COMMUNICATION DEPARTMENT
MINISTRY OF COMMUNICATION,
TRANSPORT, POST AND CONSTRUCTION
LAO PEOPLE'S DEMOCRATIC REPUBLIC

NO. I

BASIC DESIGN STUDY ON THE PROJECT FOR IMPROVEMENT OF NATIONAL ROAD NO.9 IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

MARCH 1999

JAPAN INTERNATIONAL COOPERATION AGENCY
KATAHIRA & ENGINEERS INTERNATIONAL
KOKUSAI KOGYO CO., LTD.

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PREFACE

In response to a request from the Government of Lao People's Democratic Republic (Lao PDR), the Government of Japan decided to conduct a basic design study on the Project for Improvement of National Road No.9 and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Lao PDR a study team from July 5 to August 15 and from October 17 to 31, 1998.

The team held discussions with the officials concerned of the Government of Lao PDR, and conducted field studies at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Lao PDR from February 16 to 25, 1999 in order to discuss a draft basic design, and as this result, the present report was finalized.

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

I wish to express my sincere appreciation to the officials concerned of the Government of Lao People's Democratic Republic for their close cooperation extended to the team.

March, 1999

Kimio Fujita
President
Japan International Cooperation Agency

March, 1999

Letter of Transmittal

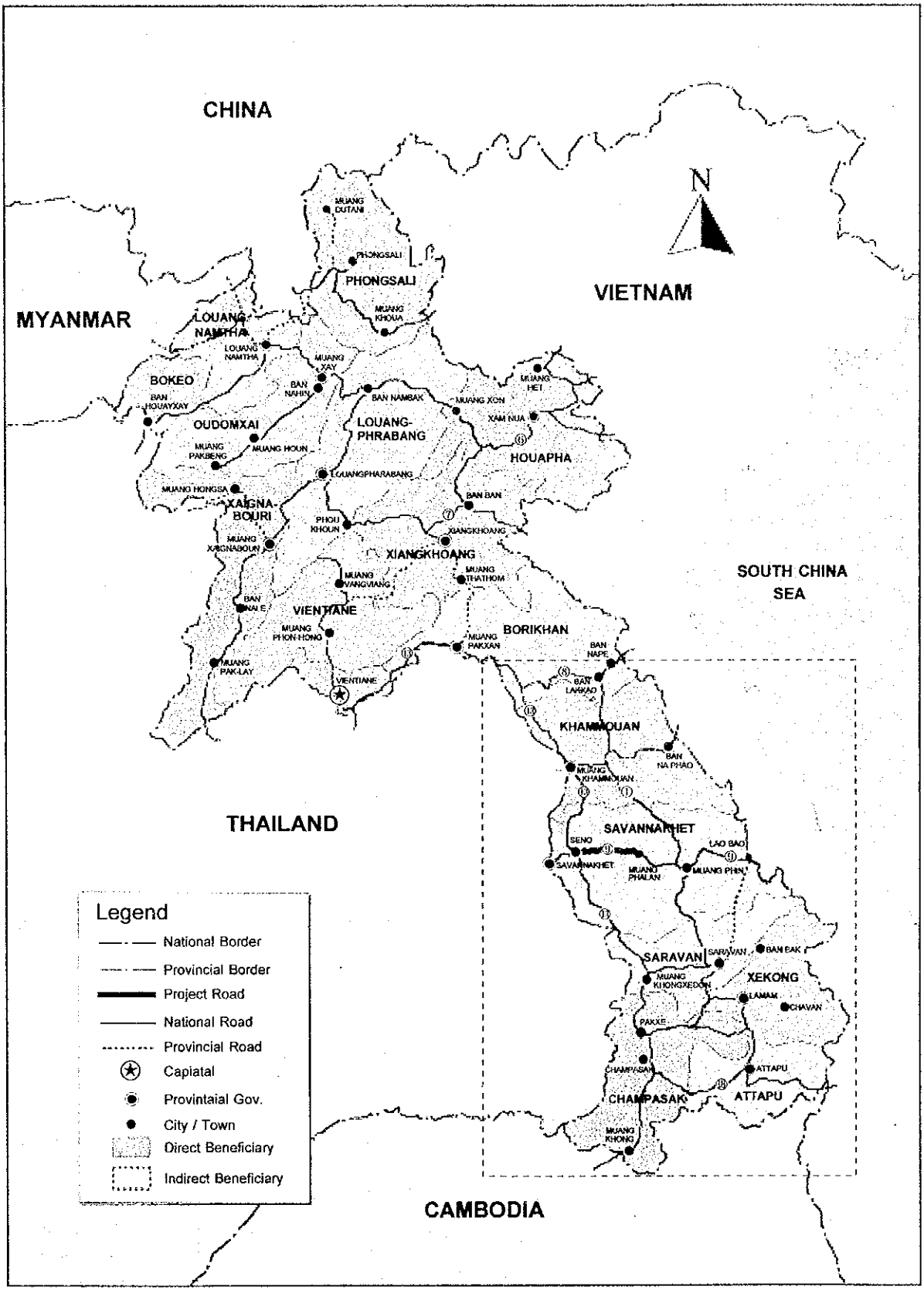
We are pleased to submit to you the basic design study report on the Project for Improvement of National Road No.9 in Lao People's Democratic Republic.

This study was conducted by Katahira & Engineers International and Kokusai Kogyo Co., Ltd., under a contract to JICA, during the period from June 30, 1998 to March 15, 1999. In conducting the study, we have examined the feasibility and rationale of the project, with due consideration to the present situation of Lao PDR, and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

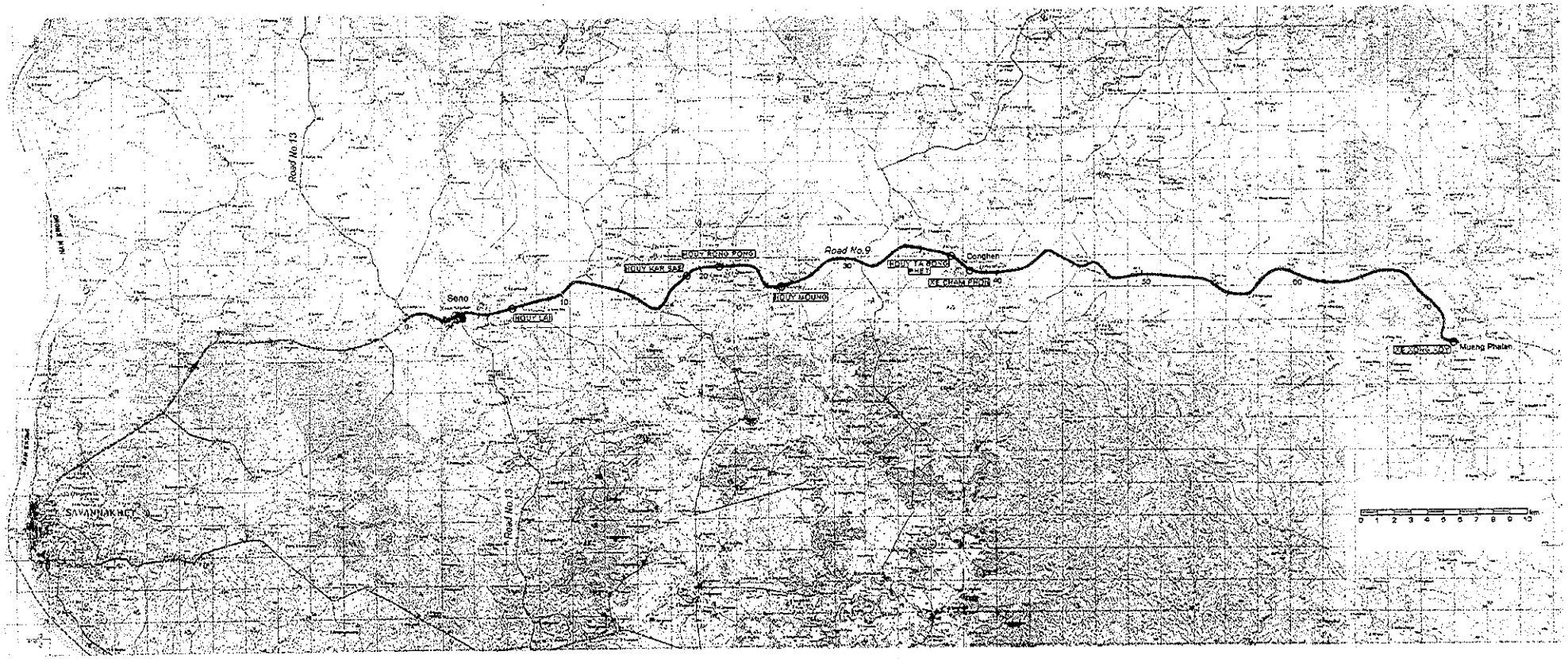
Finally, we hope that this report will contribute to further promotion of the Project.

Very truly yours,

Tsuneo Bekki
Project Manager,
Basic Design Study Team on the Project for
Improvement of National Road No.9
in Lao People's Democratic Republic
Katahira & Engineers International



Location Map



PROJECT ROAD

PERSPECTIVE (Westside View at 8.0 km point)

Abbreviation

AASHTO	:	American Association of State Highway and Transportation Officials
A C	:	Asphalt Concrete
A D B	:	Asian Development Bank
A D T	:	Average Daily Traffic
C B R	:	California Bearing Ratio
D B S T	:	Double Bituminous Surface Treatment
D C T P	:	Department of Communication, Transport and Post
D / D	:	Detailed Design
E S A L	:	Equivalent Single Axle Load
F / S	:	Feasibility Study
I D A	:	International Development Association
k p h	:	kilometer per hour
M C T P C	:	Ministry of Communication, Transport, Post and Construction
O E C F	:	Overseas Economic Corporation Foundation
P C U	:	Passenger Car Unit
P D R	:	People's Democratic Republic
p s i	:	pounds per square inch
R C	:	Reinforced Concrete
R O W	:	Right of Way
S B S T	:	Single Bituminous Surface Treatment
S N	:	Structure Number
U X O	:	Unexploded Ordnance
V P D	:	Vehicle Per Day

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CHAPTER 1

BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

Lao People's Democratic Republic is located in the Indochina Peninsula as a landlocked country with a total area of 236,800 sq. km, bordered to the west by Thailand and to the east by Vietnam. The national population in 1996 is 4.98 million, almost half of which resides in three lowland provinces, Vietiane, Savannakhet and Champasack, occupying about 17% of the total area.

The transport system in Lao PDR heavily depends on road, river and aviation, among which road accounts for 92% of cargo and 95% of passenger transport. The north-south spine of the highway system, National Road No.13 runs along the Mekong river to the Cambodian border in the south, and the east-west road, National Road No.6,7,8,9 and 18 are linked to a road in Vietnam, giving Lao access to Vietnamese seaport.

In recent years, the Government of Lao PDR has concentrated, among other important policies, on improving road infrastructure with special emphasis on the rehabilitation and improvement of the national road network. As a result of a considerable effort, the improvement was remarkably progressed, but still in urgent need to promote economic development and socio-economic activity.

National Road No.9 was identified by the East-West Transport Corridor Study, ADB, December 1996, as a high priority project to be urgently improved since it plays a vital role in the national road network, and connects Lao PDR with Thailand and Vietnam. Road No.9 runs from Savannakhet to Lao Bao, the Vietnam border, via Seno, with a total length of approximately 240 km. The pavement of its 2-lane carriageway is seriously damaged.

In view of such road conditions, Lao PDR planned to improve the section of National Road No.9 from Seno to Lao Bao, about 208 km including 17 bridges, in order to encourage the internal and external trade. To implement the project, Lao PDR requested Japan's grant aid assistance for the section from Seno to Muang Phalan, about 73 km including 7 bridges.

In response to the request, the Government of Japan decided to the conduct a basic design study on the Project. The Japan International Cooperation Agency (JICA) dispatched the Basic Design Study Team from July 5 to August 15 and from October 17 to 31, 1998, for field surveys and discussions with the officials of the implementing agency in Lao PDR.

The Study Team, during its stay in Lao PDR, confirmed the background, objectives and contents of the Project, collected relevant data, and surveyed the project site. After returning to Japan, the Study Team evaluated the Project in respect of necessity, socio-economic effects, appropriateness and other factors, and studied a basic design and implementation plan.

