, "Results of Pavement Roughness Assessment". The shown results were converted to international roughness index (IRI) equivalents by the following approximate relationship formula presented by Kazdornii.

In case of Russian-made bump integrator (S) <= 300cm/km

$$IRI = 4.387 \times 10^{-1} - 3.367 \times 10^{-2} \times S + 1.742 \times 10^{-3} \times S^2 - 1.225 \times 10^{-5} \times S^3 + 3.677 \times 10^{-8} \times S^4 - 4.124 \times 10^{-11} \times S^5$$

In case of S > 300cm/km,

$$IRI = 6.76 + 0.00241 \times S$$

The results summarized and rated is shown in Table 7.1.5 (1) and Table 7.1.5 (2).

Table 7.1.5 (1) : Road Roughness on the Karabutak Road Section

Roughness Measurement with Russian-made Bump Integrator	Approximate IRI Equivalent	Rating	Total length (km)	Percentage of road at this rating (%)
< 105	< 6 (< 4)	Good	20	8
105-125	6-7.2 (4-7)	Fair	27	10
125-160	7.2-9.2 (7-9)	Poor	15	5
> 160	> 9.2 (> 9)	Very Poor	213	77
		Total	275	100

Note : The figures in parentheses are recommended by JICA and WB.

Table 7.1.5 (2) : Road Roughness on the Atyrau Road Section

Roughness Measurement with Russian-made Bump Integrator	Approximate IRI Equivalent	Rating	Total length (km)	Percentage of road at this rating (%)
< 105	< 6 (< 4)	Good	-	-
105-125	6-7.2 (4-7)	Fair	-	-
125-160	7.2-9.2 (7-9)	Poor	-	-
> 160	> 9.2 (> 9)	Very Poor	83	100
		Total	83	100

Note : The figures in parentheses are recommended by JICA and WB.

(3) Pavement Surface Condition

The extent and severity of surface defects were observed and recorded by visual inspections made by the Study Team. The results of the visual inspections are shown in Appendix II-2, "Results of Road Visual Inspection". From the results, two types of damage are considered : damage apparently due to a structural deficiency of the pavement and damage due to non structural reasons.

1) Damage Due to Pavement Structural Deficiency

Defects caused by a structural deficiency of the pavement essentially include deformations such as rutting, depressions, and cracks such as crocodile cracks.

The overall assessment of structural deficiency, based on 3-point scale is shown in Table 7.1.6.

Table 7.1.6 : Overall Assessment of Structure Deficiency

Sort of Damage	Karabutak Road Section		Atyrau Road Section	
	Percentage (%)	Rating	Percentage (%)	Rating
Deformation	32.8	2~3	4.7	2~3
Cracking	21.0		46.4	

Note : Pavement Defect Scale :
Percentage of length damaged <10% 1, 10% <=and<50% 2, >=50% 3

Data Source : JICA Study, 1996

2) Damage due to Non-Structural Reasons

This defect is generally unrelated to pavement structural bearing capacity. This is caused either by defective construction, poor material quality which include potholes, bleeding, corrugations, stripping, edge damage, loss of bitumen and small cracks.

The overall assessment of the conditions, based on a 3-point scale is shown in Table 7.1.7.

Table 7.1.7 : Overall Assessment of Non-Structural Deficiency

Sort of Damage	Karabutak Road Section		Atyrau Road Section	
	Percentage (%)	Rating	Percentage (%)	Rating
Longitudinal & transverse crack	20.2	2~3	91	2~3
Edge damage	12.1		20.0	
Sagging	7.0		60.7	
Waviness	23.0		41.2	
Bleeding	6.2		3.6	
Potholes	6.0		-	

Note : Pavement Defect Scale :
Percentage of length damaged <10% 1, 10% <=and<50% 2, >=50% 3

Data Source : JICA Study, 1996

The various superficial defects in each road section noted during the Study are described below.

In the Karabutak ~ Kzyl Orda border road section, severe potholes and edge damage are particularly concentrated at section km 975m to km 1030. Loss of bitumen and stripping are seen in common at sections km 1030 to km 1170km and km 1200 to km 1230km, and section km 1170 to km 1200 is a dirt road with severe rutting and potholes due to traffic. There are isolated longitudinal and transversal cracks, which appear mainly caused by large temperature swings, loss of interlock and adhesion, and aggravation by lack of maintenance. Uneven surface and depression are seen as main shoulder defect.

In the Atyrau ~ Mahambet road section, a loss of bitumen was noted at irregular intervals. Surfaces damages by flood inundation in 1993 and 1994 are common in this section, particularly the damages are seen at the lower altitude points.

By combining the two sets of rating in the matrix as shown in Table 7.1.8, one single parameter reflecting the overall pavement surface condition can be obtained.

The parameter thus obtained would reflect the surface quality and condition, as shown in Table 7.1.9.

Table 7.1.8 : Determination of Surface Condition Parameter

Rating		Non-Structural Deficiency		
		1	2	3
Structural	1	1	2	3
Deficiency	2	3	4	5
	3	5	6	7

Table 7.1.9 : Surface Quality of Surface Condition

Rating	Parameter	Description
Good	1	Ride comfortably at 100km/h or above. No sagging, rutting, potholes, cracks, waviness, or bleeding noticeable
Fair	2~3	Ride comfortably up to 100km/h. At 80km/h moderately perceptible movements or large undulations may be felt. Associated with occasional longitudinal and transverse cracks, moderate rutting, and shallow potholes exist.
Poor	4~5	Except for the worst roads in this category its possible to ride comfortably up to 60~80km/h, its not possible to avoid driving across the defects in the road resulting in frequent sharp movements or swaying. The defects in the road surface are deep rutting, very poor quality patches, severe clacking, and frequent deep and uneven waviness.
Bad	6~7	Necessary to reduce speed below 30km/h, severe disintegration of the road surface associated with many deep deformations or cracking and extreme waviness or sagging.

Data Source : JICA study, 1996

Road surface ratings of the priority project roads are summarized in Table 7.1.10 (1) and Table 7.1.10 (2).

Table 7.1.10 (1) : Road Surface Condition on the Karabutak Road Section

Sub Section (km)	Structural Deficiency Rating	Non-Structural Deficiency Rating	Surface Condition Parameter	Rating
965-971	2	2	4	Poor
972-977	2	2	4	Poor
978-1069	2	2	4	Poor
1070-1075	2	2	4	Poor
1076-1088	2	2	4	Poor
1089-1103	2	2	6	Bad
1104-1117	2	2	4	Poor
1118-1126	2	3	7	Bad
1127-1131	2	3	5	Poor
1132-1136	2	1	3	Fair
1137-1151	2	2	4	Poor
1152-1155	3	2	6	Bad
1156-1162	3	3	7	Bad
1163-1166	3	3	7	Bad
1167-1178	3	3	7	Bad
1179-1181	3	3	7	Bad
1182-1190	3	1	5	Poor
1191-1225	2	3	5	Poor
1226-1229	2	1	3	Fair
1230-1232	3	2	6	Bad
1233-1240	1	2	2	Fair

Data Source : JICA study, 1996

Table 7.1.10 (2) : Road Surface Condition on the Atyrau Section

Sub Section (km)	Structural Deficiency Rating	Non-Structural Deficiency Rating	Surface Condition Parameter	Rating
1-71	3	3	7	Bad
72-83	1	3	5	Poor

Data Source : JICA study, 1996

(4) Pavement Strength Condition

The assessment of pavement strength was based on estimation of K (actual vs. required pavement strain modulus).

K=E (actual)/E (required), E (actual) is determined by adjusting the value of the pavement modulus of stain, derived from actual deflection measurements.

$$E\ (actual) = D \times P\ (1 - M^2) / I$$

Where : D (cm) = Diameter of contract area tire/pavement
P (mega Pascal) = Tire pressure
M = Poisson coefficient
I (cm) = Deflection

The formula for determining the required pavement stain modulus, E (required), is given below ;

$$E\ (required) = 85 \log (NP \times a) - 288$$

Where : NP = The value obtained by converting the project daily truck traffic, at the end of the pavement's design life to the equivalent number of heaviest vehicles per lane.

a = Factor depending on type of surfacing.
For hot dense asphalt concrete, a = 7,000

Along the Karabutak ~ Kzyl Orda border road section and the Atyrau ~ Mahambet road section the average values for required E were estimated as 159 Mpa and 246 Mpa (Mega pascal) respectively.

Based on the results obtained, about 52% of the Karabutak ~ Kzyl Orda border road section is rated poor (K=0.55~0.85) and the rest is bad (K<0.55), and about 100% of the Atyrau ~ Mahambet road section is rated bad, as summarized in Table 7.1.11 (1) and Table 7.1.11 (2), and shown in Appendix II-5, Road Condition Chart".

Table 7.1.11 (1) : Pavement Strength Estimates on the Karabutak Road Section

Sub Section	K-Ratio	Rating	Sub Section	K-Ratio	Rating
965-1009	0.47	Bad	1010-1022	0.59	Poor
1023-1027	0.62	Poor	1028-1035	0.79	Poor
1036-1077	0.67	Poor	1078-1098	0.59	Poor
1099-1112	0.62	Poor	1113-1135	0.69	Poor
1136-1153	0.53	Bad	1154-1176	0.46	Bad
1177-1190	0.36	Bad	1191-1225	0.52	Bad
1226-1230	0.85	Poor	1231-1232	0.35	Bad
1233-1240	0.84	Poor	-	-	-

Data Source : JICA study, 1996

Table 7.1.11 (2) : Pavement Strength Estimates on the Atyrau Road Section

Sub Section	K-Ratio	Rating	Sub Section	K-Ratio	Rating
1-4	0.35	Bad	5~35	0.24	Bad
36-83	0.38~0.45	Bad	-	-	-

Data Source : JICA study, 1996

These results indicate a substantial deterioration of pavement condition. This deterioration is due to a lack of maintenance over a past few years, and to the heavier trucks passing on the road now.

(5) Overall Pavement Condition

A "Pavement Quality Index" is established by combining the surface condition parameter (see Table 7.1.8) and the K-ratio, according to the matrix shown in Table 7.1.12.

Table 7.1.12 : Determination of Pavement Quality Index

Rating		Structure Condition Parameter (K ratio)			
		> 1	0.85-1	0.55-0.85	< 0.55
Surface Condition	1	Q_0	Q_1	Q_2	Q_3
Parameter	2-3	S_1	Q_2	Q_3	Q_4
	4-7	S_2	Q_3	Q_4	Q_5

Each pavement quality index value corresponds to a pavement condition, as shown in Table 7.1.13.

Table 7.1.13 : Pavement Conditions Corresponding to Pavement Quality Index Rating

Quality Index	Condition
Q_0	Good Condition
S_1	Surface damage due to a construction defect in the upper layer
S_2	Very unusual surface damage, would require investigation
Q_1-Q_2	Limited pavement structure damage
Q_4-Q_5	Heavy pavement structure damage
Q_3	Uncertain case, requiring further investigation

Ratings Q4 and Q5, heavy pavement structural damage, is corresponding to the road over 96% of the length of the Karabutak ~ Kzyl Orda border road section and 100% of the length of the Atyrau road section.

Pavement Damage Evaluation using Parameter quality index ratings is summarized as Table 7.1.14 (1) and Table 7.1.14 (2), and shown in Appendix II-5, "Road Condition Chart".

Table 7.1.14 (1) : Pavement Damage Evaluation on the Karabutak Road Section

Sub section	Index	Damage	Sub section	Index	Damage
965-971	Q_5	Heavy	972-977	Q_5	Heavy
978-1069	Q_4	Heavy	1070-1075	Q_4	Heavy
1076-1088	Q_4	Heavy	1089-1103	Q_4	Heavy
1104-1117	Q_4	Heavy	1118-1126	Q_4	Heavy
1127-1131	Q_4	Heavy	1132-1136	Q_4	Heavy
1137-1151	Q_5	Heavy	1152-1155	Q_5	Heavy
1156-1162	Q_5	Heavy	1163-1166	Q_5	Heavy
1167-1178	Q_5	Heavy	1179-1181	Q_5	Heavy
1182-1190	Q_5	Heavy	1191-1225	Q_5	Heavy
1226-1229	Q_3	Uncertain	1230-1232	Q_5	Heavy
1233-1240	Q_3	Uncertain	-	-	-

Data Source : JICA study, 1996

Table 7.1.14 (2) : Pavement Damage Evaluation on the Atyrau Road Section

Sub section	Index	Damage	Sub section	Index	Damage
1-71	Q_5	Heavy	72-83	Q_5	Heavy

Data Source : JICA study, 1996

7.1.5 Condition of Culverts

The Karabutak ~ Kzyl Orda border road section has 62 culverts along its 275 km length, and the Atyrau ~ Mahambet road section has 22 culverts along its 83 km length. Appendix II-6, "Results of Visual Culvert Inspection" indicates their location, type, size, and of condition.

To evaluate the condition of the culverts, the extent and severity of defects such as scour, settlement, damage to headwalls and wingwalls, and missing headwalls and / or aprons were noted. The most common and serious defects for the culverts were broken, settled down and washed out.

From the overall rating for each inspected culvert, the number of pipe and box culverts in fair or bad condition were determined. Out of total 68 existing pipe culverts, 11 were thus estimated be in fair condition, 17 in bad condition. Of 12 box culverts, 5 were rated in fair condition and 2 were in bad condition. In other words, 8 culverts were classified as fair and 19 as bad on the Karabutak ~ Kzyl Orda Border road section, and 8
culverts were classified as fair on the Atyrau ~ Mahambet road section.

The condition of culverts on the Karabutak ~ Kzyl Orda border road section and the Atyrau ~ Mahambet road section is shown in Table 7.1.15 (1) and Table (2).

Table 7.1.15 (1) : Estimated Number of Culverts in Each Condition
(Karabutak-Kzyl Orda Border Road Section)

Section	Culvert	Dimension					Condition			
		Diameter or	No. of Orifice			Length	Fair		Bad	
(km-km)	Type	width/Height	1	2	3	(Average)	%	No.	%	No.
965 - 1154	Pipe	1.0	14	4	2	16.0	15	3	20	4
		1.5	12	8	5	16.0	20	5	20	5
1154 - 1240		1.0	6	2	-	16.0	0	-	75	6
		1.5	-	3	1	16.0	0	-	50	2
956-1154	Box	2 x (2.5 x 2.0)	-	2	-	17.0	-	-	100	2

Data Source : JICA Study Team, 1996

Table 7.1.15 (2) : Estimated Number of Culverts in Each Condition
(Atyrau-Mahambet Road Section)

Section	Culvert	Dimension					Condition			
		Diameter or	No. of Orifice			Length	Fair		Bad	
(km-km)	Type	width/Height	1	2	3	(Average)	%	No.	%	No.
0-83	Pipe	1.0	8	2	-	14.0	-	3	-	-
		1.5	-	1	-	14.0	-	-	-	-
	Box	(3.5 x 1.5)	10	-	-	12.0	50	5	-	-

Note : Figure in the round bracket means average width and height.
Data Source : JICA Study Team, 1996

7.2 Preliminary Improvement Design

The preliminary Improvement design is covering pavement improvement, vertical realignment, and culvert repair or replacement. The improvement design is separated into following steps :

(1) Establishment of appropriate design standards and methodology.
(2) Identification of sub-sections.
(3) Identification of typical improvement types.
(4) Determination of pavement strength requirements.
(5) Evaluation and selection of pavement alternatives.
(6) Establishment of preliminary pavement improvements.

7.2.1 Establishment of Design Standard and Methodology

The design standards for the geometric design and the pavement design were based on the future traffic forecasts.

The road category III was selected based on the traffic forecasts for the year 2018 (i.e. 20 years after the design year), which was about 1,848 vpd (3,983 pcu) for the Karabutak road section and 3,645 vpd (5,907 pcu) for the Atyrau road section. Category III road standard has a total width of 12m which includes 7.0m width of carriageway and two 2.5m width shoulders on either side.

The pavement design was based on both AASHO design method and FSU (Former Soviet Union) design standards and, the traffic volume for the year 2013 (i.e. 15 years after the design year), was used as the basis for pavement design.

7.2.2 Identification of Sub-Sections

From the result of the Section 7.1 "Assessment of Road Condition", The Karabutak ~ Kzyl Orda border road section and the Atyrau ~ Mahambet road section were divided into homogeneous sub-sections, according to the following characteristics :

(1) Climatic zone
(2) Average embankment height
(3) Average road width
(4) Average pavement composition and thickness
(5) Pavement quality index

Sub-sections are shown in Table 7.2.1 (1) and Table 7.2.1 (2).

Table 7.2.1 (1) : Sub-Sections of the Karabutak Road Section

Subsections (km)	Average Embankment Height (m)	Pavement Thickness Base course (cm)	Surf. Course (cm)	Pavement Quality Index
965-971	1.9	-	-	Q5
972-977	0.5	-	-	Q5
978-1069	0.7	22	4	Q4
1070-1075	1.1	8	6	Q4
1076-1088	0.4	-	-	Q4
1089-1103	1.1	18	5	Q4
1104-1117	0.6	12	6	Q4
1118-1126	0.9	-	-	Q4
1127-1131	0.6	12	4	Q4
1132-1136	3.2	-	-	Q4
1137-1151	0.3	-	-	Q5
1152-1155	1.2	-	-	Q5
1156-1162	0.6	-	-	Q5
1163-1166	1.2	-	-	Q5
1167-1178	0.7	-	12	Q5
1179-1181	1.0	-	-	Q5
1182-1190	0.7	-	-	Q5
1191-1225	1.0	-	15	Q5
1226-1229	1.0	24	4	Q3
1230-1232	1.3	-	-	Q5
1233-1240	1.4	-	-	Q3

Data Source : JICA Study, 1996

Table 7.2.1 (2) : Sub-Sections of the Atyrau Road Section

Subsections (km)	Average Embankment Height (m)	Pavement Thickness Base course (cm)	Surf. Course (cm)	Pavement Quality Index
1-71	1.0	4	19	Q5
72-83	1.4	-	-	Q5

Data Source : JICA Study, 1996

7.2.3 Identification of Typical Improvement Types

Four typical improvement types were identified, as shown in Table 7.2.2.

Table 7.2.2 : Typical improvement Type

Type I : Raising of Embankment and Construction of Pavement	
Condition	Embankment height is inadequate in places, in addition existing pavement is heavily damaged.
Solution	Remove existing asphalt layer, raise embankment as need and place new pavement.
Type II : Construction of New Subbase, Base and Surface Courses with Widening	
Condition	Existing pavement is heavily damaged, sand/gravel layer (subbase) is nonexistent or insufficient. Existing road width is narrow.
Solution	Remove asphalt layer, place new subbase, base and surface course. Carriageway / shoulder widening.
Type III : Construction of New Subbase, Base and Surface Courses	
Condition	Existing pavement is heavily damaged, sand/gravel layer (subbase) is nonexistent or insufficient.
Solution	Remove asphalt layer, place new subbase, base and surface course.
Type IV : Thickening of Subbase, and Construction of New Base and Surface Courses	
Condition	Existing pavement is heavily damaged, sand/gravel layer (subbase) not thick enough
Solution	Remove asphalt layer, increase subbase thickness, and place base and asphalt courses.

7.2.4 Pavement Strength Requirements

(1) General

The pavement thickness is designed on the basis of the design CBR of the subgrade and the number of 10 ton equipment axle load applications in one direction over ten years.

This design method was established through original methods and the experience of the Japan Highway Public Corporation and on the basis of ASSHO Road Test results. Therefore, FSU standards and design methodology is not adopted, FSU standards are applied to determine whether alternative pavement structures are feasible.

(2) Analysis of Traffic Load

The number of 10 ton equivalent axle load applications (Total number of axles passing over the pavement over ten years expressed in terms of 10 ton axle load applications) is estimated from the number of axle load based on the traffic demand forecast made by the Study Team.

Table 7.2.3 (1) and Table 7.2.3 (2) indicate cumulative number of 10 ton equipment axle load on the Karabutak and Atyrau road sections.

