NO.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE IMPROVEMENT OF NATIONAL ROAD NO.1 (PHNOM PENH-NEAK LOUENG SECTION) IN THE KINGDOM OF CAMBODIA

MARCH 2005

JAPAN INTERNATIONAL COOPERATION AGENCY
GRANT AID MANAGEMENT DEPARTMENT

GM
JR
05-008

PREFACE

In response to a request from the Royal Government of the Kingdom of Cambodia, the Government of Japan decided to conduct a basic design study on the Project for the Improvement of National Road No.1 and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cambodia a study team three times from March 3 till March 27, from April 17 till May 22, and from August 26 till September 9, 2004 respectively.

The team held discussions with the officials concerned of the Royal Government of Cambodia, and conducted field studies at the study area. After the team returned to Japan, further studies were made. Then, three missions were respectively sent to Cambodia from October 21 till November 4, 2004 in order to discuss a draft design, conduct the supplementary study from January 22 till February 10, 2005, and the environment baseline survey undertaken from March 5, till March 19, 2005, then, as this result, the present report was finalized.

I hope that this report will continue to the promotion of the Project and to the enhancement to friendly relations between two countries.

I wish to express my sincere appreciation to the officials concerned of the Royal Government of the Kingdom of Cambodia for their close cooperation extended to the team.

March 2005

Seiji KOJIMA
Vice President
Japan International Cooperation Agency

March 2005

Letter of Transmittal

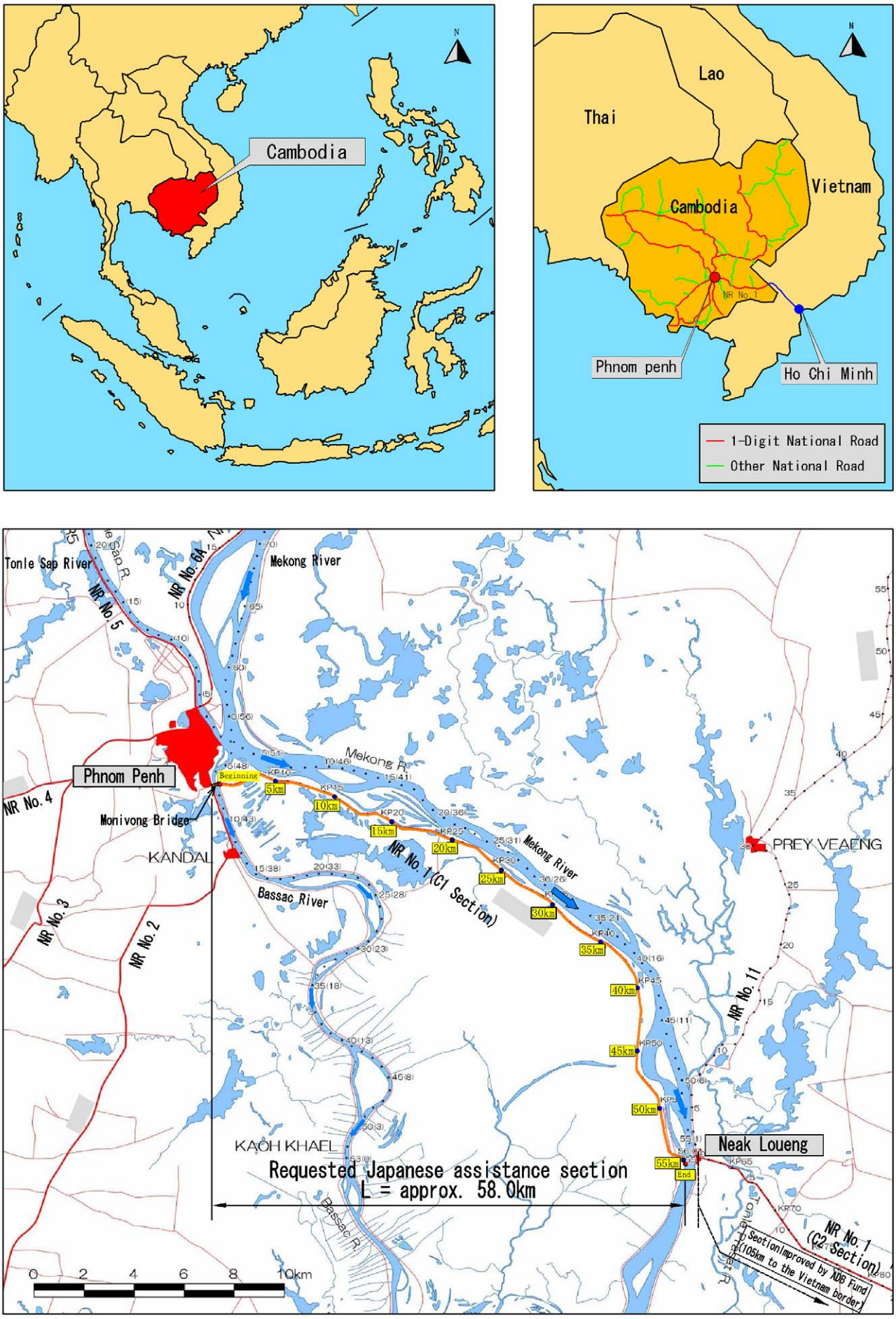
We are pleased to submit to you the basic design study report on the Project for the Improvement of National Road No.1 (Phnom Penh – Neak Loueng Section) in the Kingdom of Cambodia.

This study was conducted by Consortium between Katahira & Engineers International and CTI Engineering International, under a contract to JICA, during the first year period from March 1, 2004 till February 28, 2005, the second year period from March 2, till March 31, 2005. In conducting the study, we have examined the feasibility and rationale of the Project, with due consideration to the present situation of Cambodia and formulated the most appropriate Basic Design for the Project under Japan's grant aid scheme.

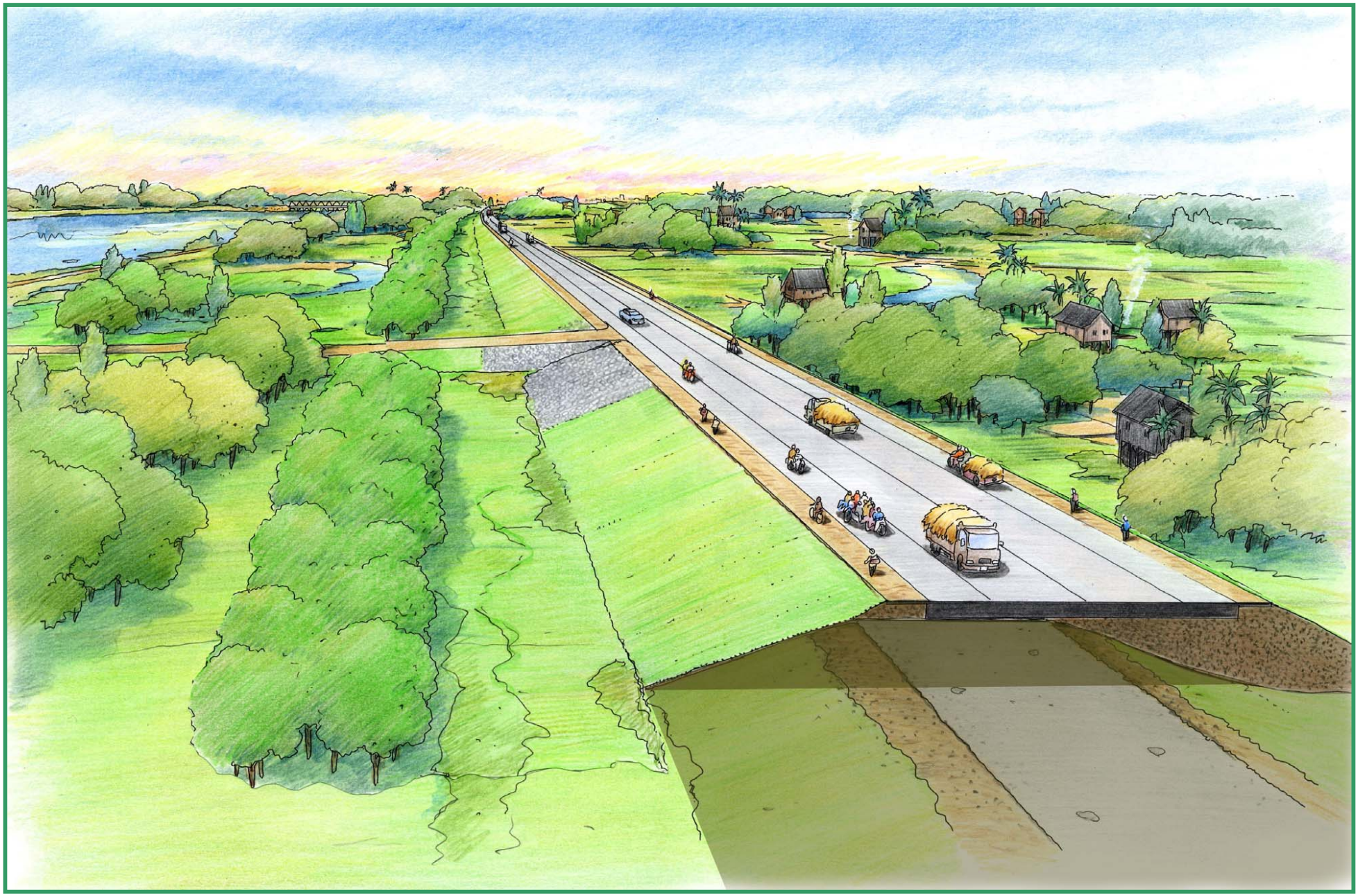
Finally, we hope that this report will contribute to further promotion of the Project.

Very truly yours,

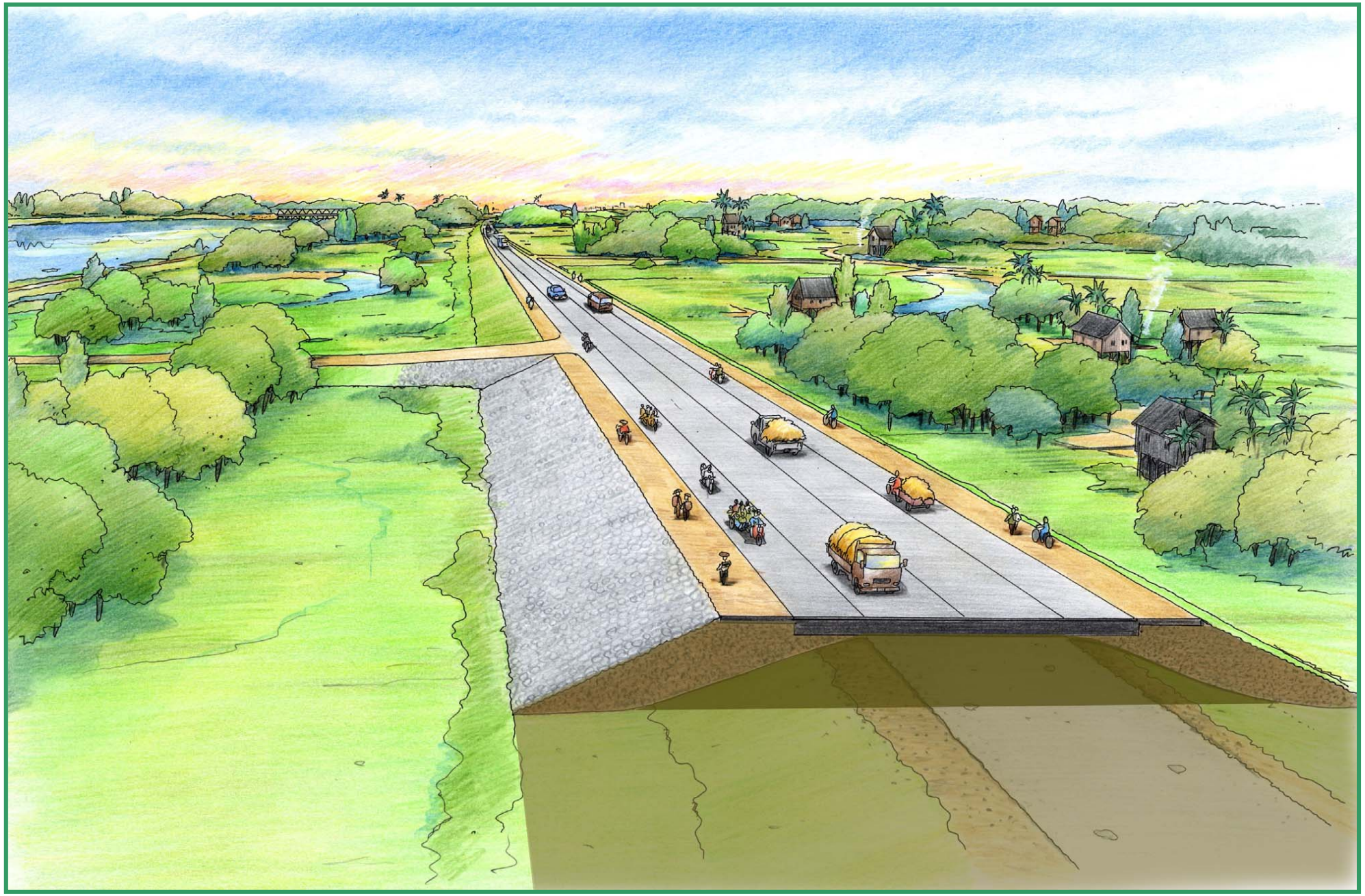
Tsuneo BEKKI
Chief Consultant/O&M Planner
Basic Design Study Team on the Project for The Improvement of National Road No.1 (Phnom Penh – Neak Loueng Section)
Consortium between Katahira & Engineers International and CTI Engineering International



Location Map



PERSPECTIVE (WIDENING OF ONE ROAD SIDE)



PERSPECTIVE (WIDENING OF BOTH ROAD SIDES)

AS-BUILT PHOTOS

Western Side View from Monivong Bridge Eastern Area
(near Sta. 0+000)

Existing Road Circumstance
(near Sta. 13+600)

Pipe Culvert PC-1
(near Sta. 23+983)

Existing Road Circumstance
(near Sta. 25+360)

Water Gate WG-1
(near Sta.28+432)

Existing Waterway Conditions
(near Sta. 28+432)

Road Surface Conditions of Water Gate BC-5
(near Sta. 41+006)

Existing Road Circumstance
(near Sta. 42+190)

Replacement Bridge No.2
(near Sta. 42+800)

Replacement Bridge No.3
(near Sta. 47+940)

Water Gate BC-11
(near Sta.42+995)

Existing Road Circumstance
(near Sta.55+100)

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AASHTO	:	American Association of State Highway and Transportation Officials
AC	:	Asphalt Concrete
ADB	:	Asian Development Bank
AH	:	Asian Highway
BC	:	Box Culvert
BCU	:	Bridge Construction Unit
BOD	:	Biological Oxygen Demand
CBR	:	California Bearing Ratio
C.C.P	:	Cast-in-place Concrete Pile
CO	:	Carbon Monoxide
DMS	:	Detailed Measurement Survey
DO	:	Dissolved Oxygen
EL	:	Elevation
E/N	:	Exchange of Note
ESAL	:	Equivalent Single Axle Load
F/S	:	Feasibility Study
GDP	:	Gross Domestic Product
GOJ	:	Government of Japan
HCM	:	Highway Capacity Manual
HV	:	Heavy Vehicles
H.W.L	:	High Water Level
IRC	:	Inter-Ministerial Resettlement Committee
JICA	:	Japan International Cooperation Agency
LV	:	Light Vehicles
MC	:	Motor Cycles, Motorbike
MPWT	:	Ministry of Public Works and Transport
MRC	:	Mekong River Commission
NO_2	:	Nitrogen Dioxide
PAPs	:	Project Affected Persons
PC	:	Pre-stressed Concrete
PC	:	Pedal Cycles
PCU	:	Passenger Car Unit
PH	:	Ionized Hydrogen Concentration Index
PRW	:	Provisional Road Width
RAP	:	Resettlement Action Plan
RCC	:	Road Construction Center
ROW	:	Right of Way
SN	:	Structure Number
SO_2	:	Sulfate Dioxide
SS	:	Suspended Solid
T/N	:	Tender Notice
TSP	:	Total Suspended Particulated
UNDP	:	United Nations Development Program
V/C	:	Traffic Volume/Traffic Capacity
V/C	:	Verification of Contract

SUMMARY

National Road No.1 connects the Cambodian Capital "Phnom Penh" and "Ho Chi Minh City" the primary commercial city in Vietnam. Furthermore, this national road forms a part of the Asian Highway (A-1) as a well-known international arterial road.

The improvement project for this national road belongs to the National Second Five-year Plan (2001-2005) and has a high priority. The section with about 105 km from Neak Loueng up to the border of Vietnam has been improved in 2003 by ADB.

However, because the section with about 56 km from Phnom Penh to Neak Loueng is located within the floodplain parallel to the Mekong River, it is the most difficult section to apply the design and construction. As a result, ADB excluded this section from their improvement list.

The traveling speed is restricted with an average of just about 30 kph due to severe damages of the section mentioned above, therefore the improvement of the section is an urgent problem by which the Royal Government of Cambodia is confronted.

To cope with the problem, the Royal Government of Cambodia requested a grant aid from Japan to improve the said section.

To analyze a hydraulic influence upon the requested area was arisen to necessity, and the Feasibility Study on the Improvement of National Road No.1 (Phnom Penh – Neak Loueng section) had carried out. Approximately one thousand and eight hundred (1,800) households were assumed to be affected due to the road widening. Then the Preparatory Study (Social Environmental Consideration Support Study) was carried out to confirm the fundamental agreement on the road improvement from the PAPs those must be resettled. Then, as a result 70% ~ 80% of agreement from these PAPs was confirmed.

In response to the above-mentioned request, the Government of Japan (GOJ) decided to implement the Basic Design Study. JICA dispatched the Basic Design Study Team for the next three (3) periods: from March 3 till March 27, from April 17 till May 22 and from August 26 till September 9, 2004. The Basic Design Study Team carried out the study in the Project area including the discussion with the Government of Cambodia.

After returning to Japan, the Basic Design Study Team conducted the Basic Design with the optimum project contents based on the outcomes of field investigation, and thus prepared the Basic Design Outline by summarizing those detail contents. Finally, JICA dispatched a Basic Design Outline Presentation Team from October 21 till November 4, 2004, and presented the outline of Basic Design together discussion with the Royal Government of Cambodia.

Additionally, the team of Supplement Study has been dispatched for environment social considerations from January 22, 2005 till February 10, 2005, and another for Environment Baseline Survey from March 5, 2005 till March 19,2005, to the Royal Government of Cambodia.

Conclusively, the outline of the Project to be proposed is as below based on the results of basic design outline presentation.

Target Road	National Road No.1 (Section from Phnom Penh Municipality to Neak Loueng) 55.98 km long
Construction of Cross-section	(1) Monivong Bridge Eastern Area Section: Sta. 0+000 - Sta.1+800 ① 4-lane carriageway for 4-wheel vehicles (4 @ 3.5 m = 14.0 m) ② 2-lane carriageway for motorbike (2 @ 2.5 m = 5.0 m) ③ Sidewalk (Standard is 2.5 m x 2 = 5.0 m, and variation on some sections) (2) General Section: Sta. 1+800 - Sta.54+740 ① 2-lane carriageway for 4-wheel vehicles (2 @ 3.5 m = 7.0 m) ② 2-lane carriageway for motorbike (2 @ 2.5 m = 5.0 m) ③ Sidewalk (2 @ 2.5 m = 5.0 m, and variation on some sections) and/or Shoulder (2 @ 1.0 m = 2.0 m) (3) Special Section: Other large-scale market area and Neak Loueng area
Design Speed	80 kph (Except large-scale market or populated area)

Major Contents of the Project:

Item		Contents/Scale
1. Improvement of Road	Widening of Road Width	i) All the way with **55.98** km (Sta. 0+000 - Sta. 55+980) ii) 4-lane Section: **1.8** km iii) 2-lane Section: **54.18** km
	Raising of Road Surface	Almost all the way excluding the vicinity of the **beginning** and the **ending**
	Pavement	i) All the way: **55.98** km ii) 4-wheel lane carriageway, Motorbike lane carriageway, sidewalk, and shoulder
2. Widening of Shoulder on Roadside Service Facilities	Small-scale Market Area	**3** nos.
	Bus Stop/Emergency Evacuation Space	**20** nos.
	School/Hospital Area	**i)** School : **31** nos. **ii)** Hospital : **9** nos.
3. Bridge (PC I-girder Type)		**3** bridges: i) Length: **240.6** m (**68.8** m + **103** m + **68.8** m) ii) Replacement: **2** bridges iii) Newly Construction: **1** bridge
4. Culvert		Nine (9) nos.: i) Pipe Culvert: **2** nos. (reconstruction), Total Length: **50.1** m ii) Box Culvert: **7** nos. (Reconstruction: **2** nos., New Construction: **5** nos.), Total Length: **107.1** m
5. Road Drainage Facilities		i) Side Ditch: Total Length of **2,230** m ii) Drainage Pipe: Total Length of **5,045** m
6. Revetment/Riverbed Protection on the Openings	Revetment	i) Bridge: **3** nos. ii) Culvert: **9** nos.
	Riverbed Protection	i) Bridge: **3** nos. ii) Culvert: **9** nos.
7. Measures for Slope Erosion/Scouring	Greenbelt	i) Gross total : L=**2,800** m
	Wet Masonry	The Mekong River side: L=**1,060** m
8. Measures for Embankment Weak Foundation (Soft Ground)	(1) Replacement by High-quality Soils	i) The Mekong River Side: L=**16.52** km ii) Colmatage Side: L=**44.96** km
	(2) Replacement by Sands	i) The Mekong River Side: L=**0.80** km ii) Colmatage Side: L=**1.72** km
9. Crossing		Improvement of i) **Chbar Ampov** Crossing; and ii) **Tiger Beer** Crossing
10. Ancillary Facilities	(1) Retaining Wall	i) Masonry Retaining Wall: L=**1,635** m ii) RCL Retaining Wall: L=**1,166** m
	(2) Road Marking & Traffic Sign	i) Road Marking: Centerline, Carriageway, Lateral Line, and **39** nos. of Pedestrian Crossing ii) Traffic Sign: **20** nos. of Regulation Sign, **112** nos. of Warning Sign, and **21** nos. of Guide Sign
	(3) Guardrail	i) The Mekong River Side: L=**180** m ii) Colmatage Side: L=**180** m
	(4) Guidepost	**1,010** nos.
	(5) Access to the Connecting Roads	**269** nos.
	(6) Road Hump	**6** nos.
	(7) Truck Scale	**2** nos.

The Project will be undertaken by the Grant Aid of Japan and the detailed design and construction periods are planned to be seven (6.5) months and fifty two (52) months respectively. Total project costs of 8,194 million Japanese yen (Japanese Government's payment: 7,562 million Japanese yen, Cambodia Government's Payment: 632 million Japanese yen) were estimated.

At the beginning, the Project was planned to be implemented in two (2) phases as follow:

Phase 1 : Sta.23+900 - Sta.55+980
Phase 2 : Sta.0+000 - Sta.23+900

However, it was necessary to take a cautious countermeasures and obtain a reasonable agreement from PAP, then the Project is divided into following three (3) stages.

Stage - 1 : Construction of No.2 and No.3 Bridges.
This is the most urgent component to rehabilitate.
Stage - 2 : Improvement from Sta.13+100 to Sta.55+980 (end point).
Improvement work will proceed from the end point to the beginning.
Stage - 3 : Improvement from Sta.0+000 to Sta.13+100.

Both Stage - 2 and Stage - 3 make the Project available to take flexible countermeasures considering a prospective agreement from PAP.

The direct beneficiaries by the Project are those residents with the populations of 2.42 million (2003) live in Phnom Penh (populations of 1.23 million) and Kandal Province (populations of 1.19 million), and indirect beneficiaries are 13.29 million populations (expectancy in 2003) of the whole nation. The advantageous effects resulted from the implementation of the Project are summarized as below.

- Function as an arterial road will improve because the existing road is narrow and congested with mixed vehicles and motorcycles traffic. This is causing the lower efficiency of traffic flow and significantly disturbing the function as an arterial road.
- Not enough traffic service facilities are provided, existing vehicle parking space and side walk are narrow or none. These make the residents inconvenient. Along the market area, school and hospital area new traffic service facilities are considered in the Study to improve the road function as life line.
- As a result of increased traffic capacity and improved mobility, trip time between Phnom Penh and Neak Loueng can be shortened as 45 - 50 minutes by upgrading the traveling speed from about 30 kph now up to 80kph for most sections.
- Traffic accidents, caused by mixed traffic, are expected to be reduced by the implementation of traffic separation between four and two wheels drivings. In addition, the provision of traffic sign board, guardrail, and hamper is also expected to increase traffic safety for vehicles and residents.
- At present, the load limits are 15 tons for the existing one-lane temporary Bailey bridges. Transport of large-scale goods can be made more efficient by applying the design loads of 20 tons together with the widening of bridge's width.
- To improve the soundness of road surface and safe traveling at the time of flood by improving the road elevation as flood control measures. Moreover, the flood control effects on the Mekong River can be strengthened by the construction/installation of more waterway openings (3 bridges, 2 pipe culverts and 7 box culverts). In addition, the agricultural promotion in the Colmatage side can be expected by the scaling up of farmlands to be irrigated by the inflow of overflow floodwater.
- The rainwater discharged into the road during raining will cause the lowering of traffic function and the inhibition of traffic safety because no rainwater drainage facilities exist within the urbanized area. Such situation can be resolved by installing the road surface drainage facilities.
- Socio-economic activities become active through the promoted people and physical exchanges due to the improved function of National Road No.1. Moreover, living standards will be upgraded together with the improvement of user-friendliness along the road because of the enhanced function of living road.

As mentioned above, significant advantageous effects will be expected from the Project. In addition, the regional gaps between the Capital Phnom Penh and local region can be eliminated by facilitation of human and physical migration. It can be judged that the Project to be undertaken by the Grant Aid of Japan is appropriate from the viewpoint of contributing the Cambodian nationwide socio-economic vitalization. However, it is considered that both of personnel and funds are unsatisfactory in management and maintenance for the Project.

Therefore, maintenance shall be adequately done by the Government of Cambodia to manifest/sustain the Project's significant advantageous effects. Especially, the cleanup activities for the road and bridge drainage facilities are most important. Moreover, it is considered that the significant advantageous effects of the Project can be enlarged through the improvement on the sections other than the tie-up target section to be carried out by self-help efforts.

This Grant Aid Project is implemented on condition that the Royal Government of Cambodia shall obtain an appropriate agreement from PAP relating to the involuntary resettlement.

Moreover, the Royal Government of Cambodia is required to make valid the provided facilities through the restriction of driving speed and traffic safety education to the residents etc. after completion of the Project.

TABLE OF CONTENTS

[Appendices]

[Appendices in Separate Volume]

Chapter 1 Background of the Project

Road networks in Cambodia had been ruined due to the lack of maintenance, damage by flooding, destruction by bombing or mines and load increase of vehicles etc., which are brought from the Civil War during 1970 to 1980's. Since 1993, donor countries such as Japan, and international funding agencies as ADB and World Bank has started to provide Cambodia with the assistance to restore infrastructure, however, as of 2003, road repaired under modern technology is 1,200 km which accounts for 60% of the trunk road, so that the improvement of the roads which connect the center of provinces with Phnom Penh is an urgent issue.

Under such circumstances, the Royal Government of Cambodia put up one of the targets, to restore and reconstruct main national trunk roads for the improvement of road transport networks, under the "National Second Five-year Plan" for Socio-economic Development, from 2001 to 2005. The National Road No.1 is the most important infrastructure having multipurpose functions such as international trunk road, regional development and life road. However, due to traffic congestion and damages to the pavement brought from increase of traffic, and the location of road alignment in floodplain, are causing traffic obstruction. The Royal Government of Cambodia made a request of Grant Aid for the improvement of the National Road No.1 Phnom Penh to Neak Loueng Section, to the Government of Japan, as part of road improvement plan.

Upon the receipt of the request, the Government of Japan has dispatched the delegation and carried out the F/S of Development Plan, from April 2002 to March 2003, and the result of the Study resulted in execution of the Preliminary Study in January 2004.

Contents of the Request

The contents of the original request were as follows:

1) Road improvement, including road structures etc., of about 56km on the National Road No.1 between Phnom Penh and Neak Loueng especially, remedial works to the damage, such as bridges and culverts etc., caused by the flood occurred in AD 2000.
2) Improvement of the Monivong Bridge with a length of 283 m.

Among the requests, both Governments agreed on the conducting the Basic Design Study on item 1), but not item 2).

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

(1) Overall Goal and Project Purpose

The Royal Government of Cambodia, formulates three (3) national development objectives. In the Second Five-year Socio-economic Development Plan (year 2001-2005). The three objectives are:

- Economic growth that is broad enough to include sectors where the poor derive their livelihood;
- Social and cultural development; and
- Sustainable use of natural resources and sound environmental management.

Development of the basic infrastructure in the transport sector is essential in achieving an economic growth with equity and social development. The policy objective of developing the transport infrastructure is to be attained by giving first priority to road rehabilitation with an associated improvement in operations and maintenance capability. The plan has three main aims:

- To rehabilitate and reconstruct the main national roads, thereby improving land transport throughout the nation;
- To build road links to neighboring countries, thereby opening up some of the more remote areas of the country to international trade and tourism; and
- To develop a sustainable road maintenance program, thereby assuring that investment in road rehabilitation and reconstruction generates sustainable benefits.

The road network in Cambodia consists of 4,165 km of national roads (1,988 km of 1-digit national roads and 2,177 km of 2-digit national roads), 3,615 km of 3-digit provincial roads and 31,000 km of rural and strategic roads. National Road No.1, which is the project road, extends from Phnom Penh Municipality to Ho Chi Minh City the primary commercial city in Vietnam. The National Road No.1 is also the Asian Highway No. A-1 and serves as the Second East-West Corridor, which is given a high priority in this plan.