As a result, a draft basic design of the improvement of the road section from Seno to Muang Phalan, about 73 km, was proposed. After explanation and consultation on the draft basic design with the officials of Lao side, the basic design of the Project is developed.

CHAPTER 2

CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

In 1986 Lao PDR had decided to apply the New Economic Mechanism policy which conducts an economic management to a market economy. The policy states that the improvement of social basis is essential to achieve a lively economic activity. As one of the practical way of achievement, the improvement of existing national road network is the most important project to inspire the exchange of human and material resources.

National Road No.9 with a total length of 240 km approximately, links Savannakhet city in the west and Lao Bao in the east, the Vietnam border, via Seno City. As a East-West Transport Corridor, it plays a vital role of main trunk which crosses the Savannakhet province the second largest province in Lao PDR, a country without seaport, gives a access to the South China Sea via Vietnam.

The project road from Seno to Muang Phalan which locates near the capital of Savannakhet province is one of the busiest of traffic in the Road No.9. However the existing road condition shows many potholes, alligator crackings and localized failing areas with the collapse of AC surface or stripping of AC base course.

The existing road condition decreases the safety and comfort for the traffic and the improvement is in urgent requirement. The Government of Lao PDR has concentrated, among the major road infrastructure, without improving the National Road No.9 the socio-economic development in Savannakhet province is hard to achieve it.

From this point of view the improvement of National Road No.9, as a one of the high priority project, is expected to be urgently improved since it plays a vital role in the national road network in Lao PDR.

2.2 Basic Concept of the Project

2.2.1 Existing Condition of the Project Road

The major national roads in Lao PDR are No.1, 2, 4, 6, 7, 8, 9 and 13. Road No.13 with a total length of 1,370 km is the main trunk road in the country, which links Luang Prabang in the north and Khong in the south passing through the major urbanized areas of Vientiane, Savannakhet and Pakse. National Roads No.7, 8 and 9 lead to the Vietnamese border, and No.1 to China.

National Road No.9 was constructed in two sections. The first section between Seno to Sepon, Km 0 – Km 163, with a 7 m carriageway and 1 m shoulders, was designed by the Russian Design Institute and constructed by the MCTPC during 1984 to 1988. The second section from Sepon to the Vietnamese border, Lao Bao, Km 163 – Km 208, with a 6 m carriageway and 1 m shoulders, was designed and constructed by Vietnamese engineers and contractors between 1982 and 1986.

2.2.1.1 Existing Condition of the Road

The existing conditions of the Project road from Seno to Muang Phalan, approximately 73 km are described below (Refer to Appendix 6; Road Condition Survey).

(1) Traffic

The Central Corridor, Road No.9, is one of the most heavily traffic routes on the national road network in Lao with a daily traffic of 300 vehicles per day. The typical composition of existing traffic flow is as follows:

- High proportion of motor cycles
- Lower proportion of commercial vehicles
- Higher proportion of buses
- Relatively low levels of daily traffic (low levels of the vehicle ownership & economic activity and generally poor state of the roads)

(2) Alignment

The horizontal and vertical alignments of the road appear acceptable except at few sections in which the horizontal curve radius are below the design requirements.

According to the Russian design documents, the road was designed with the following geometric criteria:

- Minimum horizontal curve radius 250 m
- Minimum vertical crest curve radius 5,000 m
- Minimum vertical sag curve radius 2,000 m
- Maximum gradient 5 %

(3) Road Width

The existing road width varies from 7.5 m to 10.0 m with the following carriageway and shoulders.

- Carriageway width ; 6.5 m ~ 8.0 m
- Shoulder width ; 1.0 m ~ 2.0 m

(4) Pavement

The existing pavement consists of DBST surfacing, macadam base and subbase with a total thickness of about 400 mm, as shown in Figure 2.2.1-1.

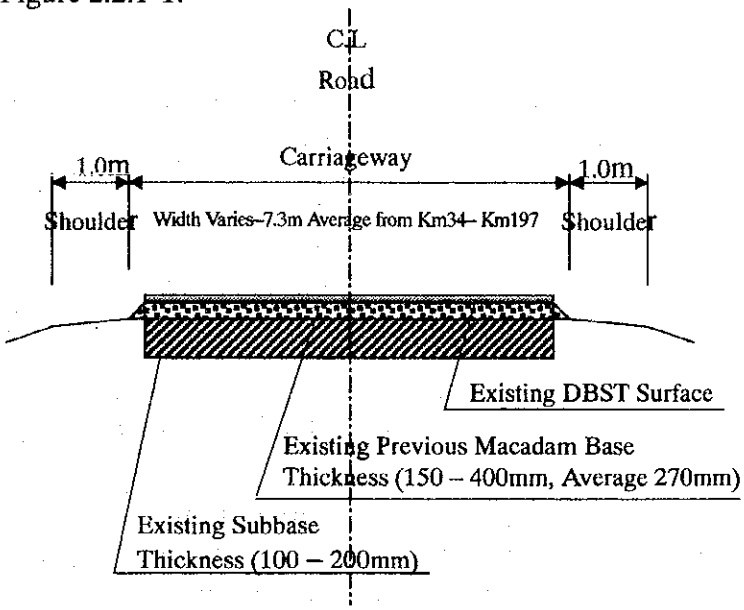


Figure 2.2.1-1 Existing Pavement

The existing pavement, in general, shows several types of deficiencies and deteriorations including traverse/longitudinal/alligator crackings, localized failure spots, removal of surface materials, potholes, depression, etc. The existing conditions of pavement are briefly presented in Table 2.2.1-1.

Table 2.2.1-1 Existing Condition of Pavement

Chainage KM	Functional Condition	Structural Condition	Remarks
KM 0 ~ KM19	Fair/Good	Low/medium severity	
KM19 ~ KM26	Very Bad	High severity	Many localized failing spots
KM26 ~ KM35	Bad	Medium severity	
KM35 ~ KM37	Very Bad	High severity	Seriously localized failing spots
KM37 ~ KM42	Fair/Bad	Low/medium severity	
KM42 ~ KM55	Very Bad	High severity	Many localized failing spots
KM55 ~ KM62	Bad	Low/medium severity	
KM62 ~ KM72	Very Bad	High severity	Many localized failing spots
KM72 ~ KM73	Fair	Low severity	

Note; Structural conditions were evaluated based on severity of alligator cracking.

(5) Culverts and Drainage

In the section of the Project road, there are 44 pipe culverts. The existing culverts were generally observed to provide a reasonably adequate cross drainage capacity with inlets/outlets at both sides. The roadside drainages are gravel ditches except those in some urban sections and steep gradient areas where concrete type ditch was used. No serious defects were observed.

(6) Road Facilities

Traffic signs were provided at adequate spots such as urbanized areas, school zones, junctions and the load limit of bridges. Concrete posts were installed at curved sections, but no posts at bridge approaches. Bus stops were located at reasonable spots in urbanized areas.

2.2.1.2 Existing Condition of the Bridges

There are 7 bridges along the Project road with the types and dimensions, as summarized in Table 2.2.1-2.

Table 2.2.1-2 Summary of Bridges

Bridge Number	Bridge Name	Chainage (KM)	Bridge Type	Bridge Length (m)	Carriageway Width (m)	Side walk (m)	Design Load (t)
1	HOUY LAI Bridge	6.925	R,C,Simple Girder	24	8.0	2 x 1.0	30
2	HOUY KAR SAE Bridge	18.823	R,C,Simple Girder	54	8.0	2 x 1.2	30
3	HOUY RONG PONG Bridge	20.979	R,C,Simple Girder	39	8.1	2 x 1.2	30
4	HOUY MOUNG Bridge	25.431	R,C,Simple Girder	39	8.3	2 x 1.1	30
5	HOUY TA BONG PHET Bridge	36.848	R,C,Simple Girder	42	8.5	2 x 1.2	30
6	XE CHAM PHON Bridge	38.663	Simple Steel Girder	100	7.0	2 x 1.25	30
7	XE XONG XOY Bridge	72.807	Steel Continuous Girder	100	7.0	2 x 1.40	30

In general, the existing conditions of bridges are fairly reasonable to carry traffic loads, although structures show some deficiencies such as spalled concrete of structural members, inadequate cover of concrete, damaged expansion joint, etc.
Deficiencies of bridges in view of traffic functionality are summarized as follows (Refer to Appendix 7 : Existing Condition and Rehabilitation Method of Bridges):

- Deck slab
  Deck concrete slab of almost all bridges has irregular surface with considerable amount of hairline cracks.
- Deck drainage
  Deck drainage has no drainage path so that surface water can not be discharged.
- Steel hand railing
  Most of the steel hand railing are damaged or corroded.
- Score protection
  - Pier foundation of No.4 bridge was scoured.
  - Abutment slope protection of No.7 bridge was damaged.
- Sidewalk at bridge approach
  No sidewalk was provided at bridge approach.

2.2.2 Evaluation on Importance of the Project Road

2.2.2.1 Importance of the Road

Based on these findings and examinations, the importance of the Project Road is evaluated and summarized on the following aspects.

- Role in road network
- Traffic Demand
  - Early Stage
  - Final Stage
- Socio-economic development
  - Beneficiary
  - Agriculture
  - Stockbreeding

(1) Role in Road Network

National Road No.9 is currently playing a vital role in the national

road network passing through Savannakhet province, connecting National Road No.13 to the west. It forms the key elements as the most important transport facility in the influenced area.

The important role of National Road No.9 was identified, not only in the region, but in the road network on inter-regional or international level as a means of east-west corridor transport, by the several studies including the East-West Transport Corridor Project, ADB.

The East-West Transport Corridor Project includes their components, a bridge crossing the Mekong River near Mukdahan in Thailand and Savannakhet in Lao, upgrading Road No.9 through Lao to Road No.1 in Vietnam, to provide access to Da Nang port as a primary destination for corridor traffic.

National Road No.9 with a total length of approximately 240 km connects systematically and effectively three countries, namely Thailand, Lao PDR and Vietnam. Figure 2.2.2-1 shows the international network related to Road No.9.

(2) Traffic Demand

Comparing with the North Corridor Road No.8, and the Southern Corridor, Road No.9 (Central Corridor) is currently the most heavily traffic route with a daily traffic flow approaching 300 vehicles.

The present and forecast average daily traffic at Lao Bao along Road No.9 is shown in Table 2.2.2-1.

Table 2.2.2-1 Present and Forecast Traffic

Average Daily Traffic

		Motor-cycle	Bus	Car, Pick-up	Commercial Vehicle	Total
Existing 1995	International	20	13	10	72	115
	Domestic	73	14	10	73	170
	Total	93	27	20	145	285
Forecasted in 2000 *		455	347	168	420	1,390
in 2010 *		1,128	575	414	922	3,039
in 2020 *		2,787	934	1,065	2,026	6,812

* Forecast traffic with the construction of Mekong Bridge and upgrading Road No.9 and related roads.