Table 7.2.3 (1) : Cumulative Number of 10 ton Equipment Axle Load on the Karabutak Road Section

Vehicle Type		Axle Load (Ai)	Standard 10 ton Equivalence Factor Single $(Ai/10)^4$	Tandem $(Ai/18)^4$	Number of Axle Load (Ni/day)	Equivalent Axle Load ESAi=Ni x $(Ai/10)^4$ or $(Ai/18)^4$
H. Truck	8.1t<=T<=14t	18.0	-	1.000	188	188
	T>14t	20.0	-	1.525	365	557
L.Truck	T<=5t	5.6	0.098	-	168	16
	5.1t<=T<=8t	10.0	1.000	-	252	252
Bus	Heavy	9.7	0.874	-	11	10
	Light	4.9	0.055	-	15	1

(1) Equivalent Standard 10 ton Axle Load/day	1024
(2) Accumulative Equivalent Standard 10 ton Axle Load [(1) x 30days x 12 months x 10/2 years]	184.32x 10^4
(3) Accumulative Equivalent Standard 10 ton Axle Load/lane [(2) x 0.55]	101.38x 10^4

Data Source : JICA study, 1996 (based on the estimated 2013 ADT)

Table 7.2.3 (2) : Cumulative Number of 10 ton Equipment Axle Load on the Atyrau Road Section

Vehicle Type		Axle Load (Ai)	Standard 10 ton Equivalence Factor Single $(Ai/10)^4$	Tandem $(Ai/18)^4$	Number of Axle Load (Ni/day)	Equivalent Axle Load ESAi=Ni x $(Ai/10)^4$ or $(Ai/18)^4$
H. Truck	8.1t<=T<=14t	18.00	-	1.00	153	153
	T>14t	20.00	-	1.52	98	149
L.Truck	T<=5t	5.59	0.0976	-	483	47
	5.1t<=T<=8t	10.00	1.0000	-	301	301
Bus	Heavy	93.67	0.8744	-	269	235
	Light	4.85	0.0553	-	351	19

(1) Equivalent Standard 10 ton Axle Load/day	904
(2) Accumulative Equivalent Standard 10 ton Axle Load [(1) x 30days x 12 months x 10/2 years]	162.72 x 10^4
(3) Accumulative Equivalent Standard 10 ton Axle Load/lane [(2) x 0.55]	89.50 x 10^4

Data Source : JICA study, 1996 (based on the estimated 2013 ADT)

(3) Characteristics of Subgrade

The characteristics of the subgrade were obtained through CBR estimation of the subgrade, subbase, and base course samples taken at 50km interval (or less) along the Karabutak ~ Kzyl Orda border road section and the Atyrau ~ Mahambet road section.

CBR values were converted using the formula below, based on correlation of soil testing according to AASHO method, because of a lack of CBR testing equipment.

$$CBR = A \times Es - B$$

where ; A : coefficient
B : coefficient
Es : Soil deformation modules, Mpa

This formula based on correlation of soil testing according to AASHTO method and VSN 46-83 (8,9), is derived by experts of Moscow Road-Transport Institute.

Table 7.2.4 (1) : Characteristics of Subgrade on the Karabutak Road Section

Location	Subgrade	Characteristics of Subgrade				
		Design Resil. Modulus (Mpa)		CBR		Internal Friction
(km)	soil	Sub. soil	Base	Soil	Base	Angle (°)
991+800	Fine sand	100	140	10	12	38
1036+500	Fine sand	100	150	10	12	38
1069+000	Dune sand	75	120	8	12	33
1098+900	Dune sand	75	130	8	12	33
1129+500	Fine sand	100	155	10	12	38
1191+25	Light sand	65	110	4	10	29

Data Source : JICA study, 1996

Table 7.2.4 (2) : Characteristics of Subbase on the Atyrau Road Section

Location	Subgrade	Characteristics of Subgrade				
		Design Resil. Modulus (Mpa)		CBR		Internal Friction
(km)	soil	Sub. soil	Base	Soil	Base	Angle (°)
48+100	Light loam	65	70	6	6	29

Data Source : JICA study, 1996

(4) Pavement Thickness Design

The pavement thickness is determined according to the following procedure. Values of TA, asphalt mixture equivalent layer depth and the thickness of each layer are obtained. The thickness of each layer should be set, based on a full consideration of locally available materials, climatic conditions, and ease of construction.

The minimum thickness of each layer, required by local design standards, is as follows :

(l) Dense asphalt concrete grain size 5~13 : 6cm

(II) Open graded asphalt concrete grain size 5~20 : 6cm
(III) Crushed stone base course (>2.5 dmax) : 10cm
(IV) Sand/gravel subbase (>3.0 dmax) : 15cm

(a) Determination of TA

The TA value is obtained from Fig. 7.2.1, using the subgrade design CBR calculated in Paragraph (3) and the number of 10 ton equipment load applications obtained in Paragraph (2).

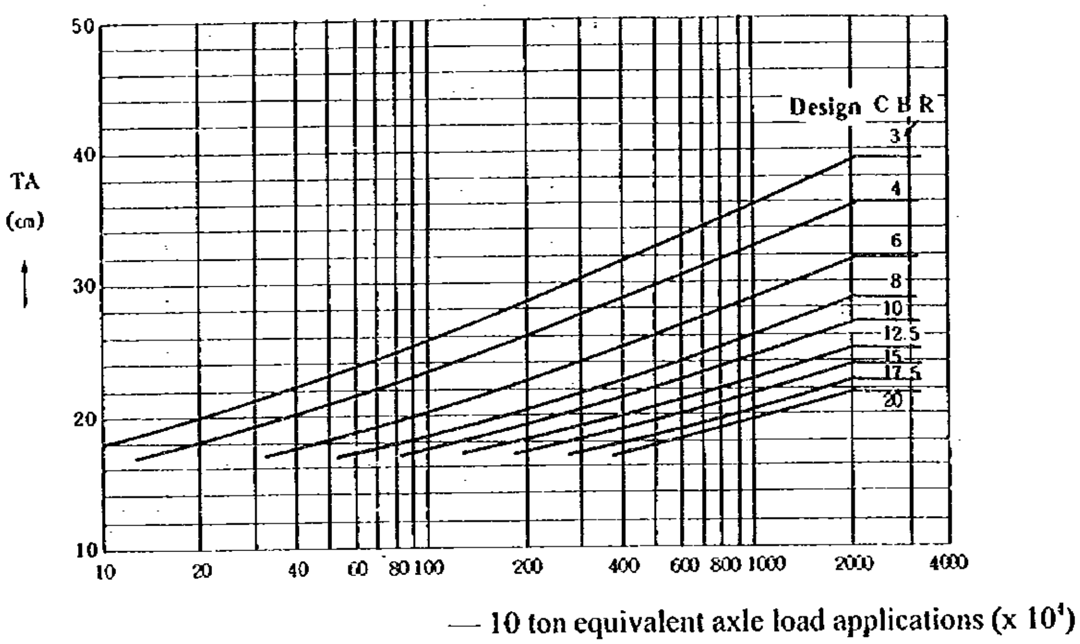


Fig. 7.2.1 : Design Curves for TA

(b) Minimum Thickness of Asphalt Mixture Layer (T min.)

The asphalt mixture layer of the traffic lane should consist of the surface course, the binder course and the hot mixing asphalt stabilized base course. Its total thickness should be determined so as to satisfy the minimum limit shown in Table 7.2.5.

Table 7.2.5 : Minimum Thickness of Asphalt Mixture Layer (T min.)

Classification	Minimum Thickness of Asphalt Mixture Layer	Remarks
Asphalt stabilized base course	18cm ~ 20cm	In principle, the total thickness of the surface course and the binder course should be 10cm

Data Source : Japan Highway Public Corporation

(c) Determination of the Thickness of Each Layer

The thickness of each layer Ti(i = 1,2,3) is determined so as to satisfy the following equation :

$$TA = a_1T_1 + a_2T_2 + a_3T_3$$
$$T_1 + T_2 >= T\ min.$$

where, T_1 : Thickness of surface and binder courses (cm)
T_2 : Thickness of base course (cm)
T_3 : Thickness of subbase course (cm)
a_1~a_3 : Coefficients of relative strength shown in Table 7.2.6.

Table 7.2.6 : Coefficients of Relative Strength

T	Construction Method	Conditions	Coefficient of Relative Strength		
			a_1	a_2	a_3
T_1	Asphalt surface course and binder course		1.00	-	-
T_2	Hot mixing asphalt stabilization		-	0.8~0.68	-
	Granular	Modified CBR >=80	-	0.32	-
	Cement stabilization	Compressive strength >=30 kgf/cm²	-	0.45	-
T_3	Granular material	Modified CBR >=30	-	-	0.25
	Cement stabilization	Modified CBR >=60	-	-	0.28

Data Source : Japan Highway Public Corporation

Pavement structure together with alternative layer thickness for of the Karabutak ~ Kzyl Orda border road section and the Atyrau ~ Mahambet road section are shown in Table 7.2.7 (1), Table 7.2.7 (2), and Table 7.2.7 (3). The applied layer thickness is selected from among alternatives taking into consideration the easiness and cost of construction.

Table 7.2.7 (1): Pavement Structure Alternatives for the Karabutak Road Section

Type I, Type IV $T_A = 20$ [CBR : 6, AEAL : 101.38 x 10^4]

No.	Thickness of Layers (cm)				Total Thickness (cm)
	Surface	Binder	Base course	Subbase course	
	Dense Asphalt concrete	Open Graded Asphalt concrete	Crushed Stone Base course	Sand/Gravel Subbase	
1	4	6	10	35	55
2	4	6	15	25	50
3	4	6	20	20	50
4	4	6	25	15	50
Selected:	Dense A.C : 4cm, Open A.C : 6cm, Crushed stone : 15cm, Sand/Gravel : 25cm				

Data Source : JICA Study, 1996

Table 7.2.7 (2) : Pavement Structure Alternatives for the Karabutak Road Section

Type III					T_A = 18 [CBR : 8~10, AEAL : 101.38 x 10^4]
No.	Thickness of Layers (cm)				Total Thickness (cm)
	Surface	Binder	Base course	Subbase course	
	Dense Asphalt concrete	Open Graded Asphalt concrete	Crushed Stone Base course	Sand/Gravel Subbase	
1	4	6	10	25	45
2	4	6	15	20	45
3	4	6	20	15	45
Selected:	Dense A.C : 4cm, Open A.C : 6cm, Crushed stone : 15cm, Sand/Gravel : 20cm				

Data Source : JICA Study, 1996

Table 7.2.7 (3) : Pavement Structure Alternatives for the Atyrau Road Section

Type I, Type II					T_A = 20 [CBR : 6, AEAL : 89.50 x 10^4]
No.	Thickness of Layers (cm)				Total Thickness (cm)
	Surface	Binder	Base course	Subbase course	
	Dense Asphalt concrete	Open Graded Asphalt concrete	Crushed Stone Base course	Sand/Gravel Subbase	
1	4	6	10	35	55
2	4	6	15	25	50
3	4	6	20	20	50
Selected:	Dense A.C : 4cm, Open A.C : 6cm, Crushed stone : 15cm, Sand/Gravel : 25cm				

Data Source : JICA Study, 1996

7.2.5 Road Improvement Solutions

In all Sections, the existing pavement is damaged heavily (pavement Quality Index Q_4 or Q_5), and should be reconstructed after removed of the asphalt layer. The reconstruction measure is classified into 4 types as Improvement Type I~IV.

Improvement Type I

The sections with average embankment height of less than 1.0m are inadequate for frost heave protection, so it is necessary to fill-up the embankment approximately 0.5m more. Type I consists basically of filling-up the embankment and new pavement construction. For the pavement structure calculation, Type I is adopted for the sections of which CBR value of the subgrade is 6, and of which accumulative equivalent standard 10 ton axle load/lane(AEAL) is 101.38*104. The pavement structure consists of four layers : dense-graded asphalt concrete 4cm, open-graded asphalt concrete 6cm, crushed stone base course 15cm and sand/gravel subbase course 25cm (Fig. 7.2.1 (1)).

Improvement Type II

The sections with average carriageway width of less than 7.0m do not meet Category III road standard, so it is necessary to widen the carriageway. Improvement Type II is to widen the carriageway, to remove the existing black stone asphalt layer and to construct new pavement. For the pavement structure calculation, Type II is adopted for the sections of which CBR value of the subgrade is 6, and of which Accumulative equivalent standard 10 ton axle load/lane(AEAL) is 89.5*104. The pavement structure consists of four layers : dense-graded asphalt concrete 4cm, open-graded asphalt concrete 6cm, crushed stone base course 15cm and sand/gravel subbase course 25cm (Fig. 7.2.1 (2)).

Improvement Type III

Type III is to construct new pavement after removal of the existing asphalt layer, and is divided into 2 sub-types (Type III-1 and Type III-2). For the pavement structure calculation, Type III-1 and Type III-2 is adopted for the sections of which accumulative equivalent standard 10 ton axle load/lane(AEAL) is 101*104, Type III-1 is adopted for the sections of which CBR value of the subgrade is more than 10, and Type III-2 is adopted for the sections of which CBR value is between 9 and 5. The former's structure consists of 4cm of dense-graded asphalt concrete, 6cm of open-graded asphalt concrete, 15cm of crushed stone base course and 20cm of sand/gravel subbase course, and the later's structure consists of 4cm of dense-graded asphalt concrete, 6cm of open-graded asphalt concrete, 15cm of crushed stone base course and 25cm of sand/gravel subbase course (Fig. 7.2.1 (3) & (4)).

Improvement Type IV

In some sections, having usable existing subbase, Type IV which is to construct new pavement instead of existing black stones and to thicken the existing subbase is adopted. For the pavement structure calculation, Type IV is adopted for the sections of which CBR value of the subgrade is 6, and of which accumulative equivalent standard 10 ton axle load/lane(AEAL) is 101.4*104. The pavement structure consists of 4cm of dense-graded asphalt concrete, 6cm of open-graded asphalt concrete, 15cm of crushed stone base course and 15cm of sand/gravel subbase course (Fig. 7.2.1 (5)).

The Improvement Types I~IV are illustrated in Fig. 7.2.1 (1) to Fig. 7.2.1 (5). The Improvement Types for each sub-section of the priority projects is shown below in Table 7.2.8.

Table 7.2.8 : Road Improvement by Type of Improvement for Priority Projects

Sub-section (km)	Improvement Types	Subsection (km)	Improvement Types
Karabutak ~ Kzyl Orda Border Road Section			
965-971	III-1	1152-1155	III-1
972-977	I	1156-1162	I
978-1069	I	1163-1166	III
1070-1075	III-1	1167-1178	I
1076-1088	I	1179-1181	III-1
1089-1103	III-1	1182-1190	I
1104-1117	I	1191-1225	III-2
1118-1126	III-1	1226-1229	IV
1127-1131	I	1230-1232	III-1
1132-1136	III-1	1233-1240	IV
1137-1151	I	-	-
Atyrau~Mahambet Road Section			
1-71	I	72-83	II

Data Source : JICA Study, 1996

The road improvement plan for the Karabutak to Kzyl Orda Border road section and the Atyrau to Mahambet road section is shown in Fig. 7.2.2 (1) and Fig. 7.2.2 (2) respectively.