The overall goal and project purpose are as follows:

- Overall Goal : To stimulate socioeconomic activities in Cambodia.
- Project Purpose : To improve the movement of people and goods between Phnom Penh Municipality and Ho Chi Minh City.

(2) Basic Concept of the Project

This project aims to improve National Road No.1 (Phnom Penh - Neak Loueng Section),

approximately 56 km long including opening sections and revetments, to achieve the above over all goal.

However, approximately 105 km section of from Neak Loueng to the border of Vietnam has improved as a part of the Asian Highway No. A-1 in 2003 by ADB fund.

This section, approximately 56 km long, and located at the floodplain paralleling the Mekong River, is difficult to be designed and constructed. Moreover, the flood in 2000 has caused extensive damage to this section. Before this survey, the Feasibility Study in 2002 and Preparatory Study on the confirmation of Environmental and Social Consideration for the Project in 2003 was implemented.

The project is expected to smoothen the traffic and shorter the travel time as a result of the improvement of the road function.

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

The following twelve (12) items are established as the design policy for the Project, out of which the first five (5) items are related to the basic concept with regard to formulation of the framework of the Project and the remaining seven (7) items are related to the other relevant matters.

2.2.1.1 Improvement Policy in Consideration of Mekong River Flood

(1) Design Flood Level and Design Road Level

Following the concept of the Feasibility Study, the annual maximum water level recorded on September 20, 2000 in the annual maximum water levels since 1960 at Chaktomuk gauging station (located at the confluence between the Mekong River and the Bassac River in Phnom Penh) is set as the Design Flood Level. However, the Design Flood Level of entire section of the Project is set adding the flood water level at Prek Yourn Water Gate, Koki Thom Water Gate, and Neak Loueng gauging station.

The return period of this Flood Level is calculated at approximately 12 years in the Feasibility Study. But based on the reexamination, the return period of this Flood Level seems to be 50-year to 100-year of return period.

Since the design standards for determining high water level is not available in Cambodia, the "Ordinance for Structural Standard for River Administration Facilities" has been referred to for the purpose. Moreover, the determined figure is effective to present an overflow on the road, accordingly the deterioration of the asphalt concrete surface course and gravel base course would be prevented, and the Design Road Level against flood is therefore set as follows:

Design Road Level = Design Flood Level + Freeboard (over 50cm)

The relation between the Design Flood Level and the Existing and Design Road Level is shown in Table 2.2.1.1-1 and Figure 2.2.1.1-1.

Table 2.2.1.1-1 Design Flood Level and Existing and Design Road Level

Location	Monivon Bridge East Coast	Confluence between Mekong and Bassac	Prek Pol Water Gate	Prek Yourn Water Gate	Koki Thom Water Gate	Neak Loueng
Station	0+000	3+500	28+430	31+100	45+740	55+300
Design Flood Level	10.18	10.18	9.04	8.92	8.40	7.79
Existing Road Level	14.06	9.97	9.86	9.43	8.88	8.04
Existing Road Level-Water Level	3.88	-0.21	0.82	0.51	0.48	0.25
Design Road Level	14.06	11.31	10.10	10.00	9.45	8.04
Design Road Level - Water Level	3.88	1.13	1.06	1.08	1.05	0.25

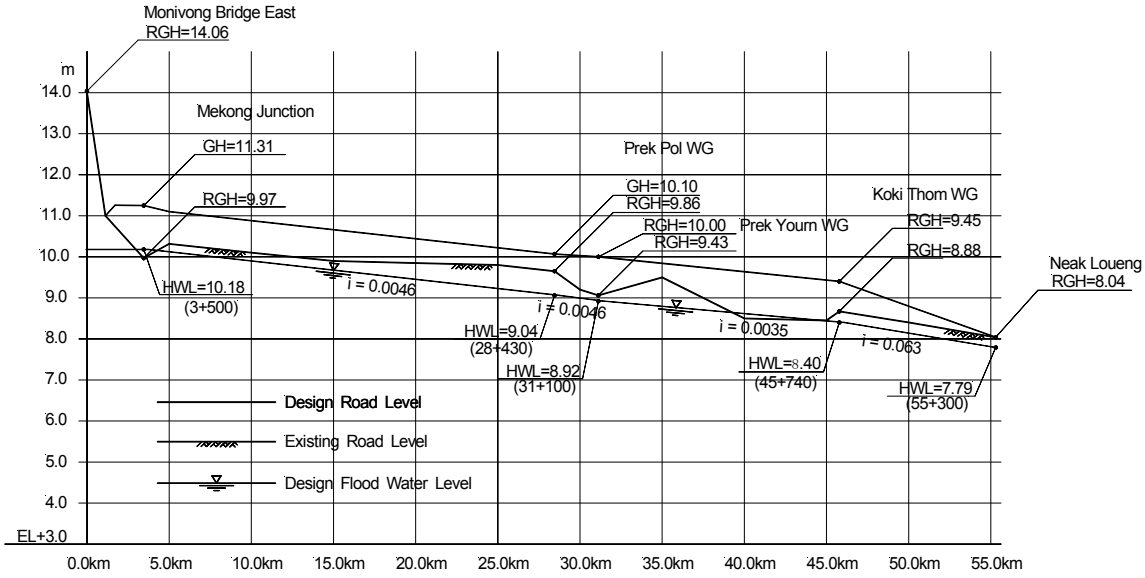


Figure 2.2.1.1-1 Design Flood Level and Existing/Design Road Longitudinal Section

(2) Hydraulic Characteristics at Opening Structure

1) Purpose of Placing Opening Structures

The purpose of placing opening structures is flood control, that is the flood water level between Phnom Penh and Neak Loueng and crossing National Road No.11 will decrease due to the inflow of the Mekong River to the floodplain. At this point, the influence to agriculture and residences caused by the inflow of floodwater are considered sufficiently.

2) Scale of Entire Opening Section

The Feasibility Study proposed the scheme for increasing the present discharge flow to the floodplain by placing new opening structures subject to a limitation of 3,600 m^3/s of the

calculated flow discharge through the floodplain. All designs in this study follow the scheme mentioned above.

3) Setting of the Opening Structure Locations

The opening structure locations are determined, considering the scheme for new construction and improvement of opening structures proposed in the Feasibility Study and hearing survey to the residents along the Project road in this survey.

4) Inflow Analysis

The inflow analysis in this survey on floodwater from the opening section at design flood water level resulted to a total inflow amount of 3,600m^3/s which is nearly equal to the ability of floodplain.

However, in the Feasibility Study the total inflow amount is 2,798m^3/s (which is 78% of 3,600m^3/s) and the efficiency of water level decrease at Chaktomuk gauging station is:

10.18m→10.07m (decrease of 11cm)

Consequently, water level decrease of more than 11cm is expected on the setting of the opening structure locations in this survey.

(3) Influence to National Road No.11

There is no riskiness of flood damage increasing, because:

- Although two bridges on National Road No.11 were seriously damaged by the flood in 2000, these two bridges were improved to be 80m long bridge each. They are safe with the present flood flow at rate and discharge.
- At Sta.47+967 and Sta.42+830, the road embankment was open cut against further damage of road embankment. There are two temporary bridges there now. The ability of flood flow in the floodplain is included in this plan.

(4) Influence to Residents, Agriculture, Revetment, and Riverbed Protection

It is actually difficult to estimate quantitatively the influence that the inflow of floodwater due to the new opening sections has on the Colmatage side. However, merit and demerit of social and environmental influence to the residents can be assumed as follows:

(Positive impact)

- Activation of agriculture due to spread of irrigation farmland
- Improvement of local drainage
- Increase of fishery resources due to spread of living and laying area for fish

(Negative impact)

- Deterioration of living surroundings due to scouring of existing farmland and residential land
- Weakening road structure due to concentration of floodwater at opening section.
- Unpredictable change of the ecosystem.

In this Basic Design, revetment and riverbed protection at opening section are designed to reduce the demerits described above and not to cause a great loss.
Moreover, the Study Team requested the Royal Government of Cambodia to confirm the scale of influence due to the new opening, and to implement the reasonable compensation to the residents when it's confirmed.

2.2.1.2 Improvement Policy in Environmental and Social Considerations

(1) Results on IEIA and ISIA by F/S

Both IEIA and ISIA were conducted during F/S stage. As for the involuntary resettlement, it was estimated as category B (potential negative impacts on the environment and society are not significant). However, in accordance with the revised JICA guideline for Environmental and Social Considerations (April 2004), it is re-estimated as category A which needs the treatment of the matter requires care.

Moreover, based on the results of F/S, cautious measures were taken to confirm the environmental and social considerations (especially involuntary resettlement) during Preparatory Study, Basic Design Study and Supplemental Study Stages.

As for the noise vibration, air pollution, water pollution, fauna and flower these constitutes parts of natural conditions, Environmental Baseline Survey has conducted in March 2005.

Followings are the lines to reflect those studies.

(2) Environmental Considerations

1) Setting of the Opening Section

Refer to "2.2.1.1 Improvement Policy in Considerations of Mekong River Flood" mentioned above, the opening structure locations and the structures are set not only for the purpose of reducing the flood water level at Phnom Penh but also for considering the use of drainage, irrigation and so on based on hearing survey to residents along the Project road. In terms of new openings, for there might be unexpected damages to those, the baseline study prior to the commencement of the implementation and the follow-up study after the completion should be undertaken.

2) Implementation Method

The implementation method of considering the environment around the site is adopted based on the following:

- To select the construction method generating as minimal noise and vibration as possible in urbanized areas;
- To definitely carry-out traffic control during construction and to pay enough attention to road safety; and
- To treat construction wastes properly.

(3) Consideration of Resettlement

Resettlement of the PAPs is the most important problem for the implementation of the Project. It is therefore the essence that the number of PAPs shall be minimized and that all stakeholders agree with this project.

The concept of improvement minimizing PAPs is shown as follows.

1) Cross Section

Typical Cross Section

The impact by the set-up of lane's number and width was minimized from the viewpoint of environmental and social considerations taking the road function (mobility, safety and countermeasures on flooding) into consideration. Moreover, reduction of negative impact was planned by adopting the one-side widening, and thus the utmost utilization was applied to the previously setback sections.

Future Cross Section

The Government of the Cambodia has a plan of future cross section with road widening of 4-vehicle lanes, because National Road No.1 locates as a part of the Asian Highway. The lane composition is shown as follows while the future cross section is shown on Figure 2.2.1.2-1.

- Vehicle Lane ; 3.50m x 4
- Motorbike Lane ; 2.50m x 2
- Shoulder or Sidewalk ; 1.00m x 2 or 2.50m x 2

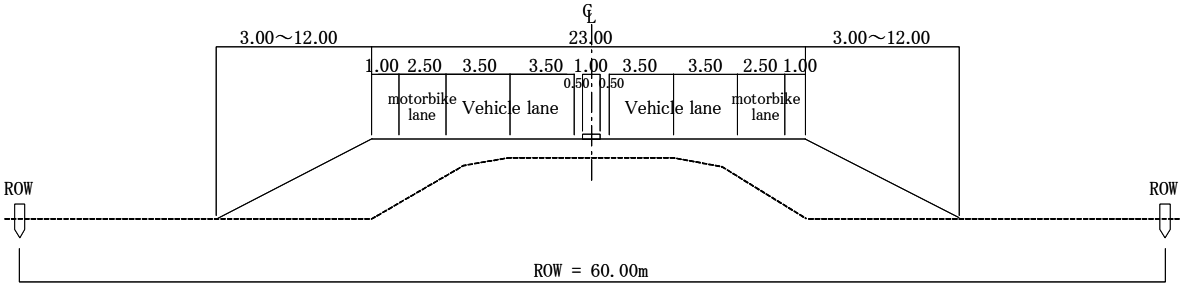


Figure 2.2.1.2-1 Future Cross Section

Cross section with Road Widening in Unpopulated Areas

The comparative study on the following two (2) cases of road widening method was made for the unpopulated area such as the section from Sta.23+900 to Sta.53+400.

Case 1 : Widening at one side (Colmatage side)

Case 2 : Widening at both sides (the Mekong River and Colmatage sides)

Case 1 was adopted based on the following reasons by the Royal Government of Cambodia. Cross Section with road widening in unpopulated area is illustrated in Figure 2.2.1.1-2.

① Widening at one side is compatible with the future development plan of National Road No.1 of the Government of the Cambodia.

② Approximately four hundred (400) less number of houses at the Colmatage side seem to be affected by construction of the road comparing with the Mekong River side.

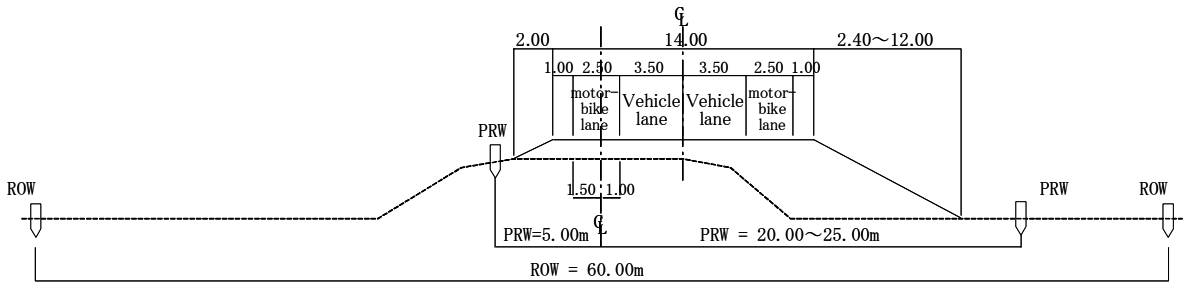
③ The set-back method of relocation may be acceptable in the unpopulated area, comparing with relocation to other places.

④ During construction, 2-lane can be maintained in case of one side widening, but only 1-lane is available in case of both sides widening at construction segments.

⑤ Widening at the one side can save the construction cost by eliminating double works, especially re-construction of costly embankment/river bank slope which are required in case of both sides' widening.

⑥ At the Colmatage side, bush/wasteland/floodplain are generally observed comparing with the Mekong River side where the land utilization such as agriculture is active.

⑦ Economic and stable road structure can be expected by widening the Colmatage side due to the utilization of the stable slope at the Mekong River side against the flooding after many years.



Section : Sta.23+900 − Sta.53+400 (2-lane)

Figure 2.2.1.2-2 Cross Section with Road Widening in Unpopulated Areas

Cross Section with Road Widening in Populated Areas

The comparative study on the following two (2) cases of road widening method was made for the populated area such as the section from Sta.1+800 to Sta.23+900 and from Sta.53+400 to Sta.54+740.

Case 1 : Widening at one side (the Mekong River side or Colmatage side)

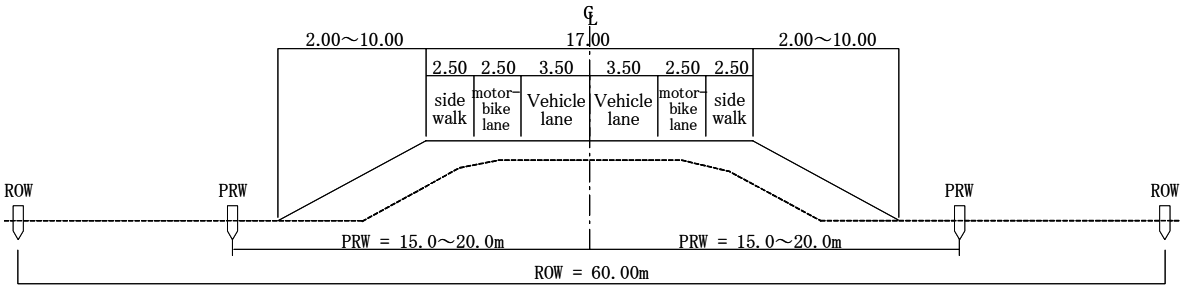
Case 2 : Widening at both sides (the Mekong River side and Colmatage side)

Case 2 was adopted for the populated area based on the following reasons by the Royal Government of the Cambodia. The cross section with road widening in populated area is illustrated in Figure-2.2.1.2-3.

① There exist houses at both sides of the road relatively closely so that many houses are to be affected by the construction of the road. Fair treatment on them is considered to be vital.

② At the densely developed urban areas such as the beginning point of the road (Sta.0-Sta.1+800) and Kokir Market area (Sta.13+500-Sta.14+000), no widening shall be planned.

③ The relocation to other places of affected houses is inevitable because the set-back method of relocation can not be applied because no more space at back side.



Section : Sta. 1+800 − Sta.13+500 (2-lane)
Sta.14+000 − Sta.15+700 (2-lane)
Sta.16+640 − Sta.23+900 (2-lane)
Sta.53+400 − Sta.54+740 (2-lane)

Figure 2.2.1.2-3 Cross Section with Road Widening in Populated Areas

Cross Section at Urbanized Area and Market Area

- Sta.0+300～Sta.1+800

  Allowing for the cost performance, the necessity brought from the density of affected houses, road width is minimized due to applying retaining wall limited in this section only. In this case, houses from which road access is difficult occur. For this problem, it will be decided by consultations with the residents at DMS implementation whether Cambodian side compensates construction cost for access improvement or resettlement.

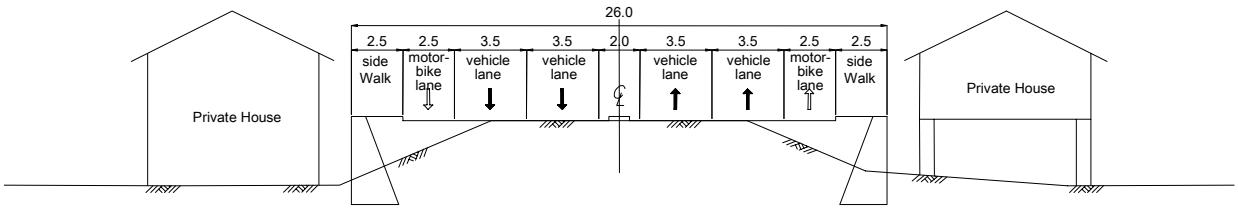


Figure 2.2.1.2-4 Cross Section with Road Widening at Urbanized Area

・ Sta.13+500～14+000: Kokir Market

No resettlement will occur due to the improvement within existing road width, no additional road right of way. Moreover, parking lane is separated from vehicle lane by sidewalk due to setting up parking lane outside the sidewalk. Therefore parking cars don't occupy vehicle lane and traffic safety is improved. Parking lane can be widened under this lane composition by Cambodian efforts.

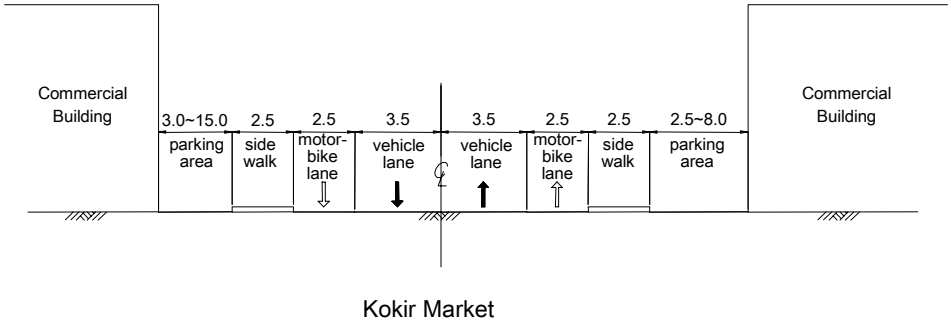


Figure 2.2.1.2-5 Cross Section with Road Widening at Market area

2) Road Alignment

Plan Road Elevation

The lower road elevation is, the narrower the road width becomes. Then, minimizing PAPs can be possible. Therefore, considering technical view, plan road elevation is decided counting the three (3) points below.

① High water level is the highest water level recorded in year 2000.

② Road elevation is satisfied with a free board of 50 cm and with minimized pavement thickness.

③ The balance of earth volume between cut and embankment and longitudinal alignment of the road are considered.

3) Construction Method and Provisional Road Width

The construction method by which Corridor of Impact (COI) is minimized is adopted, and Provisional Road Width is set based on the COI.

4) Location of Opening Section

Opening sections are planned at the location where there is no influence by running water to agricultural land and residential land at the floodplain side and resettlement and compensation is minimized to the utmost.

5) Setting of Green Belt (Plantings)

Green Belt is set up at Colmatage side of bridge opening and the velocity of flow at flood is reduced. Therefore, the degree of the erosion by water flow is reduced and the landscape is improved.

6) Traffic Service Facilities

- Ordinary Market Area

  Shoulder is widened as Parking Area at six market areas except relative big markets.
- Bus Stop / Refuge Space

  Shoulder is widened as bus stop/refuge space at the twenty (20) intersections at connection road, which are connected to National Road No.1 and used for the traffic to the centers of village and the public buildings.
- School/Hospital Area

  Shoulder is widened to increase the serviceability for going to schools/going to a hospital at thirty-one (31) schools and nine (9) health centers along the Project road. In addition, marking of crosswalk is set up.
- Access to the Connecting Roads

  The installation designing of smooth access to the public/private roads of 269 places to be connected with the National Road No.1 was carried out. The difference in level between the National Road No.1 and the connecting roads will cause the traffic obstacle because the proposed road surface elevation at National Road No.1 is higher than the existing one by 50 cm. Therefore, mutual smooth access shall be considered to assure the user-friendliness.
- Road Hump

  Within the urbanized area and market area, six (6) road humps were installed to reduce the traveling speed for the resident's safety and traffic accident prevention.

Moreover, taking the increase of numbers and speed up of traffic into account, an appeal to enforce the traffic safety campaign and restriction of driving speed by the Royal Government of Cambodia are necessary to utilize these facilities effectively.

2.2.1.3 Bridge Location and Length

(1) Bridge Location

Three (3) new bridges were proposed in the Feasibility Study. Locations of the proposed three bridges were verified through field survey by local residents in the Kingdom of Cambodia as shown in Table 2.2.1.3-1. Two (2) bridges proposed at the same location as the existing bailey bridges, and the location of the other bridge is proposed at the upstream side of Bridge No.2 as shown in Table 2.2.1.3-2.

Table 2.2.1.3-1 List of the Title of Representative of Local Residents (Kingdom of Cambodia)

Position
Deputy Director, District Leuk Daek
Officer of Water Resource, District Leuk Daek
Director of Public Works, District Leuk Daek
Director of Commune, Kom Pong Phnom, District Leuk Daek
Director of Commune, Preak Ton Laup, District Leuk Daek
Director of Public Works, District Kean Savay
Director of Commune, Koki, District Kean Savay
Deputy Chief of the Technical Office of the Heavy Equipment Center

(2) Bridge Length

Bridge Length is basically the same as the Feasibility Study, but widened a little to provide the allowance for slope erosion and maintenance space in front of abutments. Table 2.2.1.3-3 shows the length of bridges.

Table 2.2.1.3-3 Bridge Length

Bridge Name	Bridge Length (m)	Bridge Location
Bridge 1	68.8	Sta. 42+155.0 - Sta. 42+223.8
Bridge 2	103.0	Sta. 42+750.0 - Sta. 42+853.0
Bridge 3	68.8	Sta. 47+905.0 - Sta. 47+973.8

(3) Span Length

The minimum span length is designed as 20 m, according to the river discharges between 510 m^3/s and 914 m^3/s, based on the design criteria while the discharge is above 500 m^3/s and below 2,000 m^3/s by the "River Structure Standard, Japan River Association". Span lengths of No.1 Bridge and No.3 Bridge, which have three (3) spans, are 21.4 m both. And, span length of No.2 Bridge, which has four (4) spans, is 24.1 m.

Table 2.2.1.3-2 Results of Field Survey on Bridges

No.	Station (Km)	Existing Bridges (Length)	Proposed Bridges		Requirement of Local Residents				Team Observation
			F/S	B/D	Proposed Station	Proposed Bridges (Length)	Elevation of Invert	Purpose of Bridge Openings	
Bridge 1	42 +110	None	PC-I Shape Girder Bridge (L=66m)	PC-I Shape Girder Bridge (L=68.8m)	42 +190	PC-I Shape Girder Bridge (L=68.8m)	50cm higher than ground level	Drainage	Relocated 80m to Neak Loueng (downstream), because of existence of a water channel in the Mekong River Side.
Bridge 2	42 + 800	Bailey (L=100m)	PC-I Shape Girder Bridge (L=100m)	PC-I Shape Girder Bridge (L=103.0m)	42 + 800	PC-I Shape Girder Bridge (L=103.0m)	Ground level	Drainage	Main flow coming with right angle to the bridge, Existing channel in Mekong side.
Bridge 3	47 +940	Bailey (L=66m)	Re-fill	PC-I Shape Girder Bridge (L=68.8m)	47 + 940	PC-I Shape Girder Bridge (L=68.8m)	Ground level	Drainage	Local people request not to re-fill, Existing channel in length of 1500m which is but not straight in Mekong side.
Bridge 3	48 +400	None	PC-I Shape Girder Bridge (L=66m)	None	-	-	-	Drainage	No additional opening is required.

2.2.1.4 Culvert Location and Length

(1) Location

Thirteen (13) culverts were proposed in the Feasibility Study. The requests regarding the proper locations and needs of these culverts from the representatives of district were confirmed. As the result of the discussion, it is confirmed that the appropriate locations of nine (9) culverts were decided with minor adjustments, shown in Table 2.2.1.4-1 while they replied that four (4) culverts (BC2, BC3, BC6, BC7) were not needed. They requested that special three (3) locations except BC2 should not be placed because the arrangement of compensation would be difficult when the inflow would affect the farmlands and the residential lands within the floodplain. The requests from districts are as shown in Table 2.2.1.4-2. Nine (9) culverts, two (2) pipe culverts and seven (7) box culverts, are set up at nine (9) locations below each due to the above-mentioned points.

Table 2.2.1.4-1 Location of Culverts

Pipe1	Sta. 23+983	BC4	Sta. 36+880	BC9	Sta. 46+930
Pipe2	Sta. 24+823	BC5	Sta. 41+006	BC10	Sta. 48+740
BC1	Sta. 32+420	BC8	Sta. 44+350	BC11	Sta. 49+995

It is confirmed that nine (9) culverts are set up with a view to local storm sewage and drainage of floodwater of the Mekong River and only BC11 has a function of irrigation canal.

(2) Proposed Elevation of Culvert

Culvert invert elevation is set at the elevation which is nearly same as existing ground level or existing culvert elevation. And following the Feasibility Study, design high water level is the highest water level in year 2000 and the freeboard is over 1 m. While widths of box culvert are: BC11 is 3-box 2 m wide, others are 2-box 2 m wide in the Feasibility Study, BC5 is 3-box 2 m wide same as existing culvert due to the request of residents. And while the two (2) pipe culverts are 1-pipe 1 m in diameter each in the Feasibility Study, Pipe1 is 1-tube with one (1) meter in diameter and Pipe2 is 2-tubes with one (1) meter in diameter.

With above considerations, the elevation and the width of culverts are shown in the Table 2.2.1.4-3.

Table 2.2.1.4-2 The Requirements from Local Residents

No.	Station	Existing Culvert Nos of Cell@W*H	Proposed Culvert (F/S) Nos of Cell@W*H	Requirement of Local Residents				Remarks
				Proposed Station	Proposed Culvert Nos of Cell@Width	Elevation of Invert	Purpose of Opening (Culvert)	
Pipe 1	23 + 983	Pipe D=0.5m	Pipe D=1.0m	23 + 983	Pipe D=1.0m	Ground level	Local drainage	The culvert is required to be allocated at present location
Pipe 2	24 + 823	Pipe D=0.9m	Pipe D=1.0m	24 + 823	Pipe 2 cells D=1.0m	Ground level	Local drainage	Two cells of pipe is required
BC 1	32 + 420	None	Box with Gate 2cells 2.0*5.4m	32 + 420	Box with stop log 2cells 2.0m	Ground level	Local drainage	The location of culvert is required to be allocated considering topographic
BC 2	32 + 750	None	Box with Gate 2cells 2.0*6.4m	None			No necessary	No requirement of culvert
BC 3	33 + 200	None	Box with Gate 2cells 2.0*4.7m	None			Not to be installed to protect agricultural and residential areas	No requirement of culvert
BC 4	36 + 870	None	Box with Gate 2cells 2.0*6.3m	36 + 880	Box with stop log 2cells 2.0m	50 cm higher than ground level	Local drainage	The location and elevation of culvert is required to be allocated considering topographic condition.
BC 5	41 + 006	Box 3cells 2.0x4.6m	Box with Gate 2cells 2.0*5.6m	41 + 006	Box with stop log 3cells 2.0m	Channel bed level	Local drainage	The size and elevation of existing culvert is required to be kept
BC 6	41 + 770	None	Box with Gate 2cells 2.0*5.2m	None			Not to be installed to protect agricultural area	No requirement of culvert
BC 7	43 + 460	None	Box with Gate 2cells 2.0*5.4m	None			Not to be installed to protect agricultural area	No requirement of culvert
BC 8	44 + 360	None	Box with Gate 2cells 2.0*5.0m	44 + 350	Box with stop log 2cells 2.0m	Ground level	Local drainage	The location of culvert is required to be allocated considering topographic
BC 9	46 + 920	None	Box with Gate 2cells 2.0*4.5m	46 + 930	Box with stop log 2cells 2.0m	Ground level	Local drainage	The location of culvert is required to be allocated considering topographic
BC 10	48 + 760	None	Box with Gate 2cells 2.0*5.2m	48 + 740	Box with stop log 2cells 2.0m	Ground level	Local drainage	The location of culvert is required to be allocated considering topographic
BC 11	50 + 002	Box 3cells 2.0x5.4m	Box with Gate 3cells 2.0*5.8m	49 + 995	Box with stop log 3cells 2.0m	Channel bed level	Local drainage Irrigation	The size and elevation of existing culvert is required to be kept

Table 2.2.1.4-3 Width and Elevation of Culverts

Culvert	Dimension	Design High Water Level (m)	Invert Evasion (m)	Inside Height (m)
Pipe 1	Dia.=1.0m, 1cell	9.24	5.5	Φ1m
Pipe 2	Dia.=1.0m, 2cells	9.21	6.0	Φ1m
BC 1	Width 2.0m, 2cells	8.88	4.5	5.4m
BC 4	Width 2.0m, 2cells	8.72	4.5	5.3m
BC 5	Width 2.0m, 3cells	8.58	4.0	5.6m
BC 8	Width 2.0m, 2cells	8.46	4.5	5.0m
BC 9	Width 2.0m, 2cells	8.35	5.0	4.4m
BC 10	Width 2.0m, 2cells	8.25	4.0	5.3m
BC 11	Width 2.0m, 3cells	8.15	2.9	6.3m

(3) Form of Culvert

Structure of culvert is concrete considering local actual result and economical efficiency. However, stop log is set up at the Mekong River side of each culvert due to the request of local residents. This stop log is necessary for the maintenance of culvert and as a blockage of the opening in an emergency. This aims at the closure of the openings in case of culvert maintenance and emergency situations, and to control the impact to the farmlands etc. within the Colmatage side.