Source: Final Report, Volume 2, East-West Transport Corridor Study, ADB, 1997

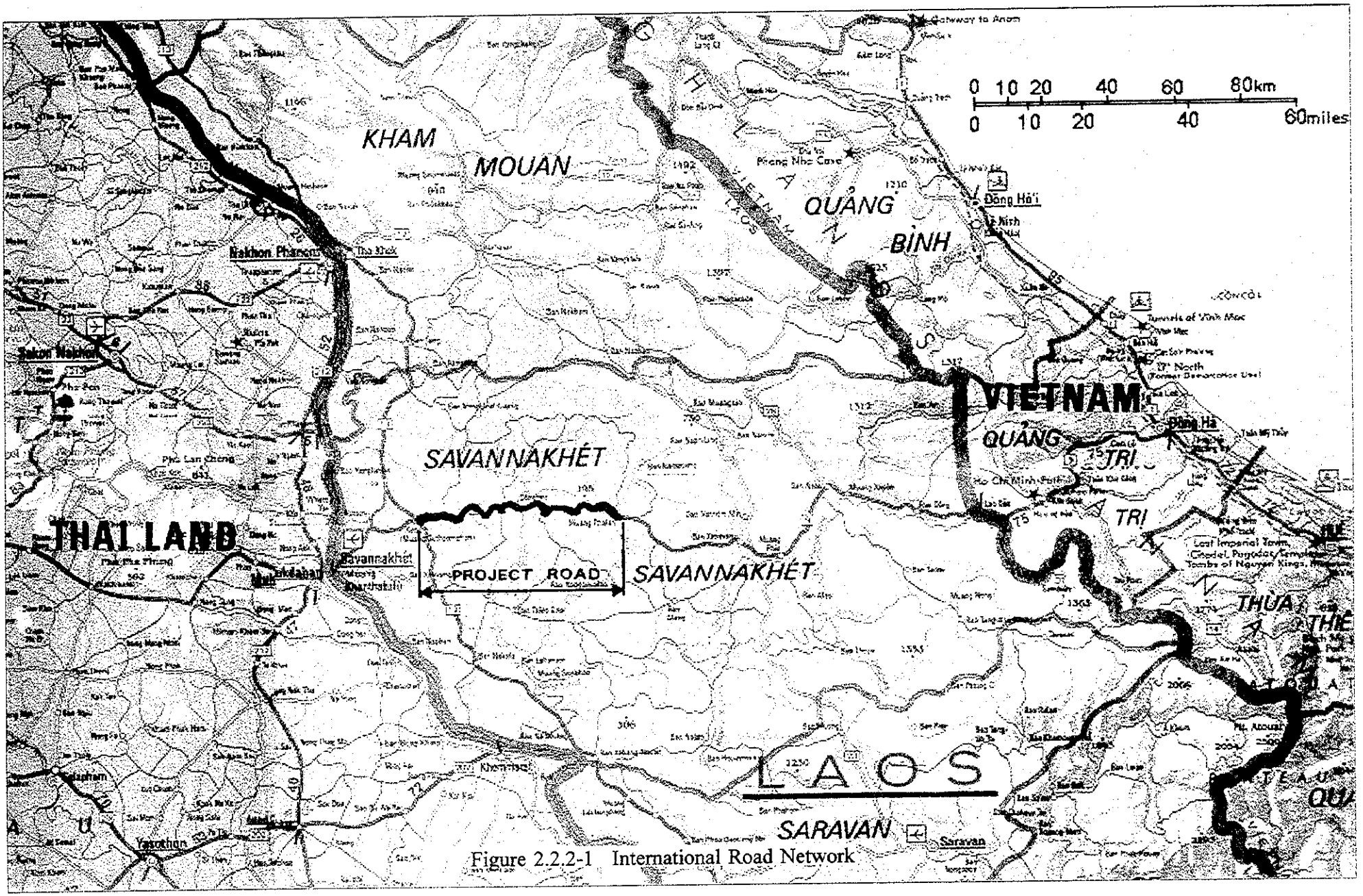


Figure 2.2.2-1 International Road Network

The analysis on forecast traffic demand indicates that traffic volume in the Year 2000 will be about 5 times that in 1995 with the construction of Mekong River Bridge and upgrading of Road No.9 and related roads (Final Stage). After 2000, the traffic volume will increase with an annual average growth rate of more than 8%. It is therefore, evaluated that Road No.9 will play a vital role not only inside the region but also an inter-regional base.

Before the completion of the bridge and upgrading projects mentioned above (Early Stage), the Study Section with approximately 73 km from Seno will handle traffic volumes as an access road from the influence area to Road No.13.

(3) Socio-economic Development

The improvement of Road No.9 is also expected to contribute for the socio-economic development in the region, particularly on the sectors of agriculture and livestock for considerable number of beneficiaries.

Beneficiary

Population of Savannakhet province is estimated to be 711,500 in 1997, approximately 15% of total population in Lao PDR. This population will compose the direct beneficiaries from the Project in view of socio-economic development of the province, smooth commodity flow and development of external trade.

All the population of southern provinces, which are the provinces of Attopeu, Sekong, Saravane and Champasack, with about 1.67 million is considered to benefit indirectly from the Project.

Table 2.2.2-2 Population by Province

Unit; Thousand in 1997

Province	Area (Km^2)		Population	
1. Savannakhet	21,774	(9.2%)	711.5	(15%)
2. Vientiane Municipality	3,920	(1.6%)	555.1	(11%)
3. Champasack	15,415	(6.5%)	531.1	(11%)
4. Luangprabang	16,875	(7.1%)	386.4	(8%)
5. Xayabury	16,389	(6.9%)	309.0	(6%)
6. Vientiane	15,927	(6.7%)	303.5	(6%)
Whole Country	236,800	(100%)	4,845.8	(100%)

Source: Basic Statistic-97, National Statistic Center, Lao PDR

Agriculture

Savannakhet province is economically dominated by agriculture and forestry. Rice is the main crop in the province, which share 19% of total production in the country.

Table 2.2.2-3 Rice Production

Unit; Ton in 1997

1. Savannakhet	318,750	(19 %)
2. Champasack	204,550	(12 %)
3. Vientiane Municipality	187,200	(11 %)
4. Saravanh	127,800	(8 %)
Whole Country	1,660,000	(100 %)

Source: Basic Statistic-97. National Statistic Center, Lao PDR

Livestock

Livestock is an important production in Savannakhet province, having 28% of buffalos, 19% of cattle, 14% of goats and sheep, of total products in the country.

Table 2.2.2-4 Number of Livestock

Unit: Thousand heads

Item	Whole Country		Savannakhet		Ranking by Provinces
Buffalo	1,223.8	(100 %)	236.8	(28 %)	1
Cattle	1,227.5	(100 %)	341.1	(19 %)	1
Pig	1,813.0	(100 %)	144.2	(8 %)	4
Goats and Sheep	165.0	(100 %)	22.7	(14 %)	3
Poultry	11,947.0	(100 %)	841.1	(7 %)	7

Source: Basic Statistic-97. National Statistics Center, Lao PDR.

2.2.2.2 Importance of the Bridges

As described in Section 2.2.2.1, Road No.9 is currently carrying a reasonable number of traffic, and expected to handle a high traffic demand in the near future.

The importance of bridges along this international highway cannot be neglected. Removal/new construction of these bridges will waste the investment already spend for the construction of bridges, and hamper the movement of people and commodities. This situation can not afford to wait for the duration of reconstruction of deteriorated bridges.

2.2.3 Examination on Necessity of Improvement Measures for the Project Road

Based on the field investigation and analysis, improvement measures required for the Project Road were carefully examined taking into consideration the importance of the Project Road.

2.2.3.1 Improvement Measures for the Road

Improvement measures necessary for the road are summarized in Table 2.2.3-1, in comparison with ADB's proposal, in which the basic concept employed in examining the necessary measures is the same.

In the Project Section, the followings are the special issues which require urgent improvement.

- Removal of unsuitable materials under shoulder
- Improvement of unchannelized intersection at Seno

Tables 2.2.3-2 and 3 present repair methods for culvert and drainage system, and improvement measures for traffic facilities.

No other special issues were found in the Project Section.

2.2.3.2 Rehabilitation Measures for the Bridges

Measures to improve the structural capabilities of bridges were not recommended because the existing bridges are in reasonable condition and do not show structural deterioration due to traffic loadings.

However, the surface of deck slab of bridges is so rough that riding comfort is not in acceptable condition, which require urgent remedial measures. Table 2.2.3-4 shows the proposed rehabilitation measures in comparison with ADB's proposal.

In the Project Road, the special issues requiring urgent remedy are as follows.

- Rehabilitation of deck slab abrasion/surface irregularity
- Construction of sidewalk at bridge approach

Table 2.2.3-1 Proposed Improvement Measures for Road

Items	JICA	ADB
1. Design Standards	MCTPC Road Design Manual with modifications.	MCTPC Road Design Manual with modifications
2. Road Design Class	Class II. (3000-8000 PCU)	-
3. Design Speed	• 100 kph Flat/Level Terrian • 50~70 kph (Populated area)	- 100 kph (West of Zepon) Flat - 80 kph (East and Zepon) Rolling - 50~70 kph (Populated area)
4. Road Cross Section	- No of lane : 2 - Lane with : 3.5m - Shoulder : 1.5m 2.5m (populated area) - Paved shoulder : 1.0m (t=5cm) : 2.5m (t=5cm)	- No of lane : 2 - Lane with : 3.5m - Shoulder : 1.5m 2.5m (populated area) - Paved shoulder : 1.0m (SBST)
5. Alignment	- Follow Existing Alignment	- Follow Existing Alignment
6. Pavement	- Pavement Life 8 years - 1.8 million ESAL application - Overlay on Existing Pavement -Min 5cm AC -Min 5cm Bituminous Treated Base -Min 12 or 15cm Base -Preparation of Pre-Overlay repair - New Construction -Min 5cm AC -Min.5cm Bituminous Treated Base -10.0cm Base -28cm Cement Treated Subbase -CBR=5 Subgrade	- 8 million equivalent standard axle - Overlay on Existing Pavement -Min 5cm AC -Min 1cm SBST -17.5cm Base -17.5cm Subbase -Trimming of existing surface (50~100mm) - New Construction -Min 5cm AC -Min 1cm SBST -Min 17.5cm Base -Min 17.5cm Subbase -15cm Lower Subbase(CBR=15) -CBR=5 Subgrade
7. Unsuitable Material under Shoulder	- Removal and replace with permeable materials	-
8. At-grade Intersection at Seno	- Improve as channelized or signed intersection	

Table 2.2.3-2 Proposed Repair Methods for Culvert and Drainages

Defect	JICA	ADB
1. Gaps at joint	- The existing culverts had been constructed at reasonable locations. - Those are in fair condition with adequate drainage capacity. - The extension of culvert length is not required because of no widening, except a culvert Seno. - Based on above, no repair is Required.	- Clean and refill joint with mortar or bituminous filler
2. Inadequate cover		- Chemical surface treatment or path repair
3. Spalled or bony concrete		- Cutback and path repair with non-shrink mortar
4. Scour		- Repair or provide new gabion or rock protection
5. Damaged stone masonry		- Replace stone and grout joint
6. Badly damaged roof slab in box culvert		- Replace

Table 2.2.3-3 Proposed Improvement Measures for Traffic Facilities

Defect	JICA	ADB
Traffic sign	- According to Lao Road Design	- According to Lao Road Design
Lane marking	- Centerline delineation - Edgeline delineation	- Centerline delineation - Edgeline delineation
Guard post / rail	- High embankment - Tight curve - Bridge approach (Steel guard rail)	- Embankment (more than 4.5m) - Tight substandard curve - Bridge approach
Bus stop	- Provide at populated areas	- Provide at populated areas

Table 2.2.3-4 Proposed Rehabilitation Methods for Bridges

Defect	JICA	ADB
1. Deck slab Abrasion	- Cover with asphalt concrete (t=5.0cm)	- Cover with asphalt concrete
2. Damaged expansion joint	- No seriously damaged joint - Butt- joint (Bridge No.1,2,3,4 and 5) must be covered with AC - Finger steel joint (Bridge No.6 and 7), no repair	- install new
3. Inadequate deck drainage	- For Bridge No.1,2,3,4 and 5, drainage paths will be provided through crossfall in AC surfacing - For Bridge 6 and 7, no repair	- Provide new drainage paths through kerbs and crossfall in AC surfacing.
4. Damaged /corroding steel railing	- Existing steel railing which has a few places of damage and corroding, repair	- Repair, clean and paint
5. Spilled or bony concrete	- No repair because of no structural deficiencies	- Cut bars and path repair with non-shrink mortar
6. Cracked concrete	- No repair because of no structural damages.	- Inject with epoxy
7. Inadequate cover	- No repair because of no progress in corroding of steel reinforcing bars.	- Chemical surface treatment or path repair
8. Corroded steel bearing	- No repair because of no serious problem.	- Clean and paint
9. Aged paint on steel girders	- Fair condition of painting, no repair.	- Clean and paint
10. Damaged score protection	- Repair with gabion	- Repair or provide new gabion or rock protection
11. No sidewalk at bridge approach	- Construct sidewalk with RC guide post.	-

2.3 Basic Design

2.3.1 Design Concept

The basic design concept of the Project is to improve the section of Road No.9 from Seno (Km.0) to M. Phalan (Km.73) so as to accommodate the expected traffic demand during the design life, and ensure the provision of safety and reliable means of transportation.