Fig. 7.2.1(1) : Cross-Section of Road for Type-I Improvement

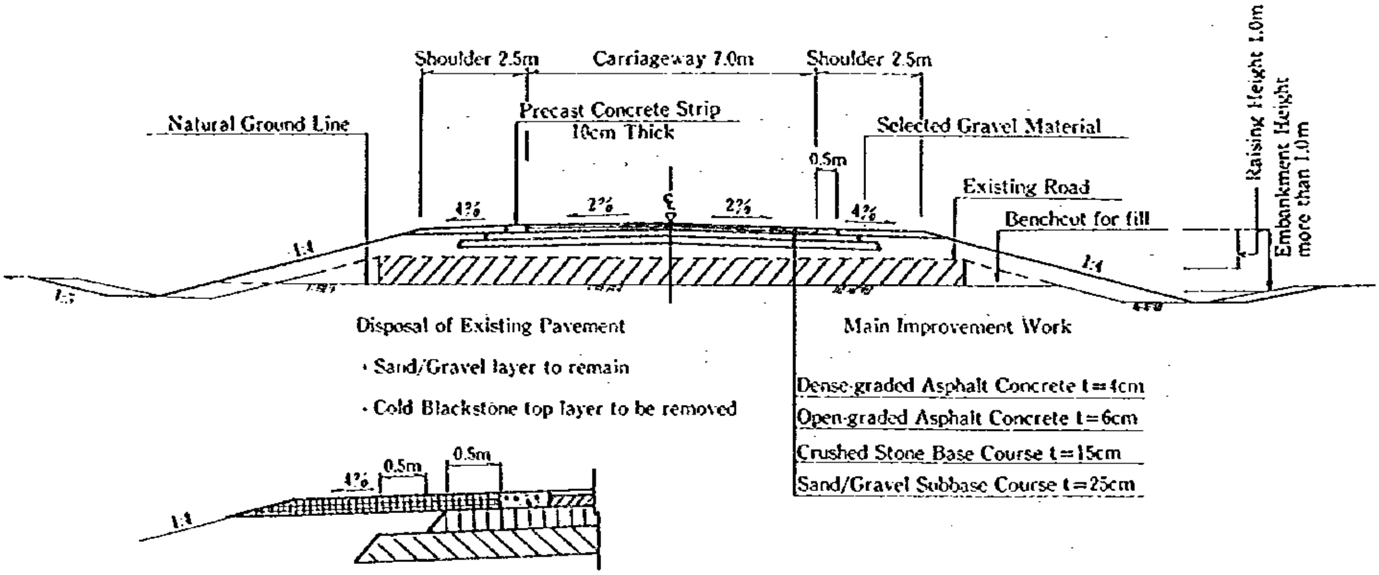


Fig. 7.2.1(2) : Cross-Section of Road for Type-II Improvement

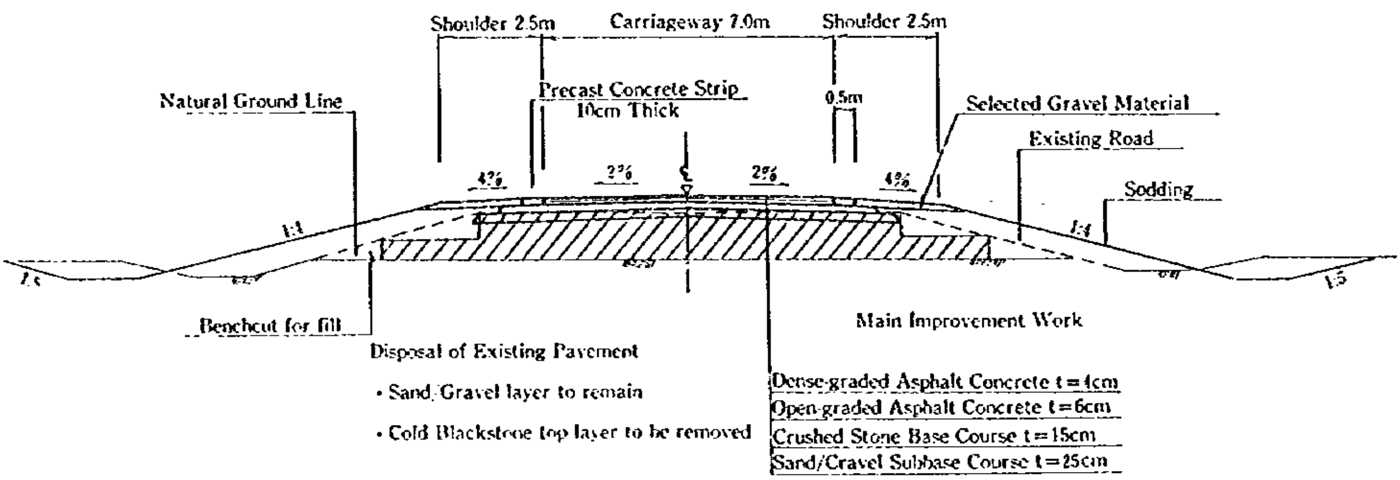


Fig. 7.2.1(3) : Cross-Section of Road for Type-III-1 Improvement

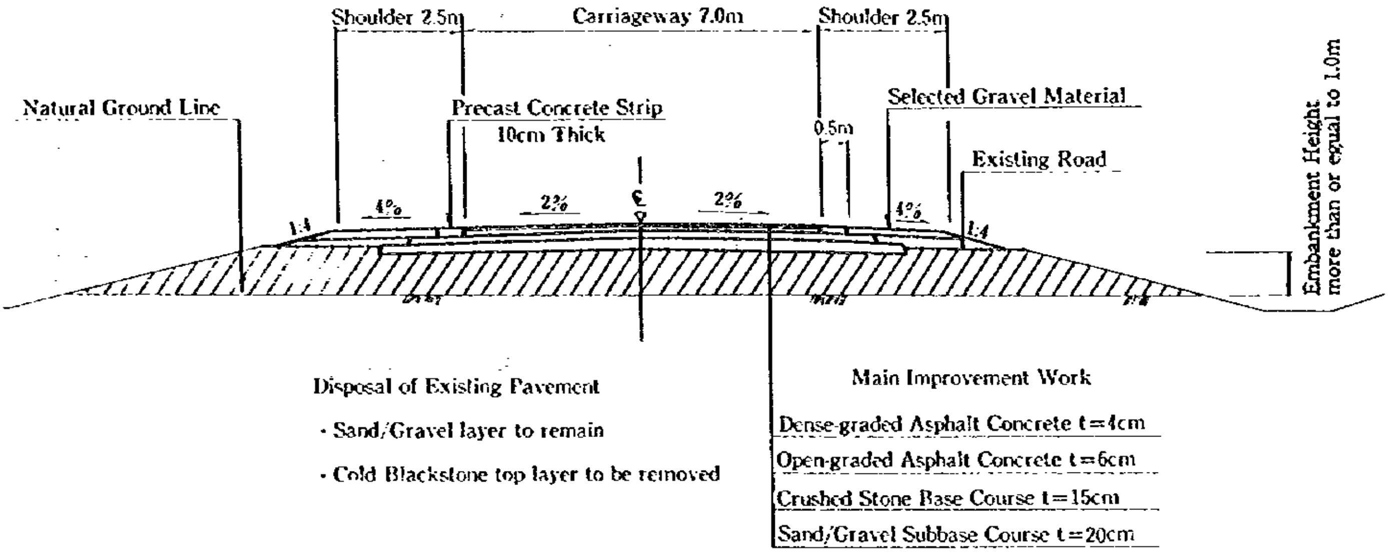


Fig. 7.2.1(4) : Cross-Section of Road for Type-III-2 Improvement

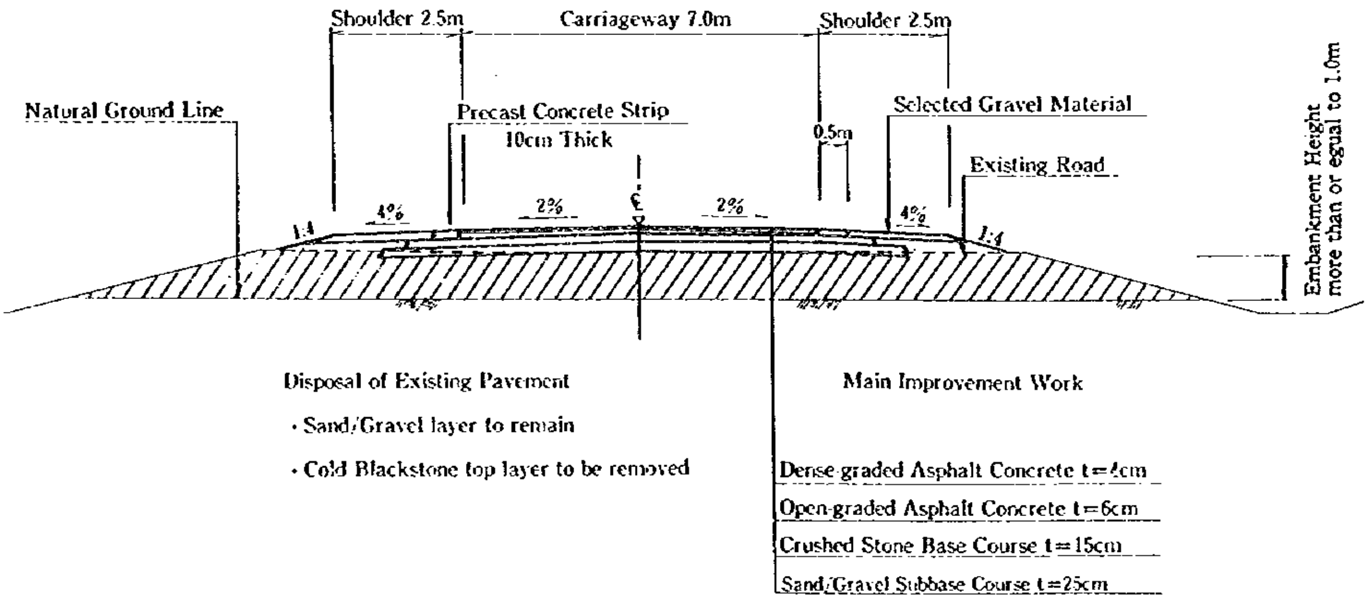
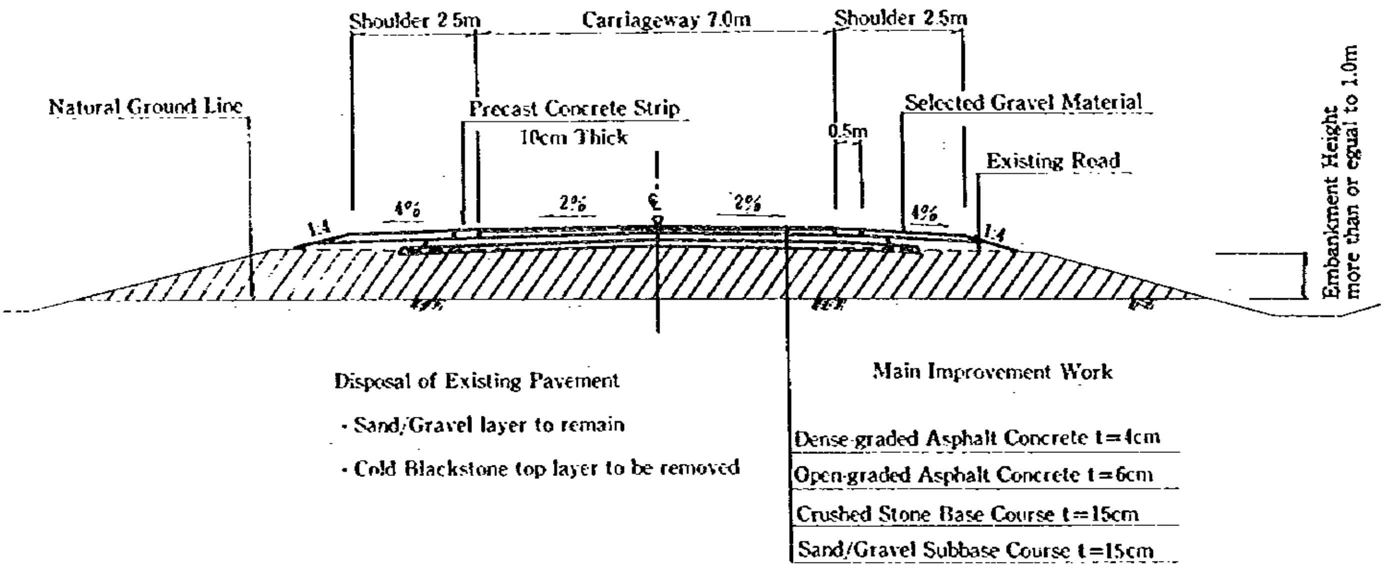


Fig. 7.2.1(5) : Cross-Section of Road for Type-IV Improvement



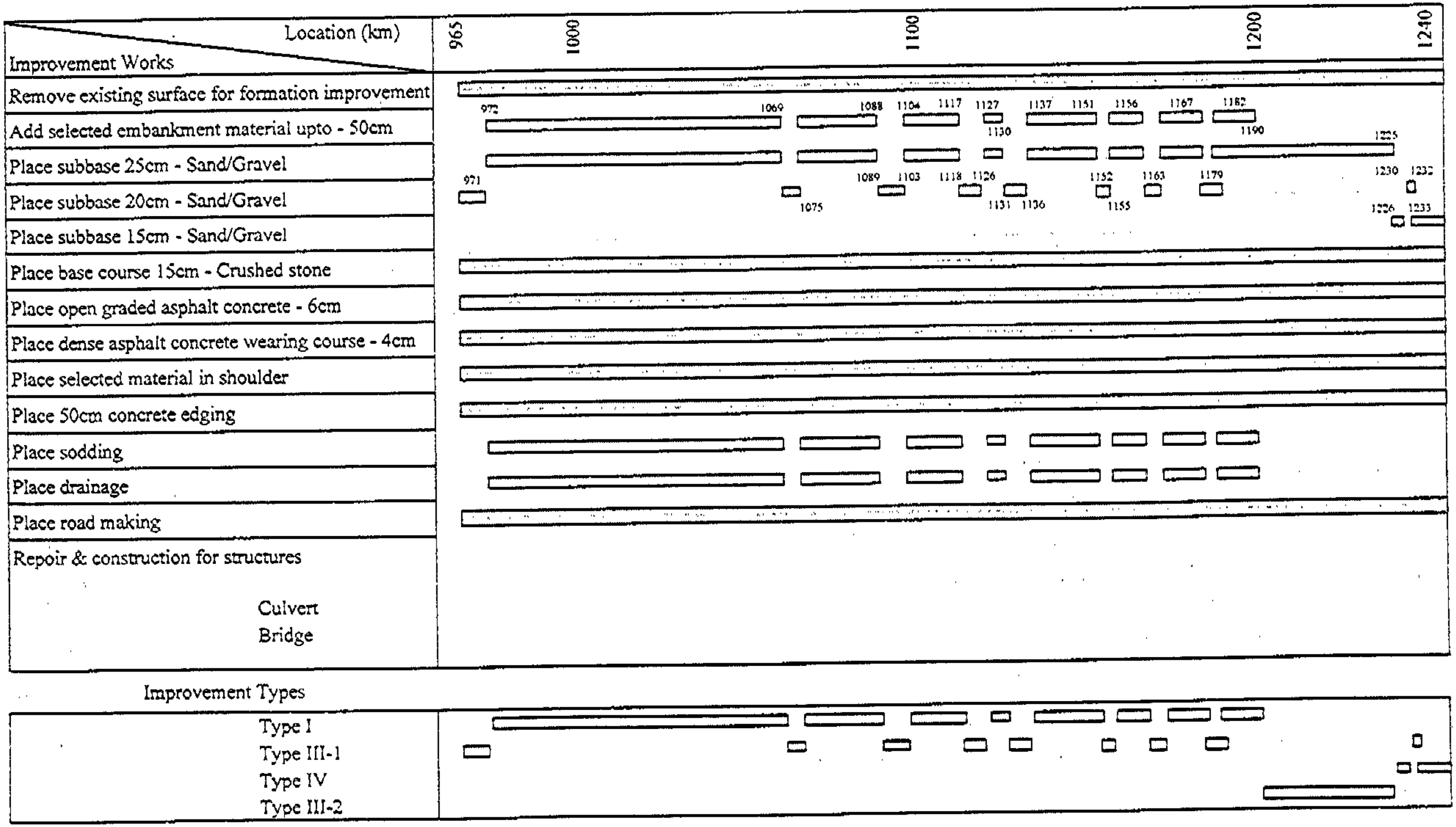


Fig. 7.2.2 (1) : Road Improvement Plan on the Karabutak ~ Kzyl Orda Border road section

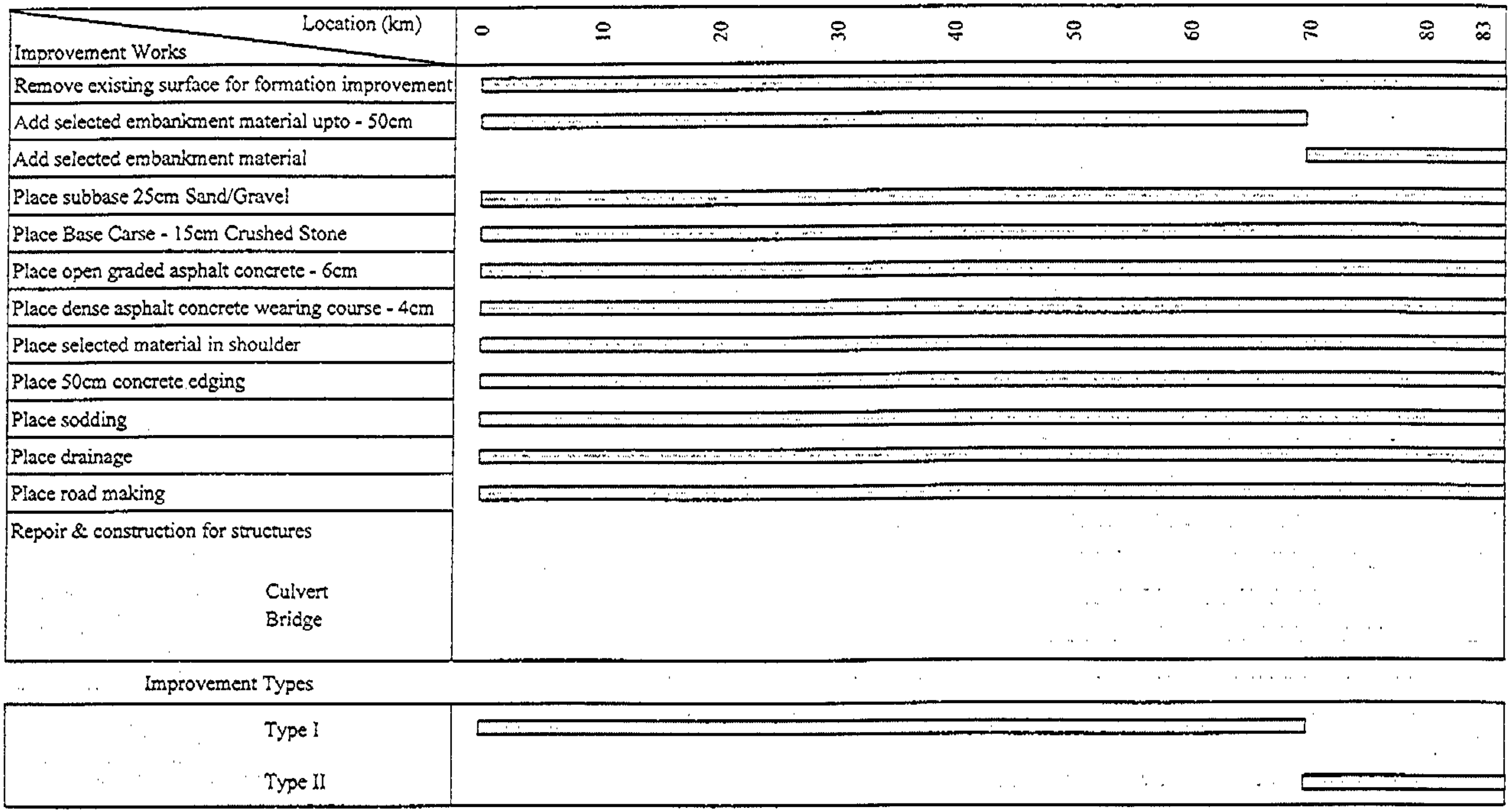


Fig. 7.2.2 (2) : Road Improvement Plan on the Atyrau ~ Mahambed road section

7.2.6 Flood Measurement

As described in section 3.4.2 (3), according to the Scientific Investigation Report written by the Water Resource Committee of the Republic of Kazakhstan, the Caspian Sea in Atyrauskaya state is characteristic to have periodic water level fluctuations of 6~7m at 70~100 years cycle. But the design water level for facilities along the coast of the Caspian Sea was estimated 22.5m under the sea level.

In the Atyrau~Mahambet road section, the planed road seems not to be flooded because the formation level of the road is higher than the design level. However, in the future, it is predicted that the road sections which have a low embankment height are flooded as like the experience in 1993 and 1994, in case of unexpected increase of the water of not only the Caspian Sea itself, but also the Ural river which flows into the Caspian Sea.

Therefore, to solve the above problem, the following measures are taken to improve the road.

(1) The road sections, km 43.00 ~ 43.15, km 48.40 ~ 48.42, km 56.50 ~ 56.62, km 61.35 ~ 61.50, km 67.80 ~ 67.93, km 69.10 ~ 69.30, km 71.20 ~ 71.50, km 73.80 ~ 73.95, km 74.70 ~ 74.90, km 78.80 ~ 78.95, which have low embankment heights are redesigned with suitable embankment heights (more than 1.0m), and equalizer channels by culverts are installed in the embankments to prevent the rise of water and to allow drainage of flood water (when detailed designs are made, the locations and dimensions of the new culverts should be reconsidered based on detailed field survey and hydrological data)

Equalizer channels by culverts are shown in Table 7.2.9.

Table 7.2.9 : Equalizer Channels by Culverts

Location (km)	Type	Dimension (m)	No. of Places
43.00 ~ 43.15	Box culvert	3 (2.0 x 1.5)	3
48.40 ~ 48.42	〃	〃	1
56.50 ~ 56.62	〃	〃	2
61.35 ~ 61.50	〃	〃	3
67.80 ~ 67.93	〃	〃	2
69.10 ~ 69.30	〃	〃	4
71.20 ~ 71.50	〃	〃	6
73.80 ~ 73.95	〃	〃	3
74.70 ~ 74.90	〃	〃	4
78.80 ~ 78.95	〃	〃	3

Data Source : JICA study, 1996

(2) The pavement composition and thickness are designed considering the decrease of the strength of the subgrade during floods.

Chapter 8 Bridges for Priority Project

Chapter 8 Bridges for Priority Project

8.1 General

8.1.1 Basic Concept of Improving of Bridges

The bridge improvement implementation policy was decided as follows in conformity with the evaluation of the existing bridges. For improving the existing bridges, the removal of structural flaws, as well as repairing of the destroyed places, should be executed on them.

(1) Places to be Repaired

(a) To renew the extremely deteriorated bridges.
(b) To replace the hollow slab beams with T type slab for renewed bridges because the thickness of the current hollow slab beams is too thin.
(c) To repair the destroyed part of the beams.
(d) To renew the all of the handrail.
(e) To repair the worn out slab.

(2) Repair of Structural Defects

(a) Not to use Pile bent type abutment for the bridges to be renewed (to be constructed), and to improve the abutments and to reform the retaining wall for the bridges to be repaired (to be improved).
(b) To strengthen some piers which are too slender and to repair the connection between horizontal member and vertical member for the bridges to be improved.
(c) To install the transverse beams for all bridges.
(d) To extend the span of some bridges to avoid that the abutments contact with the lake water.

8.1.2 Weather Conditions

The concrete cast in hot weather, more than 30 degrees Celsius, should make accelerated set or hair crack. Thus the quality control of the concrete would be difficult.

The other hand, were the concrete cast in the atmosphere of cold weather, below zero degrees, the concrete should sustain by the frost damage. Also the curing concrete work would be difficult.

Therefore, when the implementation program of the project is planned, the countermeasure how to execute the field concrete casting work cope with the atmosphere should be devised.

8.1.3 Soil Conditions

(1) The Karabutak ~ Kzyl Orda border road section

To get the existing bridge soil data, boring survey for soil had been executed on this section by the Study Team.