2.2.1.5 Road Facilities

(1) Ordinary Market Area

Shoulder is widened to the both sides or one side as parking area at three (3) market areas except relative big markets. Refer to the Table 2.2.1.5-1.

Table 2.2.1.5-1 Ordinary Market Area

No.	Name	Station (km)	Right/Left From Phnom Penh	Village
1	Pre Eng Market	5 + 800	Both	Metapheap
2	Samrong Thom Market	35 + 730	Both	Phom Sting
3	Koki Thom Market	45 + 680	Both	Koki Thom

(2) Bus Stop / Refuge Space

Shoulder is widened as bus stop/refuge space at the twenty (20) intersections at connection road, which are connected to National Road No.1 and used for the traffic to the centers of village and the public buildings. Refer to the Table 2.2.1.5-2.

(3) School/Hospital Area

Shoulder is widened to increase the serviceability for going to school/going to a hospital at thirty-one (31) schools and nine (9) health centers along the Project road. In addition, marking of crosswalk is set up. Refer to the Table 2.2.1.5-3.

Conceptual plan of road facilities above are shown in the Figure 2.2.1.5-1.

Table 2.2.1.5-2 Locations of Bus Stop/Refuge Space (Connection Road)

No.	Station (Km)	L/R View from Phnom Penh	Village
01	3+326	L	Veal Sbov
02	6+940	L	Preak Aeng
03	8+102	L	Chrouy Ampel
04	9+527	R	Kbal Kaoh
05	11+202	L	Phum Thum
06	16+306	L	Slap Ta Dun
07	19+830	R	Dei Edth
08	22+825	R	Khsom
09	28+309	L	Bantery Dek
10	30+077	L	Chey Otdam
11	30+966	L	Chey Otdam
12	32+000	L	Prek Taker
13	33+700	L	Chrouy Dang
14	37+455	R	Samrong Thom
15	39+600	L	Samrong Kaer
16	41+200	L	Por Mouv
17	44+278	L	Koki Thom
18	48+968	L / R	Crouy Dong
19	50+068	L	Kompang Phnum
20	54+924	R	Prek Tunlop

Note: L means the left side, R means the tight side

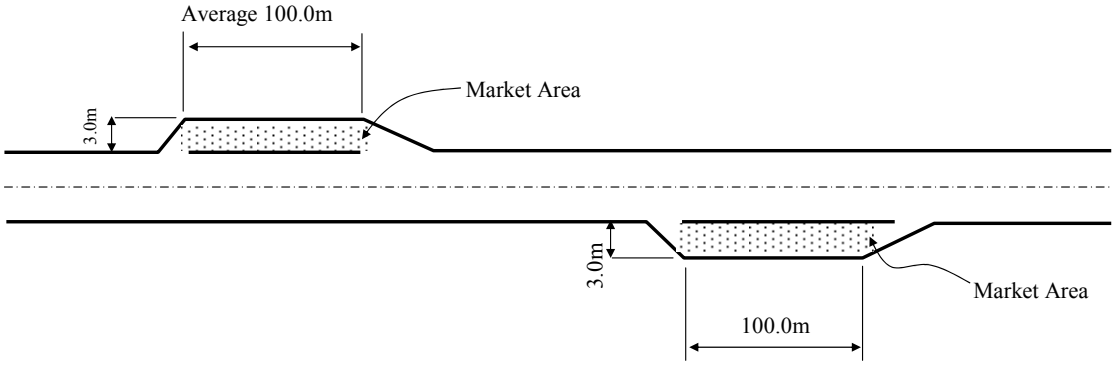
Table 2.2.1.5-3 School/Hospital Areas

Location of Schools

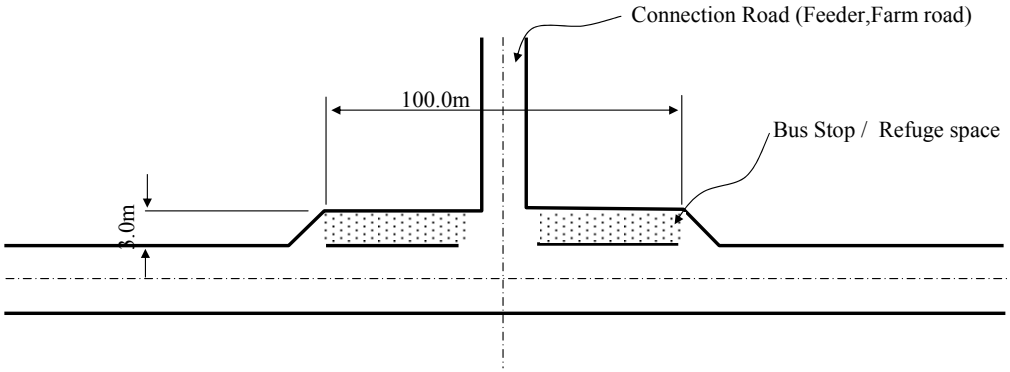
No.	Name	Station (Km)	L / R (From Phnom Penh)	Village
1	Chbar Ampou High School	1 + 572	R	Beang Chouk
2	Kdey Takoy Primary School	3 + 918	R inside	Kdey Takoy
3	Veal Sbov Primary School	4 + 984	L	Svay Ta Ouk
4	Prek Eng High Primary School	5 + 874	L	Kbal Chrouy
5	Prek Eng High School	6 + 098	R inside	Toul Tachan
6	Mache Mavoan Primary School	8 + 102	L inside	Chrouy Ampel
7	Cham Par Primary School	9 + 000	L inside	Chrouy Ampel
8	Youk Bath Primary School	10 + 325	R	Youk Bath
9	Rek Smay Primary School	12 + 310	L	Phum Thom
10	Koki Primary School	13 + 887	R inside	Toul Thnot
11	Hun Sen Slaket Primary School	15 + 257	L	Slap Ta Oun
12	Voth Kos Primary School	16 + 306	L inside	Slap Ta Oun
13	Day Eth Primary School	17 + 675	R	Day Eth Kos Phos
14	Chey Vora Mant No. 7 High School	17 + 793	R	Day Eth Kos Phos
15	Sdauv Kan Leang Primary School	20 + 540	R	Sdauv Kan Leang
16	Khsom Primary School	22 + 825	R	Khsom
17	Banteay Daek Primary School	25 + 475	L	Kandal Loeu
18	Porti Prek Primary School	27 + 362	L	Kandal Kroum
19	Chhey Ouk Dom Primary School	28 + 748	R	Chhey Ouk Dom
20	Chhey Moung Koul Primary School	32 + 000	L inside	Prek Taker
21	Prek Treang Primary School	35 + 040	R	Prek Treang
22	Doy dos Primary School	38 + 777	R	Samrong Kaer
23	Samrong Primary School	39 + 600	L inside	Samrong Kaer
24	Por Mouv Primary School	41 + 200	L inside	Por Mouv
25	Koki Thom High School	44 + 050	L inside	Koki Thom
26	Koki Thom Primary School	45 + 124	R	Koki Thom
27	Samrong Thom Primary School	45 + 495	L inside	Crouy Dong
28	Kompong Phnom Primary School	51 + 993	R	
29	Hun Sen Kompong Phnom High School	52 + 311	R	Umpel Tek
30	Kompong Cham Loueng Kindergarten	54 + 860	L	Kam Pong Cam Loueng
31	Kompong Cham Loueng Primary School	54 + 860	R	Kam Pong Cam Loueng

Location of Hospitals

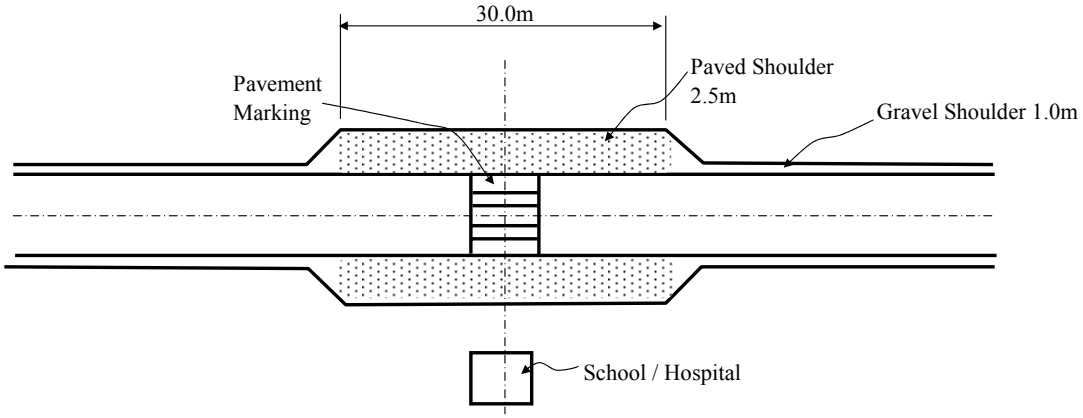
No.	Name	Station (Km)	L / R (From Phnom Penh)	Village
1	Prek Eng Health Center	6 + 300	L	Kbal Chrouy
2	Kbal Koh Health Center	9 + 966	R	Prek Thom
3	Phum Thom health Center	12 + 333	R	Phum Thom
4	Kien Svay Hospital	13 + 890	R	Toul Thnot
5	Dey Eth Health Center	17 + 490	R	Day Eth Kos Phos
6	Banteay Daek Health Center	25 + 362	L	Kandal Loeu
7	Koki Thom Health Center	34 + 830	R	Koki Thom
8	Kompong Phnom Health Center	45 + 228	R	Kbal Chrouy
9	Samrogn Thom Health Center	48 + 968	L inside	Crouy Dong



Ordinary Market Area



Bus Stop / Refuge Space



School and Hospital Zone

Figure 2.2.1.5-1 Conceptual Plan of Road Facilities

2.2.1.6 Consideration on Natural Conditions

The Project area, inundated for about four months during rainy season and highly dried in dry season, is located in the floodplain paralleling the Mekong River. It is formed by agricultural zones using the flood water and desolate lands those are not cultivated on both the Mekong River side and the Colmatage side.

The area is almost flat and the Mekong River bank with a height of 3-6m is constructed therein, the crown of which is utilized as the "National Road No.1". Ground is composed of weak layer of silty soils.

The following measures shall be taken to reflect the said natural conditions.

- Provision of waterway openings on the bank as flood control measures for Phnom Penh urban area;
- Revetment/riverbed protection on the waterway openings;
- Erosion protection work on the bank;
- Slope protection on the water colliding front of the bank;
- Mitigation measures against wave action on the bank slope; and
- Countermeasure for soft ground on the high embankment and toe of slope

2.2.1.7 Consideration on Socio-economic Conditions

The Project area is predominantly agricultural area with two (2) big markets (one is located at the beginning and the other is Kokir Market) and three (3) roadside markets. Most of the residential houses are wooden-made built over the piles and connected with National Road No.1 by the embankment. There are some villages along the road with pagoda (temple), school and hospital at the center.

The following measures are necessary to keep the above-mentioned life style and cultural tradition.

- Resettlement measures to prevent disturb the community from being disturbed;
- Provision of parking spaces at the market areas;
- Provision of evacuation spaces in case of emergency (flooding); and
- Access measures to schools/hospitals

2.2.1.8 Consideration on Construction and Procurement Conditions

Since the Royal Government of Cambodia has rich experience of completing foreign assisted projects, the Project is expected to be implemented without any problems on construction and

procurement. In principle, all the equipment and materials are procured in Cambodia as far as available, while for those unavailable locally such as gabion, large-scale plant machinery and large-scale vibration rollers are procured from Japan or third countries.

2.2.1.9 Participation of Local Construction Companies

The construction is to be undertaken by a Japanese Contractor and local contractors will participate in the Project in provision of personnel, lease of equipment, and sub-contractual works. For local contractors/personnel to easily participate in the Project, simple structures, simple construction method and easy quality control method are available to adopt.

2.2.1.10 Implementing Agencies' Ability in Management and Maintenance

Management and maintenance of the Project road after completion will be undertaken by the Municipal/Provincial Departments of Public Works and Transport and the Ministry of Public Works and Transport, the former taking charge of daily maintenance works and the latter repair/rehabilitation works. The personnel for these works have been secured but the technical and financial capacity of the agencies concerned is not always enough. To facilitate the maintenance works, the pavement and structures with high durability are designed within the reasonable range, at the same time the technical transfer related to the management and maintenance shall be considered through road construction stage.

2.2.1.11 Establishment of Facility Grade

The National Road No.1 is one of the most import arterial roads in Cambodia and forms a part of the Asian Highway. Therefore, the road shall have the minimum grade to meet such an international standard and roles as well as the above-mentioned considerations.

2.2.1.12 Construction and Procurement Method and Construction Period

The construction plan shall be prepared in due consideration of the safety of road users and construction workers during construction and environmental preservation measures during and after construction. The land for detour during construction is to be temporarily borrowed by the Royal Government of Cambodia.

It is the rainy season from July to November in the Project area. The implementation schedule is prepared aiming at the early completion with required quality by selecting/distinguishing workable items in both rainy and dry seasons.

2.2.1.13 Environment Baseline Survey

In terms of natural conditions along the project road, such as noise, vibration, air and water pollution, though the F/S has undertaken it, upon the suggestion of the JICA Advisory Council of Environmental and Social Consideration Review, the following works have been carried out for data collection and the measurement and analysis of them, prior to the commencement of the project implementation.

(1) Noise

The Equivalent Noise Level (L_{Aeq}) for 12 hours of each site ranges from 58.8 to 68.7dB, and its maximum was given by T-1 point, and the minimum by T-5 point. The source of noise are mostly from horning of cars. All the sites, except T-1 point, exceeds the limit of the allowable level under the Environment Standards, by 2 - 24db.

The noise criteria in Japan is stipulated as 70 db in day time where adjacent to the trunk road.

Table 2.2.1.13-1 Survey Result of Noise Level

Survey Point	Distance from Road Center to Household Limit (m)	Land Use	＊Equivalent Noise Level (L_{Aeq}) ［dB］			Max.（L_{Amax}）［dB］	Environment Criteria in Cambodia	Environment Criteria in Japan
			12 hours	Max.	Min.			
T-1	15	Vicinity of Hospital, School etc.	68.7	69.6	67.7	102.5	45	70
T-2	30	Residential Area	62.1	63.9	60.2	95.7	60	
T-3	30	Vicinity of Hospital, School etc.	62.6	64.3	61.0	95.4	45	
T-4	30	Residential Area	62.0	63.8	60.1	88.7	60	
T-5	30	Residential Area	58.8	60.1	57.0	91.2	60	

(2) Vibration

The equivalent noise level for 12 hours of each site ranges form 33.0 to 40.9db, the maximum being given by T-3 point and the Minimum by T-5 point. The change of noise is moderate and constant at each site, and does not show the significant variation in time wise. According to the criteria in Japan, maximum LAeq in the commercial area is 70 db and 65 db is stipulated in the residential area.

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* Equivalent Noise Level: One of the evaluation methods of noise level, being the average of “n” monetary noise energies (db)

* 40 dB: Quiet residential area in the afternoon, 50 dB: quiet office room, 60 dB: common conversation, 70 dB: noisy street

Table 2.2.1.13-2 Measurement Result of Vibration Level

Survey Point	Distance from Road Center to Household limit [m]	Land Use	＊Equivalent Vibration Level (L_{eq}) [dB]			＊Hourly Vibration Level (L_{10}) [dB]			Criteria in Japan
			12 hours	Max.	Min.	12 hours	Max.	Min.	
T-1	15	Vicinity of Hospital and School	38.2	39.6	36.2	41.3	42.7	39.5	70
T-2	30	Residential Area	39.9	41.0	37.7	43.2	44.6	41.1	70
T-3	30	Vicinity of Hospital and School	40.9	41.7	39.5	44.4	45.6	42.9	70
T-4	30	Residential Area	39.7	41.9	34.8	42.6	45.7	37.6	65
T-5	30	Residential Area	33.0	36.2	30.6	35.6	37.4	33.7	65

(3) Traffic Survey

During day time from 6:00 to 18:00 for 12 hours on weekly days, the sectional traffic volume survey has been carried out for each direction with four vehicle classification. The result of the 12 hours survey is shown on the table 2.2.1.13-3, and the ones of water sampling and traffic volume, noise, vibration and the points of air pollution survey are shown on the table 2.2.1.13-1.

Comparing with the result conducted during B/D stage, PCU at T-1 and T-2 are almost same figure, the latest PCU at T-4 and T-5 are 20% - 30% less than that of B/D stage.

However, considering the survey points and traffic volume in each category are very close, the latest result is worth to trust.

Table 2.2.1.13-3 12 hours Sectional Traffic Volume Survey Result (Unit: Number)

Survey Point	Station No.	Surrounding Environment	Motor-Bike	Auto-mobile	Small Cargo	Large Cargo	Total	Total (PCU)
T-1	1+600	School	22,638	3,853	1,728	721	28,940	14,376
T-2	4+100	Resident House	19,058	5,968	1,589	475	27,090	14,500
T-3	5+900	Vicinity of School	17,213	3,372	1,492	532	22,609	11,535
T-4	35+200	Temple	2,558	1,051	662	213	4,484	3,317
T-5	46+000	Resident Houses	2,514	968	722	175	4,379	3,155

Vehicle Classification：1) Auto-Mobile：Motor Cycle, Motor Bike Trailer
2) Passenger Car：Sedan Type Car, Station Wagon, Pick-Up Track, Jeep, Light Track
3) Light Cargo Truck：Mini Bus, Cargo Truck less than 2 tons loading
4) Large Cargo Truck: Cargo Truck more than 2 tons loading, Large Bus, Semi and full Trailer, Large Special Vehicle.

Equivalent Vibration Level: One of the Evaluation Methods of vibration level, being the average of "n" momentary vibration energy(db).

Time Wise Vibration： L_{10} means the point value of top 80%、L_{50} means the center value of all the data、L_9 means the minimum value.

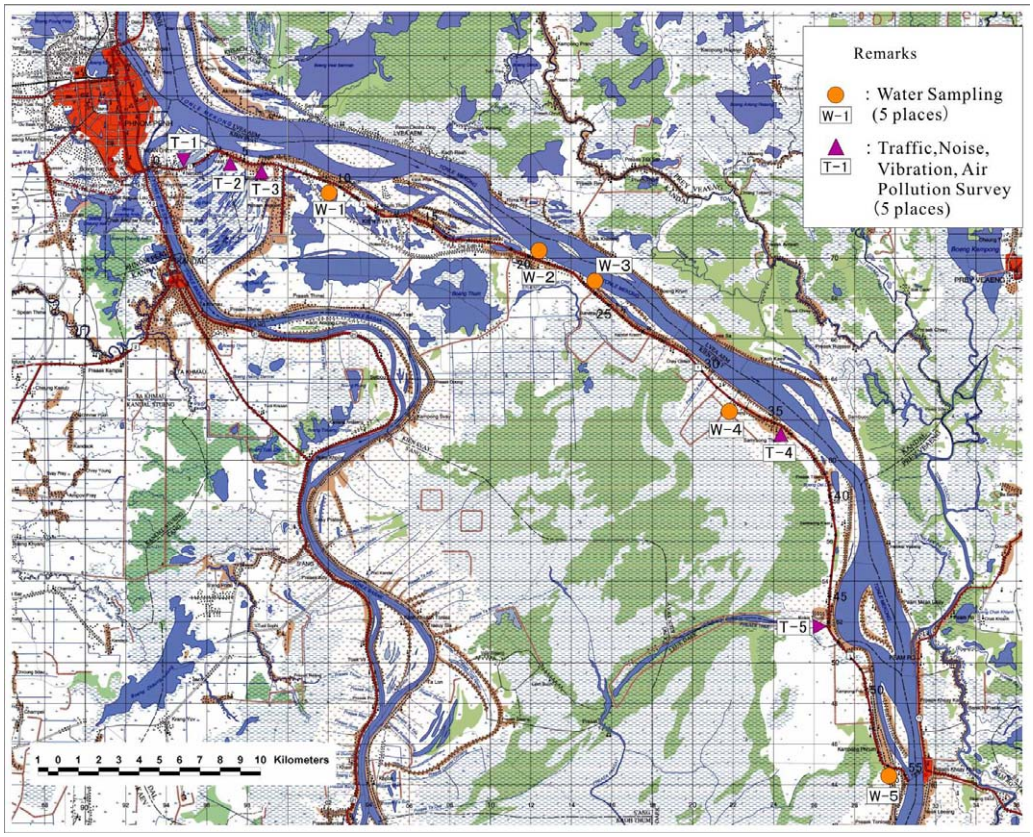


Figure 2.2.1.13-1　Location Map of Survey Points

(4)　Air Pollution

Measured concentration of carbon monoxide is 3～14ppm, 0.009～0.055ppm for nitrogen dioxide, 0.003 (Capable Measurement Minimum Value)～0.011ppm for sulfate dioxide, 0.005（Capable Measurement Minimum Value）～0.436ppm for all particles, T-1 shows the highest records in all the tested items. Only the result of the item of all the particles, exceeds the allowable limit of environment standards by 0.100mg/m_3.

Table 2.2.1.13-4 Measurement Result of Air Pollution

Survey Point	Carbon Monoxide (CO) [ppm]		Nitrogen Dioxide (NO2) [ppm]		Sulfate Dioxide (SO2) [ppm]		All Paricles (TPM) [mg/m^3]	
	Test Result	Standard	Test Result	Standard	Test Result	Standard	Test Result	Standard
T-1	14	less then 20ppm	0.055	less than 0.100ppm	0.011	less than 0.100ppm	0.436	less than 0.100mg/m^3
T-2	3		0.040		0.004		0.151	
T-3	6		0.010		ND<0.003		0.105	
T-4	3		0.013		ND<0.003		0.0507	
T-5	10		0.009		ND<0.003		ND<0.005	

(5) Water Pollution

The concentration of ionized hydrogen is (ph)7.1～8.3, 1.3～8.9mg/l for solvent oxygen, 20～290mg/l for suspended solid（SS）and 0.25～19.1mg/l for B.O.D. In comparison with each criterion of environment standards, W-3 and W-5 exceeds the allowable limit on D.O and W-4 does in B.O.D.

Table 2.2.1.13-5 Comparison of the Test Data with the Standards of Sampled Water

Survey Point	Station No.	Location of Sampling	Concentration of Ionized Hydrogen (ph) [－]		Disolved Oxygen (DO) [mg/l]		Suspended Solid (SS) [mg/l]		Biological Oxygen Demand (BOD) [mg/l]	
			Test Result	Standard	Test Result	Stand-ard	Test Result	Stand-ard	Test Result	Stand-ard
W-1	9+760	Domestic well	7.1	6.0～9.0	2.0	more than 2.0 mg/l	24	less than 50 mg/l	1.15	less than 30 mg/l
W-5	54+500	Domestic well	6.6		1.3		20		0.25	

Table 2.2.1.13-6 Comparison of the Test Data with Required River Water Standards

Survey Point	Station No.	Location of Sampling	Ionized Hydrogem Concentration (ph) [－]		Dissolved Oxygem (DO) [mg/l]		Suspended Solid (SS) [mg/l]		Biological Oxygem Demand (BOD) [mg/l]	
			Test Result	Standards	Test Result	Standards	Test Result	Standards	Test Result	Standards
W-2	20+000	Mekong River	8.3	6.5～8.5	7.4	2.0～ 7.5mg/l	24	25～ 100mg/l	0.42	1.0～ 10.0mg/l
W-3	23+300	Fish Culturing	8.3		8.9		98		19.1	
W-4	32+700	Pond near C-Box No.1	7.7		4.4		290		4.61	

(6) Fauna and Flora

Field investigation and hearing has been carried out every 1.0 km approximately along the existing and newly planned road, and every 1km wide to the direction of Colmatage from the points of openings, to seek for wild species, and which gave an result of 133 species of flora and 113 species of fauna(fishes and birds) being existed.

There is no flora being in the fear of extinction. It has been revealed that, in connection with fauna, there are 14 endangered species, existed around the openings of the planned road, such as fishes, birds, reptiles, amphibians and mammals), which are active in rainy season only.

As the water table in Mekong River and Bassac River increases in the rainy reason, the fin move through the opening to the spawning ground in Colmatage. After depositing spawn, the cycle of the nature shows that, those fin move to Bassac River, or stay at the pond which is going to run dry, then as a result caught by fisher mean / feathers.

As for the new opening structure, the No.1 Bridge seems to affect the movement of fin, however, the opening width is approximately 65m only which shows the rate width is less than 0.2% of the Project Road length. And only small scale of movement would be carried out.

Therefore it is concluded that the new opening would not affect to the ecosystem in Colmatage.

Figure 2.2.1.13-1 shows the distributing of rare spices.

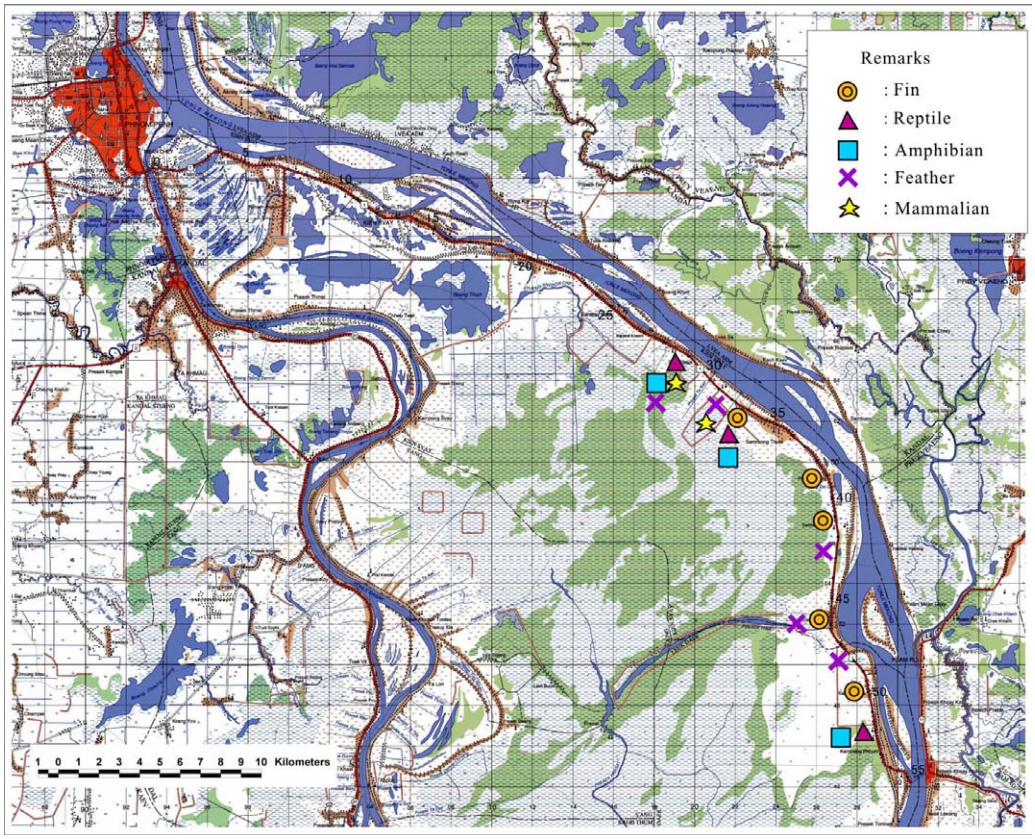


Figure.2.2.1.13-2 Distribution Map of Rare Spices

Base on the latest baseline survey, it is pointed out that the environment survey should be carried out properly during the construction stage by Japanese side in accordance with the environment management plan. After the completion of the construction, it is recommended that the Royal Government of Cambodia shall undertake those survey / hearing survey and analysis of data continuously.

Some surveyed results over the Cambodian domestic criteria, Japanese side is ready to submit those data to Ministry of Environment in Cambodia upon their request. Japan side would like to require them to study and review their criteria by comparing with other international ones.

2.2.2 Basic Plan

2.2.2.1 Overall Plan

Based on the basic concept established in Section 2.1, the overall plan of the Project was developed as shown in Table 2.2.2.1-1. Refer to Figure 2.2.2.1-1.

Table 2.2.2.1-1 Major Component of the Project

Item	Request	Plan
Road Improvement	58.00 km	55.98 km
Bridge	3 nos.	3 nos.
Culvert	13 nos.	9 nos.
Monivong Bridge	(Rehabilitation)	None

As for the grade of the Project, Asian Highway Standard and Cambodian Standard are used as standards of this design and other criteria such as AASHTO, Japan Road Association are used as subsidiaries.

Design Criteria for Road Design :

AASHTO : Highway Capacity Manual, 1965

AASHTO : Guide for Design of Pavement Structure, 1993

United Nations, Economic and Social Commission for Asia and the Pacific :
Asian Highway (AH) Classification and Design Standards

Kingdom of Cambodia, Ministry of Public Works and Transport :
Road Design Standard (Part1, 2 and 3)

Design Criteria for Bridge and Culvert :

AASHTO : Standard Specification for Highway Bridges

Japan Road Association : Specification for Highway Bridges

Japan River Association : Cabinet Order Concerning Structural Standards for River Management Facilities, etc.