The basic design concepts discussed and agreed upon by the MCTPC and the Study Team are summarized hereunder.

2.3.1.1. Road Improvement

(1) Basic Design Elements

The basic design elements were reviewed in accordance with the Road Design Manual (Provisional Use), Vientiane, 1996, Communication Department, MCTPC, taking into consideration the geometric design standards of the two countries, Vietnam and Thailand which are presented in Table 2.3.1-1.

Through review and discussions with concerned agencies, the following major design elements as shown in Table 2.3.1-2 were adopted.

Table 2.3.1-2 Major Design Concept

Road Design Class		Class II	
Traffic	(ADT)	3000 ~ 8000	
Design Speed	(km/h)	100 50 ~ 70	(Flat Terrain) (Populated Area)
Lane Width	(m)	3.5	
Shoulder Width	(m)	1.5 2.5	(Flat Terrain) (Populated Area)

Table 2.3.1-1 Comparison of Major Design Elements

Lao PDR																					
Road Design Class	I			II			III			IV			V			VI			VII		
Traffic	> 8000			3000-8000			1000-3000			300-1000			100-300			50-100			< 50		
Administrative Classification	National/Provincial Road												Access/Local/Minor Rural Road								
Terrain	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
Design Speed (km/hr)	100	80	60	100	80	60	80	60	40	80	60	40	60	40	20	60	40	20	40	30	20
Number of Lanes	4			2			2			2			2			1			1		
Lane Width (m)	3.75	3.75	3.5	3.75	3.75	3.5	3.5	3.5	3.0	3.0	3.0	3.0	2.75	2.75	2.5		3.5			3.5	
Carriageway (m)	15	15	14	7.5	7.5	7	7	7	6	6	6	6	5.5	5.5	5		3.5			3.5	
Vietnam																					
Category of Road	I			II			III			IV			V			VI			VII		
Daily Traffic	> 6000			3000-6000			1000-3000			300-1000			50-300						< 50		
Importance of Highway	International Highway (Special Importance)			International Highway			Secondary Trunk Road						Interregional Provincial Road						Regional Provincial Road		
Terrain	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
Design Speed (km/hr)	120	-	-	100		80	80	-	60	60	-	40	40	40	25				25	25	15
Number of Lanes	4			2			2			2			1						1		
Lane Width (m)	3.75	-	3.75	3.75	-	3.75	3.5	-	3.5	3.0	-	2.75		3.5						3.5	
Carriageway (m)	15	-	15	7.5	-	7.5	7	-	7	6	-	5.5		3.5						3.5	
Thailand																					
Road Class	0			1			2			3			4			5			Urban Area		
Traffic	above 8000			4000-8000			2000-4000			1000-2000			300-1000			below 300			-		
Road Classification																					
Terrain				F	R	M							F	R	M	F	R	M	F	R	M
Design Speed (km/hr)				90-110	80-110	70-90							7-90	55-70	40-55	6-80	5-60	3-50	60	60	60
Number of Lanes	4			2			2			2			2			1			-		
Lane Width (m)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5				3.5	3.5	3.5
Carriageway (m)	14	14	14	7	7	7	7	7	7	7	7	7	7	7	7		8		-	-	-

- Road Design Class and Traffic
  According to Road Design Manual, Road Design Class II is classified as Provincial Road with design traffic volume of 3000 ~ 8000 ADT, while Road No.9 is a national road. However, Class II was adopted because of the predicted traffic volume of 3,039 ADT in the Year 2010 and 6,812 in 2020 including the number of motorcycles.

- Design Speed
  The Road Design Manual provides that the design speed shall be 100 km/hr, 80 and 60 for flat, rolling and mountainous terrain, respectively. In accordance with the Manual, the design speed of 100 km/hr was adopted in rural flat area, and 50~70 km/hr, for populated area taking into account of traffic safety of inhabitant in the area.

- Road Width
  The Road Design Manual regulates the road width of 3.75m for flat and rolling terrain, and 3.5m for mountainous terrain. However, a road width of 3.5m for flat terrain was adopted taking into consideration the basic traffic capacity of rural road and construction cost.

- Shoulder Width
  A wide shoulder of 2.5m with pavement surface was adopted in populated areas considering sizable number of local traffic including motorcycle and convenience of inhabitant. In rural area, a width of 1.5m with gravel surface is adopted.

(2) Basic Design Planning

- Centerline of Road
  The existing centerline of road was proposed to be respected so that the new centerline can follow as closely as possible, to eliminate acquisition of new right of way, except sections at which the existing horizontal alignment are substandard.

- Vertical Alignment of Road
  The elevation of new road was preferred to follow that of the existing road in order not to hamper the present roadside services, providing that the minimum gradient for surface water can be attained.

- Road facilities and control devices such as bus stop, road marking, guide post, traffic sign etc. were proposed to be installed in accordance with the Road Design Manual, Communication Department, MCTPC or international standards.

2.3.1.2 Pavement Rehabilitation

(1) Pavement Structures

- Surface Structures
  Asphalt concrete (AC) type of surface course was preferred taking into consideration the fair number of overloaded vehicles and to prevent rainfall penetration into pavement structure.

- Base and Subbase Course
  Cement treated subbase course and granular base course were recommended to optimize the utilization of local materials. Bituminous-treated base was also adopted as top layer of base course to provide surface for AC, and to prevent dust during construction.

(2) Life of Initial Pavement Structure

- Performance period (life) of initial pavement structure was recommended to be 8 years which is equivalent to that of AC pavement in other tropical countries, considering the maintenance capability of MCTPC.

(3) Rehabilitation Design Planning

- Full-depth reconstruction and overlay with AC pavement methods were adopted depending on the existing condition of pavement, CBR of subgrade and roadside drainage condition.

2.3.1.3 Bridge Rehabilitation

- Basic Design Planning
  In general, measures to increase the structural durability and strength of existing bridges involve a huge amount of cost, this is not practicable except for measures that have warrant effect such as prolonging a life of structure against cost spend for.

The bridges are in a reasonable condition at present, and do not show structural deterioration due to traffic loading, therefore no counter measures for structural deficiencies were proposed.

- Improvement of Riding Comfort
  The surface of deck slab of existing bridges is so rough that riding comfort is less than acceptable level. Therefore, such surfaces was recommended to be improved by applying AC overlay except for bridges No.6 and No.7.

2.3.1.4 Others

The climate conditions at the project area is stable i.e. variation of the temperature is not so much, a ground does not freeze or a rainfall amount is proper. Therefore no special consideration was taken in connection with the natural conditions.

The project road that runs in the populated area is busy with the water drawers and bicycles in the morning and afternoon. The improvement with 2.5m shoulder width is designed to cope with the contemporary utilization. The designed bus stops and bus bays are expected to improve a convenience for the inhabitant lives along the project road.

The local construction business along the project road is a still developing situation, the supply of the local engineers or the construction equipment is not sufficient in quantity or quality, in this respect an appropriate design such as rip rap ditch as a road facility was applied for the project.

The simple and durable road facilities are designed to ease a maintenance work that will be carried out by the Communication Department after the completion of the project.

The grade of the improved project road would be with the minimum satisfactory condition because this project aims at the rehabilitation of the existing situation.

2.3.2 Design Criteria

Based on the basic design concept adopted in Section 2.3.1, a design criterion was established in accordance with the design standard of Road Design Manual (Provisional Use), Communication Department, MCTPC, as shown in Appendix 8 (Design Standards).

2.3.2.1 Road Improvement

(1) Geometric Design Standards

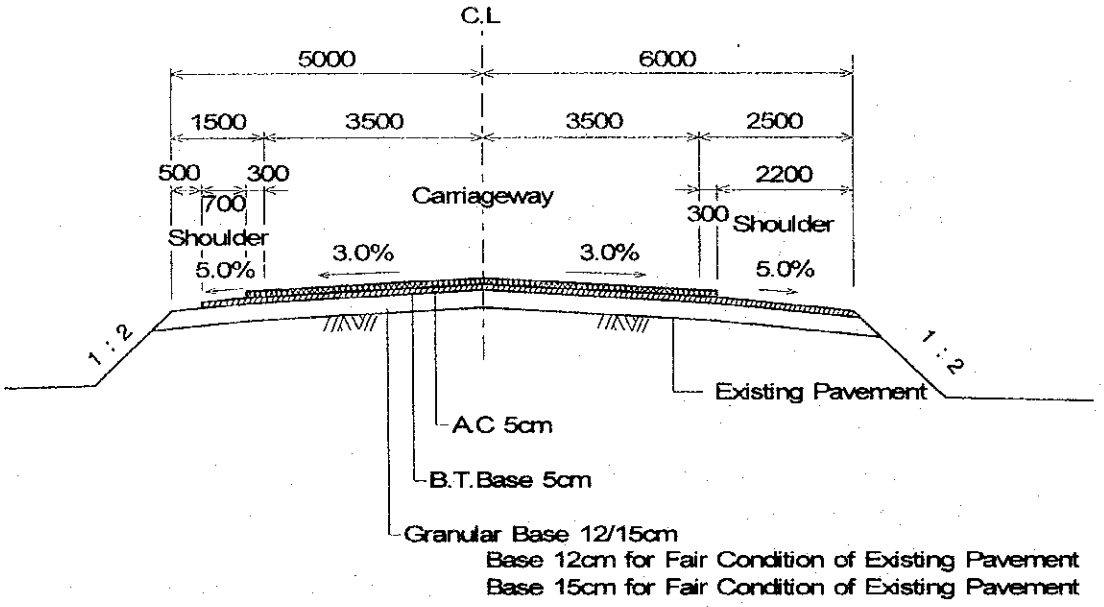
Table 2.3.2-1 summarizes the geometric design standards selected for the Project.

Table 2.3.2-1 Geometric Design Standards

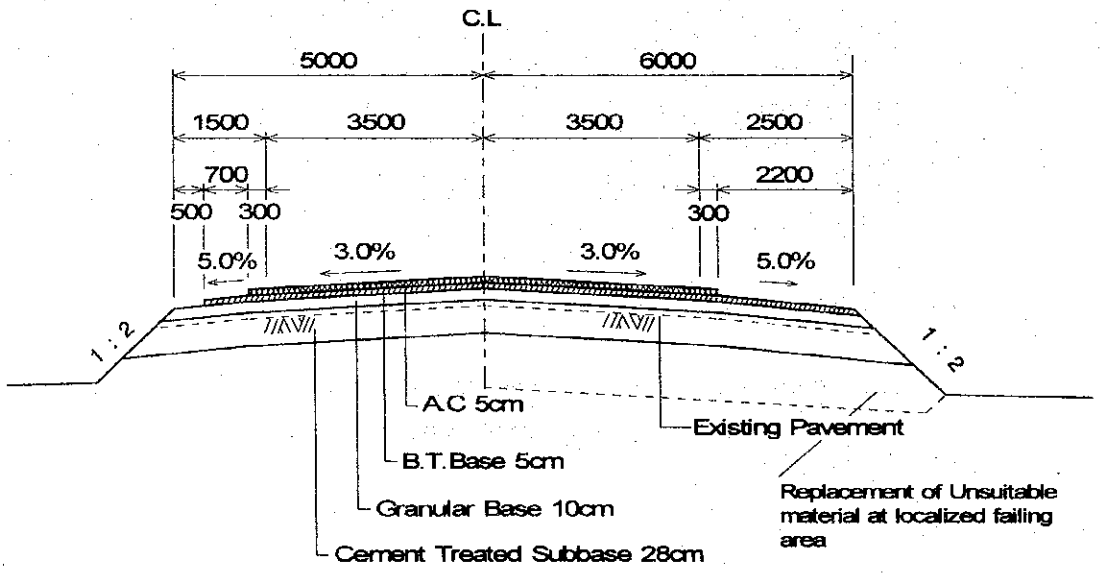
Items	Description
Road Design Class	Class II, Traffic 3000 ~ 8000
Design Speed	100km/h (Flat Terrain)
Lane Width	3.5m
Shoulder	1.5m (Rural Area), 2.5m (Populated Area)
Max. Gradient	5% (Flat Terrain), 6% (Rolling Terrain)
Min. Horizontal Curve	400m (Flat Terrain), 250m (Rolling Terrain)
Min. Vertical Curve	10km (Crest), 3km (Sag)
Cross Fall (Carriage)	3%
Cross Fall (Shoulder)	5% (Paved), 5% (Unpaved)
Road Reserve	60m
Bridge Design Line Load	HS-25-44
Max. Axle Load	9.1t

(2) Standard Cross Section

In accordance with the geometric design standards, the standard cross sections were developed as graphically illustrated in Figure 2.3.2-1.