According to the investigation result, soil condition of this section are very profitable for construction of the bridges.

Because there is solid clay in the shallow place, which is hard enough for the supporting heavy load, almost all the foundations of the existing bridges are laid directly on the ground. However, the clay has the nature which softens when it contains enough water in the long period, the grounding surface between foundation and the earth is scoured off by the flood with comparatively long-range. Therefore the foundations of the bridges should be inserted into the ground sufficiently so as not the ground surface to be scoured off by the flood.

On the contrary, though the places where the soft clay is deposited thick is no more than 20 m, the foundations have to be supported by the piles.

(2) The Atyrau ~ Mahambet road section

According to the existing soil data, the thickness of the accumulation layer is bigger than the Karabutak ~ Kzyl Orda border road section. Taking into consideration that this area is located near the Caspian Sea, it is possible to understand it. Therefore when the bridges are constructed the foundation should be supported by the piles. The required length of piles of some places would be 20 m or more. In the meantime, in Kazakhstan, as for the concrete piles which are produced at the factory, the maximum length is 11.5 meters. Therefore, when using these piles, the device which join the piles are necessary.

8.1.4 Specifications

Generally speaking, the bridge construction manual which is used in Kazakhstan does not have a big difference comparing the manual which is used in the other countries. However, as for the way of thinking of the live load, there is a little difference. For in the specification, it is prescribed that the caterpillar loads of a tank which total weight is 80 ton should be considered in the design of the bridges. Therefore the way of thinking on the live load should be followed the way of thinking of the international standard such as AASHTO.

8.2 Preliminary Design

In conformity with the basic concept of improving bridges, the following preliminary design has been executed.

8.2.1 General

As this preliminary design is for the feasibility study, main efforts on this design are not concentrated on the decision of the configuration but on the analysis of the quantity and cost of the construction of the bridges. Therefore the configuration drawing of this section is not based on the detailed structural calculation sheet of the design but depend on the existing data in Japan.

In the detailed design stage, the detailed design of each bridge which is consistent with the each circumstance should be executed.

8.2.2 Design

(1) Superstructure

(a) Increasing of Cross Sectional Area

The PC hollow pretension beams of span 18 m length which are produced in Kazakstan have been compared with product in Japan. The result is as follows.

Produced in Kazakstan→3,695 cm^2 / m   Thickness of slab→6.5 cm
Whereas in Japan   →4,135 cm^2 / m   Thickness of slab→14.0 cm

Meanwhile, as for moment inertia of the both beams, they are almost the same figure (2.5×10^6 cm^4).

Judging from the above fact, it could be said that the beams produced in Kazakstan is very thin and very weak of the bending stiffness. In fact, the thickness of the slab 6.5 cm is extremely thin considering the load of heavy traffic in future.

Taking the above situation into considering, the hollow slab beam produced in Kazakstan would not be used but T type reformed beams would be adopted.

(b) Installation of Transverse Beams

Distributing the live load to other main beams, transverse beams should be fixed between main beams regardless of the beams are improved or renewed. However, as for the beams of existing hollow slab bridges, for the transverse beams would not be fixed in the installed beams, the beams would not to be reused. Thus the typical cross section is shown in Fig. 8.2.1.

(2) Substructure

As mentioned before any pre-cast blocks would not be used. Out line of the configuration of the substructure is shown in Fig. 8.2.2 and Fig. 8.2.3.

(3) Wings to be Improved

The wings for improving bridges are to be renovated for prevention of moving of soil to the front of the pile bent type abutment as shown in Fig. 8.2.4.

Fig. 8.2.1 : Superstructure

Cross Section

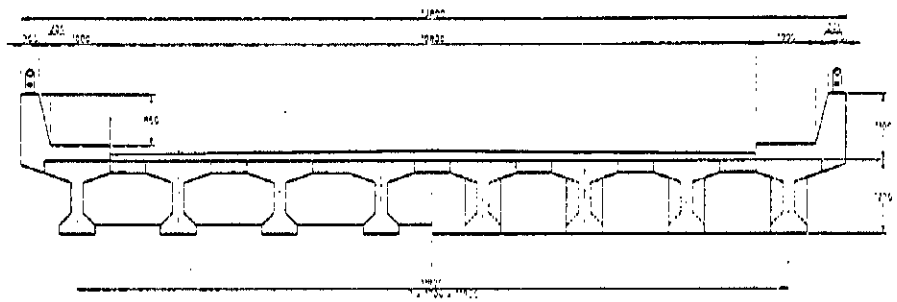


Fig. 8.2.2 : Abutment

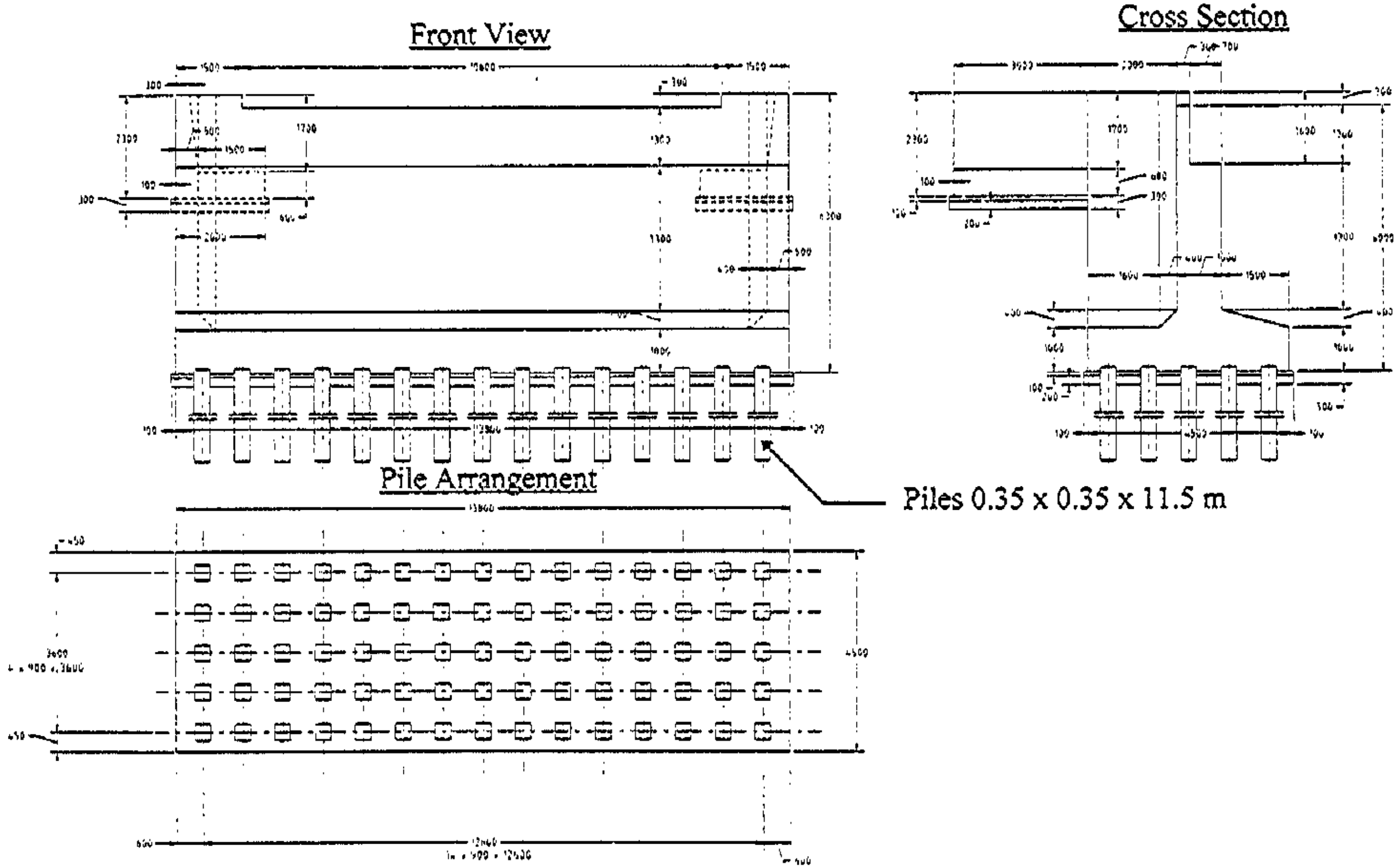


Fig. 8.2.3 : Pier

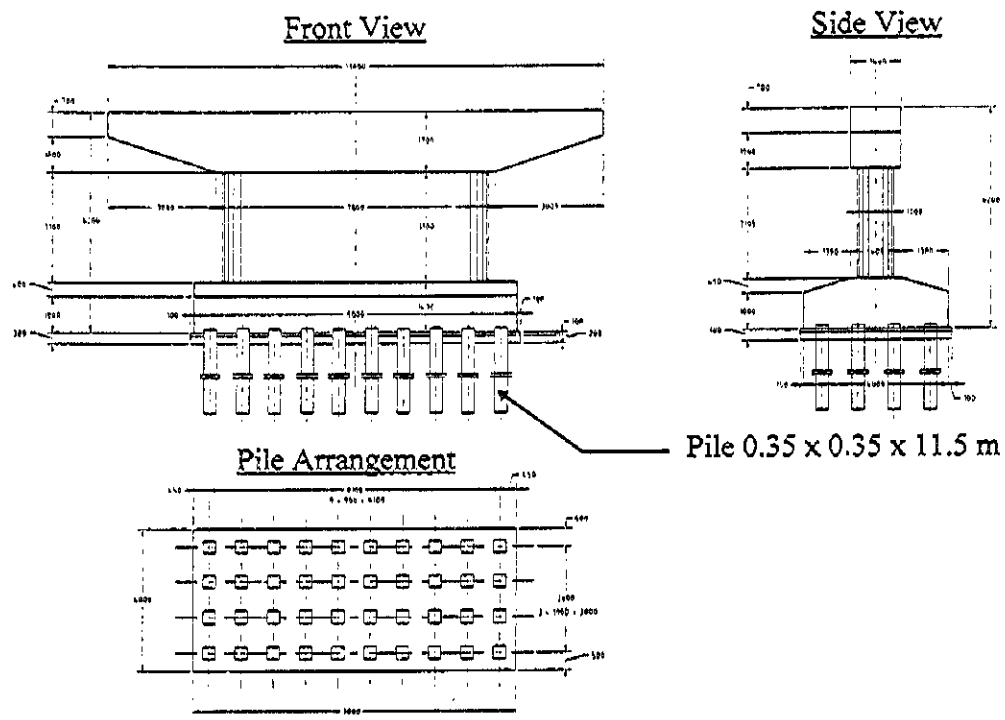
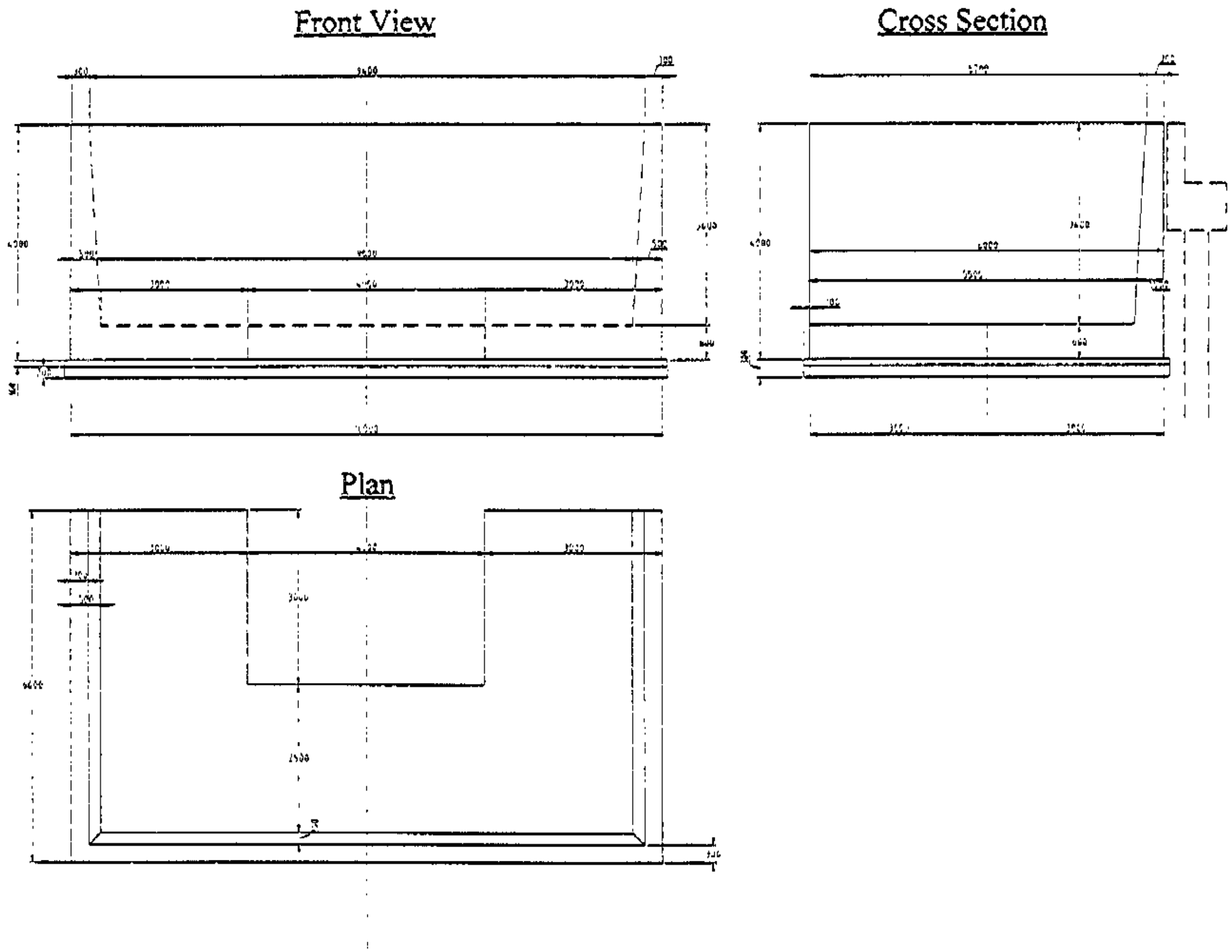


Fig. 8.2.4 : Improvement of Wing Wall



8.2.3 Volume of Works for Cost Estimation

(1) Bridge to be constructed

Here, the quantity of the standard bridge with two simple 24 m spans would be taken up as a subject of the project cost analysis. Volume of each work item are summarized in Table 8.2.1. The detail calculation of volume is described in Appendix III-3.

Table 8.2.1 : Volume of Works to construct a standard bridge

Item	Unit	Quantity	Number of Places	Total Quantity	Remarks
Concrete Volume					
(1) Abutment	m^3	134.90	2	269.80	
(2) Retaining Wall	m^3	5.64	4	22.56	
(3) Approach Board	m^3	19.44	2	38.88	
(4) Pier	m^3	99.07	1	99.07	
Total	m^3			430.31	
Structural Excavation					
(1) Abutment	m^3	244.20	2	488.40	
(2) Retaining Wall	m^3	21.60	4	86.40	
(3) Approach Board	m^3	74.34	2	148.68	
(4) Pier	m^3	100.00	1	100.00	
Total	m^3			823.48	
Piling Work (Pile 0.35 X 0.35 X 11.5 m)					
(1) Abutment	Nos.	75	2	150	
(2) Pier	Nos.	40	1	40	
Total	Nos.			190	
Superstructure Work					
(1) Beam Installation	Nos.	16	1	16	
(2) Transverse Beam	Nos.	16	1	16	
(3) Bridge Surface Work	m^2	678.96	1	678.96	
Demolition Work					
(1) Beams	m^3	146.72	1	146.72	
(2) Slab, Curb etc.	m^3	5.50	1	5.50	
(3) Abutment	m^3	110.01	2	220.02	
(4) Retaining Wall	m^3	4.45	4	17.80	
(5) Approach Board	m^3	9.72	2	19.44	
(6) Pier	m^3	78.25	1	78.25	
Total	m^3			487.73	
Scaffolding Work					
(1) Abutment	m^3	231.60	2	463.20	
(2) Pier	m^3	182.40	1	182.40	
Total	m^3			645.60	

(2) Bridge to be Improved

Here, the quantity of the standard bridge with one simple 24 m span would be taken up as a subject of the project cost analysis. Volume of each work item are summarized in Table 8.2.1. The detail calculation of volume is described in Appendix III-3.

Table 8.2.2 : Volume of Works to improve a standard bridge

Item	Unit	Quantity	Number of Places	Total Quantity	Remarks
Concrete Volume					
(1) Wing Wall	m^3	57.63	2	115.26	
(2) Approach Board	m^3	14.40	2	28.80	
Total	m^3			144.06	
Structural Excavation					
(1) Wing Wall	m^3	231.00	2	462.00	
(2) Approach Board	m^3	50.40	2	100.80	
Total	m^3			562.80	
Superstructure Work					
(2) Transverse Beam	Nos.	6	1	6	
(3) Bridge Surface Work	m^2	246.00	1	246.00	
Demolition Work					
(1) Approach Board	m^3	7.20	2	14.40	
(2) Slab, Curb etc.	m^3	5.50	1	5.50	
(3) Retaining Wall	m^3	4.45	4	17.80	
Total	m^3			37.70	

8.2.4 Improvement Program

According to the investigation of the existing bridges, the following improvement plane would be applied.

(1) Bridges on the Karabutak ~ Kzyl Orda Border road section

The number of bridges, their type of structure and dimensions along with the measures of improvement for bridges on this road section are given in Table 8.2.3. The location of bridges is shown in Fig. 8.2.5.

(2) Bridges on the Atyrau ~ Mahambet road section

The number of bridges, their type of structure and dimensions along with the measures of improvement for bridges on this road section are given in Table 8.2.4. The location of bridges is shown in Fig. 8.2.6.