Kingdom of Cambodia, Ministry of Public Works and Transport ;
Road Design Standard (Part1, 2 and 3)
Bridge Design Standard

United Nations, Economic and Social Commission for Asia and the Pacific :
Asian Highway (AH) Classification and Design Standards

Live Load :

AASHTO HS-20-44

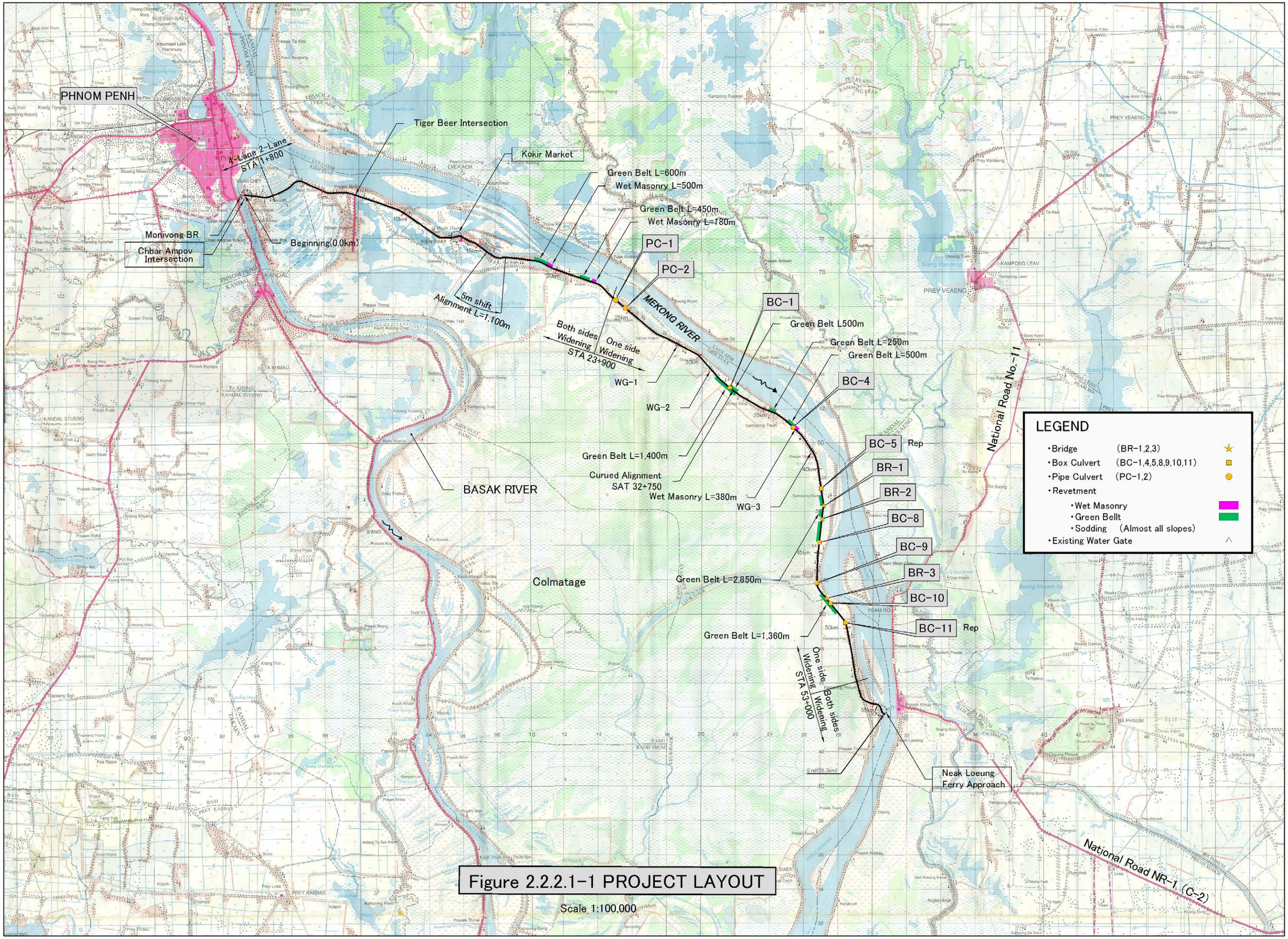


Figure 2.2.2.1-1 PROJECT LAYOUT

Scale 1:100,000

2.2.2.2 Road Design

(1) Geometric Design Criteria

Design Criteria which is adopted in this Basic Design are shown in the Table 2.2.2.2-1.

Table 2.2.2.2-1 Geometric Design Criteria

Item	Asian Highway (AH)		Cambodia Standard	F/S	B/D Study	Remarks
	Category I	Category II				
Design Speed	100kph	80kph	100kph (80kph)	80kph	80kph	Adopt AH Category II
Number of Lanes	4 or more	2	-	4 - 6, mix vehicle & motorbike lanes varies	2 or 4 for vehicle lane + motorbike lane	depend on the V/C ratio of the section
Lane Width	3.5m		3.5m	3.0 - 3.5m for vehicle lane 2.0 - 2.5m for motorbike lane	3.5m for vehicle lane 2.5m for motorbike lane	Follow AH
Shoulder Width	3.0m		3.0m	1.0m	1.0m	
Median Width	3.0m	N/A	4.0m	2.0m	2.0m	
Crossfall (for Lane) (for Shoulder)	2% 3 - 6%		2.5 - 3% 4 - 5 %	3% 4%	3% 4%	for AC surface for gravel surface
Max. Super-elevation (e)	10%		6 ~7%	6%	4%	use small value for local road user
Min. Radii to Omit Transition Curve	1,500m	900m	-	900m (380m) absolute	900m	Follow AH
Min. transition Curve Length	85m	70m	-	70m	70m	Follow AH
Min. Curve Radii	350m	215m	495m (360m)	280m	280m	minimum for e = 4%
Max. Grade	4%		3 - 5% (4 - 6%)	4%	4%	follow AH

Note: kph means km per hour

As described in 2.2.1.11. Establishment of Facility grade, the criteria of Asian Highway Category II is adapted to satisfy the minimum grade as an international arterial road.

(2) Examination of Number of Lane

1) Future Traffic Demand

The target year of the Project was year 2015 or after 10 years from the commencement of construction in the Feasibility Study, but the time of commencement of construction is later them that of the Feasibility Study. Therefore, the target year for the Project is set at year 2016.

On the present traffic volume, which is the base of future traffic demand, traffic survey of the present Basic Design is compared with the prospective traffic volume in year 2004 in the Feasibility Study and the result of the comparison is shown in Table 2.2.2.2-2.

Table 2.2.2.2-2 Traffic Volume in Year 2004 (12 Hours, Both Sides)

	Forecast in F/S						Actual Counted Number in B/D					
	PC	MC	LV	HV	Total (veh.)	Total (PCU)	Total (PCU)	Total (veh.)	HV	LV	MC	PC
PCU Ratio	0.25	0.25	1.25	3.75					3.75	1.25	0.25	0.25
0km-100	3,042	90,827	10,743	1,064	105,676	40,886	38,938	103,546	570	11,056	89,575	2,345
0km+100	3,272	55,879	9,507	977	69,635	30,335	26,776	72,730	432	7,081	61,350	3,867
1km+500	-	-	-	-	-	-	14,362	28,914	475	5,471	21,690	1,278
3km+500	-	-	-	-	-	-	12,471	24,515	360	5,082	18,643	430
5km+000	967	10,981	3,111	512	15,571	8,796	11,203	22,286	278	4,658	16,746	604
7km+000	1,142	10,897	2,701	385	15,125	7,830	8,189	16,116	275	3,197	11,344	1,300
12km+500	721	9,485	2,025	509	12,740	6,992	6,179	11,893	190	2,541	8,866	296
14km+500	-	-	-	-	-	-	5,953	11,561	243	2,212	8,715	391
34km+500	1,724	2,835	1,399	280	6,238	3,939	4,247	5,814	306	1,722	2,855	931
54km+500	2,155	3,921	1,307	270	7,653	4,165	4,632	8,620	198	1,784	4,279	2,359

The survey data nearly equal to the forecast value was obtained in this survey, but the volume of heavy vehicle is smaller than that projected in the survey in 2002. For this reason, it is supposed that the construction of C2 section and urgent remedial work of flood damage were completed and the decrease of construction vehicles besides the heavy vehicles detoured to the other national roads due to the load limit caused by the Bailey bridges. There was an indication that traffic survey for 24 hours should be implemented because of greater traffic volume of heavy vehicles in the night-time on other National Roads. However, Neak Loueng Ferry does not run from 21:00 to 6:00 next morning, therefore it is not necessary at this section that the day-night ratio of traffic volume is adjusted. In the Feasibility Study the traffic survey was conducted for a day during weekday, but in this survey the traffic survey is carried out for 2 days during weekday and the average of those 2 days traffic volume is adopted. Therefore, traffic survey in this survey is more reliable than that in the Feasibility Study. The survey data in this survey is used as present traffic volume.

For future traffic demand, OD matrix was made and the expanding factor of traffic volume was decided in the Feasibility Study. The expanding factor of traffic volume of each year is shown in

Table 2.2.2.2-3 (Average year growing ratio in the round bracket).

Traffic data are shown in Appendix 8.

Table 2.2.2.2-3 Expanding Factor of Traffic Volume

TYPE	2005	2010	2015	2020
PC	1.08 (2.6%)	1.21 (2.4%)	1.35 (2.3%)	1.50 (2.3%)
MC	1.21 (6.6%)	1.61 (6.1%)	2.16 (6.1%)	2.88 (6.1%)
LV	1.28 (8.6%)	1.83 (7.8%)	2.59 (7.6%)	3.63 (7.4%)
HV	1.25 (7.7%)	1.75 (7.2%)	2.41 (7.0%)	3.29 (6.8%)

The traffic volume of C2 section is growing at a rate of 4% and that limited to heavy vehicle is growing at a rate of 8% actually. The expanding factor of traffic volume in the Feasibility Study corresponds to the present condition, and the traffic survey results as of March 2005 substrate that the adapted factor is appropriate. Therefore, the future traffic volume is calculated with this factor. In this case, future traffic demand at the goal year of this project is shown in Table 2.2.2.2-4.

Table 2.2.2.2-4 Future Traffic Demand

Station	Year 2016 (Nos. of Vehicle in 12 hrs)			
	PC	MC	LV	HV
Expanding factor	1.37076	2.2767	2.72573	2.52501
0-100	3,054	179,598	25,563	1,240
0+100	5,036	123,007	16,372	940
1+500	1,664	43,489	12,650	1,034
3+500	560	37,379	11,750	783
5+000	787	33,576	10,770	605
7+000	1,693	22,745	7,392	598
12+500	385	17,776	5,875	413
14+500	509	17,474	5,114	529
34+500	1,212	5,724	3,981	666
54+500	3,072	8,579	4,125	431

2) Analysis of Service Level

Service level of road is the base when the number of lane of the project road is examined. Recently, decline of travel speed is an index to judge the service level. But, traffic volume/traffic capacity (V/C ratio) is used in this survey because continuous fixed point measurement and observation is necessary.

The relation between service level and V/C ratio is shown in HCM (Highway Capacity Manual, 1965) and presented in Table 2.2.2.2-5.

Table 2.2.2.2-5 Relation Between Service Level and V/C Ratio in HCM

Level-of-Service		V/C	
Level	Operation Condition	Rural Area	Urban Area
Level A	Free Flow (Primarily)	Under 0.20	Under 0.60
Level B	Free Flow (Reasonably)	Under 0.45	Under 0.70
Level C	Stable Flow	Under 0.70	Under 0.80
Level D	Between Stable and Unstable	Under 0.85	Under 0.90
Level E	Unstable (Extremely)	Under 1.00	Under 1.00
Level F	Forced Flow	-	-

Service level of Urban Arterial Road should be Level C in AASHTO. And service level of Rural Arterial Road should be Level B (Level C in mountain area). For this project section, the peak V/C ratio of the target year in case of opposite 2-lane is calculated shown in Table 2.2.2.2-6, assuming that Possible Traffic Capacity of 4-wheel vehicle is 2,000 PCU/hr and for motorbike is 2,640 PCU/hr.

Table 2.2.2.2-6 Peak Traffic Volume Per Hour and V/C Ratio in Year 2016

	Year 2016 (Peak-hour in veh.)				Year 2016 (Peak-hour)		V/C (2-lane)	
	PC	MC	LV	HV	4-wheel Vehicle	Motorbike	4-wheel Vehicle	Motorbike
PCU Ratio	0.25	0.25	1.25	3.75	(PCU)	(PCU)	2,000	2,640
0km+100	604	19,681	1,637	75	2,328	5,071	1.16	1.92
1km+500	283	6,088	1,139	83	1,735	1,593	0.87	0.60
3km+500	106	5,607	1,058	63	1,559	1,428	0.78	0.54
5km+000	142	4,701	862	48	1,258	1,211	0.63	0.46
7km+000	389	3,412	665	48	1,011	950	0.51	0.36
12km+500	31	2,133	470	33	711	541	0.36	0.20
14km+500	41	2,097	409	53	710	535	0.36	0.20
34km+500	133	687	438	67	799	205	0.40	0.08
54km+500	246	1,201	619	52	969	362	0.48	0.14

Because service level of vehicle lane is critical in case of opposite 2-lane, the relation between V/C ratio of 4-lane and service level is shown in Figure 2.2.2.2-1.

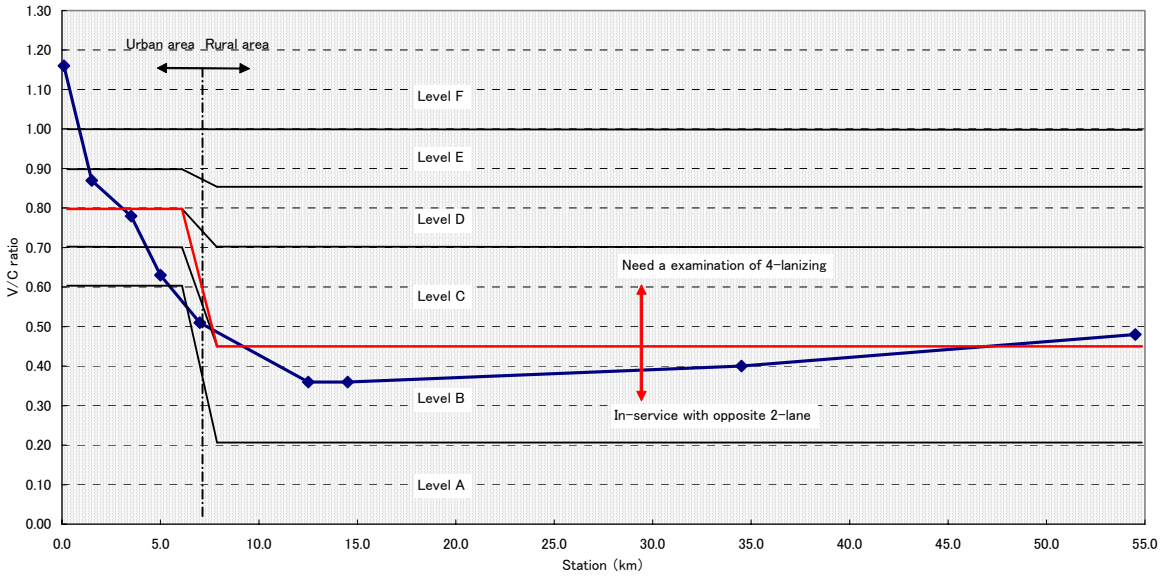


Figure 2.2.2.2-1 Relation between V/C Ratio of 4-lane and Service Level

Referring to above figure, in the urban area, section up to Sta.1+500 is under level D of service level, therefore opposite 2-lane needs 4-lane. In the Project, considering the transition of 4-lane section and the expansion of urban area, the section from Sta.0+100 to Sta.1+800 is designed as 4-lane. In rural area, V/C ratio is almost satisfied with service level B indicating no service level problem, therefore, the road in rural area is designed as 2-lane to minimize the impact to PAPs.

2.2.2.3 Pavement Design

(1) Pavement Design

Condition：① Standard-sized car and large-size car are considered as traffic Load except motorbike.

② Equivalent Conversion Factor of 18kip Equivalent Single Axle Load (ESAL) is the calculation result based on the axial load investigation in the Feasibility Study.

③ Duration in-service is 10 years from 2007 to 2016.

④ Traffic volume is calculated from the expanding factor decided in the Feasibility Study based on the traffic volume in this survey on 2004.

1) Evaluation of Subgrade Soil and Traffic Load

It was found that the bearing capacity of subgrade was weaker than was expected. In general, a soft subgrade which CBR under 3 is re-constructed with new subgrade materials. Therefore, the existing subgrade will be removed and replaced with good quality soil at the section where CBR is under 3. The division of the section and CBR of each section based on the CBR test result are shown in Table 2.2.2.3-1 while the above-mentioned detail is shown in the Figure 2.2.2.3-1.

On the other hand, ADB only carried out the urgent heightening of embankment (rehabilitation works) on the damaged sections and overtopping sections without CBR tests as a immediate countermeasure. However, the Project reflected the pavement design by the section divisions based on the results of CBR tests to be conducted about every 2 kms.

Table 2.2.2.3-1 Division of the Section and CBR of Each Section

Division of section	Section I 0 - 5km	Section II 5km - 15km	Section III 15km - 23km	Section IV 23km - 32km	Section V 32km - 55km
Section CBR	3.0	4.1	2.0	3.0	0.9
Replacement of subgrade soils	Partial Replacement	-	Replacement (Modified CBR4)	Partial Replacement	Replacement (ModifiedCBR4)

When subgrade is constructed, goal design CBR is set. But, in this survey, the comparative evaluation of the composition of pavement is implemented with considering that design CBR is changeable with some various subgrade improvements. Cumulative 18 kip ESAL (W_{18}) a lane in service duration is shown in Table 2.2.2.3-2, which is the traffic load of each section.

Table 2.2.2.3-2 Cumulative 18 kip ESAL per Lane in Service Duration

Station	Cumulative 18kip ESAL		
	Calculated Value	Division of Section	Design Value
0km+100	2.82×10^6	Section I	3.08×10^6
1km+500	3.08×10^6		
3km+500	2.60×10^6		
5km+000	2.02×10^6		
7km+000	1.98×10^6	Section II	2.02×10^6
12km+500	1.37×10^6		
14km+500	1.74×10^6		
34km+500	2.18×10^6	Section III, IV and V	2.18×10^6
54km+500	1.42×10^6		

Note): 90 % of the traffic volume is loaded at Sta.0km+100 and 1km+500 of 4-lane section.

2) Required Structural Number

Each coefficient used in decision of Structural Number is as follows:

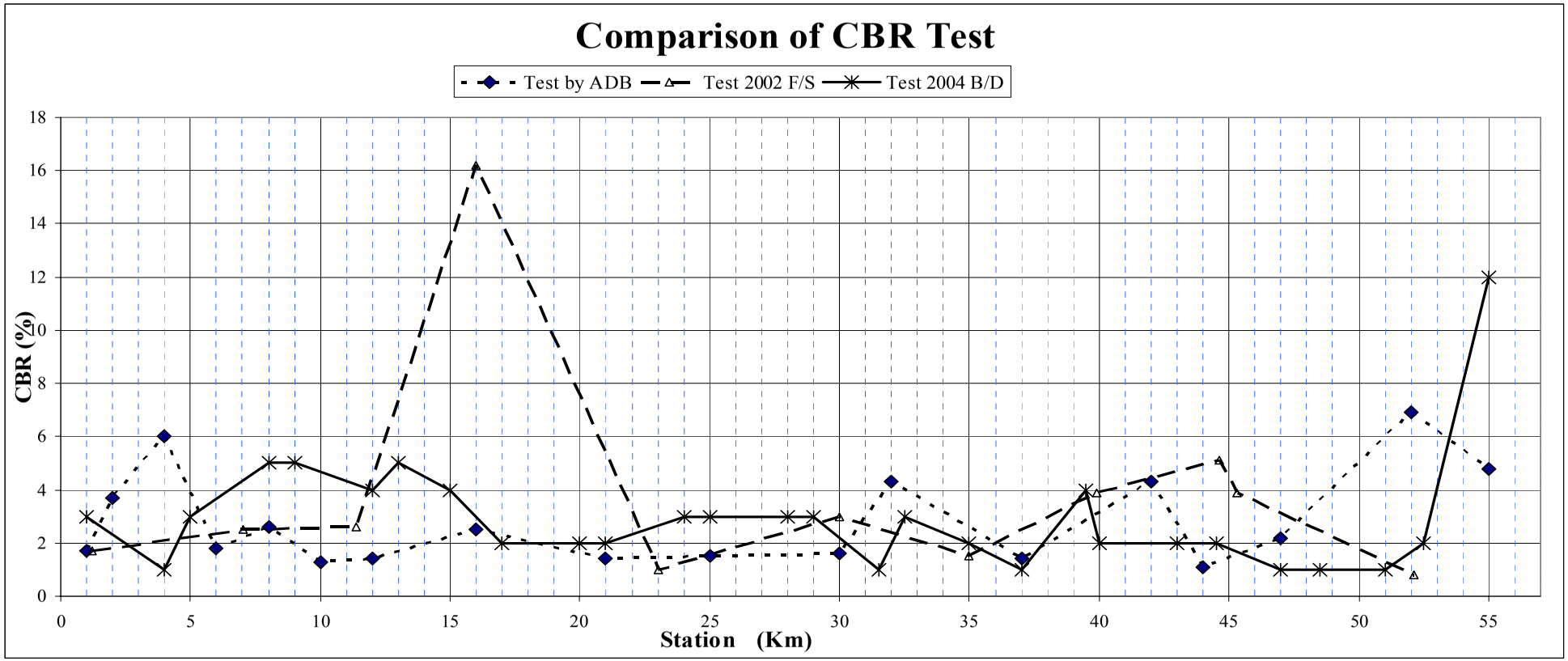
Reliability (R) : 80% (Lowest recommended level of urban principal arterials)
Standard Deviation (S_0) : 0.45 (Standard value of flexible pavement)
Initial Serviceability (P_0) : 4.2 (Standard value of flexible pavement)
Terminal Serviceability (P_t) : 2.5 (Lowest recommended level of principal arterials)

Required SN corresponding to design CBR of each section is shown in Table 2.2.2.3-3.

Table 2.2.2.3-3 Required SN corresponding to design CBR

Design CBR	Section I	Section II	Section III - Section V
CBR=3	SN=4.645	SN=4.361	SN=4.412
CBR=4	SN=4.199	SN=3.931	SN=3.979
CBR=5	SN=3.872	SN=3.618	SN=3.662
CBR=6	SN=3.611	SN=3.376	SN=3.418
CBR=7	SN=3.411	SN=3.183	SN=3.222

The plan road minimum thickness of AC surface and crushed-stone subbase are 9 cm and 15 cm respectively referring to AASHTO standard.



Station (Km)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Test by **ADB**		1.7	3.7		6.0		1.8		2.6		1.3		1.4				2.5					1.4				1.5					1.6		4.3				1.4		3.7		4.3		1.1			2.2					6.9			4.8		
Test 2002 F/S		1.7						2.5				2.6					16.2						1.0								3.0							1.5			3.9				5.1	3.9							0.8					
Test 2004 B/D		3.0			1.0	3.0			5.0	5.0			4.0	5.0		4.0		2.0			2.0	2.0			3.0	3.0			3.0	3.0		1.0	3.0			2.0		1.0		4.0	2.0		2.0	2.0			1.0		1.0		1.0		2.0		12.0		
					Replacement																											Replacement																											
Section CBR(B/D)	3.0						4.1										2.0								3.0									0.9																								
Subgrade Construction	Cement Stabilizing						Cement Stabilizing										Subgrade replacement (Modified CBR 4) + Cement Stabilizing								Cement Stabilizing									Subgrade replacement (Modified CBR 4) + Cement Stabilizing																								
ESAL	3.08×10^6						2.02×10^6										2.18×10^6								2.18×10^6									2.18×10^6																								
Required SN (Design CBR=7)	3.411						3.182										3.222								3.222									3.222																								

Figure 2.2.2.3-1 CBR Test Result and Section Division

3) Motorbike Lane

Motorbike lane is examined considering 4-wheel vehicle passing such as the entry and exit to the road facilities, buses stopping, parking on the shoulder and so on. SN is calculated to 2.56 under the condition that 25% of cumulative 18 kip ESAL, which is 2.18×10^6, is loaded, the traffic load is $W_{18}=0.55\times10^6$ and Design CBR is 7. It is planned that subbase structure is same structure as 4-wheel vehicle lane for securing the equality of improved subgrade and stabilized sub-base, and SN satisfies it with the change of surface course thickness.

(2) Subgrade Improvement and Pavement Structure

1) Subgrade Construction

The field surface soil is cohesive soil deposited on the floodplain, and this soil is used as the material for embankment at the Project road. Following the CBR test results by the study, the bearing capacity is expected to be only 3 or 4 of CBR. There is no more good material sources because the whole sections along the Project road is floodplain, and the material to be provided from the far places is unrealistic due to immeasurable costs. Therefore, the replacement material for soft subgrade for the Project is provided with the surface soil from the place where bearing capacity is expected (modified CBR shall be 4 or more), and utilized.

The bearing capacity of subgrade is a big factor when the pavement structure is decided. The thick pavement structure supported by weak subgrade which was not improved is frequently more expensive than the pavement structure whose subgrade is improved and design CBR was increased. Referring to 2.2.2.3(1)1) mentioned above, a comparison evaluation of the design CBR is varied by different subgrade improvement is carried out to propose the most appropriate pavement structure in this survey.

The method of subgrade improvement is either lime soil stabilization or cement stabilization. However, it is not easy to obtain lime soil at the field, therefore the subgrade improvement is planed under the condition that the goal CBR15 is achieved by cement stabilization. Each thickness of stabilization corresponding to CBR of subgrade which is needed to obtain each design CBR is shown in Table 2.2.2.3-4.

Table 2.2.2.3-4 Thickness of Stabilization

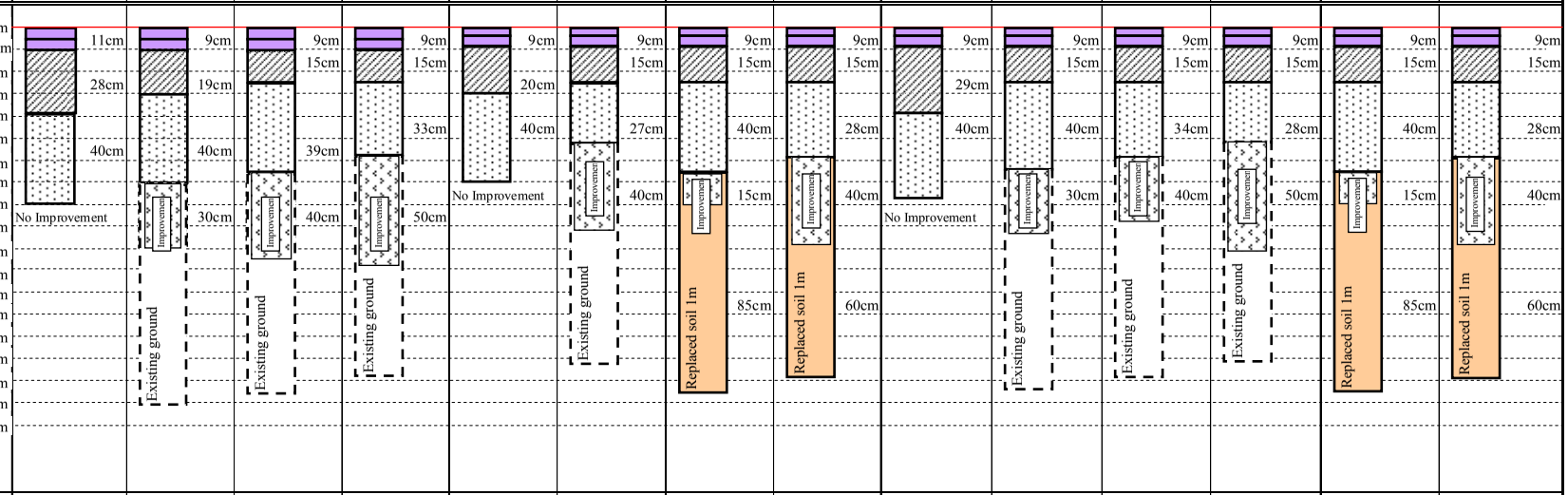
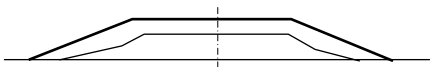
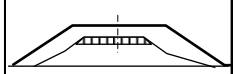
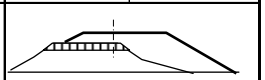
Design CBR	Thickness of Stabilization (Goal CBR15)		
	Subgrade CBR4	Subgrade CBR3	Subgrade CBR2
CBR=4	-	15cm	Refer to subgrade CBR4 due to the subgrade replacement
CBR=5	15cm	30cm	
CBR=6	30cm	40cm	
CBR=7	40cm	50cm	

2) Pavement Structure

The plan for the surface to be asphalt concrete which is typical in Cambodia is proposed. Crushed base course stone is expensive because rocky mountain is far from the Project road so that stone has to be hauled from the quarry around National Road No.2 about 67 km and/or the opposite bank by ferry about 16 km away from the Project road respectively. Because aggregate is needed for base course even if the base course is stabilized, the base course is mechanically stabilized base which is more economical than stabilized base course. However, it is possible to make an economical plan without crushed stone subbase because river sands which are available along the Project road are stabilized and the stabilized sands become the subbase.

The pavement structure is examined by varying the design CBR of each section is shown in the Table 2.2.2.3-5. Referring to this table, cases of each pavement structure whose subgrade is improved and design CBR is 7 are the most economical, and, these pavement structure are good for transfer of the load from the surface to the subbase. Moreover, because the road elevation can be low due to thin pavement structure, this pavement structure reduces the social and environment impact.