Overlay Section (TYPE-1, TYPE-2)



ReconstructionSection (TYPE-3, TYPE-4)

Figure 2.3.2-1 Standard Cross Section

2.3.2.2 Pavement Rehabilitation

(1) Design Criteria

The criteria for the structural design of pavement are established as presented in Table 2.3.2-2.

Table 2.3.2-2 Criteria for Structural Design of Pavement

Category	Value	Description
1. Design Variable		
1.1 Time Constraints		
• Performance Period	8 years	Life of Initial Pavement Structure
• Analysis Period	20 years	Planned Stage Improvement
1.2 Traffic	$3.43x10^6x0.5$	W18, Predicted Number of ESAL
1.3 Reliability		
• Standard Normal Deviate	$Z_R=0$	Not Considered, Reliability 50%
• Combined Standard Error	$S_0=0.45$	Error of Traffic and Performance Prediction
2. Performance Criteria		
2.1 Serviceability	$P_O=4.2$	Initial Design Serviceability Index
	$P_t=2.5$	Design Terminal Serviceability Index
2.2 Serviceability Difference	$P_O-P_t=1.7$	Difference between Initial and Terminal Serviceability Index
3. Material Property		
3.1 Effective Roadbed Soil Resident Modules	$M_R=7500$ psi	$M_R=1500xCBR$ (5)
3.2 Pavement Layer Material Characteristic		Modules (psi) / Layer Coefficient
• AC Surface Course		$E_{AC}=350,000$ / 0.39
• Bituminous Treated Base	1620 lb	$E_{BT}=340,000$ / 0.30
• Granular Base	CBR=80	$E_{BS}=28,000$ / 0.135
• Cement Treated Subbase	CBR=30	$E_{CT}=15,000$ / 0.115
• Granular Subbase	CBR=30	$E_{SB}=15,000$ / 0.115
• Granular Subbase	CBR=15	$E_{SB}=12,000$ / 0.09
4. Pavement Structural Characteristic		
4.1 Drainage		
• Granular Base	m=1.0	
• Granular Subbase	m=0.95	

(2) Criteria for Selection of Pavement Rehabilitation Type

1) AC Overlay

The AC Overlay method was adopted for all sections except for those sections subject to the following conditions.

- The amount of high–severity alligator cracking is so large that a complete removal and replacement of the existing surface is dictated.
- The existing stabilized base shows signs of serious deterioration that requires an inordinate amount of repair to provide uniform support for the overlay.
- The existing granular base must be removed and replaced due to infiltration and contamination by soft subgrade.
- Stripping in the existing AC surface dictates it should be removed and replaced.
- Pre-overlay repair should be feasible and effective.
  - Localized failing area
    Deteriorated area should be repaired with provision of subdrainage (if needed).
  - Alligator cracking
    All area of high-severity alligator cracking must be repaired.
  - Linear cracking
    High–severity linear cracks should be patched.
  - Rutting
    Surface rutting should be corrected by milling or placing a leveling course.
  – Surface Irregularities
    Depression, humps, and corrugations must be repaired.
- Reflection crack control (if required).

2) Full-depth Reconstruction

Full-depth reconstruction method was basically employed for all sections where overlay method cannot be technically and economically applied.

(3) Special Issues

It is reported that some layers of the existing pavements have been constructed with unsuitable materials, particularly materials under shoulders with low permeability. It is a very critical issue in rehabilitation works that such materials should be removed and replaced with permeable materials for subsurface drainage.

2.3.3 Basic Design

2.3.3.1 Road Design

The road was designed in accordance with the established design criteria.

(1) Road Shoulder

The widened road shoulders have following advantages :

- Space is provided for stopping free of the traffic lane
- Space is provided to escape potential accidents or reduce severity
- Sight distance is improved
- Space is provided for pedestrian and bicycle use.

Taking the advantages into consideration, Road Shoulders to be

1.5 m wide (1.0 m paved with BTB + 0.5m unpaved) each side of the road through non-populated area,

2.5 m wide (fully paved with BTB) each side, where road goes through villages and towns or other populated areas.

The following criteria are adopted to classify areas, places, and locations into the populated areas:

- Village, town, and thickly inhabited areas are taken as "populated area" but the areas, where are located at fair distance from the road are excluded.
- Fairly big villages are selected, which face on the road more than 300 m long.
- In case village, town, and thickly inhabited areas is located on the one side of the road, the area is deemed to be the populated area, and the widening and paving are carried out on the both side of the road.

Location of Widened Road Shoulder (2.5 m wide) is presented in the Table 2.3.3-1.

Table 2.3.3-1 Section of Widened Road Shoulder (2.5 m wide)

No.	CHAINAGE(km) B.Point	End Point	Length (km)	Village Name	Remarks
1	2.300 ~	3.800	1.500	Seno Market	Bus Bay
2	4.900 ~	5.800	0.900	Seno	
3	7.300 ~	8.000	0.700	Sanamsal	
4	8.600 ~	8.900	0.300	-	
5	15.600 ~	16.000	0.400	Dong Din	
6	21.200 ~	21.500	0.300	Kdut Kaso	
7	31.300 ~	31.800	0.500	-	
8	35.500 ~	36.400	0.900	Don Palai	
9	37.300 ~	38.400	1.100	Dong Hen	Bus Bay
10	39.000 ~	39.500	0.500	Dong Philo	
11	72.200 ~	72.800	0.600	M. Phalan	Bus Bay
	Total		7.700		

(2) Horizontal Alignment

In the ROAD DESIGN MANUAL, the design speed of 100 km/hr is provided for rural flat terrain, and also the design speed of 50-70 km/hr is provided for populated area taking into account of traffic safety of inhabitant in the area.

At the populated areas, it is achieved and exceeded the design requirement of the Manual (min. horizontal curve radius 100 m at 50 km/hr design speed).

And at the flat terrain, it is practicable to achieve the design requirement (min. horizontal curve radius 400 m at 100 km/hr design speed) for the majority of the road except 11 Curves.

These 11 Curves have been investigated, reviewed and finalized to the 5 Curves to be improved and 6 Curves to be remained as shown on the Table 2.3.3-2.

And the 11 curb sections will be sign-posted with regulatory speeds of 80 km/hr at maximum because the design speed of 80 km/hr requires min. horizontal curve radius 250 m.

Figure 2.3.3-1 graphically demonstrates the horizontal alignment of the road and the location of substandard horizontal alignment.

Table 2.3.3-2 Horizontal Alignment of the Road

IP No.	Beginning of Curve (m)	End of Curve (m)	Existing Curve Radius (m)	Design Speed (km/h)	Standard Radius (m)	Proposed Curve Radius (m)	Remarks
13	10,992	11,268	200	100	400	250	Due to obstruction of existing power pole.
18	15,948	16,412	300	100	400	300	No improvement due to populated area.
22	24,365	24,888	365	100	400	365	No improvement required.
29	30,491	30,754	300	100	400	300	No improvement due to populated area.
32	33,664	33,968	350	100	400	350	No improvement due to populated area.
43	43,363	43,889	300	100	400	300	No improvement due to populated area.
46	46,563	47,095	310	100	400	350	To be improved.
47	48,145	48,487	280	100	400	350	To be improved.
53	56,748	57,191	320	100	400	320	No improvement due to populated area.
62	69,499	69,839	260	100	400	350	To be improved.
64	70,969	71,357	300	100	400	350	To be improved.

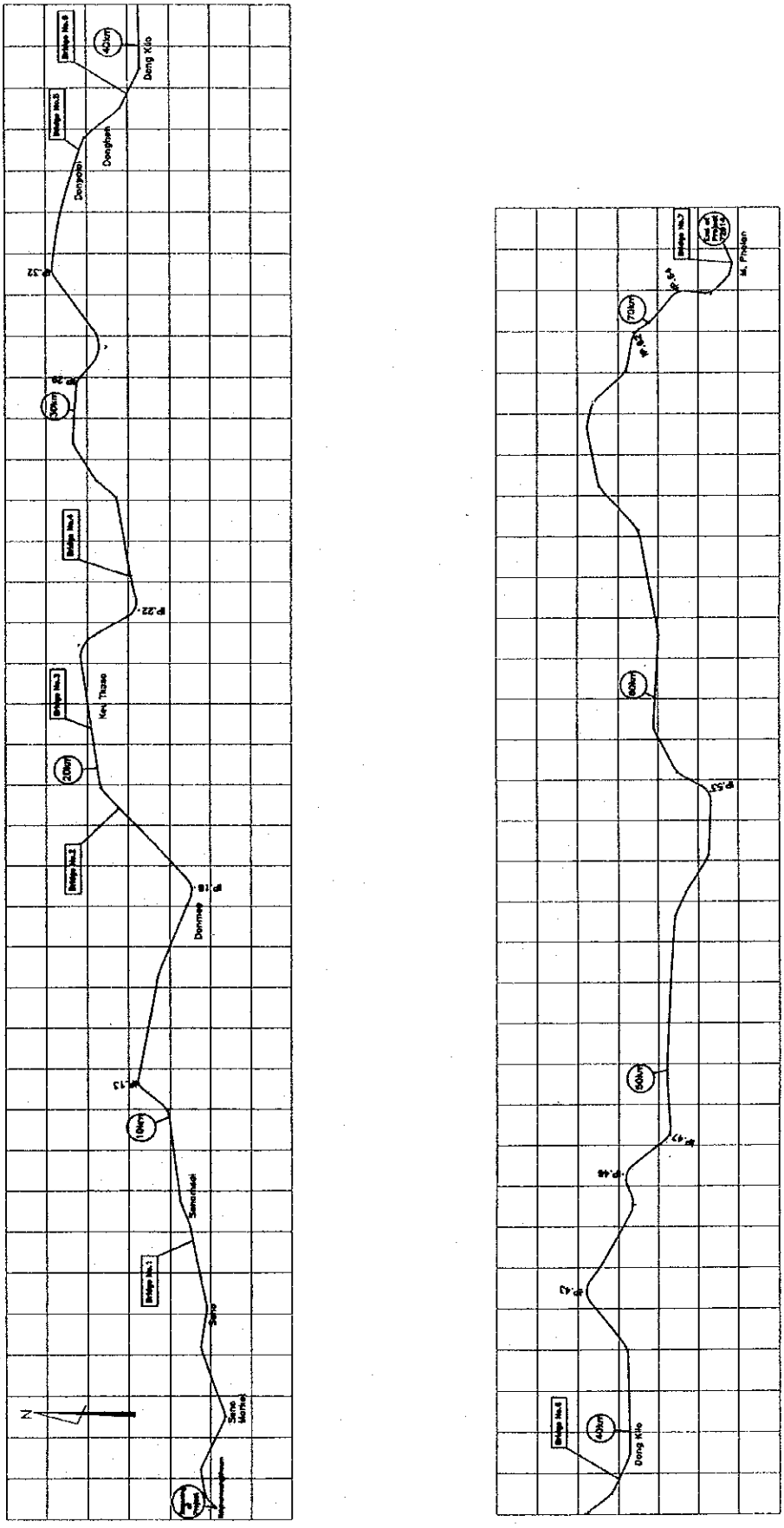


Figure 2.3.3-1 Horizontal Alignment of the Road

(3) Vertical Alignment

The project road is located at so flat terrain that there are small gradient vertical curves throughout the road.

The maximum gradient of vertical curve of the road is 3.1% and which satisfies the requirement (5.0%) of the Design Manual.

On the other hand, more than 0.3% of the gradient of vertical curve is desirable for draining surface water through road side drainages.

After consideration to the above condition, 3% of steep cross fall slope is applied, structures such as curb to hamper water draining are not provided, and careful review for infiltration of surface drained water was carried out for designing the road side drainage systems.

2.3.3.2 Pavement Design

The new pavement and overlay structures were designed based on AASHTO Guide for Design of Pavement Structures, 1993.