Table 8.2.3 : Bridges on Karabutak - Kzyl-Orda Border Road Section

Bridge	Type of Structure			Span	Width	Completion	Improvement
Number	Girder	Abutment	Pier	(m)	(m)	Year	Measure
26	PC T Type Girder	Pile bent Type	Block Stacking Type	5 @ 21.0 m	11.4 m + 2.0 m	1984	To be Improved
27	Hollow Slab Girder	Block Stacking Type		Simple 18.0 m	10.2 m + 1.5 m	1981	To be Renewed
28	PC T Type Girder	Pile bent Type	Composition Type	8 @ 22.6 m	7.0 m + 2.0 m	1974	To be Renewed
29	Hollow Slab Girder	Round Columns	Round Columns	2 @ 18.0 m	10.5 m + 2.0 m	1982	To be Renewed
30	Hollow Slab Girder	Composition Type		Simple 18.0 m	10.0 m + 2.0 m	1982	To be Renewed
31	Hollow Slab Girder	Composition Type	Round Columns	2 @ 18.0 m	10.0 m + 2.0 m	1982	To be Renewed
32	Hollow Slab Girder	Pile bent Type	Cast-in-Place Type	2 @ 18.0 m	10.0 m + 2.0 m	1982	To be Renewed

Table 8.2.4 : Bridges on Atyrau - Mahambet Road Section

Bridge	Type of Structure			Span	Width	Completion	Improvement
Number	Girder	Abutment	Pier	(m)	(m)	Year	Measure
1	PC T Type Girder	Pile bent Type	Pile bent Type	4 @ 16.0 m	8.0 m + 1.5 m	1982	To be Improved
2	PC T Type Girder	Pile bent Type	Pile bent Type	4 @ 15.0 m	8.0 m + 1.0 m	1962	To be Renewed
3	PC T Type Girder	Pile bent Type	Pile bent Type	4 @ 15.0 m	8.0 m + 2.0 m	1962	To be Renewed
4	Hollow Slab Girder	Pile bent Type	Pile bent Type	3 @ 16.0 m	8.0 m + 2.0 m	1983	To be Improved
5	PC T Type Girder	Pile bent Type	Pile bent Type	2 @ 16.0 m	8.0 m + 2.0 m	1969	To be Renewed
6	PC T Type Girder	Pile bent Type	Rigid Frame Type	3 @ 15.0 m	8.0 m + 2.0 m	1972	To be Improved
7	Reinforced T Girder	Pile bent Type	Pile bent Type	3 @ 15.0 m	8.0 m + 2.0 m	1972	To be Improved

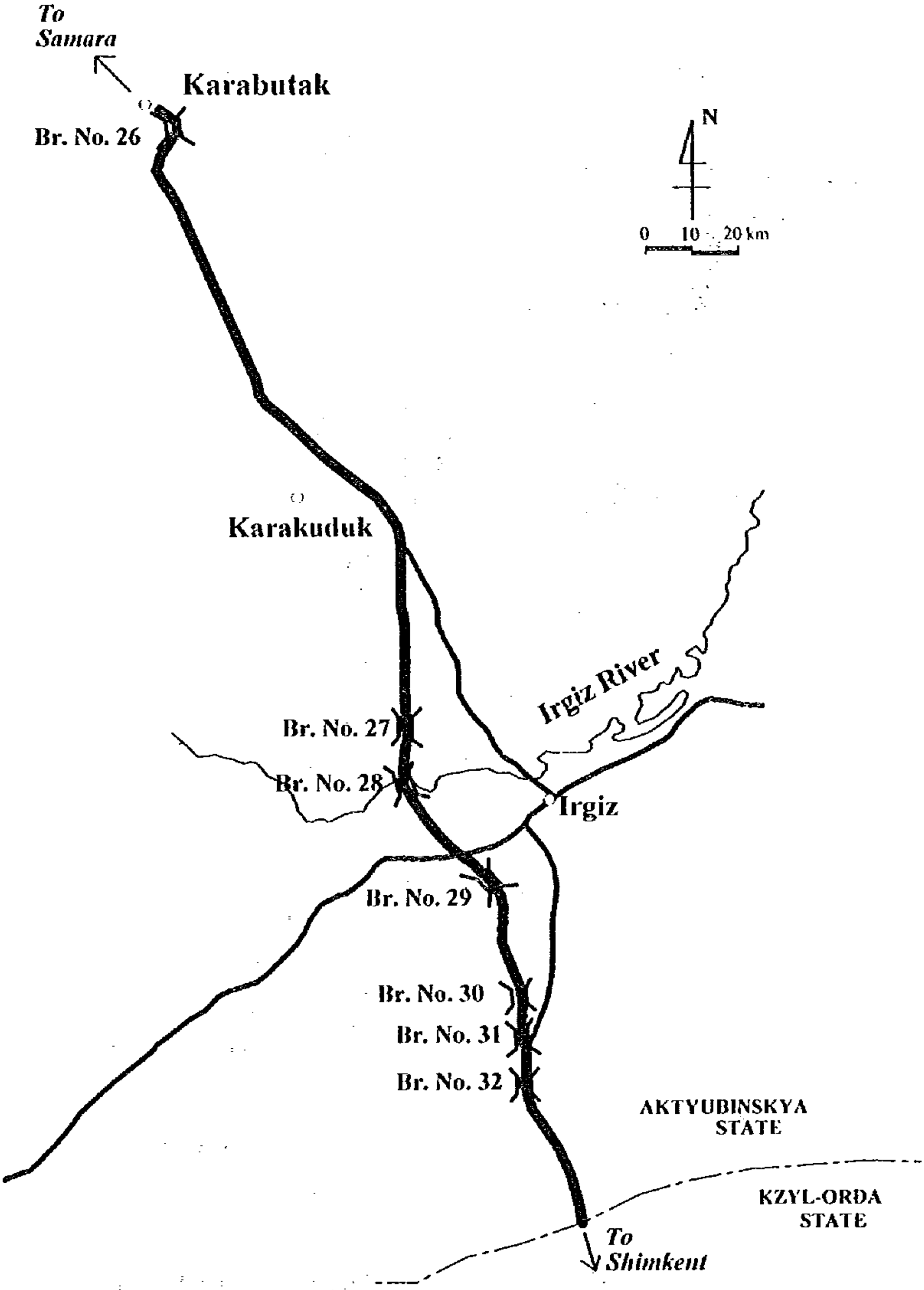


Fig. 8.2.5 : Location of Bridges on Karabutak - Kzyl Orda Border Road Section

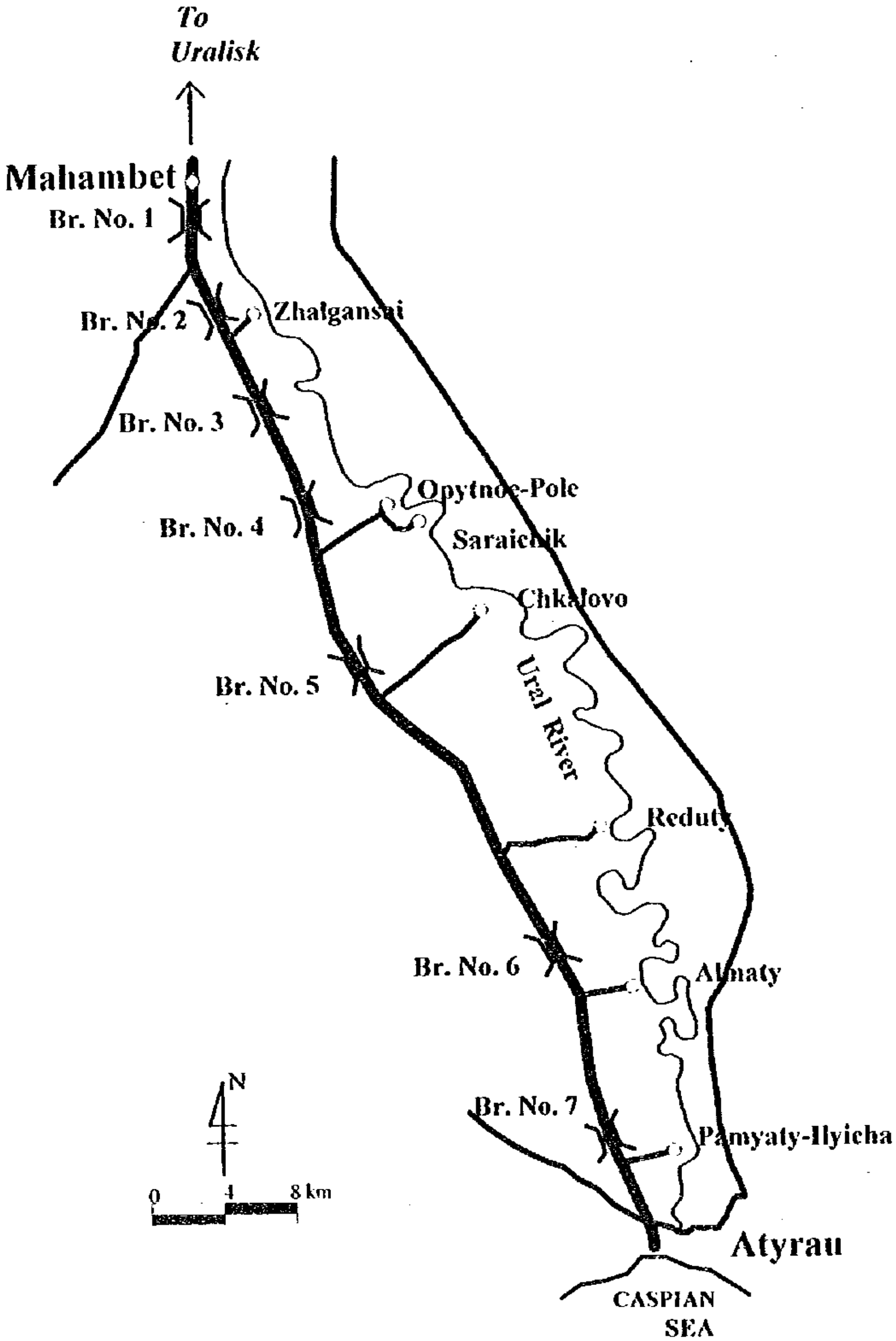


Fig. 8.2.6 : Location of Bridges on Atyrau - Mahambet Road Section

Chapter 9 Road and Bridge Improvement Cost

Chapter 9 Road and Bridge Improvement Cost

9.1 General

9.1.1 Background of Cost Estimation

In Kazakhstan, the cost of construction work has been estimated according to the procedures described in detail in standard reference manuals, such as "Manuals on Construction Cost Estimation for Cargo Transportation" and "Investment Standard per Unit on General Purpose Road" issued by FSU in 1991. The required construction activities and resources and the factors such as for cost calculation of labor, equipment and materials are given in the manuals.

Furthermore as for the standard resource-time and material components, they are given in the basic prices schedule issued by the central authorities in FSU. But, the latest available basic price schedule was made in 1991, and it has not renewed since 1991.

In the present situation which was turned into market economy, the above manuals are not reflecting actual construction activities and market price.

On the other side, there is few actual systematic data for construction cost estimation in both public sector and private sector because they have few construction experiences after independence. In fact the government of Kazakhstan who is the main public construction project client, is suffered from financial problems at the present time.

Moreover, comparing the previous planned economy state with the recent market economy state, there would be big different way of thinking on the public construction project assessment system.

The cost of the project which is accomplished under market economy, should be estimated based on the market price, and all the necessary cost for the project should be summed up in.

Therefore the Study Team started the cost estimation from the basic unit cost survey for resources such as labor, equipment and materials. In principal, the unit cost was surveyed at Actdor in Aktyubinskaya and Atyrauskaya, Department of Roads and other related organizations and private construction/material companies.

9.1.2 Basic Premise in the Cost Estimation

In determining the project implementation cost, the improvement cost of roads, culverts, and bridges are estimated separately. And the cost is further divided into direct cost, indirect cost, engineering cost, and contingencies. Direct cost consists of labor cost, equipment and material cost. Moreover local currency portion and foreign currency portion of direct cost are calculated respectively.

Basic premise is as follows :

(1) Indirect cost includes contractor's overhead and profit, and site-on cost. The contractor's overhead and profit is assumed to be 15% of the direct cost. The site-on cost is estimated separately.

(2) Engineering cost includes cost of detailed design, preparation of tender documents, bid schedule & technical specifications, construction supervision and so on. The cost is assumed to be 10% of the direct cost.

(3) Contingencies are taken as 15% of the sum of the direct cost, indirect cost, and engineering cost.

(4) The applied exchange rate between Kazakhstan Tenge and U.S. Dollar is the rate of US$1=66.5 Tenges which was applied at the Department of Roads in June, 1996.

(5) In the result of the survey, it was cleared that the unit cost of some items is different between Aktyubinskaya state and Atyrauskaya state. Therefore the cost is estimated for each state separately.

In estimating local and foreign currency portions of the project cost, the following assumptions are adopted:

(1) All labor costs are taken as a local currency portion, except cost for site managers assumed to be appointed from foreign joint venture partner.

(2) Most of construction equipment depreciation costs is taken as foreign currency portion, assuming that actual existing construction equipment is to be replaced with new imported equipment. The cost of spare parts is also assumed as foreign currency portion, however equipment running costs (fuel, lubricants, etc.) are assumed as local currency cost.

(3) Bitumen for asphalt bituminous is assumed to be imported, so it is included in foreign currency portion. The other asphalt bituminous material (gravel, crushed stone, concrete, etc.) is taken as local currency portion.

(4) Most of site running cost is taken as local currency portion.

(5) Indirect cost and engineering cost are calculated by both local currency portion and foreign currency portion, reflecting the likelihood of international joint venture.

9.1.3 Unit Cost

(1) Unit Cost for general construction work

The Study Team surveyed the unit cost related to the estimation of road construction cost. The surveyed data is applied for not only road construction work but bridge construction work. The costs were surveyed and examined in cooperation with Almaty Actodor, Actobe Actdor and Atyrau Actdor.

(a) Cost of Labor

With high unemployment in the country, the current price of labor is likely to be determined on a supply and demand basis.

At the time of the study, wages were on the rise, labor rates which examined as shown in Table 9.1.1 (1), Table 9.1.1 (2).

Table 9.1.1 (1) : Local Engineer and Labor Costs In Aktyubinskaya

(Unit : Tenge)

Sort of Man Power		Daily Labor Cost	Remark
Engineer	Civil engineer	1050	Senior engineer
	Survey engineer	915	
Labor	Foreman	996	
	Skilled labor	808	
	Labor	512	
Operator	Plant	404	
	Equipment	755	
	Driver	808	
Administration	Administrator	1260	
	Secretary	538	
	Clerk	592	

Data Source : Department of Roads, Ministry of Transport and Communications of Kazakhstan (Aktdor), Jun 7,1996

Table 9.1.1 (2) : Local Engineering and Labor Costs in Atyrauskaya

(Unit : Tenge)

Sort of Man Power		Daily Labor Cost	Remark
Engineer	Civil engineer	1096	Senior engineer
	Survey engineer	956	
Labor	Foreman	1040	
	Skilled labor	844	
	Labor	534	
Operator	Plant operator	788	
	Equipment Operator	844	
	Driver	844	
Administration	Administrator	1322	
	Secretary	562	
	Clerk	618	

Data Source : Department of Roads, Ministry of Transport and Communications of Kazakhstan (Aktdor), Jun 7,1996

(b) Cost of Materials

The main materials to be used for the project are :

- Sand/gravel for subbase
- Crushed stone for base course
- Bitumen
- Dense and open graded asphaltic concrete
- Plain concrete
- Granular sand

The cost of quarry products (including crushed stone for asphalt concrete) is a major part of improvement cost. The unit costs which were obtained from Almaty Actdor, Actobe Actdor and Atyrau Actdor as the price of June, 1996, are adopted to this cost estimation.

As for bitumen, it is assumed to import high quality bitumen from Orsk or Ufa of Russia. Therefore the price of Russian bitumen is adopted to this cost estimation.

The transportation cost of gravel and crushed stone to the construction site is estimated taking into consideration that the maximum hauling distance would be 90km under the assuming contract packages.

Estimated material costs including transportation to site, are shown in Table 9.1.2 (1) and Table 9.1.2 (2).

Table 9.1.2 (1) : Material Costs in Aktyubinskaya

Materials	Unit	Local currency (tenge)	Remark
Fuel	ton	7,903	
Crushed stone	cu.m.	923	
Sand	cu.m.	538	
Gravel	cu.m.	765	
Open graded AC	ton	1,216	
Dense AC	ton	1,533	
Bituminous BND-150/90	ton	5,310	
VNMZH-Bitumen	ton	4,975	
Excavated soil	1000 cu.m	33,075	
Sod	1000 Sq.	70,200	
Road marking	km	52,000	
Form	piece	925	
Plain concrete M-200	cu.m.	2,698	
Reinforced concrete	cu.m.	2,160	
Reinforcement bar	ton	13,003	
Mortal M-100	cu.m.	2,629	
Road signs	piece	920	

Note : The above figures include transportation costs.
Data Source : Department of Roads, Ministry of Transport and Communications of Kazakhstan, May 1, 1996

Table 9.1.2 (2) : Material Costs in Atyrauskaya

Materials	Unit	Local currency (tenge)	Remark
Fuel	ton	13,267	
Crushed stone	cu.m.	1,482	
Sand	cu.m.	424	
Gravel	cu.m.	758	
Open graded AC	ton	1,445	
Dense AC	ton	1,909	
Bituminous BND-150/90	ton	5,204	
Kerosene	ton	16,100	
Excavated soil	1000 cu.m	33,898	
Sod	1000Sq.	72,360	
Road marking	km	52,000	
Form	piece	972	
Plain concrete M-200	cu.m.	2,780	
Reinforced concrete	cu.m.	2,160	
Reinforcement bar	ton	16,044	
Mortal M-100	cu.m.	2,386	

Note : The above figures include transportation costs.
Data Source : Department of Roads, Ministry of Transport and Communications of Kazakhstan, May 1, 1996

(c) Cost of Construction Equipment

Two approaches were used to estimate equipment cost as follows.

- To be procured within the country
- To be imported from abroad

On the grounds that any construction equipment is not produced in Kazakhstan, actually the new construction machines are not able to be procured in Kazakhstan. However, Kazakhstan has been a state of FSU, the machinery made in Russia are dealt as if they are made in Kazakhstan.

The machinery for the project shall be imported from abroad. In compliance with the advice, the basic machinery unit prices of the Japanese Construction Mechanization Association are adopted for this cost estimation. As for the calculation of the fee of the machinery, only depreciation fee which is predicated on the equipment base price would be appropriated to the budget of the project.

The formula for the calculation of the machine depreciation fee are as follows.

DCH = BUP x [(DCR + MRR / SOY) + MYC] x (1 / SOH)

Where :
DCH = Depreciation Cost in Terms of Hourly
BUP = Base Unit Price
DCR = Depreciation Cost Ratio

MRR = Maintenance and Repair Cost Ratio
MYC = Management Year Cost Ratio
SOY = Standard Operating Years
SOH = Standard Operating Hours per Year

ADC = BUP x [(DCR + MRR / SOY) + MYC] x (1 / SAD)

Where :
ADC = Assigned Depreciation Cost for Daily
SAD = Standard Assigned Days per Year

Table 9.1.3 shows the rental charge of the equipment.

Table 9.1.3 : Rental Charge of Road Construction Equipment

(Unit : US$)

Construction equipment	Equipment type	Rental charge/shift	Remarks
Bulldozer	15 ton	247	
Loader	2.3 cu.m.	201	
Excavator	0.7 cu.m.	220	
Grader	3.7m 150-160HP	177	
Tandem Roller	10/12 ton	123	
PTR Roller	8/10 ton	172	
Vibratary Roller	10/12 ton	281	
Asphalt Paver	4.5 m	179	
Compressor	7.6m³/min	101	
20 Ton Tipper	20 ton	178	
Water Bowser	10,000L	157	
Chip Spreader	-	554	
Bitumen distributor	4 KL	888	
Cold Planer	2.1m	1,470	
Asphalt Plant	30 ton	301	

Data Source : Department of Roads, Ministry of Transport and Communications of Kazakhstan, May 1, 1996

(2) Unit Cost for bridge construction work

Unit cost of materials particularly required for bridge construction was surveyed in separate from road construction materials. The cost for bridge construction work is calculated by these unit cost in addition to road construction unit cost.

(a) Summary of Unit Prices of Materials

Unit price of materials required particularly for bridges construction is summarized as Table 9.1.4.

Table 9.1.4 : Summary of Unit Prices of Materials (Unit: US$)

Item	Unit	Foreign Portion	Local Portion	Total
Prestressing Cable	ton	755	75	830
Concrete Pile	Nos.	-	493	493
Hollow Slab (Span 12 m)	Nos.	-	887	887
Hollow Slab (Span 18 m)	Nos.	-	1,704	1,704
T Type Girder (Span 21 m)	Nos.	-	3,125	3,125
T Type Girder (Span 24 m)	Nos.	-	3,451	3,451
Fuel	Liter	-	0.2	0.2
Power Rates	kWh	-	0.05	0.05

(b) Construction Equipment

Unit price of Construction Machinery particularly required for bridges construction is also calculated same as for roads construction equipment.

Rental Charge of Bridge Construction Equipment particularly required is as shown in Table 9.1.5.

Table 9.1.5 : Rental Charge of Bridge Construction Equipment

Construction equipment	Equipment Type	Rental Charge Financial /shift (US$)
Bulldozer	21ton	373
Roller (Vibratory)	0.8/1.1ton	26
Tamper	60/100kg	6
Truck Crane	120ton	1871
Truck Crane	3ton	77
Hydraulic Breaker	0.7ton	90
Breaker	20kg	2
Compressor	3.6 m^3/min.	29
Diesel Hammer	RM 3.5ton	759
Diesel Hammer	RM 4.5ton	829
Concrete Pump	110 m^3/h	765

(c) Labor Costs

Unit cost of labor for bridges construction is same as for road construction Unit labor cost adopted for bridges construction cost estimation is summarized as shown in Table 9.1.6.