Table 2.2.2.3-5 Pavement Structure Examination

Section	I				II		III		IV				V	
STA..														
	0km			5km+000m		16km+000m		24km+000m				33km+000m		56km+000m
Section length	5.0km				11.0km		8.0km		9.0km				23.0km	
Existing subgrade CBR result	**3.0**				**4.1**		**2.0**		**3.0**				**0.9**	
Subgrade improvement	Not do	Do	Do	Do	Not do	Do	Do	Do	Not do	Do	Do	Do	Do	Do
Improved subgrade CBR	**3**	**5**	**6**	**7**	**4**	**7**	**5**	**7**	**3**	**5**	**6**	**7**	**5**	**7**
Required SN	4.652	3.872	3.617	3.411	3.931	3.182	3.662	3.222	4.405	3.662	3.418	3.222	3.662	3.222
Pavement structure Surface course / Base course (Asphalt Concrete) Base-course (Mechanical stabilized base) Sub-base course (Cement stabilized sand) Subgrade improvement															
Vehicle lane width	15m	15m	15m	15m	7m	7m	7m	7m	7m	7m	7m	7m	7m	7m
Vehicle lane area per 1km	15m x 1,000m = 15,000m2				7m x 1,000m = 7,000m2		7m x 1,000m = 7,000m2		7m x 1,000m = 7,000m2				7m x 1,000m = 7,000m2	
Cost (yen/1km of vehicle lane) (Direct cost)	53,400,000	50,700,000	48,600,000	48,700,000	21,600,000	21,800,000	26,200,000	25,600,000	21,800,000	23,000,000	22,600,000	22,200,000	25,700,000	25,100,000
														
	Existing Road : Only Longitudinal adjustment, no replacement of subgrade				Same as left box.		Existing road : Replacement of subgrade		Existing Road : Only Longitudinal adjustment, no replacement of subgrade				Existing road : Replacement of subgrade	
Pavement structure thickness	79cm	68cm	63cm	57cm	69cm	51cm	64cm	52cm	78cm	64cm	58cm	52cm	64cm	52cm
Consideration	Embankment is high. 1,800,000 yen higher at embankment cost.	900,000 yen higher at embankment cost.	500,000 yen higher at embankment cost.	Embankment is low.	Embankment is high. 1,500,000 yen higher at embankment cost.	Embankment is low.	Embankment is high. 1,000,000 yen higher at embankment cost.	Embankment is low.	Embankment is high. 2,100,000 yen higher at embankment cost.			Embankment is low.	Embankment is high. 1,000,000 yen higher at embankment cost.	Embankment is low.
Total cost (yen/1km of vehicle lane)	58,600,000	51,600,000	49,100,000	48,700,000	23,100,000	21,800,000	27,200,000	25,600,000	23,900,000			22,200,000	26,700,000	25,100,000
Selection				○		○		○				○		○

3) Motorbike lane

Following the result of pavement structure examination of Vehicle lane, the design CBR is 7 with subgrade improvement. The required SN is calculated to 2.56 with traffic load, which is 25 % of vehicle lane traffic load $W_{18}=0.55\times10^6$, and with the design CBR=7 when considering the longest section: Section III to Section V. In this case, the pavement structure is as follows, and, SN is adjusted with the change of surface course thickness and with the same subbase structure as the vehicle lane.

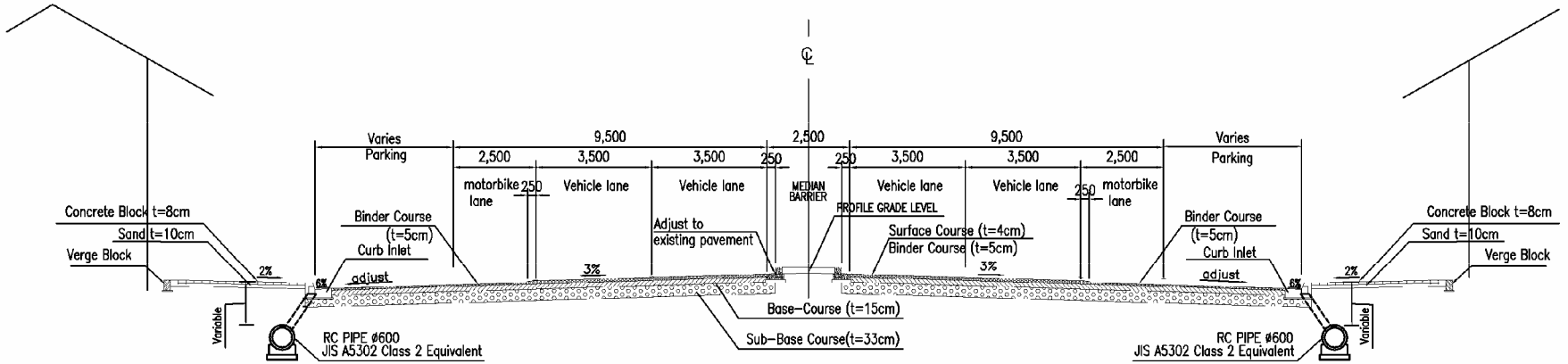
Surface Course AC	5cm	0.768
Base Course Mechanically Stabilized Base	15cm	0.797
Subbase Stabilized Soil	28cm	1.047
		Total SN=2.61

It is necessary that entry and exit of 4-wheel vehicle shall be avoided because the pavement structure of motorbike lane is weaker than that of 4-wheel vehicle lane. Therefore, the difference of 5 cm between the 9 cm of 4-wheel vehicle lane thickness and 5 cm of motorbike lane thickness is clear with the existing of the gap between them with run-off.

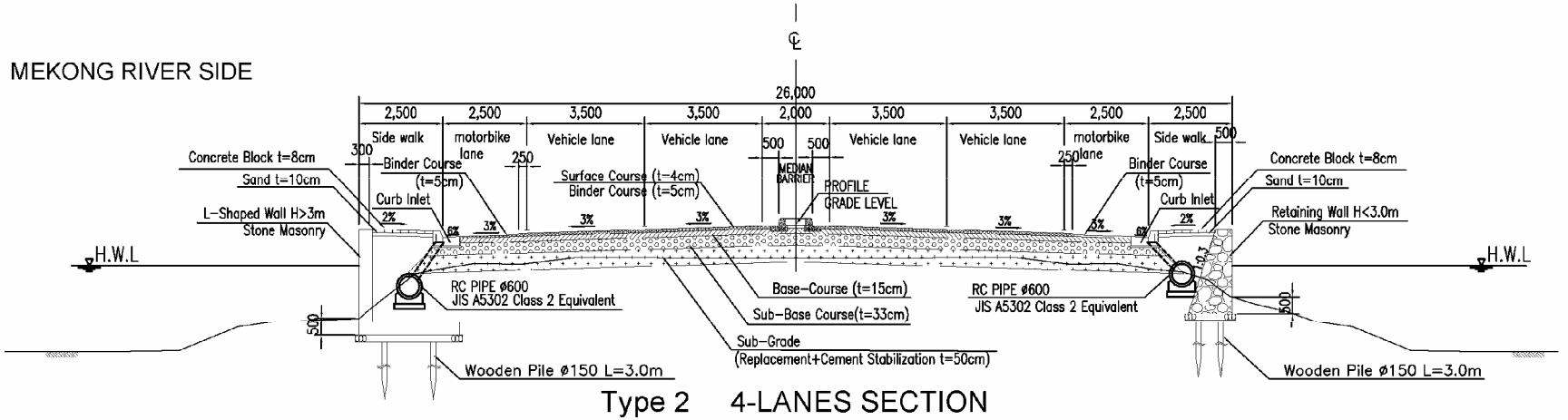
(3) Countermeasure against Inundation

The Project road combines the role of the road with the role of dyke for the Mekong River flood. In Japan, it is provided in detail that the material for embankment is managed with grain-size distribution. However, because the Project is not only an embankment for a river dyke but also an improvement of the road, it is not appropriate that the quality of the embankment material is required with extreme quality. Moreover, referring to the previous section, the whole section along the project road is floodplain with silty soil deposits and therefore, it is difficult to obtain cohesive soil for embankment. Therefore, the edge of the embankment is stabilized with cement to lower the permeability as a countermeasure against inundation in the Project.

Typical cross sections are shown in the Figure 2.2.2.3-2 to Figure 2.2.2.3-5.



Type 1 CHBAR AMPOV MARKET SECTION
(STA. 0+000 ~ 0+400)

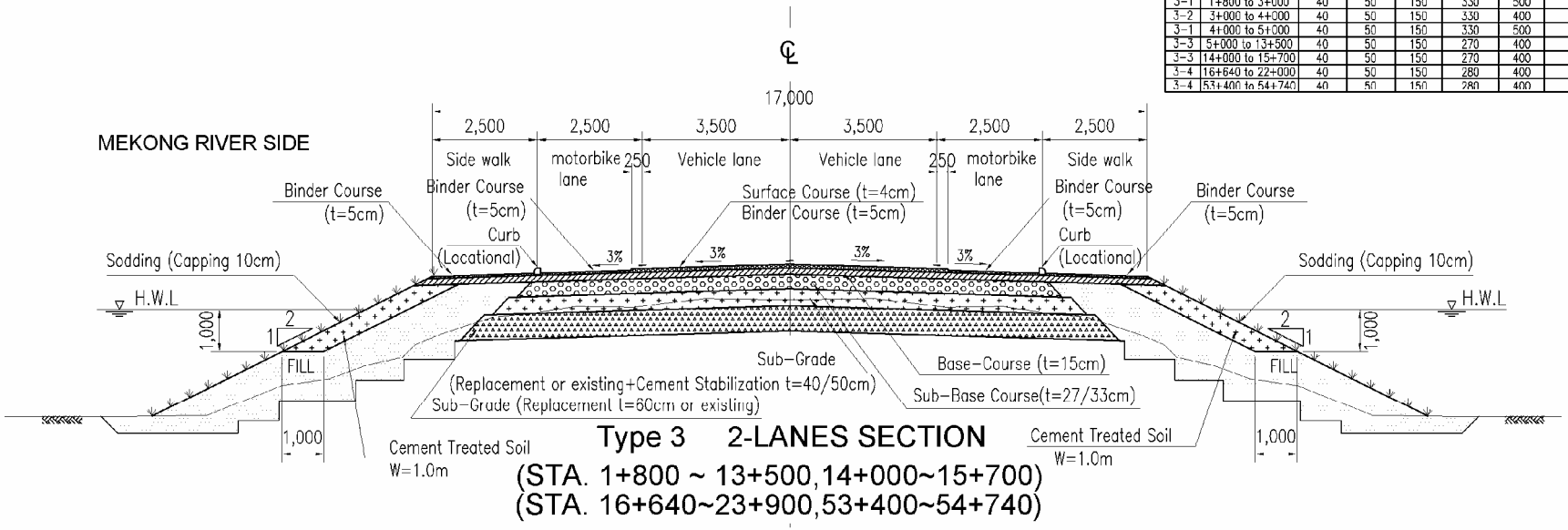


Type 2 4-LANES SECTION
(STA. 0+400 ~ 1+800)

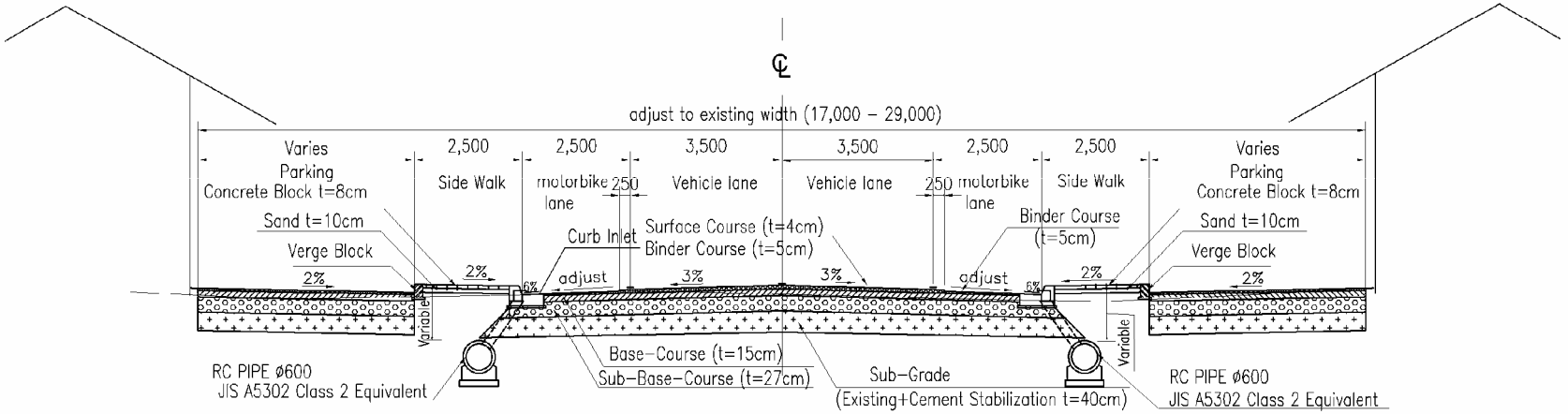
Figure 2.2.2.3-2 Typical Cross Section (Type1, Type2)

PAVEMENT STRUCTURE COMPOSITION

TYPE	STATION	SURFACE COURSE	BINDER COURSE	BASE COURSE	SUB-BASE COURSE	SUB GRADE CEMENT	SUB GRADE REPLACEMENT
3-1	1+800 to 3+000	40	50	150	330	500	–
3-2	3+000 to 4+000	40	50	150	330	400	600
3-1	4+000 to 5+000	40	50	150	330	500	–
3-3	5+000 to 13+500	40	50	150	270	400	–
3-3	14+000 to 15+700	40	50	150	270	400	–
3-4	16+640 to 22+000	40	50	150	280	400	600
3-4	53+400 to 54+740	40	50	150	280	400	600



Type 3 2-LANES SECTION
(STA. 1+800 ~ 13+500,14+000~15+700)
(STA. 16+640~23+900,53+400~54+740)



Type 4 KOKIR MARKET SECTION
(STA. 13+500 ~ 14+000)

Figure 2.2.2.3-3 Typical Cross Section (Type3, Type4)

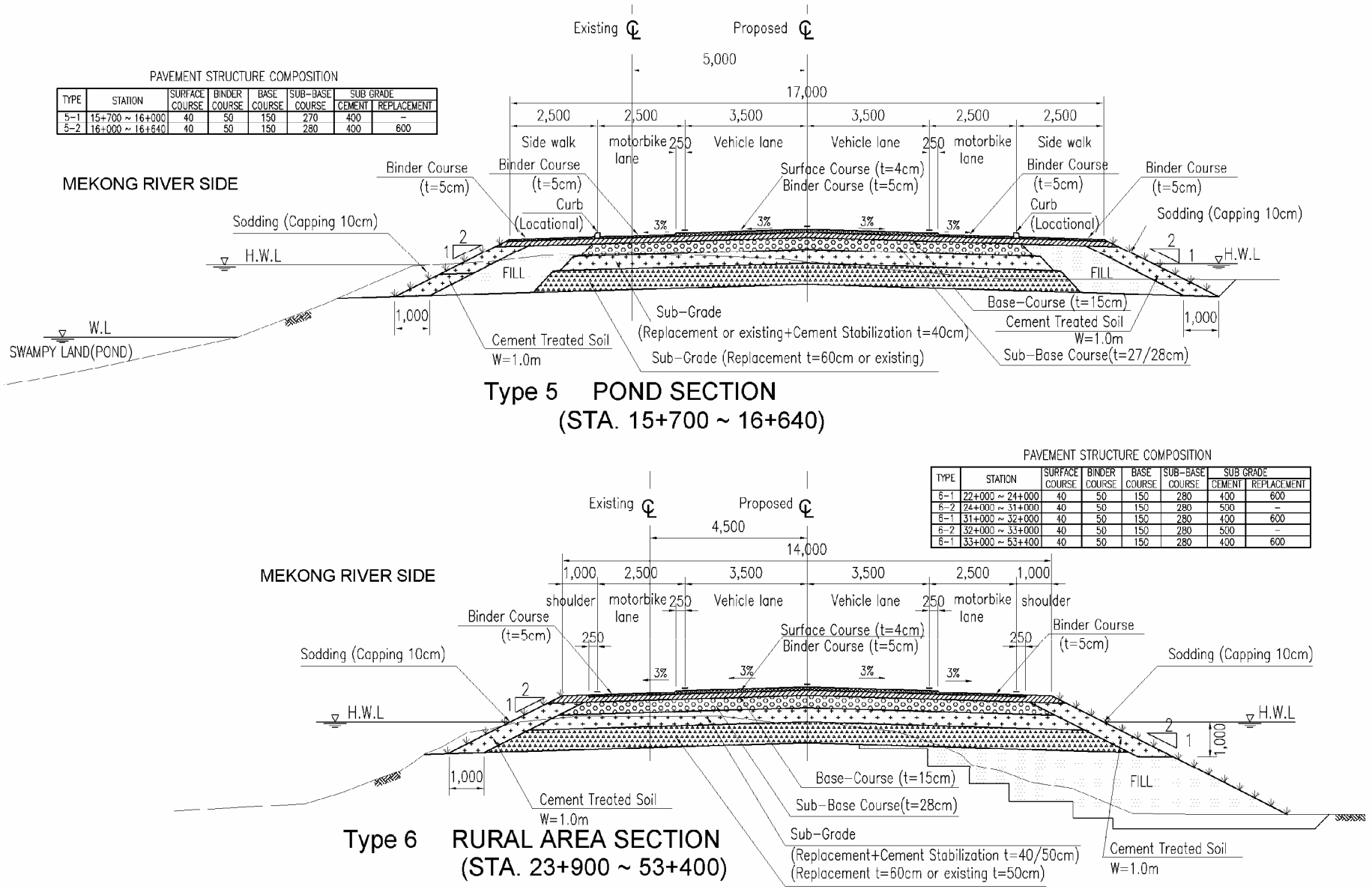
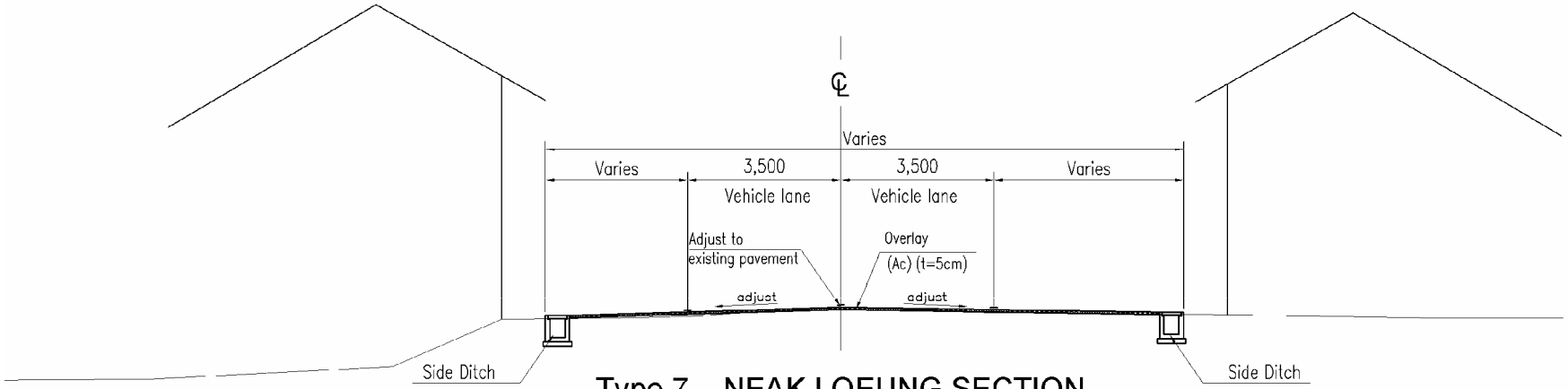
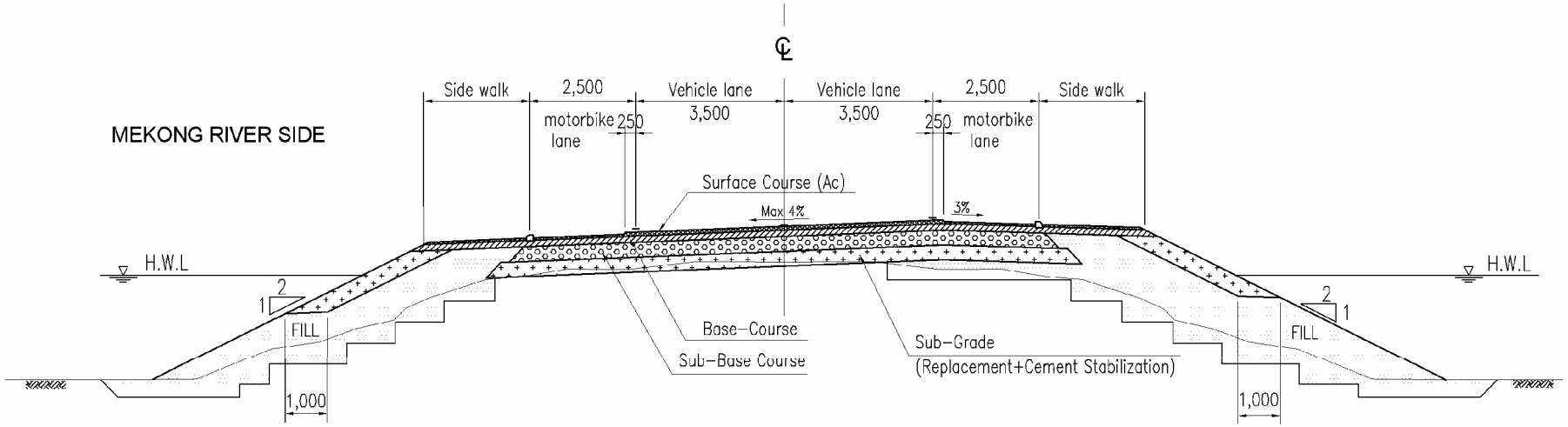


Figure 2.2.2.3-4 Typical Cross Section (Type5, Type6)



Type 7 NEAK LOEUNG SECTION
(STA. 54+740 ~ 55+980)



SUPERELEVATION ON CURVED SECTION

Figure 2.2.2.3-5 Typical Cross Section (Type7, Superelevation on Curved Section)

2.2.2.4 Bridge Design

(1) General Items

1) Design Standard

Standards : AASHTO Standard Specifications for Highway Bridges, 2002

Live Load : HS20-44

Coefficient of Horizontal Seismic Force : 0.05

2) Width of Bridge

Figure 2.2.2.4-1 shows the width of bridge.

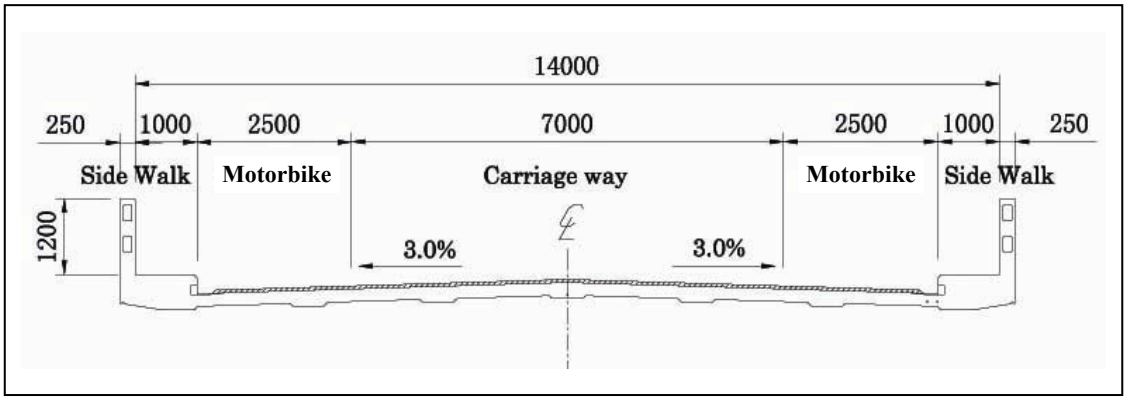


Figure 2.2.2.4-1 Width of Bridge

3) Proposed Elevation of Bridge

Proposed elevation of bridge is calculated based on the total height of pier beam, bearing, main girder, haunch, deck slab, pavement, and cross fall. The elevation of the soffit of pier beam corresponds with the High Water Level (H.W.L). The end of girders is partially cut off to lower the proposed elevation of bridges. The vertical clearance is 1.0m referring the "Ordinance for Structual Standard for River Administration Facilities" in Japan. Table 2.2.2.4-1 shows the proposed elevation of bridges.

Table 2.2.2.4-1 Proposed Elevation of Bridges

(unit : m)

Name of Bridge	H.W.L	Pier Beam	Bearing	Main Girder	Haunch	Deck Slab	Wearing Course	Cross Fall	Proposed Elevation (Minimum)
No.1	EL8.53	2.000	0.120	0.972	0.050	0.200	0.050	0.180	12.102
No.2	EL8.51	2.000	0.120	0.972	0.050	0.200	0.050	0.180	12.082
No.3	EL8.26	2.000	0.120	0.972	0.050	0.200	0.050	0.180	11.832

4) Elevation of Riverbed

The elevation of riverbed is basically the same as the ground elevation proposed during the F/S stage. The elevation of riverbed is proposed at EL3.70m at Bridge No.1 and No.3 and EL4.00m at Bridge No.2. The elevation of riverbed should be verified and subject to field adjustment before the construction of the said bridges.

(2) Structure Type of Bridge

A comparative study on the determination of Structure Type of Bridge is done for Bridge No.2 since the width of superstructure, height of abutments and piers are same, and length of span, and ground conditions are similar with the other two (2) bridges. The results of the comparative study are also applicable to the other two (2) bridges.

Hereinbefore, a comparative study is done on the abutment, pier, foundation, and superstructure respectively.

1) Abutment

The inverted T-type is recommended for abutment which is economical type for the height of 7.0m. The bottom elevation of footing should be determined according to the "River Structure Standards, Japan River Association". Location of Abutment is as shown in Figure 2.2.2.4-2.

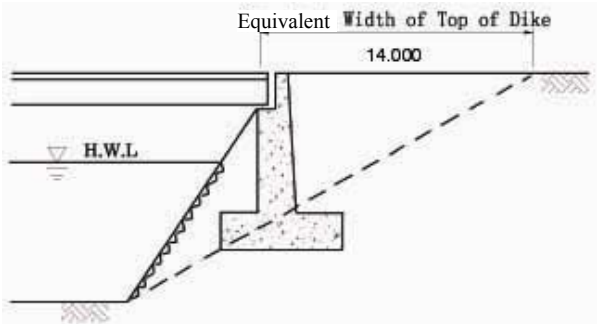


Figure 2.2.2.4-2 Location of Abutment

2) Pier

The Cylindrical Column Type with pier beams is adopted for the piers because the flow direction of floodwater varies at the pier location. The lowest elevation of pier beam corresponds to the H.W.L. The thickness of soil cover on footing is approximately 2 m. Table 2.2.2.4-2 shows the result of comparative study on Pier.

3) Foundation

Cast-in-place Concrete Pile (C.C.P) by reverse circulation drill method is adopted for the foundation, as per results of the boring test. Because the bearing strata for foundation are deeper than 50m at Bridge No.2, friction pile is recommended as the foundation type. Also, at Bridge No.1 and No.3 the bearing strata are deeper than 30m, then the friction pile is also recommended for the foundation. The length of pile is approximately 30m for these bridges. Table 2.2.2.4-3 shows the results of comparative study on the foundation.

4) Superstructure

PC I-shape Girder Bridge based on AASHTO Standard is adopted for superstructure. Soft ground exists at bridge location and the location of bearing layer is found more than 50m in depth, according to the boring data, so that friction pile foundation should be adopted. Bridges with simple beams, shorter spans, and lighter girders are adequate for the superstructure. Minimum span is 20m in length, according to River Structure Standards, Japan River Association because the flood discharge is between 500 m^3/s to 2000m^3/s. Span length of Bridge No.1and No.3 is 21.400m, and span length of Bridge No.2 is 24.100m. Table 2.2.2.4-4 shows the result of comparative study on superstructure.