(1) Design Requirements

Design requirement for flexible pavement involves various factors as shown in Table 2.3.2-2 Criteria for Structural Design of Pavement.

(2) 18-kip ESAL Prediction

Based on the traffic demand analysis and axle load surveys conducted for the East-West Transport Corridor Project, the number of 18-kip equivalent single axle load applications (18-kip ESAL Application) was estimated using damaging factors analyzed in the Corridor Project.

The forecast numbers of 18-kip ESAL applications are summarized in Table 2.3.3-3 and graphically shown in Figure 2.3.3-2.

Table 2.3.3-3 Forecast Number of 18-kip ESAL

Seno City (Overlap Section of Road 9 and 13)

Type of vehicle		Bus/ Pickup	Light Truck	Medium Truck	Heavy Truck	Articulated Truck	Total Per year
Damaging Factor		0.383	0.383	1.276	2.598	4.008	
2000	VPD	269	39	214	100	73	695
	ESAL	103.0	14.9	273.1	259.8	292.6	943.4 (344,000)
2010	VPD	577	83	469	219	160	1508
	ESAL	221.0	31.8	598.4	569.0	641.3	2,061.5 (752,000)
2020	VPD	1,238	179	1,026	475	347	3265
	ESAL	474.2	68.6	1,309.2	1,234.0	1,390.8	4,476.8 (1,634,000)

Seno-Muang Phin Section

2000	VPD	115	33	209	92	86	535
	ESAL	44.0	12.6	266.7	239.0	344.7	907.0 (331,000)
2010	VPD	241	71	461	201	189	1,163
	ESAL	92.3	27.2	588.2	522.2	757.5	1,987.4 (725,000)
2020	VPD	506	153	1,017	439	417	2,532
	ESAL	193.8	58.6	1,297.7	1,140.5	1,671.3	4,361.9 (1,592,000)

Note: VPD; Vehicle per day per 2-way.
ESAL; Number of ESAL per year per 2-way.

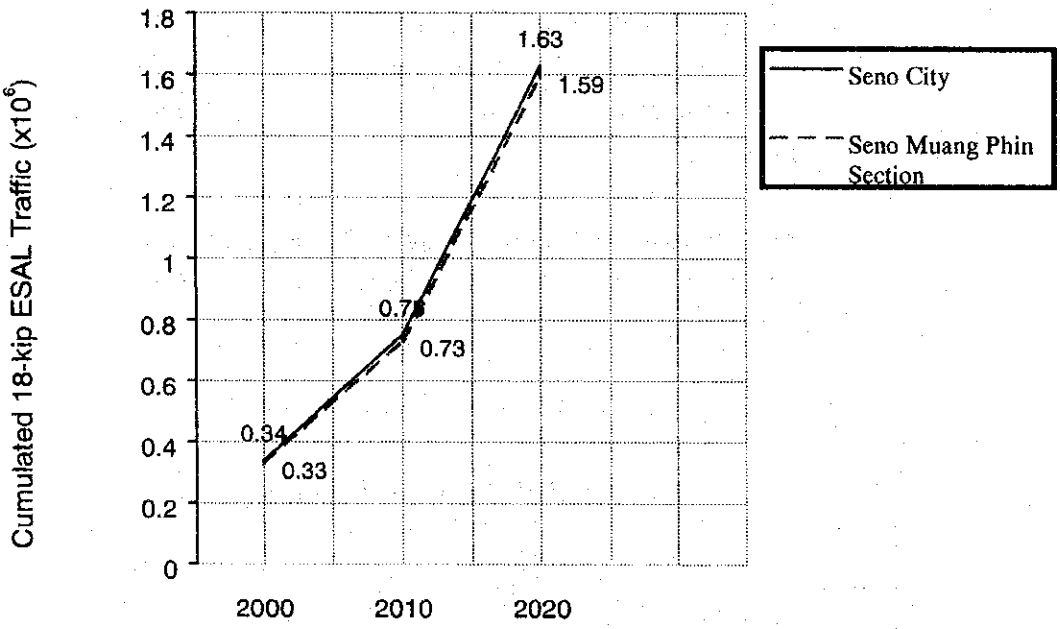


Figure 2.3.3-2 Forecasted Number of ESAL
(Two-way)

Cumulative ESAL application (two-ways) is presented in Table 2.3.3-4.

Table 2.3.3-4 Cumulative ESAL Application (Two-ways)

	Seno	Seno-Muang Phin
From 2001 to 2008 (8 years)	3.67×10^6	3.43×10^6
From 2001 to 2010 (10 years)	5.09×10^6	4.95×10^6
From 2001 to 2012 (12 years)	6.77×10^6	6.58×10^6
From 2001 to 2020 (20 years)	16.99×10^6	16.55×10^6

(3) Structural Design for Reconstruction

The structural design of pavement is based on the identification of the flexible pavement structural number (SN) to withstand the predicted number of axle load traffic (W18). Equation for flexible pavement is as follow.

$$Log_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times Log_{10}(SN + 1)$$

$$-0.2 + \frac{Log_{10}\left(\frac{\Delta PSI}{4.2 - 1.5}\right)}{0.40 + \frac{1094}{(SN + 1)^{5.19}}}$$

$$+ 2.32 \times Log_{10}(M_R) - 8.07$$

The structural numbers required for the specified period are presented in Table 2.3.3-5.

Table 2.3.3-5 Pavement Structural Number (SN)

Seno – Muang Phin Section

	W_{18}	SN
From 2001 to 2008 (8 years)	1.72×10^6	3.05
From 2001 to 2010 (10 years)	2.48×10^6	3.24
From 2001 to 2012 (12 years)	3.29×10^6	3.40

Seno Area

	W_{18}	SN
From 2001 to 2008 (8 years)	1.84×10^6	3.09
From 2001 to 2010 (10 years)	2.55×10^6	3.26
From 2001 to 2012 (12 years)	3.39×10^6	3.42

Selection of Layer Thickness

SN is converted into actual thickness of surface, base and subbase layers with the following equation.

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$$

where;

a_1, a_2, a_3 = Layer coefficients representative of surface, base, and subbase layers, respectively.

D_1, D_2, D_3 = actual thicknesses (in inches) of surface, base, and subbase layers, respectively, and

m_2, m_3 = drainage coefficients for base and subbase layers, respectively

Proposed Pavement Structure

Asphalt Concrete	=	5 cm (1.97 inches)
Bituminous Treated Base	=	5 cm (1.97 inches)
Granular Base (CBR = 80)	=	10 cm (3.94 inches)
Cement Stabilized Subbase (CBR = 30)	=	28 cm (11.02 inches)
Subgrade (CBR = 5)		

$$SN = 0.39 \times 1.97 + 0.30 \times 1.97 + 0.135 \times 3.94 \times 1.0 + 0.115 \times 11.02 \times 0.95$$
$$= 0.77 + 0.59 + 0.53 + 1.20$$
$$= 3.09 \geqq 3.09$$

(4) Structural Design for Overlay

The required thickness to increase structural capability to handle future traffic demand is determined by the following equation:

$$SN_{OL} = a_{OL} \times D_{OL} = SN_f - SN_{eff}$$

where;

SN_{OL} = Required overlay structural number.
a_{OL} = Structural coefficient for the AC overlay.
D_{OL} = Required overlay thickness, inches.
SN_f = Structural number required to handle future traffic demand.
SN_{eff} = Effective structural number of the existing pavement.

SN_{eff} From Condition Survey

$$SN_{eff} = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$$

where;

D_1, D_2, D_3 = Thickness of existing pavement surface, base and subbase layers.
a_1, a_2, a_3 = Corresponding structural layer coefficient.
m_2, m_3 = Drainage coefficient for granular base and subbase.

Layer Coefficients for Existing AC Pavement Layer

- AC Surface (Fair Condition) = 0.25
  – Low–severity alligator cracking more than 10%.
  – Medium–severity alligator cracking less than 10%.
  – Medium and high–severity transverse cracking more 5～10%.

- AC Surface (Bad Condition) = 0.17
  – Medium–severity alligator cracking more than 10%.
  – High–severity alligator cracking less than 10%.
  – Medium and high–severity transverse cracking more 10%.

- Granular Base = 0.12
  – No evidence of pumping, degradation, or contaminating by fines.

- Granular Subbase = 0.05
  – No evidence of pumping, degradation, or contaminating by fines.

Proposed Overlay Structure

Proposed Overlay Case 1; (For Existing Pavement with Low–severity alligator cracking)

$SN_{eff} = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$
$= 0.25 \times 1.18$ (3 cm) $+ 0.12 \times 7.87$ (20 cm) + neglect
$= 0.30 + 0.94$
$= 1.24$

$SN_{OL} = SN_f - SN_{eff}$
$= 3.09 - 1.24$
$= 1.85$

Proposed Section; (TYPE – 1)
Asphalt Concrete = 5 cm (1.97 inches)
Bituminous Treated Base = 5 cm (1.97 inches) Minimum.
Granular Base(CBR 80) = 12 cm (4.72 inches) Minimum.

$SN_{OL} = 0.39 \times 1.97 + 0.30 \times 1.97 + 0.135 \times 4.72$
$= 0.77 + 0.59 + 0.64$
$= 2.0 > 1.85$

Proposed Overlay Case 2; (For Existing Pavement with Medium–severity alligator cracking)

SN_{eff} = 0.17 x 1.18 (3 cm) + 0.12 x 7.87 (20 cm) + neglect
= 0.20 + 0.94
= 1.14

SN_{OL} = 3.09 - 1.14
= 1.95

Proposed Section; (TYPE – 2)

Asphalt Concrete = 5 cm (1.97 inches)
Bituminous Treated Base = 5 cm (1.97 inches) Minimum
Granular Base (CBR 80) = 15 cm (5.91 inches) Minimum

SN_{OL} = 0.39 x 1.97 + 0.30 x 1.97 + 0.135 x 5.91
= 0.77 + 0.59 + 0.80
= 2.16 > 1.95

(5) Reconstruction with Replacement

Taking into account the functional, structural conditions and subgrade CBR of existing pavement, Full-depth Reconstruction and Overlay with AC pavement were designed and adopted.

Careful investigation were carried out on the Localized Failing Areas. In the road sections where Reconstruction were adopted, the entire Replacement of badly saturated weak subgrade were judged basing on the existing conditions of pavement, subgrade CBR and road side drainage condition.

The following are significant physical factors taken for judgement for "Reconstruction with Replacement";

1) Road Side Drainage Conditions
   - paddy field
   - irrigation pond
   - swamp
2) Pavement Conditions
   - longitudinal corrugation
   - ruts
   - up-heaved shoulder
   - laterally swelled embankment

Table 2.3.3-6 presents the section of Reconstruction with Replacement (TYPE – 4) of Improve method and length.

Table 2.3.3-6 Section of Reconstruction with Replacement (TYPE - 4)

No.	CHAINAGE (m) B.Point	End Point	Length (m)	Remarks
1	16,525 ~	16,590	65	
2	22,639 ~	22,674	35	
3	23,090 ~	23,160	70	
4	23,285 ~	23,335	50	
5	36,955 ~	37,155	200	
6	48,470 ~	48,876	406	
7	52,103 ~	52,148	45	
8	53,150 ~	53,296	146	
9	63,373 ~	63,703	330	
9	69,235 ~	69,355	120	
10	71,480 ~	71,710	230	
	Total		1,697	

Figure 2.3.3-3 shows the pavement structures of proposed improvement methods together with the functional condition, structural condition, localized failing areas and C.B.R. of the existing pavement.

(6) Unsuitable Material under Road Shoulder

As described in 2.3.2.2 (3) Special Issue, unsuitable material under Road Shoulder shall be removed and replaced with selected material.

Being investigated the project road, such Replacement was planned to be carried-out as follows:

At sections of Overlay (TYPE – 1 / TYPE – 2)
Unsuitable material may not be existed or any defect was not observed, and the removal is not required particularly.

At section of Reconstruction (TYPE – 3)
It is required to specify the replacement as shown on Figure 2.3.3-4. Overall length of the section where the replacement is required are estimated 30 km in total.