Table 9.1.6 : Labor Costs (Tenge / day)

Type	In Aktyubinskaya	In Atyrauskaya	Remarks
(1) Operator (Plant)	404	788	
(2) Operator (Equipment)	755	844	
(3) Driver	808	844	
(4) Foreman	996	1,040	
(5) Skilled Labor	808	844	
(6) Labor	512	534	
(7) Welder	808	844	same as skilled labor
(8) Worker of Reinforcing Bar	808	844	same as skilled labor

9.2 Direct Improvement Cost of Road and Culvert

9.2.1 Methodology for Preparing the Cost Estimate

The following steps were taken to develop the cost estimation:

(1) For each work item, the required quantities and types of labor, equipment and material to improve one kilometer of the road are estimated based on international construction experience.

(2) The direct cost by work item to improve one kilometer of the road is calculated with the unit costs described in 9.1. The total direct cost of road improvement is derived by multiplying the per kilometer cost of each work item by the distance (km).

The improvement cost of culvert is estimated similarly, and then the sum of it and the road improvement cost become the total direct project cost of road improvement.

Required quantities of labor, equipment and materials by work item to improve one kilometer of the road is as shown in Table 9.2.1.

Table 9.2.1 : Required Construction Quantities per km of Road Improvement

(Unit : US Dollars)

Code	Operation	Quantity per km (1)	Required Time (2)	Necessary No. of Shift (1)/(2)	No. of Labor: Engineer	Foreman	Operator	Driver	Labor	No. of Equipment: Dozer Back hoe	Loader	Excavator	Grader	Tandem roller	Tire roller	Vib roller	Asph Finisher	Compressor	Dump Truck	Water Truck	Chip Spreader	Bit. Distributor	Cold Planer	Quantities of Materials: Excavated soil (cu m)	Crushed stone (cu m)	Plain Concrete (cu m)	Bitumen (ton)	Opengraded AC (ton)	Dense AC (ton)	Grav / sand (cu m)	Road marking (1 km)	Sub-grade material (cu m)	Sod (sq m)
1	Remove existing pavement break up and scarify up to 10 cm depth. Water shape	1,300 cu.m	75 hr	2			5	3	1	1			1	1		1			3				1										
2	Add up to 30 cm additional suitable material for embankment	10,891 cu.m	90 hr	13			2	3		1	1								3					10,891									
3	Provide, spread,water, shape and compact 25 cm sand/gravel subbase	900 cu.m	75 hr	12	1		1	3	1										3				1							900			
4	Provide, spread, water, shape and compact 25 cm sand/gravel subbase	1,388 cu.m	35 hr	3			3	1	1				1	1		1				1										1,388			
5	Provide, spread, water, shape and compact 20 cm sand/gravel subbase	1,100 cu.m	35 hr	3			3	1	1				1	1		1				1										1,100			
6	Provide, spread, water, shape and compact up to 15 cm crushed stone basecourse in two 15cm layers	1,373 cu.m	75 hr	2		1	3	1	1				1	1		1				1					1,373								
7	Provide and lay opengraded asphalt concrete 6 cm thick	987 ton	95 hr	1	1	1	4		3					1	1	1	1											987					
8	Provide and lay dense asphalt concrete surface course 4 cm thick	638 ton	90 hr	1	1	1	4		5					1	1	1	1												638				
9	Provide spread water, shape and compact suitable material to make up to shoulder	448 cu.m	60 hr	1	1		3	1	1				1	1		1				1												448	
10	Provide and install 30 cm wide concrete edge Kerb	2,000 m	100 hr	3	1		3	2	9			2							2							100							
11	Provide and lay sod and spread water	9,000 sq.m	800 Shift	11			4													1													9,000
12	Provide and install drainage	2,000 m	333 Shift	6		1	2		3	1				1																			
13	Provide road markings and repair roadsigns	1,000 m	500 Shift	2			1		3																						1,000		

Data Source: JICA Study Team, 1996

Note : 1 shift = 8 hours

9.2.2 Direct Cost of Road Improvement

To estimate the total road improvement cost, it is necessary to calculate firstly the unit improvement cost per km. The unit improvement cost is calculated by input the unit cost such as labors, materials and equipment into the work quantities shown in Table 9.2.1.

The direct cost per kilometer, as a result of calculation of the unit improvement cost, is shown in Table 9.2.2 (1) and Table 9.2.2 (2).

And total direct road improvement cost is estimated at US$ 42,432,000 which consists of US$ 30,515 for the Karabutak ~ Kzyl Orda road section and US$ 11,917,000 for the Atyrau ~ Mahambet road section. Summarized total costs are shown in Table 9.2.3 (1) and Table 9.2.3 (2).

Table 9.2.2 (1) : Unit Road Improvement Cost in Aktyubinskaya
Karabutak ~ Kzyl-Orda Border Road Section

(Unit : US Dollars)

Code	Operation	Quantity per km		Necessary No. of Shift	Labor: Engineer	Labor: Foreman	Labor: Operator	Labor: Driver	Labor: Labor	Equipment: Dozer/Back hoe	Equipment: Loader	Equipment: Excavator	Equipment: Grader	Equipment: Tandem roller	Equipment: Tire roller	Equipment: Vib roller	Equipment: Asph Finisher	Equipment: Compressor	Equipment: Dump Truck	Equipment: Water Truck	Equipment: Chip Spreader	Equipment: Bit Distributor	Equipment: Cold Planer	Materials: Excavated soil (cu m)	Materials: Crushed stone (cu m)	Materials: Plain Concrete (cu m)	Materials: Bitumen (ton)	Materials: Opengraded AC (ton)	Materials: Dense AC (ton)	Materials: Grav / sand (cu m)	Materials: Road marking (1 km)	Materials: Sodgrass seed (sq m)	Materials: Sod (sq m)	Total Direct Cost per km
	Unit Cost (US$)				15.8	15	11.4	12.2	7.7	247	201	220	177	123	172	281	179	101	178	157	554	888	1,470	0.5	13.9	40.6	79.8	18.29	23.1	11.5	782	6.1	1.1	
1	Cold plane to remove existing pavement break up and scarify up to 10 cm depth. Water shape	1,200	sq.m	2			114	73	15	494			354	246		562			1,068				2,940											9,867
2	Add up to 50 cm additional suitable material for embankment	10,891	cu.m	15			342	549		3,705	3,015								8,010					5,446										21,067
3	Provide, spread, water, shape and compact 15 cm sand/gravel subbase	900	cu.m	12	190		137	439	92										6,408				17,640							10,350				35,256
4	Provide, spread, water, shape and compact 25 cm sand/gravel subbase in 12.5 cm layer	1,388	cu.m	3			103	37	23				531	369		843				471										15,962				18,338
5	Provide, spread, water, shape and compact 20 cm sand/gravel subbase	1,100	cu.m	3			103	37	23				531	369		843				471										12,650				15,026
6	Provide, spread, water, shape and compact up to 15 cm crushed stone basecourse	1,373	cu.m	2		30	68	24	15				354	246		562				314					19,085									20,699
7	Provide and lay opengraded asphalt concrete 6 cm thick	987	ton	1	16	15	46		39					123	172	281	179											18,051						18,922
8	Provide and lay dense asphalt concrete surface course 4 cm thick	658	ton	1	16	15	46		39					123	172	281	179												15,200					16,070
9	Provide spread water, shape and compact suitable material to raise up to shoulder	448	cu.m	1	16		34	12	8				177	123		281				157												3,629		4,437
10	Provide and install 50 cm wide concrete edge Kerb	2,000	m	3	47		103	73	209			1,320							1,068							4,060								6,879
11	Provide and lay sod and spread water	9,000	sq.m	11			302													157													9,900	10,359
12	Provide and install drainage	2,000	m	6		80	137		139	1,482																								1,847
13	Provide road markings and repair roadsigns	1,000	m	2			23		46														100								782			951

Data Source: JICA Study Team, 1996

Table 9.2.2 (2) : Unit Road Improvement Cost in Atyrauskaya
Atyrau ~ Mahambet Road Section

(Unit : US Dollars)

Code	Operation	Quantity per km	Necessary No. of Shift	Labor: Engineer	Labor: Foreman	Labor: Operator	Labor: Driver	Labor: Labor	Equipment: Dozer 21 t & like	Equipment: Loader	Equipment: Excavator	Equipment: Grader	Equipment: Tandem roller	Equipment: Tire roller	Equipment: Vib roller	Equipment: Asph Finisher	Equipment: Compressor	Equipment: Dump Truck	Equipment: Water Truck	Equipment: Chip Spreader	Equipment: Bit. Distributor	Equipment: Cold Planer	Materials: Excavated soil (cu m)	Materials: Crushed stone (cu m)	Materials: Plain Concrete (cu m)	Materials: Bitumen (ton)	Materials: Opengraded AC (ton)	Materials: Dense AC (ton)	Materials: Gravel / sand (cu m)	Materials: Road marking (1 km)	Materials: Se Fg and mature (sq m)	Materials: Sod (sq m)	Total Direct Cost per km
	Unit Cost (US$)			16.5	15.6	12.7	12.7	8	247	201	220	177	123	172	281	179	101	178	157	334	868	1,470	0.5	72.3	41.8	78.3	21.7	24.7	11.4	792	5.4	1.1	
1	Cold plane to remove existing pavement break up and scarify up to 10 cm depth. Water shape	1,300 cu.m	2			127	76	16	494			354	246		562			1,068				2,940											5,883
2	Add up to 30 cm additional suitable material for embankment	10,891 cu.m	15			281	572		3,705	3,013								8,010					5,446										21,128
3	Provide, spread,water, shape and compact 15 cm sand/gravel subbase	900 cu.m	12	198		152	457	96										6,408				17,640							10,260				35,212
4	Provide, spread, water, shape and compact 25 cm sand/gravel subbase in 12.5 cm layer	1,384 cu.m	3			114	38	24				531	369		843				471										15,823				18,214
5	Provide, spread, water, shape and compact 20 cm sand/gravel subbase	1,100 cu.m	3			114	38	24				531	369		843				471										12,540				14,930
6	Provide, spread, water, shape and compact up to 15 cm crushed stone basecourse	1,373 cu.m	2		31	76	25	16				354	246		562				314					30,618									32,243
7	Provide and lay opengraded asphalt concrete 6 cm thick	987 ton	1	17	16	51		40					123	172	281	179											21,416						22,296
8	Provide and lay dense asphalt concrete surface course 4 cm thick	638 ton	1	17	16	51		40					123	172	281	179												18,885					19,763
9	Provide spread water, shape and compact suitable material to make up in shoulder	448 cu.m	1	17		38	13	8				177	123		281				157												2,867		3,681
10	Provide and install 50 cm wide concrete edge Kerb	2,000 m	3	50		114	76	216			1,320							1,068							4,180								7,024
11	Provide and lay sod and spread water	9,000 sq.m	11			359													157													9,900	10,416
12	Provide and install drainage	2,000 m	6		94	152		164	1,462																								1,872
13	Provide road markings and repair roadsigns	1,000 m	2			25		48																						792			855

Data Source: JICA Study Team, 1996

Table 9.2.3 (1) : Direct Cost of Road Improvement in Aktyubinskaya Karabutak ~ Kzyl-Orda Border Road Section

(Unit : US$)

No.	Operation	Length (km) (a)	Quatity Per km	Total Quantity	Unit	Unit Direct Cost/km (b)	Total Direct Cost (a) x (b) (1000US$)
1	Cold plane to remove existing pavement break up and scarify up to 10 cm depth Water, mix shape and compact existing road	275	1,300	357,500	Cu m	5,867	1,613
2	Add up to 50 cm additional suitable material for embankment	164	10,891	1,786,124	Cu.m	21,067	3,455
3	Provide, spread, water, shape and compact 15 cm sand/gravel subbase	10	900	1,388	Cu.m	35,256	353
4	Provide, spread, water, shape and compact 25 cm sand/gravel subbase in 12,5 cm layers	199	1,388	276,212	Cu.m	18,338	3,649
5	Provide, spread, water, shape and compact 20 cm sand/gravel subbase in 10 cm layers	48	1100	52,800	Cu.m	15,026	721
6	Provide, spread, water, shape and compact 15 cm crushed stone base course	275	1,373	377,575	Cu.m	20,699	5,692
7	Provide and lay opengraded asphalt concrete 6 cm thick	275	987	271,425	ton	18,922	5,204
8	Provide and lay dense asphalt concrete surface course 4 cm thick	275	658	180,950	ton	16,070	4,419
9	Provide spread water, shape and compact granular material to make up in shoulder	275	448	123,200	Cu.m	4,437	1,220
10	Provide and install 50 cm wide concrete edge Kerb	275	2,000	550,000	m	6,879	1,892
11	Provide and lay sod and spread water	164	9,000	1,476,000	Sq.m	10,559	1,732
12	Provide and install drainage	164	2,000	328,000	m	1,847	303
13	Provide road markings and repair road sings	275	1,000	275,000	m	951	262
						Total Cost	30,515

Data Source : JICA Study Team, 1996

Table 9.2.3 (2) : Direct Cost of Road Improvement in Atyrauskaya Atyrau ~ Mahambet Road Section

(Unit : US$)

No.	Operation	Length (km) (a)	Quatity Per km	Total Quantity	Unit	Unit Direct Cost/km (b)	Total Direct Cost (a) x (b) (1000US$)
1	Cold plane to remove existing pavement break up and scarify up to 10 cm depth Water, mix shape and compact existing road	83	1,300	107,900	Cu.m	5,883	488
2	Add up to 50 cm additional suitable material for embankment	83	10,891	903,953	Cu.m	21,128	1,754
3	Provide, spread, water, shape and compact 15 cm sand/gravel subbase	-	-	-	-	-	-
4	Provide, spread, water, shape and compact 25 cm sand/gravel subbase in 12,5 cm layers	83	1,388	115,204	Cu.m	18,214	1,512
5	Provide, spread, water, shape and compact 20 cm sand/gravel subbase in 10 cm layers	-	-	-	-	-	-
6	Provide, spread, water, shape and compact 15 cm crushed stone base course	83	1,373	113,959	Cu.m	32,243	2,676
7	Provide and lay opengraded asphalt concrete 6 cm thick	83	987	81,921	ton	22,296	1,851
8	Provide and lay dense asphalt concrete surface course 4 cm thick	83	658	54,614	ton	19,763	1,640
9	Provide spread water, shape and compact granular material to make up in shoulder	83	448	37,184	Cu.m	3,681	306
10	Provide and install 50 cm wide concrete edge Kerb	83	2,000	166,000	m	7,024	583
11	Provide and lay sod and spread water	83	9,000	747,000	Sq.m	10,616	881
12	Provide and install drainage	83	2,000	166,000	m	1,872	155
13	Provide road markings and repair road sings	83	1,000	83,000	m	855	71
						Total Cost	11,917

Data Source : JICA Study Team, 1996

9.2.3 Direct Cost of Culvert Improvement and Construction

The cost to improve and construct pipe culverts and box culverts was estimated based on required quantity and unit costs. The quantity of precast reinforced concrete, lean concrete, sand/gravel, and stone for each culvert type are calculated. Table 1 of Appendix II-7 shows summarized quantities, unit costs, cost per item and total costs for construction 1.0 and 1.5m diameter pipe culverts and box culverts of various sizes.

The number of culverts evaluated in fair and bad condition is shown in Appendix II-6. In the result, 8 culverts were classified as fair and 19 as bad on the Karabutak-Kzyl Orda Border road section, and 8 culverts were classified as fair on the Atyrau-Mahambet road section.

The following assumptions and approximations are adopted for culvert improvement :

(1) The construction cost of multiple culverts is estimated as approximation by multiplying the cost of a single culvert.

(2) The culvert classified as "bad" in the evaluation is required to be replaced. Therefore for improvement of such culvert, 100 % of new construction cost is counted for improvement cost.

(3) The culvert classified as "fair" in the evaluation is required to be repaired. Therefore for improvement of such culvert, 10 % of new construction cost is counted for improvement cost.

The total improvement cost is estimated by number of necessary unit (single culvert basis) and their condition. Moreover, new box culverts construction is necessary at the location where fill-up of the embankment is newly planned in the Atyrau-Mahambet road section.

The direct cost of culvert improvement for the Karabutak - Kzyl Orda Border and the Atyrau - Mahambet road section is shown later in Table 9.4.2.

The estimation of the direct improvement cost is also shown in Table 2, 3 and 4 of Appendix II-7.

9.3 Direct Improvement Cost of Bridges

9.3.1 Methodology for Preparing the Cost Estimate

The following steps were taken to develop the bridge construction cost estimation:

(1) To estimate the bridge construction cost, the simple bridge having 2 spans of 24m is put firstly as the standard bridge to estimate the construction cost of all bridges.

(2) The construction cost of the simple bridge having 2 spans of 24m was secondly calculated. And then, the calculated cost was divided by the surface area (m^2) in order to get unit bridge construction cost per m^2.

(3) Thirdly, the calculated unit bridge construction cost was multiplied by the surface area of the bridge to be constructed.

(4) Finally, the above procedure was repeated for all bridges to be constructed.

And the following steps were taken to develop the bridge improvement cost estimation:

(1) To estimate the bridge construction cost, the simple bridge having 1 span of 24m is put firstly as the standard bridge to estimate the improvement cost of all bridges.

(2) The improvement cost of the simple bridge having 1 span of 24m was secondly calculated. And then, the calculated cost was divided by the surface area (m^2) in order to get unit bridge improvement cost per m^2.

(3) Thirdly, the calculated unit bridge improvement cost was multiplied by the surface area of the bridge to be improved.

(4) Finally, the above procedure was repeated for all bridges to be improved.

Required quantities of works to construct and improve the standard bridge are as described in Chapter 8.

9.3.2 Direct Cost of Bridge Construction

As the result of calculation, the unit bridge construction cost per m^2 is as shown in Table 9.3.1. The detail calculation procedure is as described in Appendix III-4.

As the surface area of each bridge to be constructed is as shown in Table 9.3.2, the total bridge construction cost is as shown in Table 9.3.3.