Table 2.2.2.4-2 Comparative Study on Pier Type

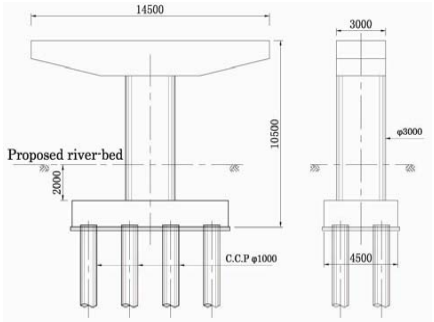
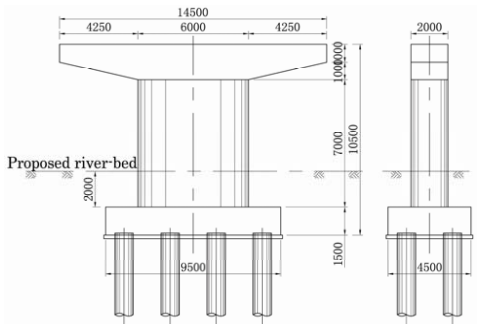
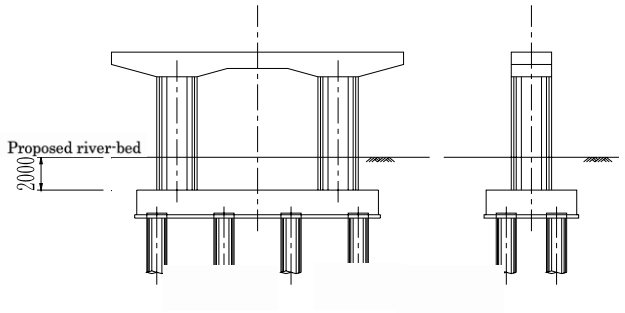
	ALTERNATIVE 1 T TYPE	ALTERNATIVE 2 WALL TYPE	ALTERNATIVE 3 RIGID FRAME TYPE
SIDE VIEW			
STRUCTURAL PROPERTIES	・Diameter of column bigger than thickness of wall type pier(diameter: biggest) ・Rebars necessary, because of long Cantilever	・Thinner thickness of wall(thickness:thin) ・Shorter cantilever	・Pier with two(2) columns(diameter : middle) ・Shorter cantilever
	Evaluation: △	Evaluation: ○	Evaluation: △
CONSTRUCTIVITY	・No cofferdam necessary on excavation work ・Supporting, forming & bar arrangement complicated because of longer cantilever	・Good constructivity as same as T type pier	・Execution of rigid corners very important
		Evaluation: ○	Evaluation: ○
CONSTRUCTION DURATION	・Three(3) months necessary to complete five(5) substructures of Bridge No.2	・Three(3) months necessary to complete five(5) substructures of Bridge No.2	・Three(3) months necessary to complete five(5) substructures of Bridge No.2
	Evaluation: ○	Evaluation: ○	Evaluation: ○
HYDROLOGICAL PROPERTIES	・The most adequate type, because of less turbulent flow of flood water at piers	・Wall type has a risk of obstruction against flood flow because of turbulent flow at piers	・Obstruction to flood flow because of adjacent two(2) pier columns
	Evaluation: ○	Evaluation: ×	Evaluation: ×
CONSTRUCTION COST	・Cheapest in construction cost ・4.95million yen/pier	・A little bit expensive in construction cost ・5.07million yen/pier	・Expensive in construction cost ・5.21million yen/pier
	Evaluation: ○ (adopted)	Evaluation: △	Evaluation: ×

Table 2.2.2.4-3 Comparative Study on Foundation

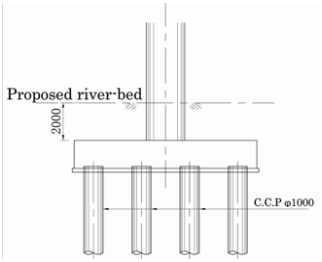
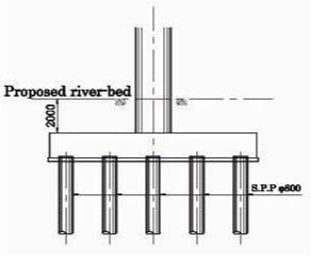
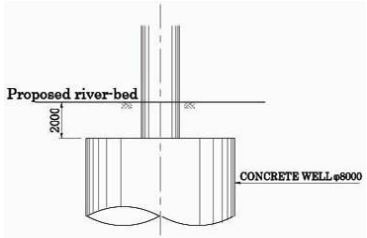
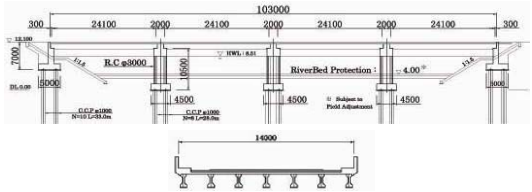
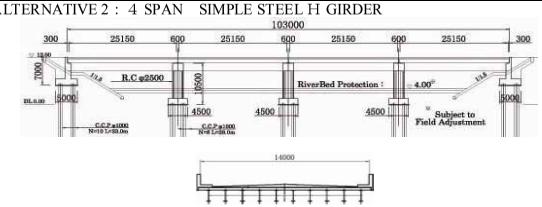
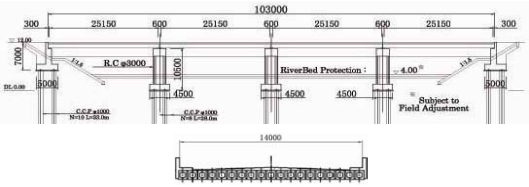
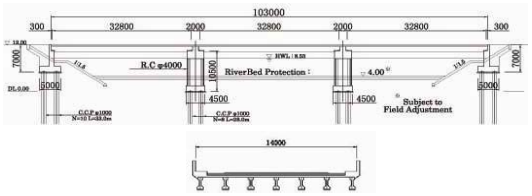
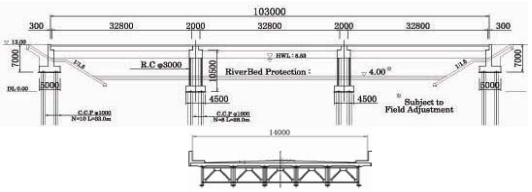
	ALTERNATIVE 1 Cast-In-Place CONCRETE PILE	ALTERNATIVE 2 STEEL PIPE PILE	ALTERNATIVE 3 WELL FOUNDATION
SIDE VIEW			
STRUCTURAL PROPERTIES	・Vertical bearing capacity & horizontal resistance both bigger, because of big diameter pile ・Quality of pile depending on construction ability ・Suitable for friction pile because of bigger friction	・Vertical bearing capacity & horizontal resistance both bigger, because of big diameter pile ・High quality due to materials fablicated in factory ・Inadequate to friction pile	・Adequate to foundation of big bridge because of big resistance ・Good quality, because of product in the air ・Longer foundation necessary, because of depending on resistance at bottom of well foundation
	Evaluation: ○	Evaluation: ×	Evaluation: ×
CONSTRUCTIVITY	・Important in construction supervision ・Yard necessary for temporary facilities & bar arrangement	・Good handling because of light weight ・Welding work necessary at joints of members	・Sinking work of well necessary ・Surcharge or water jet facilities necessary for deeper foundation
	Evaluation: △	Evaluation: ○	Evaluation: ×
ENVIRONMETNT IMPACT	・Low noise & vibration at construction ・Treatment of water pollusion & disposal of soil through excavation necessary(No problem in this project)	・Noise & vibration through construction due to driving ・Treatment of water pollusion & disposal of soil unnecessary because there is no excavation through pile construction	・No noise & vibration ・Disposal of soil necessary because of big mass excavation(No problem in this project)
	Evaluation: ○	Evaluation: ×	Evaluation: ○
CONSTRUCTION DURATION	・One(1) pile a day ・8 days for one(1) pier (Φ1.0m、8 piles, 28m/pile) ・60 days for Bridge No.2	・2 Piles a day ・8 days for one(1) pier (Φ0.8m、15 piles, 28m/pile) ・60 days for Bridge No.2	・4 months per foundation(Diameter 8.0m、28m/foundation) ・8 months for Bridge No.2(3 sets)
	Evaluation: ○	Evaluation: ○	Evaluation: ×
CONSTRUCTION COST	・Cheapest, materials for C.C.P able to be procured in the CAMBODIA ・12.0 million yen/pier foundation	・More expensive, because of imported piles ・21.0million yen/pier foundation	・Most expensive, because of bringing facilities from abroad ・84.0 million yen/pier foundation
	Evaluation: ○ **(adopted)**	Evaluation: ×	Evaluation: ×

Table 2.2.2.4-4 Comparative Study on Superstructure

BRIDGE TYPE	COST(million yen)	STRUCTURAL PROPERTIES	HYDROLOGICAL PROPERTIES	CONSTRUCTION DURATION	CONSTRUCTITITY	ENVIRONMENT IMPACT	MAINTENANCE	Evaluation
ALTERNATIVE 1 : 4 SPAN SIMPLE PC-I SHAPE GIRDER 	SUPERSTRUCTURE : 1.00 SUBSTRUCTURE : 1.00 GIRDER ERECTION : 1.00 SUBSIDIARY WORK : 1.00 TOTAL OF COST : **1.00**	・short span, reduction of weight of superstructure ・Utilizing stndard cross section of AASHTO ・Simple beam available for un-even settlement, because of friction pile ・Lower elevation of bridge due to cutting of girder end (h=1.372m)	・River-bed protection and revetment protection necessary, scouring by velocity of super-critical flow in 3～5m/s ・Measurement to local scouring around piers necessary ・Inhibitory Ratio of river cross section : 8.7%	8 Months, Construction duration within dry season	・Erection Method : Construction by erection girder method ・Erection not so difficult	・Detour necessary at construction stage. No special problem ・After completion, No problem	・Maitenance work minimal because of concrete bridge	○ (adopted)
	RESULT : ○	**RESULT : ○**	**RESULT : △**	**RESULT : ○**	**RESULT : △**	**RESULT : ○**	**RESULT : ○**	
ALTERNATIVE 2 : 4 SPAN SIMPLE STEEL H GIRDER 	SUPERSTRUCTURE : 1.78 SUBSTRUCTURE : 0.97 GIRDER ERECTION : 0.46 SUBSIDIARY WORK : 1.06 TOTAL OF COST : **1.18**	・H-shaped steel girder available due to short span ・Uniform shape of H-shaped steel girder (h=0.90m) ・Little influence due to light self-weight of gerder ・Necessary to import steel girder	・River-bed protection and revetment protection necessary, scouring by velocity of super-critical flow in 3～5m/s ・Measurement to local scouring around piers necessary ・Inhibitory Ratio of river cross section : 7.3%	9 Months, construction duration into rainy season partialy	・Erection Method : After installation of erection bent, execution by middle-size crane ・On girder of middle span, erection from deck slab after completion of side span ・Erection easy	・Wide yard unnecessary. No influence to vicinity ・After completion, No problem	・Maitenance work minimal due to corrosion-resisting steel	
	RESULT : ×	**RESULT : ○**	**RESULT : △**	**RESULT : △**	**RESULT : ○**	**RESULT : ○**	**RESULT : △**	
ALTERNATIVE 3 : 4 SPAN SIMPLE PC HOLLOW SLAB GIRDER 	SUPERSTRUCTURE : 1.39 SUBSTRUCTURE : 1.08 GIRDER ERECTION : 0.96 SUBSIDEARY WORK : 1.13 TOTAL OF COST : **1.17**	・Reduction of weight of supertructure due to short span ・Pre-cast girder by pre-tension system ・Lower height of girder(h=1.0m)	・River-bed protection and revetment protection necessary, scouring by velocity of super-critical flow in 3～5m/s ・Measurement to local scouring around piers necessary ・Inhibitory Ratio of river cross section : 8.7%	9 Months, construction duration into rainy season partialy	・Erection Method : Construction by erection girder method ・Big crane necessary because of heavy weight of girder ・Erection little difficult	・Detour necessary at construction stage. No special problem ・After completion, No problem	・Maitenance work minimal because of concrete bridge	
	RESULT : ×	**RESULT : ○**	**RESULT : △**	**RESULT : △**	**RESULT : ×**	**RESULT : ○**	**RESULT : ○**	
ALTERNATIVE 4 : 3 SPAN SIMPLE PC-I SHAPE GIRDER 	SUPERSTRUCTURE : 1.07 SUBSTRUCTURE : 0.95 GIRDER ERECTION : 1.52 SUBSIDIARY WORK : 1.13 TOTAL OF COST : **1.08**	・Bigger weight of superstructure due to long span ・Utilizing stndard cross section of AASHTO ・Lower elevation of bridge due to cutting of girder end (h=1.6m)	・River-bed protection and revetment protection necessary, scouring by velocity of super-critical flow in 3～5m/s ・Measurement to local scouring around piers necessary ・Inhibitory Ratio of river cross section : 7.8%	8 Months, Construction duration within dry season	・Erection Method : Construction by erection girder method ・Big crane necessary because of heavy weight of girder ・Erection little difficult	・Detour necessary at construction stage. No special problem ・After completion, No problem	・Maitenance work minimal because of concrete bridge	
	RESULT : △	**RESULT : ×**	**RESULT : ○**	**RESULT : ○**	**RESULT : ×**	**RESULT : ○**	**RESULT : ○**	
ALTERNATIVE 5 : 3 SPAN SIMPLE STEEL COMPOSITE GIRDER 	SUPERSTRUCTURE : 2.26 SUBSTRUCTURE : 0.85 GIRDER ERECTION : 0.37 SUBSIDIARY WORK : 1.31 TOTAL OF COST : **1.33**	・Lower influence to substructure due to light self-weight though long span ・Higher durability by corrosion protection method ・Higher girder height (h=1.7m) ・Necessary to import steel girder	・River-bed protection and revetment protection necessary, scouring by velocity of super-critical flow in 3～5m/s ・Measurement to local scouring around piers necessary ・Inhibitory Ratio of river cross section : 5.8%	8 Months, Construction duration within dry season	・Erection Method : After installation of erection bent, execution by middle-size crane ・On girder of middle span, erection from deck slab after completion of side span ・Protection equipment against overturning of girder necessary, because of higher girder	・Wide yard unnecessary. No influence to vicinity ・After completion, No problem	・Maitenance work minimal because of concrete bridge	
	RESULT : ×	**RESULT : △**	**RESULT : ○**	**RESULT : ○**	**RESULT : ○**	**RESULT : ○**	**RESULT : △**	

2.2.2.5 Culvert Design

Refer to 2.2.1.4 Culvert Location and Length. Location, size and shape are described in that section.

(1) Range of Revetment of Embankment around Culvert

The range of approach revetment of embankment is 10 m long from the end of each wing wall at upstream and downstream side to each upstream and downstream side.

(2) Parapet and Diaphragm Wall

The horizontal width of parapet and diaphragm wall of box culvert is over 1.0 m with thickness of 40 cm. However, the thickness of parapet and diaphragm wall of pipe culvert is 35 cm considering it to be smaller structure.

(3) Splice

Box Culvert

Differential settlement of box culvert may occur because the foundation ground is soft and the embankment load is not uniform to box culvert since the box culvert is extended at the position of raising of existing embankment and providing new embankment. Splice joint is placed to relieve the effects of differential settlement to the box culvert. One splice is set up at the middle of box culvert because the boundary between the existing embankment and the new embankment is at the center of the road.

Pipe Culvert

Splice is set up because pipe culvert is over 20 m long and has the danger of failure due to differential settlement and shrinkage etc. It is preferable that splice is not set up near center of embankment. Therefore, two (2) splices are set up at the pipe culvert.

(4) Notch for Stop Log

The flood around culvert flows from the Mekong River side to the flood area in the Colmatage side. Notch for stop log is set up at the Mekong River side to retain the running water for maintenance or during an emergency. The dimension is 15 cm in depth and 10 cm in width similar to the existing culvert.

(5) Steps

Cleaning and maintenance etc. are necessary during maintenance period for the culverts of the Project. The steps for maintenance are placed at both upstream and downstream sides. The width of step is 1.0 m by which managers can meet.

(6) Foundation

Each box culvert and pipe culvert has spread foundation. Replacement of good quality soil or sand is applied due to the possibility of the problem of consolidation settlement caused by the soft foundation. The location, range and depth are same as the ones decided in Section 2.2.2.9 Design of Countermeasure against Soft Ground to Embankment.

(7) Diaphragm Wall

The diaphragm wall is set up below the bottom slab for the protection of piping at the foundation ground of box culvert. The length of the diaphragm wall is 3.0 m considering the examination of infiltration route and minimum embedment length of 3.0 m.

2.2.2.6 Drainage Design

(1) Sections at which Road Drainage is Placed

Considering the proposal of the Feasibility Study and the results of the meeting with related organizations, surface drainage and urban area drainage are set up below sections where urbanization is progressing. Sections at which Road drainage is placed are presented in Table 2.2.2.6-1.

Table 2.2.2.6-1 Sections at which Road Drainage is Placed

Area Name	Section	Purpose	Collecting Area (ha)	Flow Facility	Inflow Facility	Place to Discharge
Chbar Ampov	0+000 - 1+800	Surface and Urban Area Drainage	5.640	Pipe	Curb Inlet	The Bassac River
Kokir Market	13+500 – 13+950	Surface and Urban Area Drainage	2.650	Pipe	Curb Inlet	The Mekong River
Neak Loeung	54+750 - 55+300 55+380 – 55+945	Surface and Urban Area Drainage	6.315	U Shaped Side Ditch	Top with Hole	The Mekong River

1) Chbar Ampov Section (Sta.0+000 - Sta.1+800)

The section of Sta.0+000 to 0+400 is dense commercial area and rainfall flows into the road of the section. The rain collecting area is 25m from the centerline to each left and right side considering topography inclination. The section of Sta.0+400 to 1+800 is embankment road. Therefore, rainfall does not flow from the area along the road into the road but rainfall on the road sustains on the road due to the mount-up sidewalk. Therefore, a countermeasure against road surface water is taken at this section.

2) Kokir Market Section (Sta.13+500 - Sta.13+950)

This section is dense commercial area centering the market and rainfall flows into the road. The rain collecting area is 25 m from the centerline to each left and right side considering topography inclination. Partial discharge from the market area, the area is 0.4 ha, discharges into Mekong River through the side ditch at present, but the pipe line of the drainage of the road overlaps with that side ditch. Therefore, the project drainage covers the partial discharge.

3) Neak Loeung Section (Sta.54+750 - Sta.55+300, Sta.55+380 - Sta.55+945)

This section is a commercial area crowded with people using ferry terminal for the ferry crossing the Mekong River. At the inside land of the loop road, it is not easy to clear rainfall. And the land collects with water recurrently due to the loop road surrounding the market etc. Therefore, the drainage facilities which aim to clear the inside water and road surface drainage are set up.

The details of catchment area of the road drainage facilities are shown in the Table 2.2.2.6-2.

Table. 2.2.2.6-2 Details of Catchment Area of the Road Drainage

Areas	Sections	Target Drainage Areas									Purpose	Discharge Pipes					Explanation
		Side viewed from Phnom Penh	Length	Width		Local Drainage Area	Area					Location of Outlet	Length	Diamater	Invert Level of Outlet	Design FWL	
				Road Surface	Roadside Area		Road Surface	Roadside Area	Local Drainage Area	Total							
			(m)	(m)	(m)	(ha)	(ha)	(ha)	(ha)	(ha)			(m)	(m)	(m)	(m)	
1. Chbar Ampov	0+000 – 0+400	Right	400	17.150	7.850	-	0.686	0.314	-	1.000	Road Surface & Roadside Area Drainage	Mekong River	140	0.7	7.50	10.18	Phnom Penh Municipality officers designate the location of the outlet.
		Left	400	17.150	7.850	-	0.686	0.314	-	1.000	Road Surface & Roadside Area Drainage						
		Total					1.372	0.628	-	2.000							
	0+400 – 0+500	Right	100	13.000	-	-	0.130	-	-	0.130	Road Surface Drainage						
		Left	100	13.000	-	-	0.130	-	-	0.130	Road Surface Drainage						
		Total					0.260	-	-	0.260							
	0+500 – 1+800	Right	1,300	13.000	-	-	1.690	-	-	1.690	Road Surface Drainage	Stream to Bassac River	180	0.7	7.69	10.18	Phnom Penh Municipality officers designate the location of the outlet.
		Left	1,300	13.000	-	-	1.690	-	-	1.690	Road Surface Drainage						
		Total					3.380	-	-	3.380							
2. Koki Market	13+500 – 13+950	Right	450	14.500	10.500	-	0.653	0.473	-	1.125	Road Surface & Roadside Area Drainage	Mekong River	85	0.7	7.50	9.72	The proposed discharge pipe is in the same route as existing drain for Koki Market itself, Koki Commune officers advise to improve the said existing drain for discharging the stormwater.
		Left	450	14.500	10.500	0.400	0.653	0.473	0.400	1.525	Road Surface, Roadside Area & Market Space Drainage						
		Total					1.305	0.945	0.400	2.650							
3. Neak Loeung	54+750 – 55+300	Right	550	7.000	-	-	0.385	-	-	0.385	Road Surface Drainage	Mekong River	240	0.7	4.85	7.79	The area confined by the looping road is requested to be drained out, Right side ground level of the target road is lower than the proposed pavement level, Prek Tonloab Commune officers request not to concentrate the stormwater to the right side ground w
		Left	550	7.000	-	2.418	0.385	-	2.418	2.803	Road Surface, Roadside Area & Looping Area Drainage						
		Total					0.770	-	2.418	3.188							
	55+380 - 55+945	Right	565	7.000	-	-	0.396	-	-	0.396	Road Surface Drainage						
		Left	565	7.000	-	2.336	0.396	-	2.336	2.732	Road Surface, Roadside Area & Looping Area Drainage						
		Total					0.791	-	2.336	3.127							

(2) Calculation of Rainwater Discharge Volume and Channel

1) Calculation of Rainwater Discharge Volume

The maximum rainwater discharge that rain flows from the farthest point of catchment area to the interest point is calculated by the rational formula as below.

$$Q = \frac{1}{360} C \cdot I \cdot A$$

Where:

Q : Peak rain discharge volume (m^3/sec)
C : Coefficient of discharge (Urban area=0.70, Paved road surface=0.90)
I : Rainfall intensity within the concentration time (mm/hr)
A : Rainwater catchment area (km^2)

This coefficient of discharge is weighted average value calculated with ratio of area composition of paved road and urban area (Pi).

$$C = \sum (Pi \times Ci)$$

The time that rain flows from the farthest point of collecting area to the project point is as follows.

$Tc = T_1 + T_2$

Where:

Tc : Reaching time of flow (min)
T_1 : Time that rain flows from the farthest point of water collecting area to a drainage facilities (Inflow time) (min)
T_2 : Time that rain flows through the drainage facilities to the project point (Flow down time)(min)

In this case, the minimum value of *Tc* is 10 min.

The rain intensity corresponding to *Tc* is calculated with the 2-year return period rainfall intensity formula proposed in the JICA study on drainage improvement and flood control in the Municipality of Phnom Penh in 1999.

$I = 2556.07(Tc+25.48)-0.93$

Where:

I : Rainfall intensity (mm/hr)

Tc : Reaching time of flow (min)

10 minutes rainfall intensity is *I=2556.07(10+25.48)-0.93=92.5 (mm/hr)*. This value is appropriate because concentrated heavy rain occurs from May to October due to the wet air brought by the southwest monsoon.

4) Hydraulic Analysis of Channel

The ability of flow of pipe and ditch is calculated with Manning formula below, and they are designed subject to natural flow.

$$v = \frac{1}{n} R^{2/3} \cdot i^{1/2}$$

Where:

V : Section average flow velocity (m/s)

N : Coefficient of roughness (Concrete U-shaped side ditch=0.015, Concrete pipe=0.013)

R : Hydraulic mean depth (m) (*R=A/P*, A : Flow area, P : Wetted perimeter)

i : Channel inclination

80 % flow ability of a section is designed considering an interruption of water sectional area by mixed soil. And, the range of flow velocity is from 0.6 m/s to 3.0 m/s for soil not to deposit and for a pipe not to be eroded by flow.

(3) Composition of Road Drainage Facility

1) Design Live Load

The strength of road drainage facilities is satisfied with HS20-44 of AASHTO.

2) Drainage Facility for Flow

Chbar Ampov and Kokir Market Section

Construction method that pipes are set up under sidewalk is adopted considering the landscape around mount-up sidewalk. The type of pipe is concrete pipe which is typical in Cambodia with a minimum diameter is 50 cm considering the ease of maintenance. The depth of buried pipe, that is the distance from the top of pipe to the surface of shoulder, is more than 0.5 m because of the control of the load and the vibration caused by vehicles. A pipe with the strength of "RC Pipe of JIS A 5302 class 2 in Japan" or more is necessary.

Required properties of adopted RC pipe are shown in Table 2.2.2.6-3.

Table 2.2.2.6-3 Required Properties RC Pipe (JIS A 5302 Class2 or More)

Nominal Diameter (mm)	Cracking Load (kN/m)	Inside Diameter (mm)	Thickness (mm)	Weight (kN/m)	Radius of Thickness enter (m)
500	28	500	69	2.96	0.2845
700	33	700	83	4.90	0.3915

Foundation structure is 120-degree concrete foundation.

Neak Loeung Section

RC U-shaped ditch with cover is adopted because sidewalk is not built and rainfall has to flow into the ditch and considering the safety of vehicles and pedestrians. The flow direction in the ditch cannot correspond with the direction of the longitudinal profile due to the limitation of the location of discharge facilities. Therefore, free inclination of the invert of the ditch adjusted by the thickness of the secondary work mortar is adopted.

4) Inflow Facilities

Chbar Ampov and Kokir Market Section

Curb inlets which is generally used at urban road in Cambodia, is applied as inflow facilities because the drainage facility for the storm water is under ground pipe. The longitudinal inclination at the proposed section is nearly zero, therefore the curb inlet is set up every 10 m along the road.

Neak Loeung Section

The shape of the top of U shaped ditch has a lateral divided hole for rainfall to flow in to it naturally but with strength satisfying the design live load.

5) Discharge Facility

Discharge Pipe

Rainfall collected through the pipe and the ditch flows down through the discharge pipe and is discharged from the outlet. The type of the discharge pipe is same as the drainage facility for flow described above. Therefore, the depth of buried pipe is over 0.6 m and the foundation structure is likewise 120 degree concrete foundation. Running water in the discharge pipe is also natural flow.

Outlet

The outlet is RC wing wall shape transiting the slope of the river. Foundation concrete 20 cm thick and wooden pile 3 m long are placed to prevent differential settlement. The slope protection of wet masonry is provided so that the discharge water will not erode the slope of the river. The design of wet masonry is same as the road slope protection. Therefore, the thickness of wet masonry is 25 cm and each crushed stone foundation and leveling concrete is 10 cm thick at the wet masonry covering part. Mattress gabion is to be adopted as foot protection and run off, and is filled with the material which particle size is about 20 cm in diameter. Outlet is shown in Table 2.2.2.6-4.

Table 2.2.2.6-4 Outlet

Section	Discharge Pipe		Level of Invert (m)		Discharge River or Channel	Design Flood Water Level (m)
	Name	Diameter (mm)	Discharge Pipe	Outlet Apron		
Chbar Ampov	CA Discharge Pipe 1	700	7.50	7.38	The Bassac River	10.18
	CA Discharge Pipe 2	700	7.69	7.57	Channel to the Bassac River	10.18
Kokir Market	KM Discharge Pipe	700	7.50	7.38	The Mekong River	9.72
Neak Loeung	NL Discharge Pipe	700	4.85	4.73	The Mekong River	7.79

6) Manhole

Manhole is set up for the maintenance and cleaning of pipe. The places of manhole are the section changing point, confluence point and every 50 m point in the straight section considering the cleaning equipment capacity belonging to Phnom Penh Municipality. The shape of manhole is RC box type, and the top is RC slab. The sandpit of 30 cm depth is set up between invert of manhole and the bottom of the connected pipe.

(4) The result of Hydraulic Analysis of Road Drainage Facility

The whole result of hydraulic analysis of road drainage facility is shown in the Table 2.2.2.6-5.