Breakdown is as follow;

Chainage	Length (km)
19.00 ~ 26.00	7.00
34.50 ~ 37.40	2.90
42.60 ~ 55.20	12.60
63.10 ~ 72.30	9.20
Total	31.70 km – 1.7 km = 30.00 km (TYPE – 4 and Others)

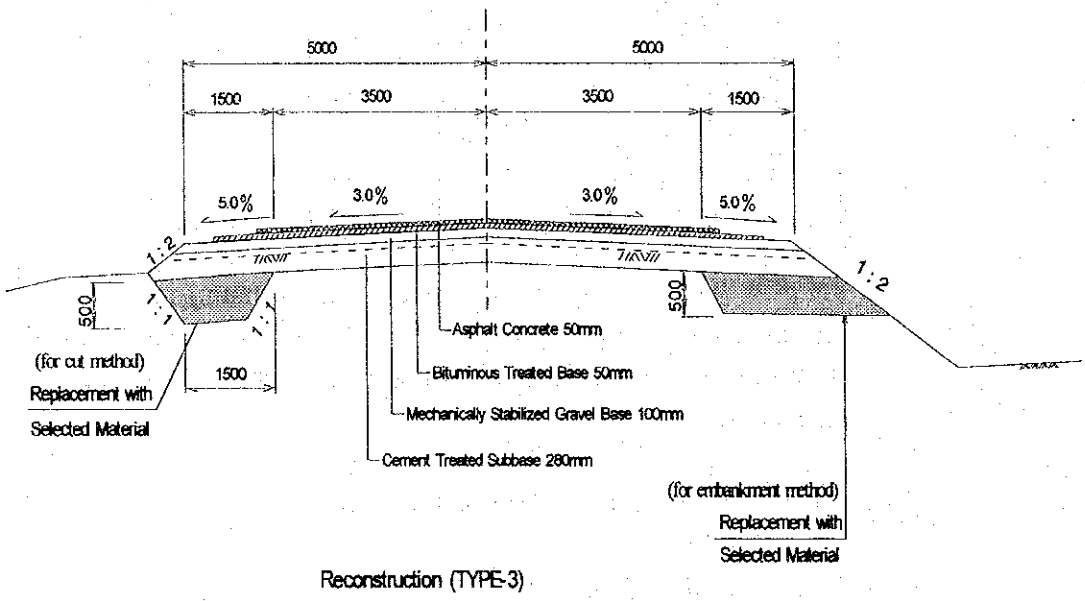
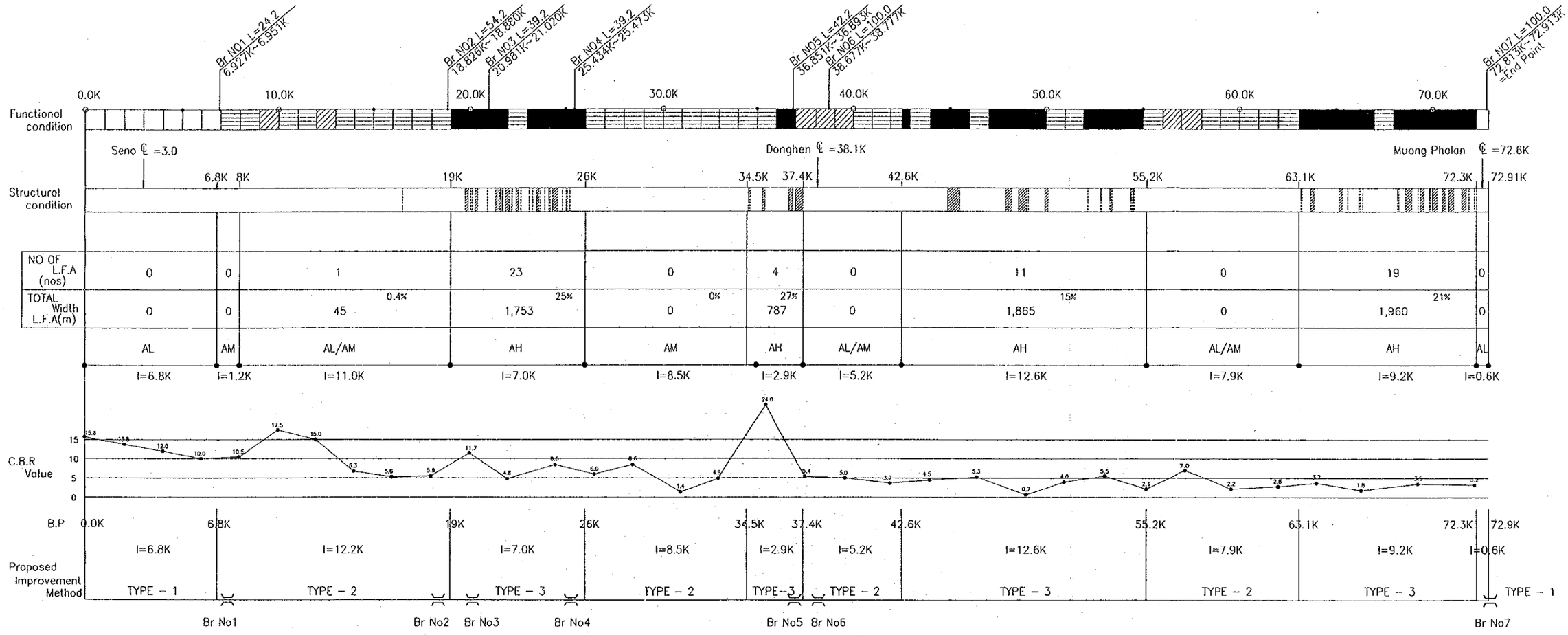


Figure 2.3.3 –4 Replacement with Selected Material

At section of Reconstruction with Replacement (TYPE - 4)
The unsuitable material is included in the existing subgrade to be removed entirely.



Functional condition

Legend

(Riding Quality)

- : Very Good
- : Good
- : Fair
- : Bad
- : Very Bad

Structural condition

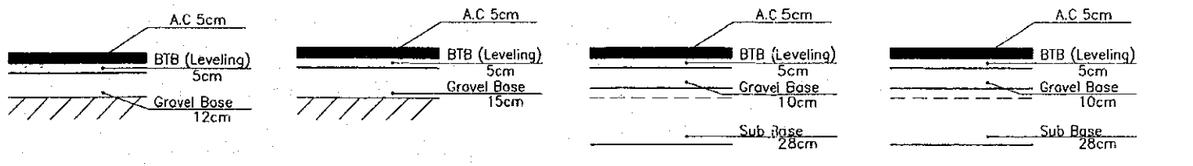
(Severity of Alligator Cracking)

- AL : Low Severity(class 1 cracking)
- AM : Mediom Severity(class 2 cracking)
- AH : High(class 3 cracking)

Localized Failing Area (L.F.A)

- : 10m~50m
- : 50m~900m

Proposed Improvement Methods



Overlay 1 = 7.4K
(On fair existing pavement)
TYPE – 1

Overlay 2 = 33.8K
(On bad existing pavement)
TYPE – 2

Reconstruction(R.C) = 30.0K
TYPE – 3

Reconstruction with Replacement(R.R) = 1.7K
(For badly Saturated Weak Sub Grade of Localized Failing Area)
TYPE – 4

Figure 2.3.3.–3 EXISTING PAVAMENT CONDITIONS AND PROPOSED IMPROVEMENT METHODS

2.3.3.3 Bridge Design

In accordance with the basic design concept and criteria, rehabilitation measures of bridges were carefully examined giving emphasis on the improvement of riding comfort rather than rehabilitation of structural deterioration and deficiencies.

The existing condition of each bridge and corresponding rehabilitation measures are summarized in Appendix 7 (Existing Condition and Rehabilitation Method of Bridges). The major repair works designed for this Project are as follows:

1) Deck slab abrasion shall be covered with asphalt concrete (t = 5cm) for improvement of riding comfort.
2) Inadequate deck drainage shall be remedied by providing suitable cross fall to drain surface water with asphalt concrete surfacing.
3) Damaged and corroding steel railing shall be repaired.
4) Gabion protection for exposed pier footing and repairing of damaged rip-rap around the abutment shall be carried out.
5) Sidewalk with RC guide posts at bridge approaches shall be provided.

2.3.3.4 Seno Intersection Design

There is an intersection for National Road No.9 with No.13 near Seno Market, which is a T-type unchannelized junction. The dominant characteristics of existing intersection are disturbed through and turning movement of main traffic and irregular movement and parking of local traffic vehicles.

To propose an improvement scheme for the intersection, the following three concepts were evaluated as summarized in Table 2.3.3-7.

- Concept 1 ; Provision of bus stop and parking area.
  Minimum level of services for bus and local traffic was provided, which are less than the existing services.
  Scheme 1~ 4.

- Concept 2 ; Provision of bus station and parking area.
  Acceptable level of services for bus and local traffic was provided, which are equal or more than existing services.
  Scheme 5, 6.

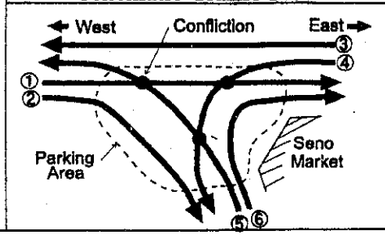
- Concept 3 ; Provision of bus stop, but no parking area.
  No parking area was provided giving a high priority to the smooth flow of main traffic.
  Scheme 7, 8.

Through discussions with Lao side, Scheme-5 was finally selected. The schematic layout of Scheme-5 is illustrated in Figure 2.3.3-4, and its main features are summarized as follow.

- T-type intersection
- 3-phase signal control at main intersection
- Un-signalized sub-intersection for parking areas.
  (but, recommend to provide traffic signal on future)
- 3-bus stations (3 x 250 = 750m^2)
- 2-parking areas (2,900 m^2)

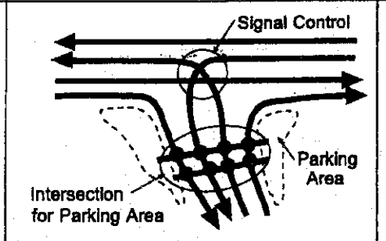
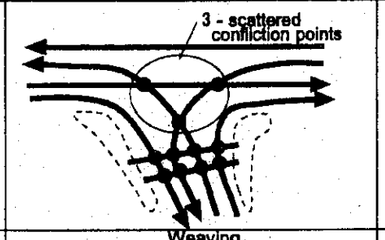
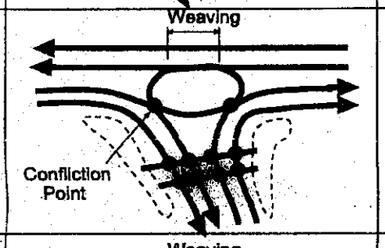
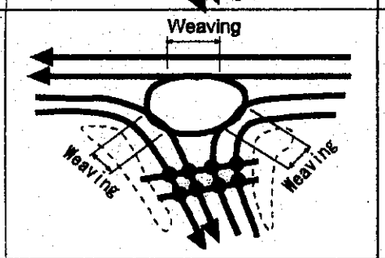
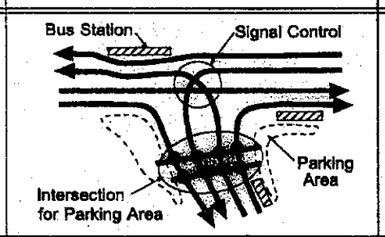
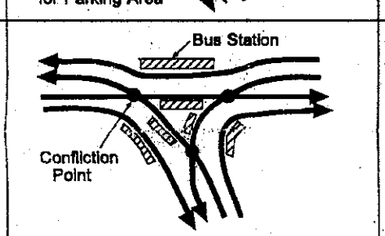
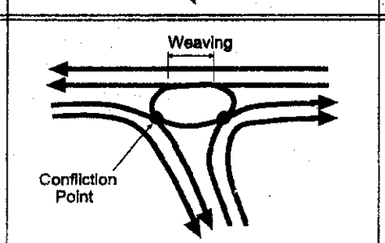
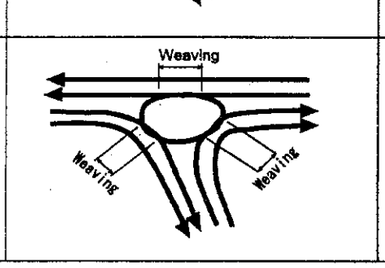
Table 2.3.3-7 Comparative Evaluation on At-grade Intersection at Seno