Table 9.3.1 (1) : Summary of Bridge Construction Cost in Aktyubinskaya (US$)

For standard bridge (678.96 $m^{2)}$

Item	Unit	Quantity	Unit Price (in US$)		Total Cost (in US$)		Total in US$	Remarks
			Foreign	Local	Foreign	Local		
Concrete Work	m^3	430.31	28.83	53.76	12,405.84	23,133.47	35,539.31	
Structural Excavation Work	m^3	823.48	5.88	2.63	4,842.06	2,165.75	7,007.81	
Piling Work	Nos.	190	120.7	501.71	22,933.00	95,324.90	118,257.90	
Superstructure Work								
Beam Installation Work	Nos.	16	234	5,198	3,744.00	83,168.00	86,912.00	
Transverse Beam Work	Nos.	16	138.81	107.09	2,220.96	1,713.44	3,934.40	
Bridge Surface Work	m^2	678.96	60.01	9.43	40,744.39	6,402.59	47,146.98	
Demolition Work	m^3	487.73	22.52	9.6	10,983.68	4,682.21	15,665.89	
Scaffolding Work	m^3	645.60	8.42	1.67	5,435.95	1,078.15	6,514.10	
Total					103,309.88	217,668.51	320,978.39	
Miscellaneous Work					36,158.46	76,183.98	112,342.44	35 % of above
Miscellaneous Work includes the cost for Temporary Road Work, Slope Protection Work and others								
Grand Total					139,468.34	293,852.49	433,320.83	

Unit Cost per m^2	205.41	432.80	638.21

Table 9.3.1 (2) : Summary of Bridge Construction Cost in Atyrauskaya (US$)

For standard bridge (678.96 m^2)

Item	Unit	Quantity	Unit Price (in US$)		Total Cost (in US$)		Total in US$	Remarks
			Foreign	Local	Foreign	Local		
Concrete Work	m^3	430.31	33.63	55.6	14,471.32	23,925.24	38,396.56	
Structural Excavation Work	m^3	823.48	5.88	2.78	4,842.06	2,289.27	7,131.33	
Piling Work	Nos.	190	120.7	502.1	22,933.00	95,399.00	118,332.00	
Superstructure Work								
Beam Installation Work	Nos.	16	234	5,199	3,744.00	83,184.00	86,928.00	
Transverse Beam Work	Nos.	16	146.15	110.61	2,338.40	1,769.76	4,108.16	
Bridge Surface Work	m^2	678.96	60.81	9.75	41,287.56	6,619.86	47,907.42	
Demolition Work	m^3	487.73	22.52	10.43	10,983.68	5,087.02	16,070.70	
Scaffolding Work	m^3	645.60	8.42	1.74	5,435.95	1,123.34	6,559.29	
Total					106,035.97	219,397.49	325,433.46	
Miscellaneous Work					37,112.59	76,789.12	113,901.71	35 % of above
Miscellaneous Work includes the cost for Temporary Road Work, Slope Protection Work and others								
Grand Total					143,148.56	296,186.61	439,335.17	

Unit Cost per m^2	210.84	436.24	647.08

Table 9.3.2 : Bridge Surface Area of New Bridge

Item	Width (m)	Length (m)	Area (m^2)	Remarks
The Karabutak ~ Kzyl Orda border road section				
Bridge Number - 27	13.8	24.6	339.48	
Bridge Number - 28	13.8	196.8	2,715.84	
Bridge Number - 29	13.8	43.2	596.16	
Bridge Number - 30	13.8	21.6	298.08	
Bridge Number - 31	13.8	43.2	596.16	
Bridge Number - 32	13.8	43.2	596.16	
The Atyrau ~ Mahambet road section				
Bridge Number - 2	11.8	64.8	764.64	
Bridge Number - 3	11.8	64.8	764.64	
Bridge Number - 5	11.8	64.8	764.64	

Table 9.3.3 : Construction Cost for New Bridges (US$)

Bridge Number	Quantity (m^2)	Unit Price		Construction Cost		Total Cost
		Foreign	Local	Foreign	Local	
The Karabutak ~ Kzyl Orda border road section						
No. 27	339.48	205.41	432.80	69,733	146,927	216,660
No. 28	2,715.84	205.41	432.80	557,861	1,175,416	1,733,277
No. 29	596.16	205.41	432.80	122,457	258,018	380,475
No. 30	298.08	205.41	432.80	61,229	129,009	190,238
No. 31	596.16	205.41	432.80	122,457	258,018	380,475
No. 32	596.16	205.41	432.80	122,457	258,018	380,475
Subtotal				1,056,194	2,225,406	3,281,600
The Atyrau ~ Mahambet road section						
No. 2	764.64	210.84	436.24	161,217	333,567	494,784
No. 3	764.64	210.84	436.24	161,217	333,567	494,784
No. 5	764.64	210.84	436.24	161,217	333,567	494,784
Subtotal				483,651	1,000,701	1,484,352
Total Cost				1,539,845	3,226,107	4,765,952

9.3.3 Direct Cost of Bridge Improvement

As the result of calculation, the unit bridge improvement cost per m^2 is as shown in Table 9.3.4. The detail calculation procedure is as described in Appendix III-3.

As the surface area of each bridge to be improved and the total bridge improvement cost are as shown in Table 9.3.5.

Table 9.3.5 : Improvement Cost for each Bridge

Bridge Number	Width (m)	Length (m)	Surface Area (m^2)	Unit Price		Construction Cost		Total Cost
				Foreign	Local	Foreign	Local	
The Karabutak ~ Kzyl Orda border road section								
No. 26	13.40	108.00	1447.20	131.20	68.87	189,873	99,669	289,542
Subtotal						189,873	99,669	289,542
The Atyrau ~ Mahambet road section								
No. 1	9.50	66.40	630.80	136.31	71.50	85,984	45,102	131,086
No. 4	10.00	66.40	664.00	136.31	71.50	90,510	47,476	137,986
No. 6	10.00	46.80	468.00	136.31	71.50	63,793	33,462	97,255
No. 7	10.00	46.80	468.00	136.31	71.50	63,793	33,462	97,255
Subtotal						304,080	159,502	463,582
Total Cost						493,953	259,171	753,124

Table 9.3.4 (1) : Summary of Improvement Bridge Construction Cost in Aktyubinskaya (US$)

For standard bridge (246.0 m^2)

Item	Unit	Quantity	Unit Price (in US$)		Total Cost (in US$)		Total in US$	Remarks
			Foreign	Local	Foreign	Local		
Concrete Work	m^3	144.06	28.83	53.76	4,153.25	7,744.67	11,897.92	
Structural Excavation Work	m^3	562.80	5.88	2.63	3,309.26	1,480.16	4,789.42	
Superstructure Work								
Transverse Beam Work	Nos.	6	138.81	107.09	832.86	642.54	1,475.40	
Bridge Surface Work	m^2	246.00	60.01	9.43	14,762.46	2,319.78	17,082.24	
Demolition Work	m^3	37.70	22.52	9.6	849.00	361.92	1,210.92	
Total					23,906.83	12,549.07	36,455.90	
Miscellaneous Work					8,367.39	4,392.17	12,759.56	35 % of above
Miscellaneous Work includes the cost for Temporary Road Work, Slope Protection Work and others								
Grand Total					32,274.22	16,941.24	49,215.46	

Unit Cost per m^2	131.20	68.87	200.06

Table 9.3.4 (2) : Summary of Improvement Bridge Construction Cost in Atyrauskaya (US$)

For standard bridge (246.0 m^2)

Item	Unit	Quantity	Unit Price (in US$)		Total Cost (in US$)		Total in US$	Remarks
			Foreign	Local	Foreign	Local		
Concrete Work	m^3	144.06	33.63	55.6	4,844.74	8,009.74	12,854.48	
Structural Excavation Work	m^3	562.80	5.88	2.78	3,309.26	1,564.58	4,873.84	
Superstructure Work								
Transverse Beam Work	Nos.	6	146.15	110.61	876.9	663.66	1,540.56	
Bridge Surface Work	m^2	246.00	60.81	9.75	14,959.26	2,398.50	17,357.76	
Demolition Work	m^3	37.70	22.52	10.43	849.00	393.21	1,242.21	
Total					24,839.16	13,029.69	37,868.85	
Miscellaneous Work					8,693.71	4,560.39	13,254.10	35 % of above
Miscellaneous Work includes the cost for Temporary Road Work, Slope Protection Work and others								
Grand Total					33,532.87	17,590.08	51,122.95	

Unit Cost per m^2	136.31	71.50	207.82

9.3.4 Summary of Bridge Construction and Improvement Cost

The summary of the construction and improvement cost for bridges is shown in Table 9.3.6.

Table 9.3.6 : Direct Cost of Bridge Construction and Improvement

Bridge Number	Construction Cost (in US$)		Total Cost in US$	Measurement
	Foreign	Local		
The Karabutak ~ Kzyl Orda border road section				
No. 26	189,873	99,669	289,542	Improved
No. 27	69,733	146,927	216,660	Renewed
No. 28	557,861	1,175,416	1,733,277	Renewed
No. 29	122,457	258,018	380,475	Renewed
No. 30	61,229	129,009	190,238	Renewed
No. 31	122,457	258,018	380,475	Renewed
No. 32	122,457	258,018	380,475	Renewed
Subtotal	1,246,067	2,325,075	3,571,142	
The Atyrau ~ Mahambet road section				
No. 1	85,984	45,102	131,086	Improved
No. 2	161,217	333,567	494,784	Renewed
No. 3	161,217	333,567	494,784	Renewed
No. 4	90,510	47,476	137,986	Improved
No. 5	161,217	333,567	494,784	Renewed
No. 6	63,793	33,462	97,255	Improved
No. 7	63,793	33,462	97,255	Improved
Subtotal	787,731	1,160,203	1,947,934	
Grand Total	2,033,798	3,485,278	5,519,076	

9.4 Total Project Cost

9.4.1 Estimate of Site-On Cost

Site-on cost includes the followings ;

(1) Contractor's mobilization and demobilization

(2) Site establishment ;
- Accommodation and offices.
- Workshops, supplies and field camps.
- Workshops, offices, laboratories and field equipment.

(3) Engineering facilities ;
- Accommodation, Offices, Equipment

(4) Management and site operating cost ;
- Management, supervision and administration
- Management support, Transportation
- Running cost for accommodation, offices, workshops, stores

(5) Quality control and contractual obligations ;
- Testing, Measurements, Compliance with various contract requirements

(6) Attendance on Engineer
- Transportation, Assistance

(7) Access, Diversions and traffic management

The following assumptions are adopted to estimate Site on-cost;

The project to improve the road of which total length is 358km is divided into 4 contract package. This is in accordance with the assumptions which maximum material haul distance is about 90km.

The construction period is planned for 30 months. This period includes 2 winter seasons (1 winter season is for 6 months). Site running costs are incurred through out the 30 months construction period.

The tentative Site-on cost is shown in Table 9.4.1.
The estimated cost of US$ 3,360,000 is for one contract package taking into consideration the establishment over 30 month period. Therefore the total Site on-cost for the Project (358km) is US$ 13,440,000.

Table 9.4.1 : Estimated Site-On Cost

(unit : US$1000)

For One Site Establishment Over 30 Month Duration	Total Cost Per Site (10^3)
- Contractor's Mobilization and Demobilization Costs	280
- Site Establishment and Running Costs	
Accommodation Offices, Workshops, Stores and Field Camps	330
Workshop, Office, Laboratory and Field Equipment	230
Engineer's Accommodation and Facilities	190
Management, Administration Supervision & Site Running Cost	1,120
Quality Control, Testing, Measurements, Contract Obligations	420
Attendance on Engineer	280
Access, Diversions & Traffic Management	510
Total	3,360

9.4.2 Total Project Costs

Total direct improvement costs are summarized in Table 9.4.2.

Table 9.4.2 : Direct Improvement Costs

(unit : US$1000)

Type of Improvement	Karabutak-Kzyl Orda B. Road Section				Atyrau-Mahambet Section	Total
	Karabutak-Irgiz		Irgiz-Kzyl Orda B.	Total		
	km					
	965-1060	1060-1154	1154-1240	965-1240	0-84	
Road Improvement Cost	11,715	9,995	8,805	30,515	11,917	42,432
Culvert Improvement/New Cost	132	48	56	236	1,587	1,823
Bridge Improvement/New Cost	290	1,950	1,332	3,572	1,948	5,520
Total Direct Cost	12,137	11,993	10,193	34,323	15,452	49,775

Data Source : JICA Study,1996

The total cost for the project consists of the following components : direct costs, indirect costs, engineering cost, and contingencies. The project's cost are summarized in Table 9.4.3, Table 9.4.4, Table 9.4.5, Table 9.4.6 and, Fig. 9.4.1(1) and Fig. 9.4.1(2).

Table 9.4.3 : Road/Culvert Improvement Cost

(unit : US$1000)

Cost Component		Karabutak-Kzyl Orda B. Road Section				Atyrau-Mahambet Section	Total
		Karabutak-Irgiz		Irgiz-Kzyl Orda B.	Total		
		km					
		965-1060	1060-1154	1154-1240	965-1240	0-84	
Direct Cost		11,847	10,043	8,861	30,751	13,504	44,255
Indirect Cost	Contractor's Over-head & Profit(15%)	1,777	1,506	1,329	4,612	2,026	6,638
	Site-on-Cost	2,932	2,932	2,932	8,796	2,932	11,728
Sub Total		16,556	14,481	13,122	44,159	18,462	62,621
Engineering Cost(10%)		1,656	1,448	1,312	4,416	1,847	6,262
Sub Total		18,212	15,929	14,434	48,575	20,309	68,883
Contingencies (15%)		2,732	2,389	2,165	7,286	3,046	10,332
Gross Total Cost		20,944	18,318	16,599	55,861	23,355	79,216

Data Source : JICA Study,1996

Table 9.4.4 : Bridge Improvement Cost

(unit : US$1000)

Cost Component		Karabutak-Kzyl Orda Road Section				Atyrau-Mahambet Section	Total
		Karabutak-Irgiz		Irgiz-Kzyl Orda B.	Total		
		km					
		965-1060	1060-1154	1154-1240	965-1240	0-84	
Direct Cost		290	1,950	1,332	3,572	1,948	5,520
Indirect Cost	Contractor's Over-head & Profit(15%)	44	293	200	536	292	828
	Site-on-Cost	428	428	428	6,284	428	1,712
Sub Total		762	2,671	1,960	5,392	2,668	8,060
Engineering Cost(10%)		76	267	196	539	267	806
Sub Total		838	2,938	2,156	5,931	2,935	8,866
Contingencies (15%)		126	441	323	890	440	1,330
Gross Total Project Cost		964	3,379	2,479	6,821	3,375	10,197

Data Source: JICA Study,1996

Table 9.4.5 : Summary of Total Project Cost

(unit : US$1000)

Cost Component		Karabutak-Kzyl Orda Road Section				Atyrau-Mahambet Section	Total
		Karabutak-Irgiz		Irgiz-Kzyl Orda B.	Total		
		km					
		965-1060	1060-1154	1154-1240	965-1240	0-84	
Direct Cost		12,136	11,993	10,193	34,323	15,452	49,775
Indirect Cost	Contractor's Over-head & Profit(15%)	1,821	1,799	1,529	5,149	2,318	7,467
	Site on Cost	3,360	3,360	3,360	10,080	3,360	13,440
Sub Total		17,318	17,152	15,082	49,552	21,130	70,682
Engineering Cost(10%)		1,732	1,715	1,508	4,955	2,113	7,068
Sub Total		19,050	18,867	16,590	54,507	23,243	77,750
Contingencies(15%)		2,858	2,830	2,489	8,177	3,486	11,663
Gross Total Project Cost		21,908	21,697	19,079	62,684	26,729	89,413

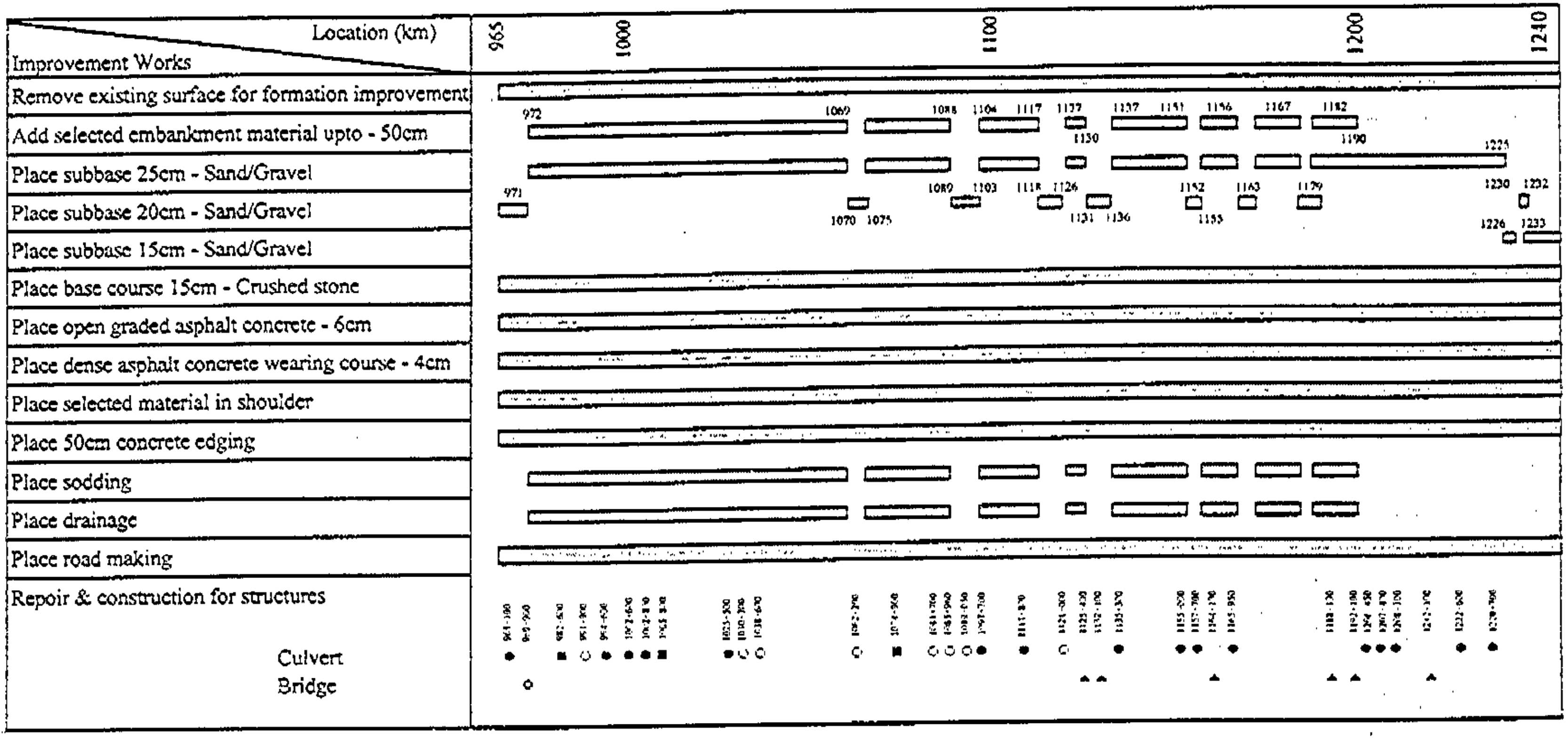
Data Source ; JICA Study, 1996

Table 9.4.6 : Total Project Cost by Local and Foreign Currency Portion

Road Section	Project Cost (US$ 1000)		
	Local Currency Portion	Foreign Currency Portion	Total
Irgiz - Kzyl Orda Border	14,309	4,770	19,079
Karabutak - Irgiz	32,704	10,901	43,605
Atyrau - Mahambet	20,047	6,682	26,729
Total	67,060	22,353	89,413

Note : 1US$ =66.5 Tenges.