Table 2.2.2.6-5 Result of Hydraulic Analysis of Road Drainage Facility

Areas	Station	Dimension of Drains													Catchment Area			Runoff Coefficient	Inflow Time	Travel Time	Rainfall Concentration Time	Rainfall Intensity	Design Discharge	
		Drainage Areas		Station	Chainage	Partial Length of Drains	Pavement Height at Curb (PH)	Inside Size of Pipe or Culvert	Invert Level of Pipe or Ditch	Inside Top Level of Pipe or Ditch (TL)	Longitudinal Slope of Pipe or Ditch	PH-TL	Velocity	80% Discharge	Road Surface	Roadside Area	Total A	C	Tin	L/V	Tc =Tin+L/V	I=2556.07x (Tc+25.48)^-0.7	Q =1/360xCxIxA	Judge
		Right	Left		(m)	(m)	(m)	(m)	(m)	(m)	(%)	(m)	(m/s)	(m³/s)	(ha)	(ha)	(ha)		(min)	(min)	(min)	(mm/h)	(m³/s)	
Chbar Ampov	0+000 - 0+500	CA-1-R		0 + 500	0	0	11.002	D=0.5	9.700	10.200		0.802												
	Road Surface &			0 + 400	100	100	10.536	D=0.5	9.200	9.700	0.500	0.836	1.360	0.240	0.130	0.000	0.130	0.80	8.89	1.11	10.00	92.5	0.027	OK
	Side Area Drainage			0 + 260	240	140	10.224	D=0.5	8.920	9.420	0.200	0.804	0.860	0.152	0.182	0.070	0.252	0.75	10.00	3.44	13.44	84.9	0.045	OK
				0 + 160	340	100	10.541	D=0.5	8.720	9.220	0.200	1.321	0.860	0.152	0.312	0.120	0.432	0.75	10.00	5.11	15.11	81.6	0.073	OK
				0 + 110	390	50	10.576	D=0.5	8.620	9.120	0.200	1.456	0.860	0.152	0.507	0.195	0.702	0.74	10.00	5.94	15.94	80.1	0.116	OK
			CA-1-L	0 + 500	0	0	11.002	D=0.5	9.700	10.200		0.802												
				0 + 400	100	100	10.536	D=0.5	9.200	9.700	0.500	0.836	1.360	0.240	0.130	0.000	0.130	0.80	8.89	1.11	10.00	92.5	0.027	OK
				0 + 260	240	140	10.224	D=0.5	8.920	9.420	0.200	0.804	0.860	0.152	0.182	0.070	0.252	0.75	10.00	3.44	13.44	84.9	0.045	OK
				0 + 160	340	100	10.541	D=0.5	8.720	9.220	0.200	1.321	0.860	0.152	0.312	0.120	0.432	0.75	10.00	5.11	15.11	81.6	0.073	OK
				0 + 110	390	50	10.576	D=0.5	8.620	9.120	0.200	1.456	0.860	0.152	0.507	0.195	0.702	0.74	10.00	5.94	15.94	80.1	0.116	OK
		Discharge Pipe 1		0 + 000	0	0	10.576	D=0.7	8.210	8.910		1.666												
				0 + 015	15	15	10.576	D=0.7	8.180	8.880	0.200	1.696	1.076	0.373	1.014	0.390	1.404	0.75	10.00	6.15	16.15	79.7	0.233	OK
				0 + 060	60	45	11.300	D=0.7	8.090	8.790	0.200	2.510	1.076	0.373	1.014	0.390	1.404	0.75	10.00	6.78	16.78	78.6	0.230	OK
				0 + 065	65	5	10.100	D=0.7	8.080	8.780	0.200	1.320	1.076	0.373	1.014	0.390	1.404	0.75	10.00	6.85	16.85	78.5	0.230	OK
				0 + 088	88	23	9.900	D=0.7	8.034	8.734	0.200	1.166	1.076	0.373	1.014	0.390	1.404	0.75	10.00	7.17	17.17	77.9	0.228	OK
				0 + 140	140	52	7.500	D=0.7	7.500	8.200	1.027	-0.700	2.439	0.845	1.014	0.390	1.404	0.75	10.00	7.49	17.49	77.4	0.226	OK
	0+500 - 1+800	CA-2-R		0 + 500	0	0	11.002	D=0.5	9.700	10.200		0.802												
	Road Surface Drainage			0 + 600	100	100	11.050	D=0.5	9.600	10.100	0.100	0.950	0.608	0.107	0.130	0.000	0.130	0.80	7.62	2.38	10.00	92.5	0.027	OK
				0 + 700	200	100	11.050	D=0.5	9.500	10.000	0.100	1.050	0.608	0.107	0.260	0.000	0.260	0.80	5.24	4.76	10.00	92.5	0.053	OK
				0 + 800	300	100	11.050	D=0.5	9.400	9.900	0.100	1.150	0.608	0.107	0.390	0.000	0.390	0.80	2.86	7.14	10.00	92.5	0.080	OK
				0 + 900	400	100	11.050	D=0.5	9.300	9.800	0.100	1.250	0.608	0.107	0.520	0.000	0.520	0.80	0.48	9.52	10.00	92.5	0.107	OK
				1 + 000	500	100	11.050	D=0.5	9.200	9.700	0.100	1.350	0.719	0.127	0.650	0.000	0.650	0.80	0.00	11.90	11.90	88.1	0.127	OK
				1 + 100	600	100	11.050	D=0.5	9.050	9.550	0.150	1.500	0.880	0.156	0.780	0.000	0.780	0.80	0.00	13.99	13.99	83.8	0.145	OK
			CA-2-L	0 + 500	0	0	11.002	D=0.5	9.700	10.200		0.802												
				0 + 600	100	100	11.050	D=0.5	9.600	10.100	0.100	0.950	0.608	0.107	0.130	0.000	0.130	0.80	7.62	2.38	10.00	92.5	0.027	OK
				0 + 700	200	100	11.050	D=0.5	9.500	10.000	0.100	1.050	0.608	0.107	0.260	0.000	0.260	0.80	5.24	4.76	10.00	92.5	0.053	OK
				0 + 800	300	100	11.050	D=0.5	9.400	9.900	0.100	1.150	0.608	0.107	0.390	0.000	0.390	0.80	2.86	7.14	10.00	92.5	0.080	OK
				0 + 900	400	100	11.050	D=0.5	9.300	9.800	0.100	1.250	0.608	0.107	0.520	0.000	0.520	0.80	0.48	9.52	10.00	92.5	0.107	OK
				1 + 000	500	100	11.050	D=0.5	9.200	9.700	0.100	1.350	0.719	0.127	0.650	0.000	0.650	0.80	0.00	11.90	11.90	88.1	0.127	OK
				1 + 100	600	100	11.050	D=0.5	9.050	9.550	0.150	1.500	0.880	0.156	0.780	0.000	0.780	0.80	0.00	13.99	13.99	83.8	0.145	OK
		CA-3-R		1 + 800	0	0	11.050	D=0.5	9.700	10.200		0.850												
				1 + 700	100	100	11.050	D=0.5	9.600	10.100	0.100	0.950	0.608	0.107	0.130	0.000	0.130	0.80	7.62	2.38	10.00	92.5	0.027	OK
				1 + 600	200	100	11.050	D=0.5	9.500	10.000	0.100	1.050	0.608	0.107	0.260	0.000	0.260	0.80	5.24	4.76	10.00	92.5	0.053	OK
				1 + 500	300	100	11.050	D=0.5	9.400	9.900	0.100	1.150	0.608	0.107	0.390	0.000	0.390	0.80	2.86	7.14	10.00	92.5	0.080	OK
				1 + 400	400	100	11.050	D=0.5	9.300	9.800	0.100	1.250	0.608	0.107	0.520	0.000	0.520	0.80	0.48	9.52	10.00	92.5	0.107	OK
				1 + 300	500	100	11.050	D=0.5	9.200	9.700	0.100	1.350	0.719	0.127	0.650	0.000	0.650	0.80	0.00	11.90	11.90	88.1	0.127	OK
				1 + 200	600	100	11.050	D=0.5	9.050	9.550	0.150	1.500	0.880	0.156	0.780	0.000	0.780	0.80	0.00	13.99	13.99	83.8	0.145	OK
				1 + 100	700	100	11.050	D=0.5	8.900	9.400	0.150	1.650	0.880	0.173	0.910	0.000	0.910	0.80	0.00	16.07	16.07	79.9	0.162	OK
			CA-3-L	1 + 800	0	0	11.050	D=0.5	9.700	10.200		0.850												
				1 + 700	100	100	11.050	D=0.5	9.600	10.100	0.100	0.950	0.608	0.107	0.130	0.000	0.130	0.80	7.62	2.38	10.00	92.5	0.027	OK
				1 + 600	200	100	11.050	D=0.5	9.500	10.000	0.100	1.050	0.608	0.107	0.260	0.000	0.260	0.80	5.24	4.76	10.00	92.5	0.053	OK
				1 + 500	300	100	11.050	D=0.5	9.400	9.900	0.100	1.150	0.608	0.107	0.390	0.000	0.390	0.80	2.86	7.14	10.00	92.5	0.080	OK
				1 + 400	400	100	11.050	D=0.5	9.300	9.800	0.100	1.250	0.608	0.107	0.520	0.000	0.520	0.80	0.48	9.52	10.00	92.5	0.107	OK
				1 + 300	500	100	11.050	D=0.5	9.200	9.700	0.100	1.350	0.719	0.127	0.650	0.000	0.650	0.80	0.00	11.90	11.90	88.1	0.127	OK
				1 + 200	600	100	11.050	D=0.5	9.050	9.550	0.150	1.500	0.880	0.156	0.780	0.000	0.780	0.80	0.00	13.99	13.99	83.8	0.145	OK
				1 + 100	700	100	11.050	D=0.5	8.900	9.400	0.150	1.650	0.880	0.173	0.910	0.000	0.910	0.80	0.00	16.07	16.07	79.9	0.162	OK
		Discharge Pipe 2		0 + 000	0	0	11.050	D=0.7	8.500	9.200		1.850												
				0 + 122	122	122	9.470	D=0.7	7.951	8.651	0.450	0.819	1.908	0.661	3.380	0.000	3.380	0.80	0.00	17.20	17.20	77.9	0.585	OK
				0 + 164	164	42	9.970	D=0.7	7.762	8.462	0.450	1.508	1.908	0.661	3.380	0.000	3.380	0.80	0.00	17.59	17.59	77.2	0.580	OK
				0 + 180	180	16	8.500	D=0.7	7.690	8.390	0.450	0.110	1.908	0.661	3.380	0.000	3.380	0.80	0.00	17.74	17.74	77.0	0.578	OK
Kokir Market	13+500 - 13+950	KM-1-R		13 + 500	0	0	9.911	D=0.5	8.600	9.100		0.811												
	Road Surface &			13 + 620	120	120	9.861	D=0.5	8.480	8.980	0.100	0.881	0.608	0.107	0.174	0.126	0.300	0.75	10.00	2.86	12.86	86.1	0.054	OK
	Side Area Drainage		KM-1-L	13 + 500	0	0	9.911	D=0.5	8.600	9.100		0.811												
				13 + 620	120	120	9.861	D=0.5	8.480	8.980	0.100	0.881	0.608	0.107	0.174	0.126	0.300	0.75	10.00	2.86	12.86	86.1	0.054	OK
		KM-2-R		13 + 950	0	0	9.733	D=0.5	8.400	8.900		0.833												
				13 + 720	230	230	9.895	D=0.5	8.170	8.670	0.100	1.225	0.719	0.127	0.334	0.242	0.575	0.75	10.00	5.48	15.48	80.9	0.097	OK
				13 + 620	330	100	9.861	D=0.5	8.070	8.570	0.100	1.291	0.719	0.141	0.479	0.347	0.825	0.75	10.00	7.86	17.86	76.8	0.132	OK
			KM-2-L	13 + 950	0	0	9.733	D=0.5	8.400	8.900		0.833												
				13 + 720	230	230	9.895	D=0.5	8.170	8.670	0.100	1.225	0.719	0.127	0.334	0.242	0.575	0.75	10.00	5.48	15.48	80.9	0.097	OK
				13 + 620	330	100	9.861	D=0.5	8.070	8.570	0.100	1.291	0.719	0.141	0.479	0.347	0.825	0.75	10.00	7.86	17.86	76.8	0.132	OK
		Discharge Pipe		0 + 000	0	0	9.861	D=0.7	7.670	8.370		1.491												
				0 + 060	60	60	9.500	D=0.7	7.550	8.250	0.200	1.250	1.272	0.441	1.305	0.945	2.250	0.75	10.00	8.69	18.69	75.4	0.353	OK
				0 + 080	80	20	9.100	D=0.7	7.510	8.210	0.200	0.890	1.272	0.441	1.305	1.345	2.650	0.70	10.00	8.97	18.97	75.0	0.386	OK
				0 + 085	85	5	7.300	D=0.7	7.500	8.200	0.200	-0.900	1.272	0.441	1.305	1.345	2.650	0.70	10.00	9.04	19.04	74.9	0.386	OK
Neak Loeung	54+750 - 55+300	NL-1-R		54 + 750	0	0	7.979	0.4x0.4	7.429	7.829		0.150												
	55+380 - 55+945			54 + 900	150	150	8.058	0.4x0.4	7.279	7.679	0.100	0.379	0.550	0.070	0.105	0.000	0.105	0.80	5.83	4.17	10.00	92.5	0.022	OK
	Road Surface &			54 + 960	210	60	8.090	0.4x0.4	7.219	7.619	0.100	0.471	0.550	0.070	0.147	0.000	0.147	0.80	4.17	5.83	10.00	92.5	0.030	OK
	Side Area Drainage			55 + 100	350	140	8.128	0.4x0.4	7.079	7.479	0.100	0.649	0.550	0.070	0.245	0.000	0.245	0.80	0.28	9.72	10.00	92.5	0.050	OK
				55 + 183	433	83	8.109	0.4x0.4	6.996	7.396	0.100	0.713	0.550	0.070	0.303	0.000	0.303	0.80	0.00	12.03	12.03	87.8	0.059	OK
			NL-1-L	54 + 750	0	0	7.979	0.6x0.6	7.229	7.829		0.150												
				54 + 900	150	150	8.058	0.6x0.6	7.079	7.679	0.100	0.379	0.721	0.208	0.105	0.504	0.609	0.65	10.00	3.57	13.57	84.6	0.093	OK
				54 + 960	210	60	8.090	0.6x0.6	7.019	7.619	0.100	0.471	0.721	0.208	0.147	0.794	0.941	0.65	10.00	5.00	15.00	81.8	0.139	OK
				54 + 960	210	0	8.090	0.8x0.8	6.819	7.619		0.471												
				55 + 100	350	140	8.128	0.8x0.8	6.679	7.479	0.100	0.649	0.873	0.447	0.245	1.519	1.764	0.65	10.00	7.59	17.59	77.2	0.246	OK
				55 + 183	433	83	8.109	0.8x0.8	6.596	7.396	0.100	0.713	0.873	0.447	0.303	1.957	2.260	0.65	10.00	9.13	19.13	74.7	0.305	OK
		NL-2-R		55 + 300	0	0	7.830	0.4x0.4	7.280	7.680		0.150												
				55 + 183	117	117	8.109	0.4x0.4	7.163	7.563	0.100	0.546	0.550	0.070	0.082	0.000	0.082	0.80	6.75	3.25	10.00	92.5	0.017	OK
			NL-2-L	55 + 300	0	0	7.830	0.5x0.5	7.180	7.680		0.150												
				55 + 183	117	117	8.109	0.5x0.5	7.063	7.563	0.100	0.546	0.638	0.128	0.082	0.461	0.543	0.65	10.00	3.25	13.25	85.2	0.084	OK
		NL-3-R		55 + 380	0	0	7.620	0.4x0.4	7.070	7.470		0.150												
				55 + 452	72	72	7.768	0.4x0.4	6.998	7.398	0.100	0.370	0.550	0.070	0.064	0.000	0.064	0.80	8.00	2.00	10.00	92.5	0.013	OK
			NL-3-L	55 + 380	0	0	7.620	0.5x0.5	6.970	7.470		0.150												
				55 + 472	92	92	7.809	0.5x0.5	6.878	7.378	0.100	0.431	0.638	0.128	0.064	0.448	0.512	0.65	10.00	2.56	12.56	86.7	0.080	OK
		NL-4-R		55 + 945	0	0	8.065	0.4x0.4	7.515	7.915		0.150												
				55 + 800	145	145	7.576	0.4x0.4	7.022	7.422	0.340	0.154	0.550	0.070	0.102	0.000	0.102	0.80	5.97	4.03	10.00	92.5	0.021	OK
				55 + 560	385	240	7.938	0.4x0.4	6.783	7.183	0.100	0.755	0.550	0.070	0.270	0.000	0.270	0.80	0.00	10.69	10.69	90.8	0.054	OK
				55 + 472	473	88	7.809	0.4x0.4	6.695	7.095	0.100	0.714	0.550	0.070	0.331	0.000	0.331	0.80	0.00	13.63	13.63	84.5	0.062	OK
			NL-4-L	55 + 945	0	0	8.065	0.4x0.4	7.515	7.915		0.150												
				55 + 800	145	145	7.576	0.4x0.4	7.022	7.422	0.340	0.154	1.015	0.130	0.102	0.286	0.388	0.68	10.00	2.42	12.42	87.0	0.064	OK
				55 + 800	145	0	7.576	0.7x0.7	6.722	7.422		0.154												
				55 + 560	385	240	7.938	0.7x0.7	6.483	7.183	0.100	0.755	0.799	0.313	0.270	1.519	1.789	0.65	10.00	7.42	17.42	77.5	0.250	OK
				55 + 560	385	0	7.938	0.8x0.8	6.383	7.183		0.755												
				55 + 472	473	88	7.809	0.8x0.8	6.295	7.095	0.100	0.714	0.873	0.447	0.331	1.888	2.219	0.65	10.00	9.05	19.05	74.9	0.300	OK
		Discharge Pipe		0 + 000	0	0	8.109	D=0.7	6.396	7.096		1.013												
				0 + 085	85	85	7.670	D=0.7	5.971	6.671	0.500	0.999	1.702	0.589	0.770	2.418	3.188	0.68	10.00	12.77	22.77	69.5	0.419	OK
				0 + 102	102	17	7.809	D=0.7	5.886	6.586	0.500	1.223	1.702	0.589	0.770	2.418	3.188	0.68	10.00	12.92	22.92	69.3	0.417	OK
				0 + 112	112	10	7.809	D=0.7	5.811	6.511	0.750	1.298	2.463	0.853	1.561	4.754	6.315	0.68	10.00	12.99	22.99	69.2	0.825	OK
				0 + 132	132	20	7.768	D=0.7	5.661	6.361	0.750	1.407	2.463	0.853	1.561	4.754	6.315	0.68	10.00	13.14	23.14	69.0	0.823	OK
				0 + 183	183	51	7.240	D=0.7	5.279	5.979	0.750	1.262	2.463	0.853	1.561	4.754	6.315	0.68	10.00	13.51	23.51	68.5	0.817	OK
				0 + 240	240	57	5.620	D=0.7	4.851	5.551	0.750	0.069	2.463	0.853	1.561	4.754	6.315	0.68	10.00	13.92	23.92	68.0	0.811	OK

2.2.2.7 Revetment and Riverbed Protection Design at Opening Section

(1) Riverbed Protection

Non-uniform flow analysis is implemented under the condition that the difference between the water level at floodplain of the Colmatage side and the water level at the Mekong River side is 1 m as well as the Feasibility Study. The structure is decided referring to the record of current speed at flood time and considering above-mentioned results of analyses.

But the revetment and riverbed protection of BC5 is same size as the existing ones as well as the Feasibility Study because the current velocity there seems to be not so high due to the topographic condition. The structure of riverbed protection is shown in the Table 2.2.2.7-1.

Table 2.2.2.7-1 Structure of Riverbed Protection

Opening Section	Mattress Gabion Length		Riprap Work Length		Rubble Stone Min. Dia. (cm)
	Upstream Side Lu (m)	Downstream Side Ld (m)	Upstream Side	Downstream Side	
Bridge (Br.1, Br.2, Br.3)	10	20	5	5	60
Box Culvert (BC1, BC4, BC8, BC10)	10	20	5	5	30
Box Culvert (BC5)	10	10	5	5	20
Box Culvert (BC9)	10	15	5	5	30
Box Culvert (BC11)	10	30	5	5	20
Pipe Culvert (Pipe1, Pipe2)	5	5	5	5	20

(2) Revetment

Revetment is set up around the bridges and the inlet and outlet of box culverts and pipe culvers for the prevention against erosion and collapse of the slope caused by water inflow. The structure of revetment is decided considering the analysis result that current velocity of flow approaches from 3 to 6 m/s at the nearest down stream point of the opening structure. The structure of revetment at opening section is shown in the Table 2.2.2.7-2.

Table 2.2.2.7-2 Structure of Revetment at Opening Section

Item	Range	Type	Structure
Bridge	Road embankment of 15 m from the front of parapet of abutment. Both inlet and outlet.	Flat Concrete Revetment	RC, thickness : 20cm Foundation crushed stone, thickness : 10cm Levelling concrete with wire mesh, thickness : 10cm At the bottom of embankment : Embedment length : 0.5m, Protecting with mattress gabion Filling with crusher-run (Dia.15 - 20cm) Foundation pile ; L=2.0m@1.5m
Culvert (Box, Pipe) *Except BC5	Road embankment of 10m from the end of the wing wall. Both inlet and outlet.	Wet Masonry Revetment	Wet masonry, thickness : 25cm Foundation crushed stone, thickness : 10cm Levelling concrete with wire mesh, thickness : 10cm At the bottom of embankment : Embedment length : 0.5m, Protecting with mattress gabion Foundation pile : L=2.0m@1.5m

The Plan of Revetment and Riverbed Protection at Opening Section is shown in Figure 2.2.2.7-1.

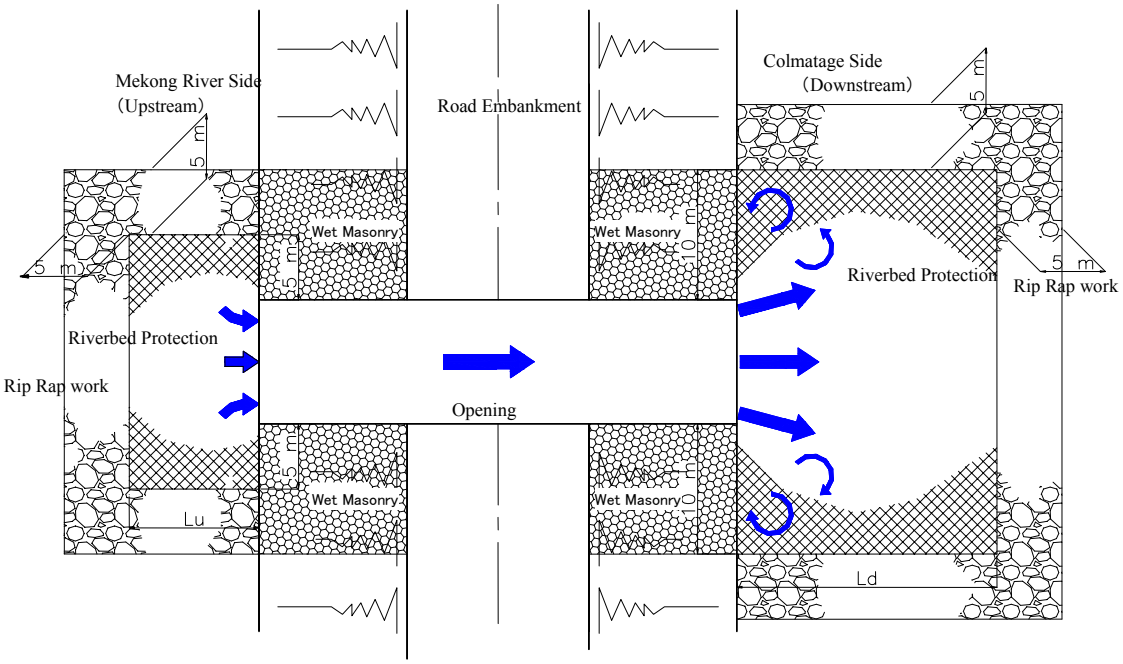


Figure 2.2.2.7-1 Plan of Revetment and Riverbed Protection at Opening Section

2.2.2.8 Design of Countermeasures against Road Slope Erosion

(1) Water Colliding Section of Road Slope

Wet masonry is setup at the slope at which the Mekong River contacts directly.

(2) Curved Section of the Road Alignment

This section is not the direct water colliding section, but the water flowing down through the irrigation channel connected to the Mekong River collides gently with the curved section of the road embankment at right-angle. Greenbelt is set up at the Mekong River side to dissipate the energy of running water to new embankment.

(3) Bridge Section

Current velocity of flooding water flowing from bridge section into Colmatage side achieves 3.9 m/s to 4.6 m/s according to the result of the analysis. The revetments are set up around bridges. And green belt is set up at Colmatage side to control turbulent flow occurring along the long section of the road.

(4) The section of road slope affected by the wave

This section is not water colliding section by floodwater. Huge continuous water surface is formed in flood season and the wave caused by the wind collides with road embankment. In the section mentioned-above and with poor luxuriance of trees along the road at present, green belt is set up to gain the effect of reducing the wave colliding.

(5) General Section of Road Embankment

Sod which is easy to be obtained at the site is transplanted to all new slopes except at the slope at which the revetment is set up to prevent against gully erosion on the slope of the embankment caused by rainfall, and slope collapse and scouring caused by inundation during flood season. Cement treated soil is applied from the top to 1.0 m below H.W.L of the slope to reinforce the countermeasure against erosion. This cement treated soil is applied at all slopes except the slope section of wet masonry revetment and staunch side slopes.

The summary of countermeasures against road slope erosion mentioned-above is shown in Table 2.2.2.8-1 and location map of countermeasures against road slope erosion is shown in Figure 2.2.2.8-1.

Table 2.2.2.8-1 Countermeasures against Road Slope Erosion

The Mekong River Side					Colmatage Side				
Symbol	Section	Length (m)	Type	Note	Symbol	Section	Length (m)	Type	Note
EP-1-L	18+500 -19+100	600	Green Belt	Water colliding section Upstream	EP-1-R	31+600 -33+000	1,400	Green Belt	Wave colliding section
EP-2-L	19+100 -19+600	500	Wet masonry	Water colliding section	EP-2-R	41+500 -44+350	2,850	Green Belt	Bridge & Wave colliding Section
EP-3-L	21+550 -22+000	450	Green Belt	Water colliding section Upstream	EP-3-R	47+610 -48+970	1,360	Green Belt	Bridge & Wave colliding Section
EP-4-L	22+100 -22+280	180	Wet masonry	Water colliding section					
EP-5-L	32+500 -33+000	500	Green Belt	Curved Section					
EP-6-L	35+300 -35+550	250	Green Belt	Water colliding section Upstream					
EP-7-L	36+000 -36+500	500	Green Belt	Water colliding section Upstream					
EP-8-L	36+500 -36+880	380	Wet masonry	Water colliding section					
Subtotal of Green Belt		2,300			Subtotal of Green Belt		5,610		
Subtotal of Wet Masonry		1,060			Subtotal of Wet Masonry		0		
Total		3,360			Total		5,610		
Total of Green Belt		7,910							
Total of Wet Masonry		1,060							
Total		8,970							
Sodding is set up at all new road slope except at the slope at which the revetment is set up. Flat concrete revetment is set up around the bridges and wet masonry revetment is set up around the culverts (box and pipe).									

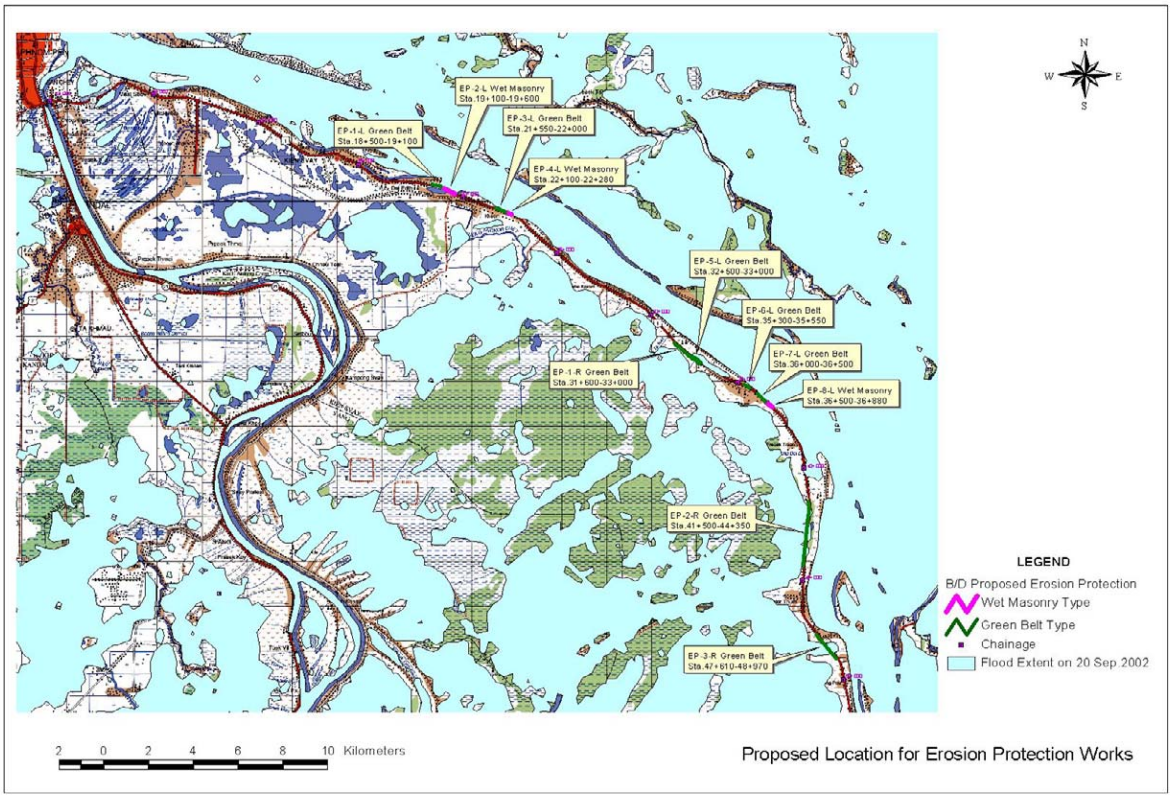


Figure 2.2.2.8-1 Location Map of Countermeasures against Road Slope Erosion

Cross section of Countermeasures against Road Slope Erosion is shown in Figure 2.2.2.8-2 - Figure 2.2.2.8-4.