Existing Traffic Problems

	Schematic Traffic Flow	Traffic Flow Problems	Local Traffic Problems
Illustrated Traffic Flow		・No channelized intersection - Non-disturbed flow ;②,③,⑥ - Disturbed flow ;①,④,⑤ ・Conflict Point : 3 points between ① and ④,① and ⑤, and ④ and ⑤	・Many public service vehicles ・Irregular movement of vehicles ※- U-turn movement ・No bus stop ・Access to/from parking areas - Parking capacity: 50 vehicles - Existing parking area: 2500m²

Evaluation (Point)
◎ Very good (5) × Bad (1)
○ Good (4) # Not acceptable (0)
△ Acceptable (3)

Evaluation of Proposed Schemes

	Type		Traffic Flow Evaluation	Local Traffic Evaluation	Rating
Bus Stop, Parking Area	Scheme-1 T-type with Parking Area		・3-phase signal control (Urban Type) △ ・Sharp curve alignment △ ・No confliction point ◎ ・No weaving ◎ ・Compatible with future improvement ○ (20 points)	・Un-signalized intersection △  ・Fair level of congestion and flow △ ・Total parking area 2800m² ◎ ・3-bus stops, a little far × (12 points)	3-2 (32)
	Scheme-2 Trumpet type with Parking Area		・Directional traffic flow (Suburban / Rural Type) ○ ・Smooth alignment ◎ ・3-conflict points well scattered, but a little slant angle △ ・No weaving ◎ ・Compatible with future improvement ○ (21 points)	・Un-signalized intersection △ same as Scheme-1 ・Fair level of congestion and flow △ ・Total parking area 1800m² ○ ・3-bus stops, a little far × (11 points)	3-1 (32)
	Scheme-3 Semi-Rotary type with Parking Area		・Semi-reversed traffic flow △ ・Sharp curve alignment △ ・2-conflict points well scattered, with almost right angle ○ ・Weaving length; a little short (l=40m) × ・Reasonably compatible with future improvement △ (14 points)	・Un-signalized intersection △ same as Scheme-1 ・Fair level of congestion and flow △ ・Total parking area 900m² × ・3-bus stops, a little far × (8 points)	– (22)
	Scheme-4 Rotary type with Parking Area		・Reversed / rotary traffic flow △ ・Very sharp curve alignment × ・No confliction point ◎ ・Weaving length, too short (l=20m) and weave in one lane # ・Less compatible with future improvement × (10 points)	・Un-signalized intersection △ same as Scheme-1 ・Fair level of congestion and flow △ ・Total parking area 2000m² ○ ・3-bus stops, a little far × (11 points)	– (21)
Bus station, Parking Area	Scheme-5 T-type with Bus Station and Parking Area		・3-phase signal control △ ・Sharp curve alignment △ ・No confliction point ◎ ・No weaving ◎ ・Compatible with future improvement ○ (20 points)	・Un-signalized intersection △ same as Scheme-1 ・Fair level of congestion and flow △ ・Total parking area 2900m² ◎ ・3-wide bus stations along sidewalk and near location (3x250=750m²) ◎ (16 points)	1 (36)
	Scheme-6 Trumpet type with Bus Station and Parking Area		・Directional traffic flow (Suburban / Rural Type) ○ ・Smooth alignment ◎ ・3-conflict points well scattered, but a little slant angle △ ・No weaving ◎ ・Compatible with future improvement ○ (21 points)	・Optional operation of Intersection (with or without intersection) ◎ ・A little congested level and traffic low △ ・Total parking area 900m² × ・4-wide bus stations along sidewalk and near location (4x250=1000m²) ◎ (14 points)	2 (35)
Bus Stop, No Parking Area	Scheme-7 Semi-Rotary type without Parking Area		・Semi-reversed traffic flow △ ・Curved but large radius alignment △ ・2-conflict points well scattered with almost right angle ○ ・Weaving length, a little short (l=40m) × ・Reasonably compatible with future improvement △ (14 points)	・No parking area # ・No intersection ◎ ・No congestion ◎ ・3-bus stops, a little far × (11 points)	– (25)
	Scheme-8 Rotary type without Parking Area		・Reversed / rotary traffic flow △ ・Very sharp curve alignment △ ・No confliction point ◎ ・Weaving length, too short (l=40m, 20m, 10m) △ ・Less compatible with future improvement × (15 points)	・No parking area # ・No intersection ◎ ・No congestion ◎ ・3-bus stops, a little far × (11 points)	– (26)

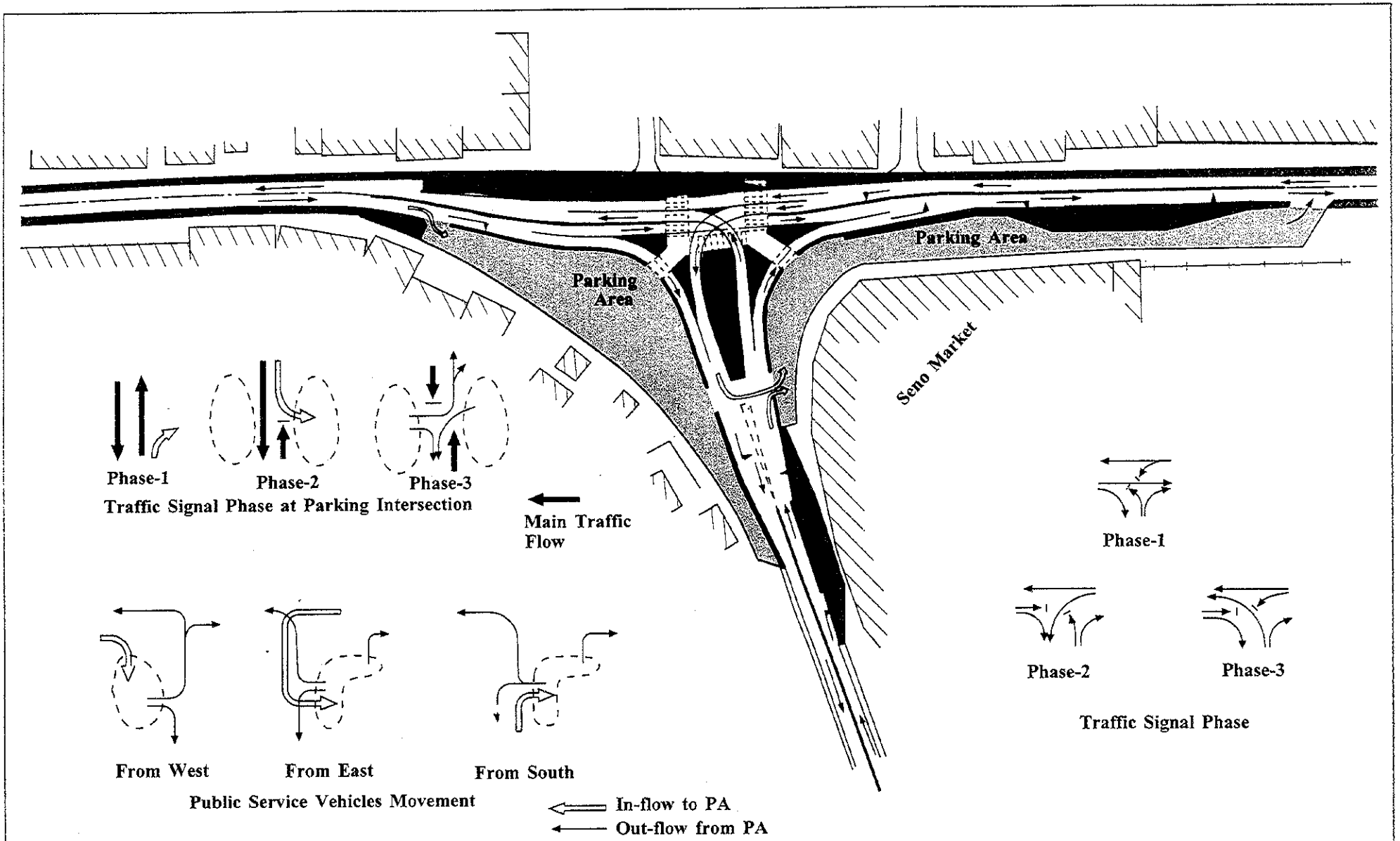


Figure 2.3.3-5 **Scheme-5 T type Intersection**
(With Parking Area and Bus Station)

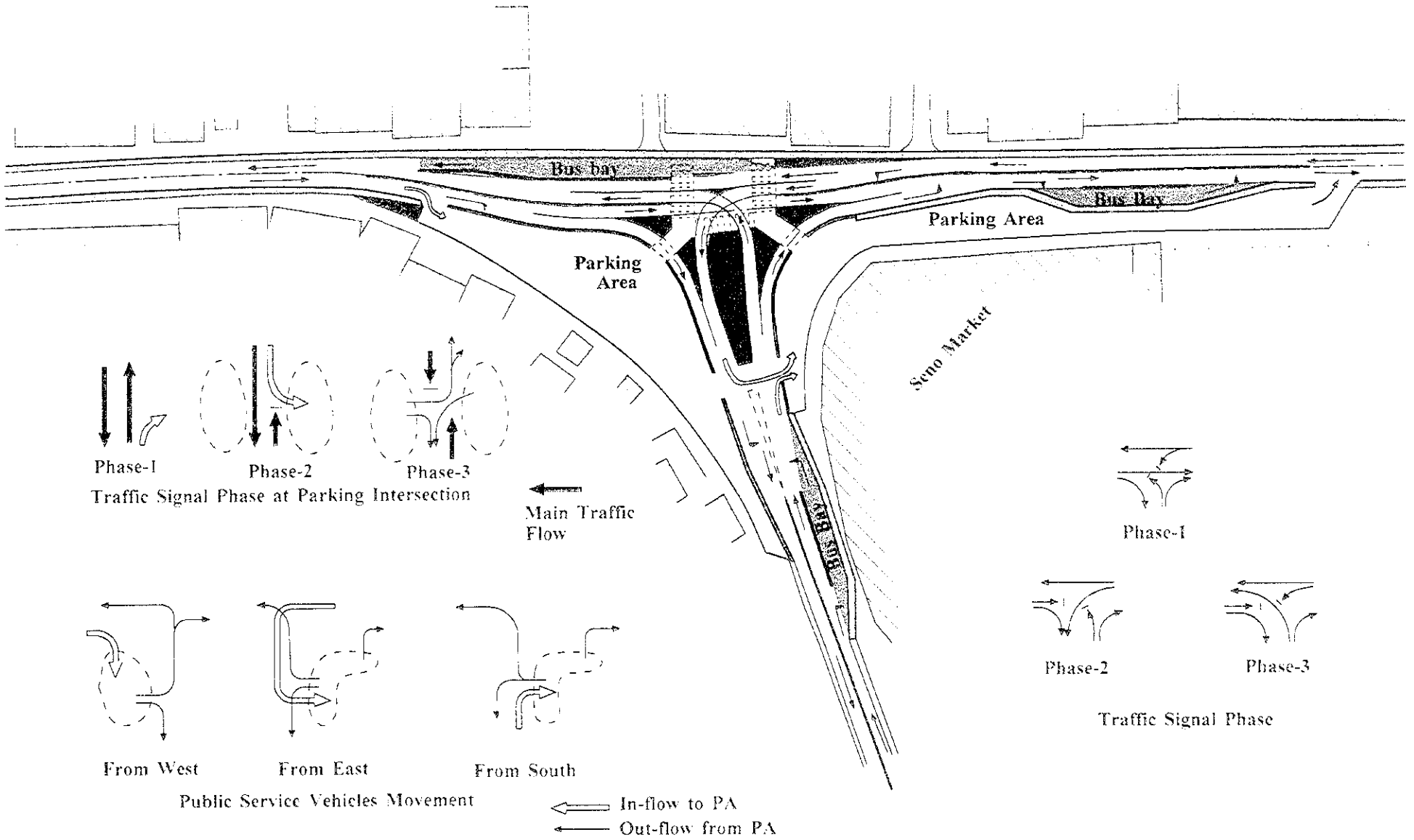


Figure 2.3.3-5 **Scheme-5 T type Intersection**
(With Parking Area and Bus Station)