Data Source : JICA Study, 1996



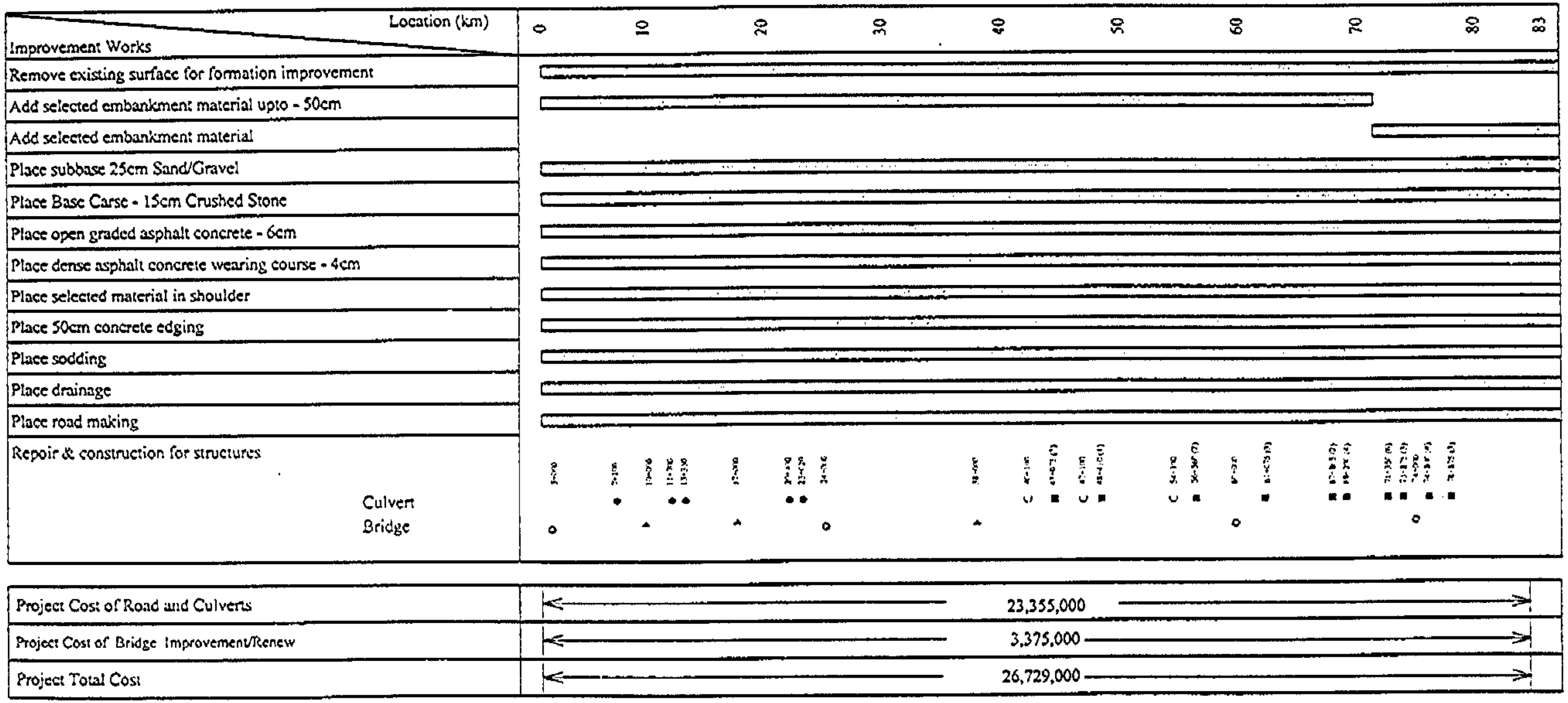
	965 –	–	– 1240
Project Cost of Road and Culvert	20,944,000	18,318,000	16,599,00
Project Cost of Bridge Improvement/Renew	964,000	3,379,000	2,479,000
Project Total Cost	21,908,000	21,697,000	19,079,000

Note : Unit : US$

Legend : ■ : Reconstruction of boxculverts ○ : Repair of pipe culverts ▲ : Reconstruction of bridges

● : Reconstruction of pipe culverts ◎ : Repair of briges

Fig. 9.4.1 (1) : Road Improvement Works and their Cost (in US$) for the Karabutak Road Section



Legend : ■ : New construction of equalizer channels (box culverts) ○ : Repair of pipe culverts ▲ : Reconstruction of bridges

● : Repair of boxculvert ◎ : Repair of briges

Note : The figure in parentheses are the number of the equalizer channels

Unit : USS

Fig. 9.4.1 (2) : Road Improvement Works and their Cost (in USS) for the Atyrau Road Section

Chapter 10 Road Maintenance for Priority Projects

Chapter 10 Road Maintenance for Priority Projects

10.1 General

New state road authority manages the road in this study, Actobe road authority in Aktyubinskaya state, Atyrau road authority in Atyrauskaya state. Actual maintenance works are executed as follows;

(1) Routine maintenance

State zholdaries do the routine maintenance work and some parts of periodic maintenance such as surface dressing, leveling of road surface. This work is contracted on negotiation basis with the road authority.

(2) Periodic maintenance, rehabilitation and improvement

This works are executed on contract basis by state zholdary and other contractors which are short-listed by the road authority, same as new construction of roads.

10.2 Road Maintenance Cost

The kinds of the works for Road Maintenance are so many that the cost is, especially in case of rough estimation, often estimated referring the results of previous works even in western developed countries such as Japan.

In Kazakhstan, the costs are calculated using the criteria of FSU in which the formula and necessary data of 1991 for the calculation are available, and estimated multiplying the coefficient included the inflation etc..

Moving to commercial market, the work on the contract base, the depreciation costs of the equipment for the works and etc. are considered to be included in the estimation. However, at present, the current way for the estimation is adequate because actual data for the estimation under the commercial market is not sufficient.

Maintenance Costs on the average are summarized in Table 10.2.1 which was prepared by Kazdornii for planning of road budget in 1996. In this report, the maintenance costs are estimated by modifying the figures in that table through discussion with Kazdornii considering "road construction cost" described in Chapter 9 and summarized as maintenance cost after improvement and maintenance cost without improvement

10.2.1 Road Maintenance Costs After Improvement

Routine maintenance costs after improvement will be as executed before road condition would be heavily damaged and reduce the road serviceability.

Estimated costs per kilometer are shown in Table 10.2.2.

Table 10.2.1 : Standard Costs of Road Maintenance and Repair

Types of pavements	Norms of money expenditures per km of the road			
	(In Tenges as on 01.01.91)		(in US$)	
	black gravel and black crash stone	gravel and crash stone	black gravel and black crash stone	gravel and crash stone
Types of works				
1.Periodic maintenance (restoration of the pavement, surface treatment, restoration of the wearing layer):	23,900	9,100	14,130	5,380
2.Routine maintenance				
2.1.Road management (organisation works, evaluation of the road condition, etc.)	282	282	170	170
2.2. Maintenance, including winter maintenance	1,430	1,430	850	850
2.3. Routine repair	2,410	2,049	1,420	1,210
2.4.Tree and shrub planting, including forestry care	774	774	460	460
Total	4,896	4,535	2,894	2,680

Remarks:
1. Source : Department of Roads
2. Refering to "Norms of money consumption (expenditure) are worked out by "Kazdornii" and are to be approved by the Ministry of Finance, Govt. of Kazakhstan
3. The routine repair costs for gravel road are estimated 15% less compared to black gravel roads.

Table 10.2.2 : Estimated Road Maintenance Costs per km for the "With Project" Case

Types of pavement	Cost per km of the Road Maintenance	
	Asphalt concrete (in Tenges as on 01.01.91)	Asphalt concrete (US$ in 1996)
Type of works		
1. Periodic maintenance (4cm overlay and 3cm leveling)	-	59,000
Frequency	-	7 years
2. Routine maintenance (annual)		
2.1 Road management (organisation works, evaluation of the road condition, etc.)	282	170
2.2 Maintenance, including winter maintenance	1,430	850
2.3 Routine repair	350	210
2.4 Tree and shrub planting, including forestry care	774	460
Total	2,836	1,676

Remarks:
1. Based on "Norms of money consumption (expenditure) which are worked out by "Kazdornii"and were approved by the Ministry of Finance of Govt. of Kazakhstan
2. Also based on discussions with "Kazdornii"

10.2.2 Road Maintenance Costs Without Improvement

Road maintenance cost without improvement is assumed that the road will be maintained to keep minimum level of serviceability. The sections of road studied have heavily damaged and many sections have almost deteriorated. The cost of routine maintenance would be much higher.

Estimated costs per kilometer including gravel and earth roads are shown in Table 10.2.3.

Table 10.2.3 : Estimated Road Maintenance Costs per km for the "Without Project" Case

Types of pavements	Cost per km of the Road Maintenance			
	black gravel and black crush stone	gravel and crush stone	black gravel and black crush stone	gravel and crush stone
	(in Tenges as on 01.01.91)		(US$ in 1996)	
Types of works				
1. Periodic maintenance (restoration of the pavement, surface treatment, restoration of the weariness layer):				
Cost	23,900	9,100	14,130	5,380
Frequency	3 years	2 years	3 years	2 years
2. Routine maintenance(annual)				
2.1.Road management (organisation works, evaluation of the road condition, etc.)	282	282	170	170
2 2. Maintenance, including winter maintenance	1,430	1,430	850	850
2.3. Routine repair	5,690	4,837	3,360	2,860
2.4.Tree and shrub planting, including forestry care	774	774	460	460
Total	8,176	7,323	4,832	4,328

Remarks:

1. Based on "Norms of money consumption (expenditure) which are worked out by "Kazdornii" and were approved by the Ministry of Finance of Govt of Kazakhstan
2 Also based on discussions with "Kazdornii"
3. The routine repair costs for gravel road are estimated 15% less compared with black gravel roads costs based on "Norms for Maintenance and Repair of Automobile roads, 1965"

10.3 Organization for Maintenance and Repair of Roads

10.3.1 Organization of State Road Authority

(1) Actobe Road Authority

Actobe road authority manages the section of Karabutak-Irgiz-Border of Kzyl-Orda state. The organization is shown in Fig. 10.3.1. There is no division for equipment maintenance, chief mechanic only.

(2) Atyrau Road Authority

Atyrau road authority is manages the section of Atyrau-Mahambet in Atyrau - Uralsk national road. The organization is shown in Fig. 10.3.2.

10.3.2 Activities of State Road Authority

The main functions of state road authority are as followings regarding maintenance and repair of road.

- Planing and order of the works
- Supervising and Inspection of work implementation
- Management of Equipment for the work

The authority owns the equipment and leases the equipment to the contractors which make a contract with the authority. The maintenance of equipment leased is mainly executed by the contractor. There are some different way in each authority.

In Aktobe road authority, the equipment inspection is carried out by the commission under the chairmanship of the chief engineer. If the contract was concluded on the 1 year term, the heavy repair such as overhaul of equipment is carried out at the expense of the authority. The maintenance and current repairs of the machinery are carried out by the contractor. If the contract was concluded on the term of more than 1 year, all the expenses for the maintenance and repair are carried out by the contractor.

In Atyrau road authority, the equipment inspection is carried out by the commission under the chairmanship of the Department of mechanization manager.

The authority is responsible for the equipment maintenance and repair if the leasing term is less than 1 year. The contractor is responsible for the equipment maintenance and repair if the leasing term is 1 year and more.

Leasing charge is temporally free, authorities are considering how to handle the equipment in detail including the leasing fee.

Fig. 10.3.1 : Organization of the Actobe Road Authority

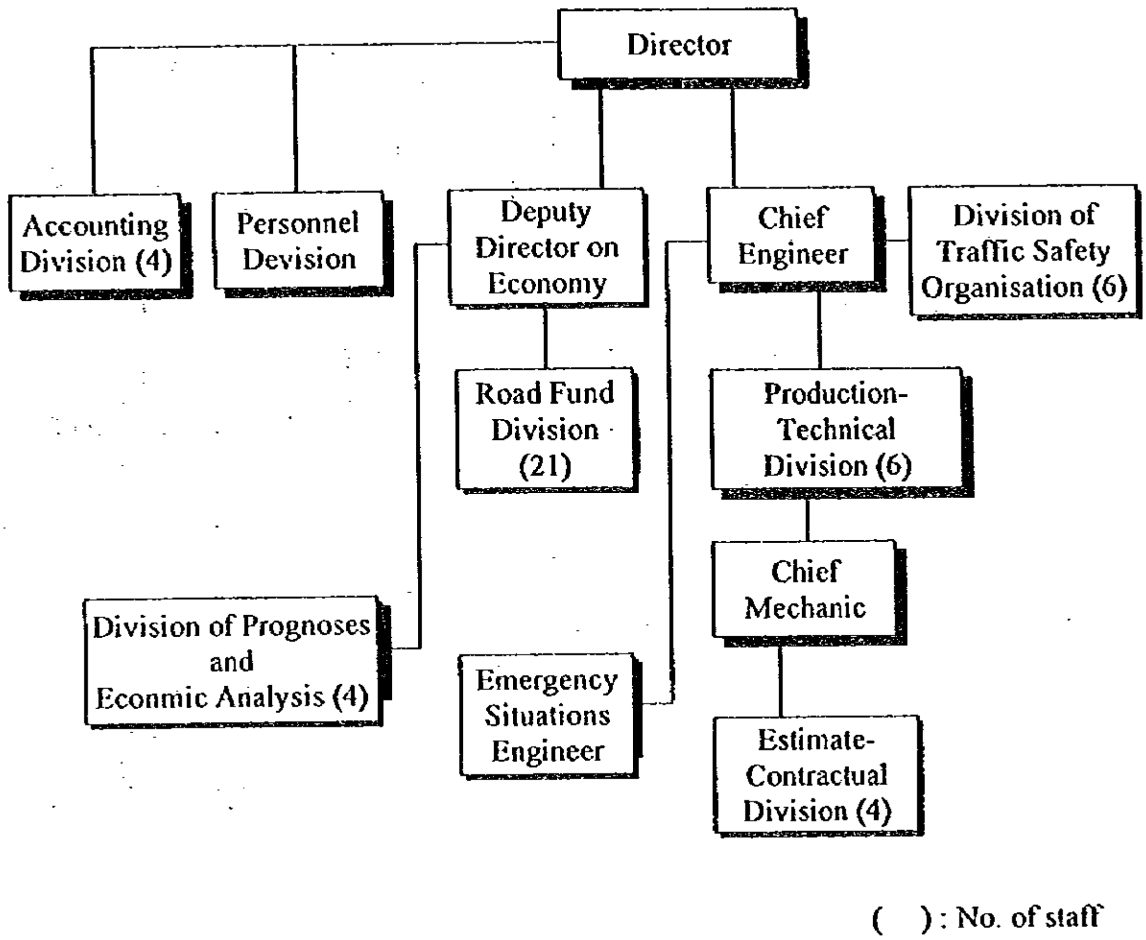
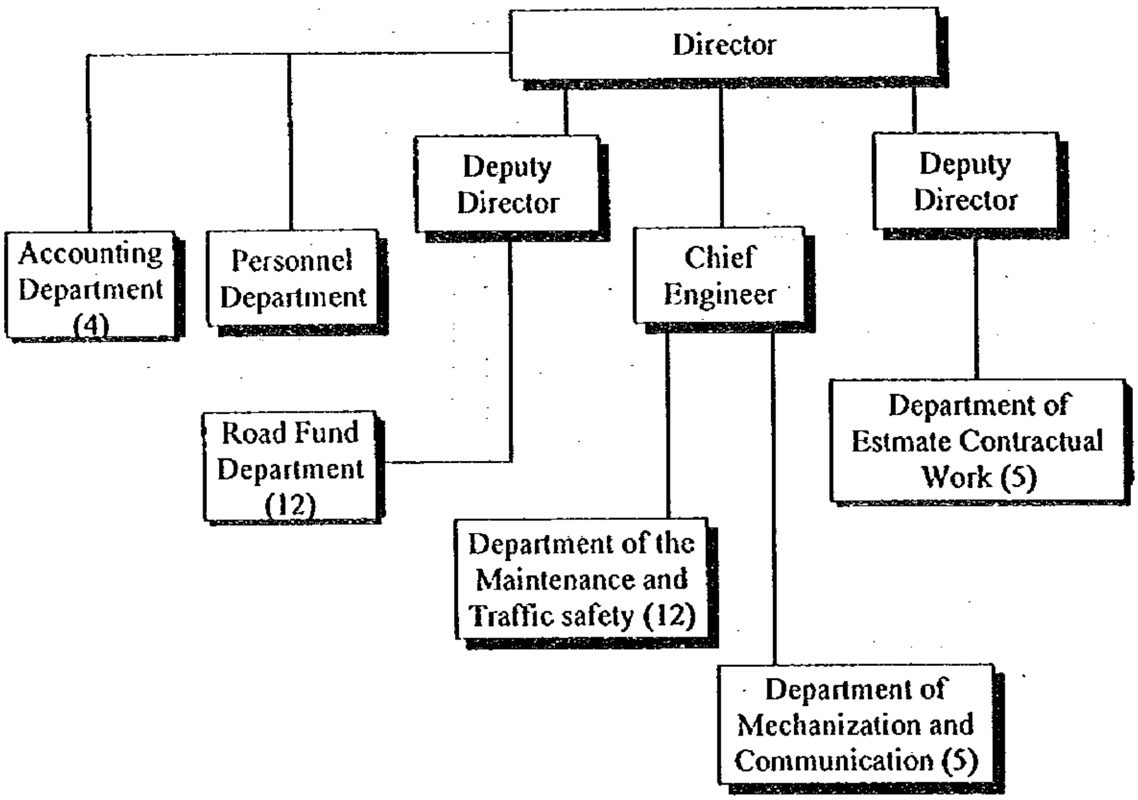


Fig. 10.3.2 : Organization of the Atyrau Road Authority



( ) : No. of staff

(1) Maintenance and repair of Equipment

The maintenance works are very important for the execution of the construction or maintenance of roads. Considering the execution of work, there are some problems in case that the owner and user of the equipment are different.

(a) It is difficult to avoid the authority' responsibility when the delay of road work come about, by equipment troubles in execution period, even if the contractor is responsible the maintenance.
(b) The authority and the contractor need the workshops for both of light and heavy maintenance of equipment. It is less efficient to consider limited machinery and tools for the maintenance.
(c) The authority must have the superintendent of the maintenance ability of the contractor, besides road maintenance. It means to need more staff in the authority.
(d) Leasing equipment is limited to the contractor which make a contract with the authority. It is less efficient to consider less number of equipment.

The authority recognizes the problems above, and need of technical support of western developed countries to handle the system efficiently with their long experiences. It has become general to divide the order and implementation of the work, in the countries, through the same system.

10.3.3 State Zholdary

Kazakhstan Zholdary continues as contractor of maintenance and repair work including new construction of road and keeps same organizations and functions as before the establishment of state road authority except ordering and superintending, as said in 3.4.5 in chapter 3.

10.4 Equipment for Maintenance and Repair of Roads

The necessary equipment for the road maintenance is leased from the authority. In this time, however, these offices actually manage the equipment.

(1) The Karabutak ~ Kzyl Orda road section

Aitekebiisky road maintenance office(Village Karabutak) manages the section, location 969-1,053 km(84 km.), Staff number is 33.

Road maintenance office (village Irgiz) manages the section, location 1,053-1,240 km(187 km), Staff number is 27.

The existing equipment and necessity of equipment are shown in Appendix IV.

(2) Atyrau-Mahambet section

Road Construction Management-1 manages the section, location 0-30 km (30 km), Staff number is 150.

Mahambet. Road Construction Management manages the section, location 30-83 km(53 km), Staff number is 48.

The existing equipment and necessity of equipment are shown in Appendix IV.

Necessary number of equipment is much less, different between each office. Road maintenance office (village Irgiz) have only 3% against necessary equipment.

As said in 3.4.5 (4) (c), the number of staff in offices would be enough if the work increasing.

10.5 Road Maintenance Management

10.5.1 Road Maintenance Management System (RMMS)

Road maintenance management is recognized to be important, and the management system is being developed by Kazdornii. The system by Kazdornii seems to bear comparison with ones in the western developed countries, though it is necessary to be checked and evaluated it. The development of the system will be delay because the lack of budget

Road condition data were renewed, based on the result of the inspection twice a year. The data include;

(1) Carriage way width
(2) Shoulder width and condition
(3) Longitudinal slope and visibility
(4) Radiuses
(5) Slope/Turns
(6) Roughness
(7) Road Grip
(8) Strength
(9) Load bearing capacity of bridges
(10) Traffic safety

The database system of road condition has almost been completed. Some inspection results were already inputted.

The system would output the following items combining the road conditions above, construction costs and traffic volume, for planning of management of roads.

(1) Make priority to the road section to be maintain and repair
(2) Necessary costs
(3) Method applied to the work
(4) Deteriorated progress
(5) Others

These systems are very useful for the management. Although the data of initial design and maintaining history are very important for the system, as mentioned before, the result of construction was, in many cases, differed from the design.

10.5.2 Superintending capability of State Road Authority

The checking activities were insufficient in each stage such as design and construction. Also the responsibility was actually not clear about the quality of the work, even though the norms was established. In that time the importance was the quantity of the work. For ensuring the quality of the work, it is very important to increase superintending capability of the authority with responsibility and to record and report the result of the work correctly. To increase that capability, not only supply of necessary equipment for construction and inspection of roads, but also training at all level of managing, engineering and all of staff with the support of the foreign experienced consultant / engineer. The recognition of quality control is more importance at Managing level of the Department of Road, to indoctrinate through training. Any sophisticate system would rely on that quality control in every stage.