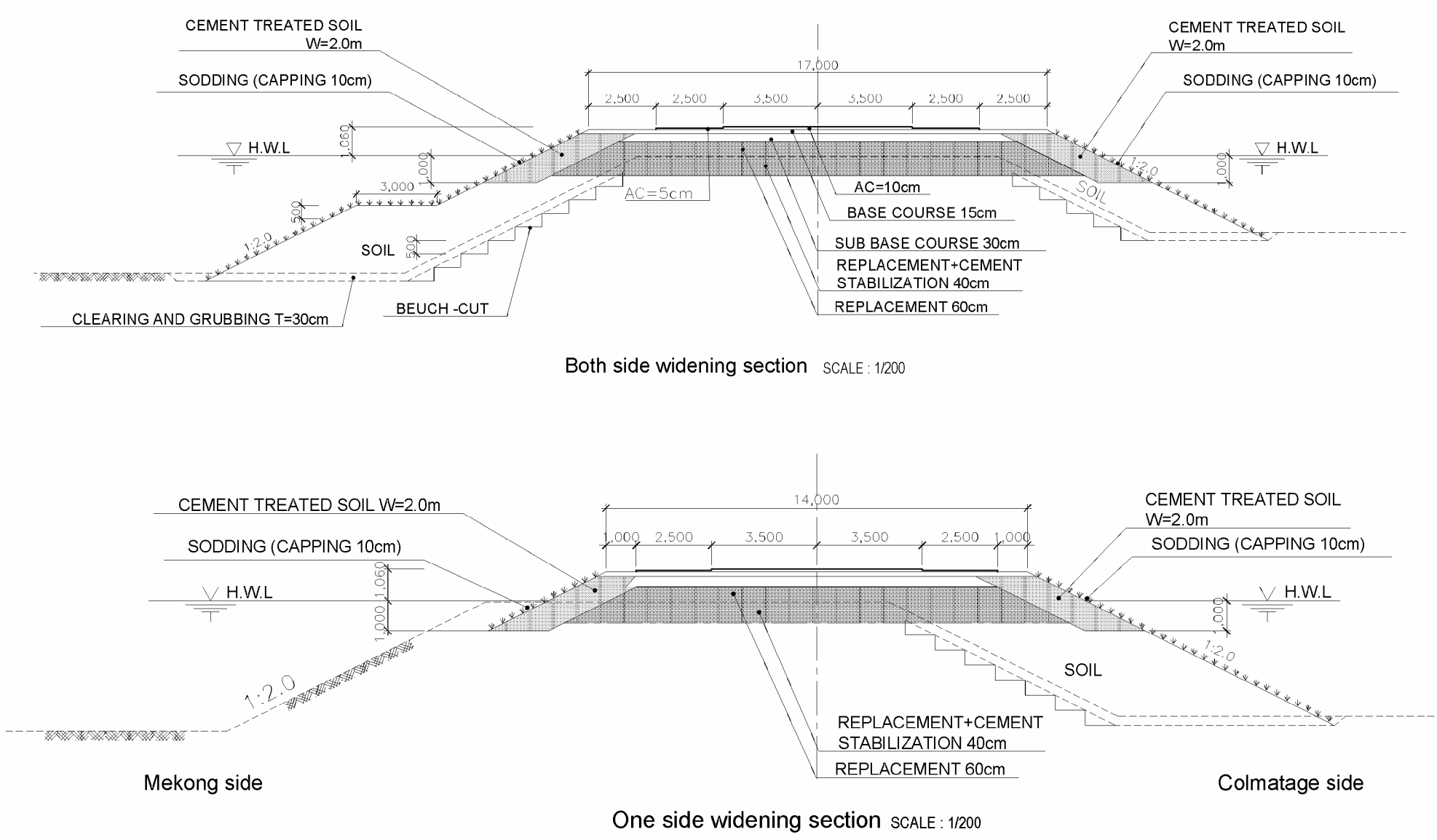
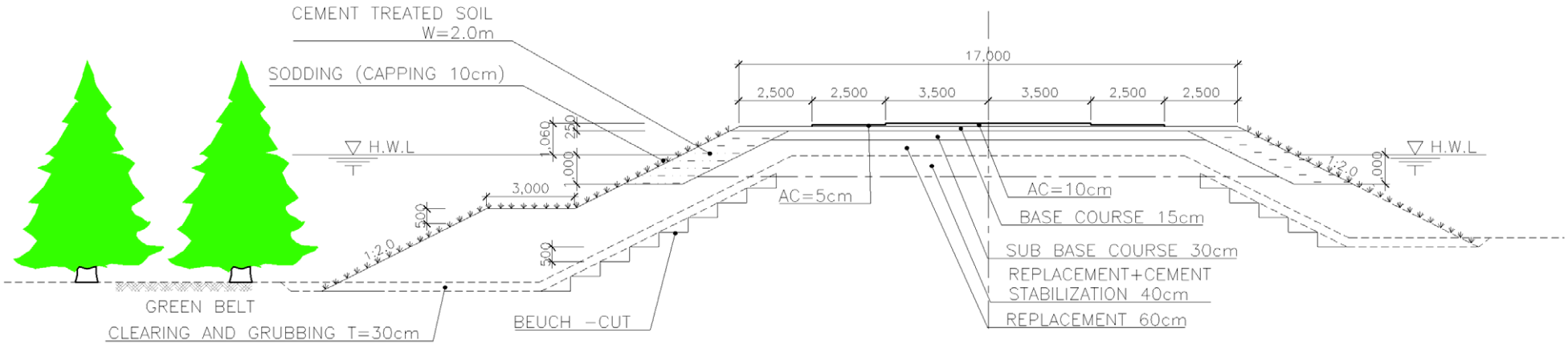
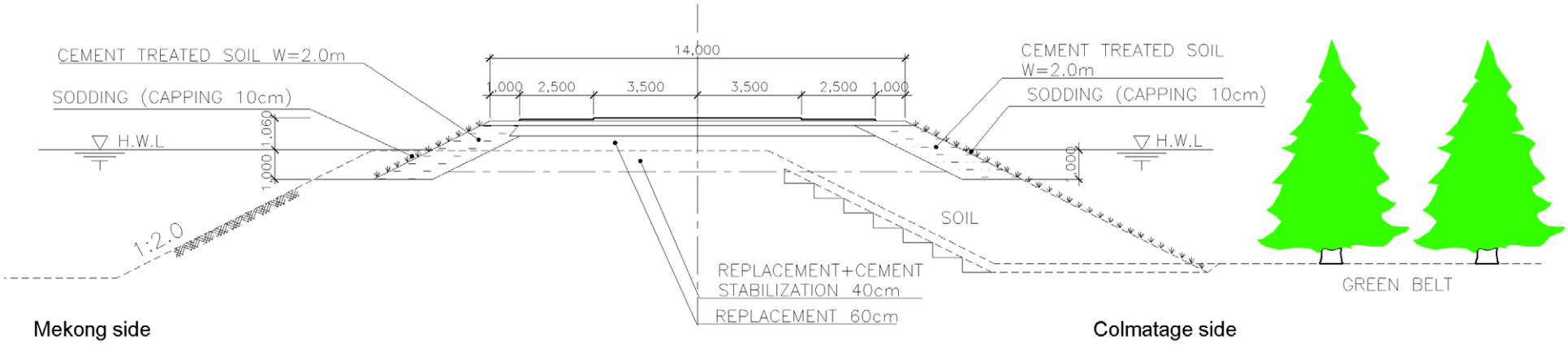


Figure 2.2.2.8-2 General Section of Road Embankment



Both side widening section SCALE : 1/200



One side widening section SCALE : 1/200

Figure 2.2.2.8-3 Green Belt

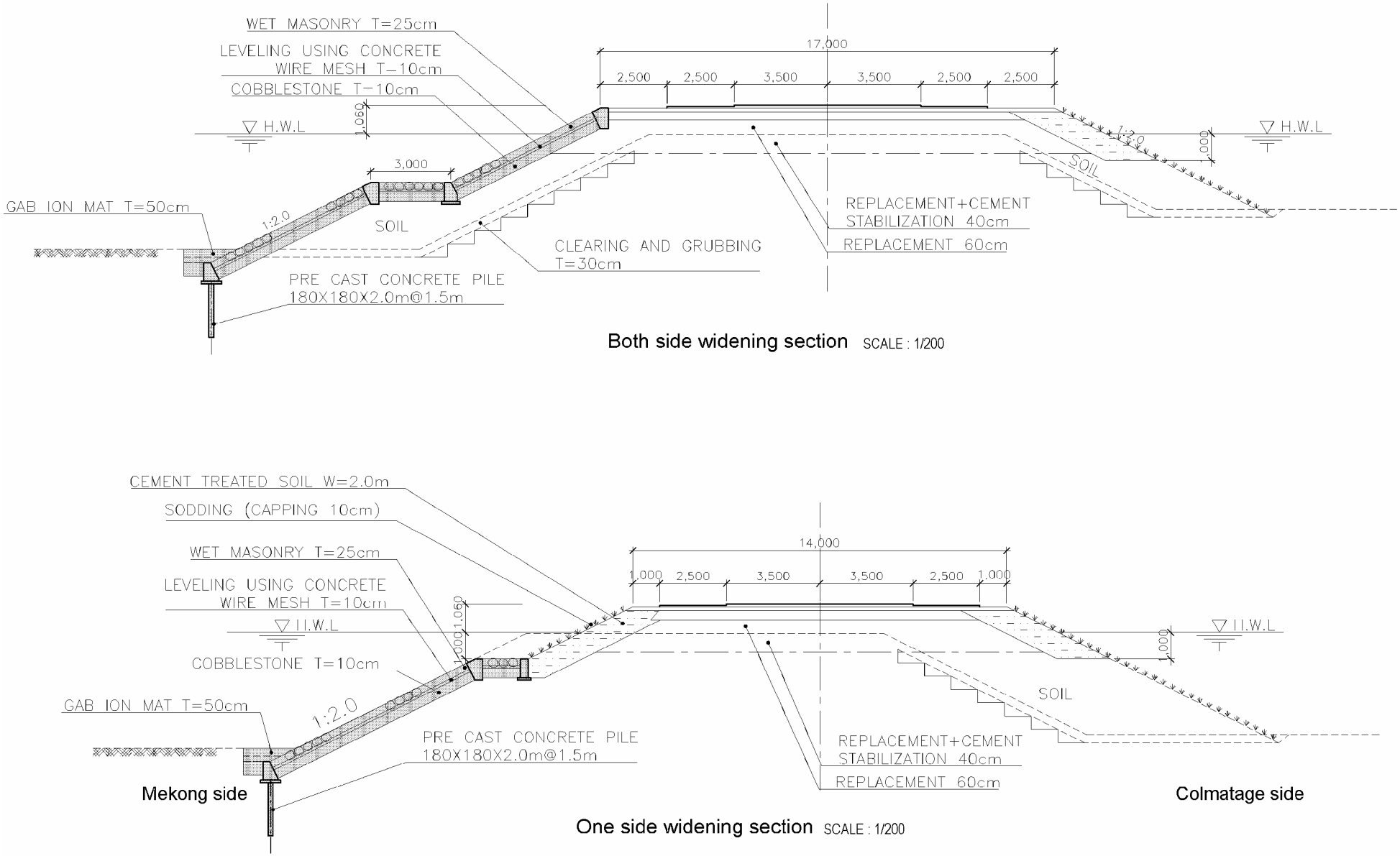


Figure 2.2.2.8-4 Wet Masonry Revetment

2.2.2.9 Design of Countermeasures against Soft Ground to Embankment

The new road embankment ground is floodplain. There are places at which soft silty cohesive soil and/or humus soil is deposited. Countermeasure against the places at which harmful consolidation settlement and/or slope slip may occur due to the embankment is designed based on the conditions below.

- Definition of the ground applied the countermeasure design
  Cohesive soil of N value ≤ 4 and Unconfined compressive strength : $q_u \leq 60 kN/m^2$
- Analyses
  One dimension consolidation settlement analysis
  Slip slope analysis
- Required Conditions for the stability of road embankment
  Residual settlement at the time of surface course work $S_r \leq 5$ cm
  Slip safety factor $Fs_{min} \geq 1.2$

Cross section of replacement method is shown in Figure 2.2.2.9-1.

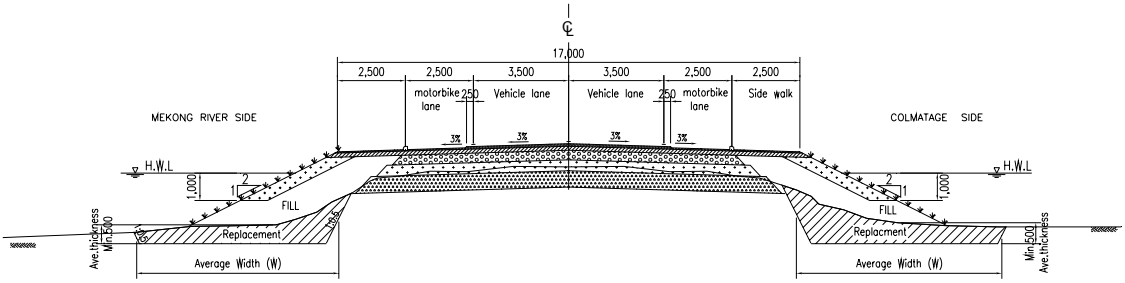


Figure 2.2.2.9-1 Cross Section of Replacement Method

Replacement thickness (t) and width (w) depend on the height and the soft layer thickness. Dimension of replacement method every section is shown in the Table 2.2.2.9-1. With regard to the classification of replacement materials, sands will be adopted for the sections where cannot be compacted due to under the water full-time, however, high-quality soils will be applied for the remaining sections.

Table 2.2.2.9-1 Dimension and Quantity of Replacement Method

Replacement by Soil

Station	Mekong Side				Colmatage Side			
	Length	Ave. Thickness	Ave. Width	Section Area	Length	Ave. Thickness	Ave. Width	Section Area
	m	m	m	m²	m	m	m	m²
0.0 km - 1.0 km								
1.0 km - 2.0 km								
2.0 km - 3.0 km	640	0.68	9.47	6.44	680	0.49	9.74	4.77
3.0 km - 4.0 km	800	0.64	8.35	5.34				
4.0 km - 5.0 km	800	1.02	5.32	5.43	800	0.76	4.32	3.28
5.0 km - 6.0 km	720	0.50	8.66	4.33	840	0.50	5.72	2.86
6.0 km - 7.0 km	560	0.87	7.93	6.90	680	0.50	6.36	3.18
7.0 km - 8.0 km	840	0.83	6.65	5.52	600	0.50	6.91	3.46
8.0 km - 9.0 km	680	0.50	8.02	4.01	840	0.50	5.37	2.69
9.0 km - 10.0 km	720	0.50	6.64	3.32	1,000	0.50	5.94	2.97
10.0 km - 11.0 km	920	0.72	5.07	3.65	920	0.56	6.68	3.74
11.0 km - 12.0 km	360	0.70	8.13	5.69	640	0.96	4.55	4.37
12.0 km - 13.0 km	840	1.39	6.94	9.65	1,000	1.84	6.16	11.33
13.0 km - 14.0 km	880	0.54	7.22	3.90	880	0.29	3.40	0.99
14.0 km - 15.0 km	680	0.81	11.01	8.92	440	0.52	3.54	1.84
15.0 km - 16.0 km	600	0.50	2.12	1.06	640	0.50	5.82	2.91
16.0 km - 17.0 km	360	0.50	21.92	10.96	560	0.80	3.71	2.97
17.0 km - 18.0 km	320	0.50	7.90	3.95	480	1.26	9.58	12.07
18.0 km - 19.0 km	640	0.80	7.86	6.29	960	1.00	8.44	8.44
19.0 km - 20.0 km	520	0.94	14.82	13.93	440	1.02	12.96	13.22
20.0 km - 21.0 km	1,000	0.50	6.32	3.16	1,000	0.66	6.10	4.03
21.0 km - 22.0 km	1,000	0.50	5.72	2.86	1,000	0.50	6.41	3.21
22.0 km - 23.0 km					1,000	0.95	7.21	6.85
23.0 km - 24.0 km					1,000	1.50	5.18	7.77
24.0 km - 25.0 km					1,000	0.83	5.51	4.57
25.0 km - 26.0 km					1,000	0.50	5.37	2.69
26.0 km - 27.0 km					1,000	0.50	5.86	2.93
27.0 km - 28.0 km					1,000	1.17	5.26	6.15
28.0 km - 29.0 km	840	0.50	5.10	2.55	1,000	0.69	6.59	4.55
29.0 km - 30.0 km					1,000	0.50	6.55	3.28
30.0 km - 31.0 km	80	1.50	2.63	3.95	920	0.80	7.51	6.01
31.0 km - 32.0 km	360	0.73	4.40	3.21	920	0.72	6.50	4.68
32.0 km - 33.0 km	480	1.82	9.97	18.15	560	0.90	7.01	6.31
33.0 km - 34.0 km					1,000	1.90	6.58	12.50
34.0 km - 35.0 km					1,000	1.77	6.32	11.19
35.0 km - 36.0 km					1,000	1.62	4.72	7.65
36.0 km - 37.0 km					1,000	1.25	7.38	9.23
37.0 km - 38.0 km					1,000	0.70	7.65	5.36
38.0 km - 39.0 km					760	0.55	11.31	6.22
39.0 km - 40.0 km					1,000	0.60	8.58	5.15
40.0 km - 41.0 km					1,000	0.75	7.36	5.52
41.0 km - 42.0 km					1,000	0.65	9.11	5.92
42.0 km - 43.0 km	240	1.48	10.25	15.17	920	0.92	10.47	9.63
43.0 km - 44.0 km	40	0.50	5.28	2.64	1,000	0.90	6.51	5.86
44.0 km - 45.0 km					1,000	1.00	4.51	4.51
45.0 km - 46.0 km					720	0.94	6.45	6.06
46.0 km - 47.0 km					1,000	1.00	16.36	16.36
47.0 km - 48.0 km	240	0.50	13.30	6.65	960	1.00	10.73	10.73
48.0 km - 49.0 km	40	0.50	20.88	10.44	1,000	2.30	6.70	15.41
49.0 km - 50.0 km					1,000	2.15	5.06	10.88
50.0 km - 51.0 km					920	1.68	5.14	8.64
51.0 km - 52.0 km					920	0.91	4.82	4.39
52.0 km - 53.0 km					1,000	1.07	5.84	6.25
53.0 km - 54.0 km	80	0.50	11.56	5.78	600	0.50	5.30	2.65
54.0 km - 54.5 km	240	0.50	14.76	7.38	360	0.50	15.00	7.50
Total	16,520				44,960			

Replacement by Sand

Station	Mekong Side				Colmatage Side			
	Length	Ave. Thickness	Ave. Width	Section Area	Length	Ave. Thickness	Ave. Width	Section Area
	m	m	m	m²	m	m	m	m²
2.0 km - 3.0 km					80	1.00	7.80	7.80
3.0 km - 4.0 km					920	1.40	4.54	6.36
4.0 km - 5.0 km					80	1.50	6.63	9.95
8.0 km - 9.0 km					200	1.50	2.79	4.19
9.0 km - 10.0 km					80	1.50	5.49	8.24
11.0 km - 12.0 km	640	1.50	5.46	8.19	360	1.50	6.83	10.25
12.0 km - 13.0 km	160	1.50	8.91	13.37				
Total	800				1,720			

2.2.2.10 Intersection Design

(1) Chba Ampov Intersection (Sta.0+000)

This intersection is contiguous to Monivon Bridge and the Kokir Market, therefore the traffic is very congested. The improvement alternatives: three (3) types such as channelized T-type intersection, channelized Y-type intersection and rotary type intersection are compared and evaluated from the viewpoint of traffic flow etc. The T-type intersection is judged as the best intersection type. However, in the case of T-type intersection, the arrangement of detour is necessary, but there is no arrangement plan of detour in the Royal Government of Cambodia which makes the improvement work of the intersection is difficult in this Project. Furthermore, drastic measure is necessary for the reconstruction of Monivong Bridge by 4-lane due to the saturation of traffic volume. Therefore, only overlay is applied to this intersection.

T-type intersection is shown in Figure 2.2.2.10-1 and the comparative evaluation is shown in the Table 2.2.2.10-1.

(2) Tiger Beer Road Intersection (Sta.6+953.1)

The service level is above C judging from the present traffic volume and from the future traffic volume 10 years later, therefore, the improvement of this intersection is ordinary T-type intersection, refer to Figure 2.2.2.10-2.

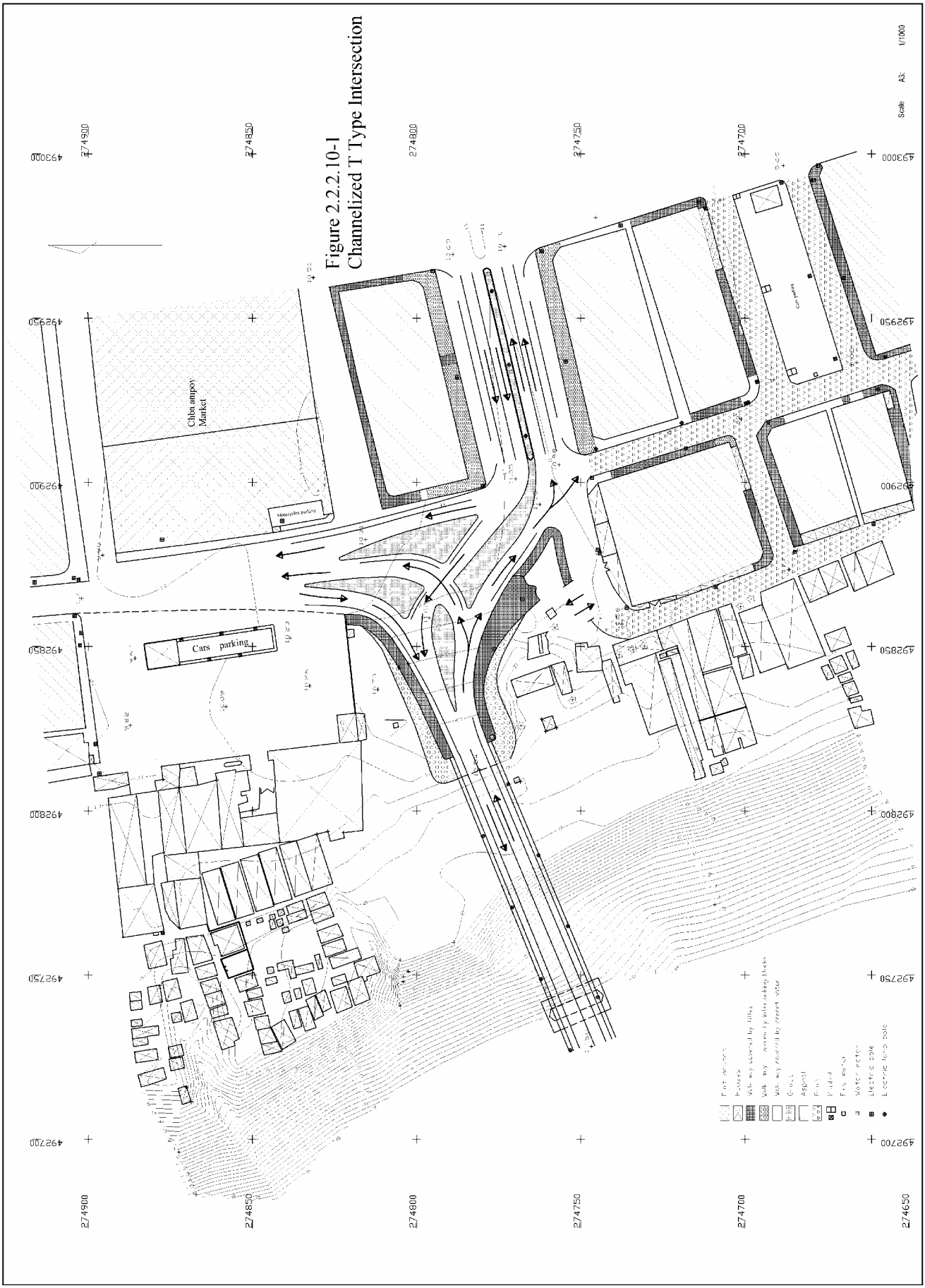
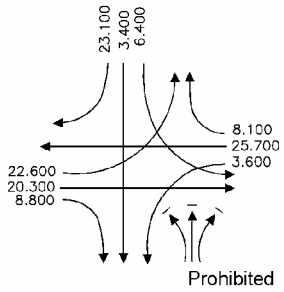
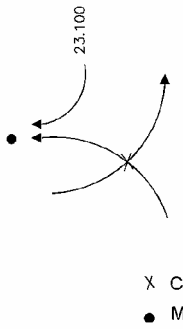
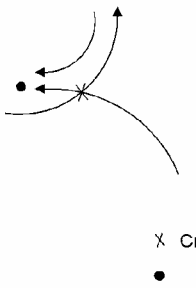
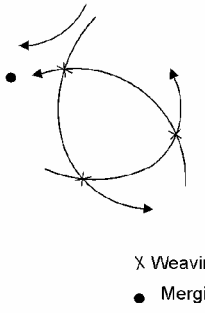


Figure 2.2.2.10-1
Channelized T Type Intersection

Table 2.2.2.10-1 Comparative Evaluation of Chbar Ampov Intersection

	Schematic Traffic Flow	Traffic characteristics
Present Traffic Condition		- Presently, the volume of motorbike is about 90% of total traffic. - Completely free flow. - Heavy side due to car parking along road side. - Present interestion type may be acceptable until the volume of traffic remains same as the present. - Asphalt concrete over lay is adopted for the improvement. X
Scheme-1, T - Type		- Channelized T-type intersection - Following movements are prohibited at the intersection and rerouted to a next intersection. (see Figure.) - Left turn from Neak Loueng - Through traffic along Market and - Left turn from Market to Neak Loueng - Points of crossing and merging of heavy traffic are separately located with reasonable distance which can provide waiting space. - Recommendable especially for vehicle movement. ○
Scheme-2, Y - Type		- Channelized Y-type intersection. - The movements same as scheme-1 are prohibited thus require the rerouting of traffic. (same as scheme-1.) - Points of crossing and merging of heavy traffic is located at same location which may create traffic congestion. - Not recommendable unless strict traffic enforcement at crossing point is implemented. △
Scheme-3, T - Rotary Type		- Rotary type intersection. - All movements are allowed. - Three point of weaving / crossing of heavy traffic may create traffic congestion. - Widening of roadway. (reconstruction of retaining wall is required.) - Recommendable only for light vehicle, but not recommendable for future. X

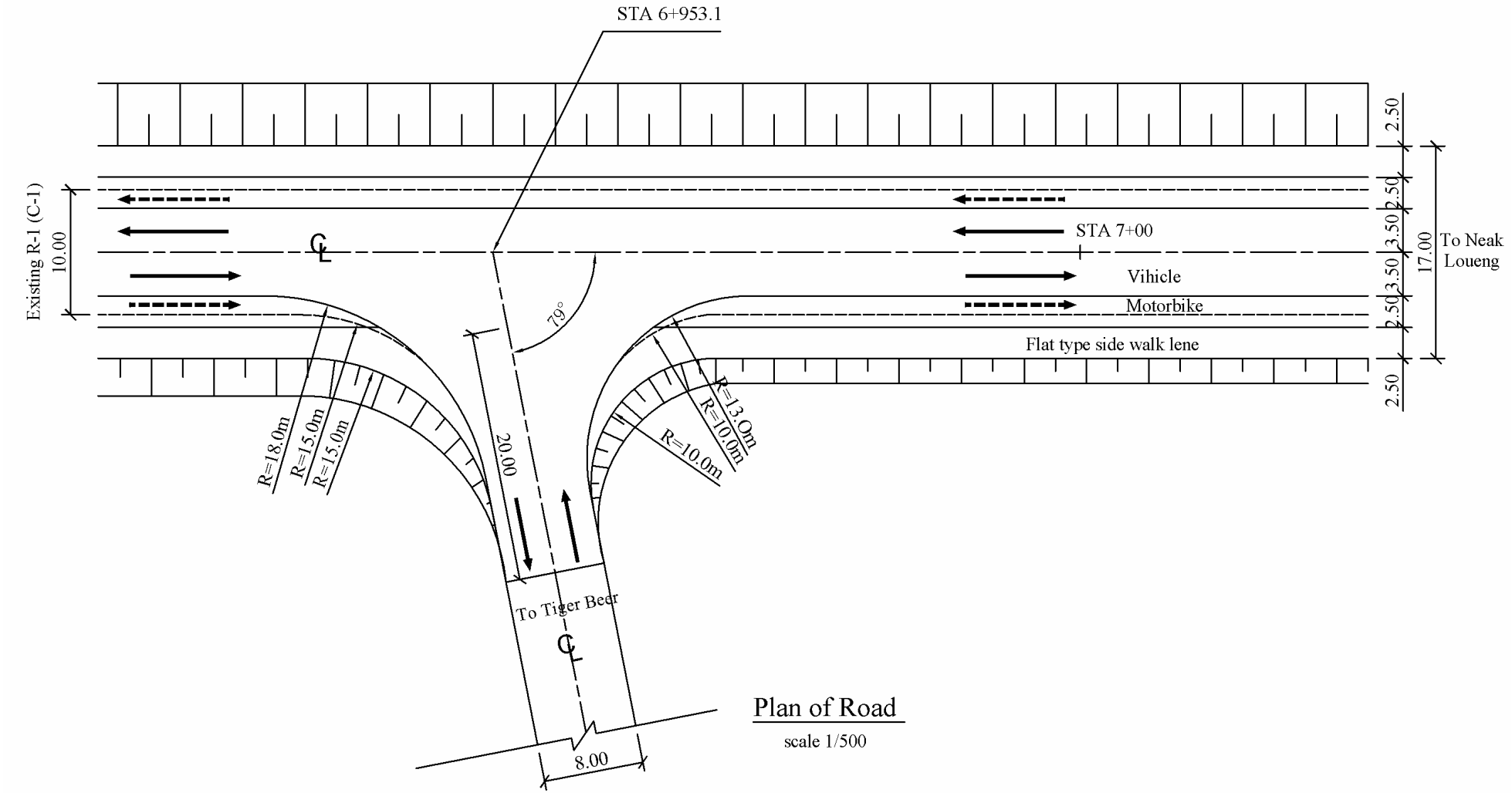


Figure 2.2.2.10-2 Tiger Beer Road Intersection

2.2.2.11 Ancillary Facilities Design

(1) Retaining Wall

Wet masonry gravity retaining wall is set up at the section from 0+300 to 1+900 instead of embankment slope to minimize the number of PAPs. The schedule of retaining wall is shown in the Table 2.2.2.11-1. The total length of wet masonry gravity retaining wall and L-shape RC retaining wall are 1,635 m and 1,166 m respectively.

Table 2.2.2.11-1 Schedule of Retaining Wall

(STONE MASONRY)

LEFT SIDE					RIGHT SIDE				
NO.	STATION		HEIGHT	LENGTH	NO.	STATION		HEIGHT	LENGTH
	START	END	H(m)	L(m)		START	END	H(m)	L(m)
1	0+450	0+490	3.0	40	1	0+460	0+485	2.5	25
2	0+490	0+506	1.0	16	2	0+485	0+505	1.5	20
3	0+506	0+530	3.0	24	3	0+505	0+530	0.5	25
4	0+530	0+550	1.0	20	4	0+530	0+590	2.5	60
5	0+550	0+565	0.5	15	5	0+590	0+630	2.0	40
6	0+586	0+605	0.5	19	6	0+630	0+670	2.5	40
7	0+605	0+630	1.0	25	7	0+670	0+725	1.5	55
8	0+630	0+650	2.5	20	8	0+725	0+765	1.0	40
9	0+650	0+690	1.0	40	9	0+765	0+880	2.5	115
10	0+690	0+705	2.5	15	10	0+880	0+930	1.5	50
11	0+705	0+725	3.0	20	11	0+930	0+945	2.5	15
12	0+725	0+750	2.0	25	12	0+945	0+990	1.5	45
13	0+750	0+775	3.0	25	13	0+990	1+035	2.5	45
14	0+775	0+800	1.0	25	14	1+035	1+065	3.0	30
15	0+800	0+810	1.5	10	15	1+085	1+095	3.5	10
16	0+810	0+825	3.0	15	16	1+100	1+115	2.0	15
17	0+825	0+850	2.0	25	17	1+165	1+248	1.5	83
18	0+850	0+874	2.5	24	18	1+252	1+290	1.0	38
19	0+874	0+905	1.5	31	19	1+290	1+350	1.5	60
20	0+935	1+010	1.0	75	20	1+775	1+810	2.5	35
21	1+010	1+050	2.5	40	21	1+810	1+830	1.0	20
22	1+050	1+090	1.5	40					
23	1+095	1+130	0.5	35					
24	1+130	1+150	1.0	20					
25	1+150	1+170	3.0	20					
26	1+230	1+245	2.0	15					
27	1+245	1+280	1.0	35					
28	1+635	1+670	1.5	35					
29	1+765	1+785	1.5	20					
LEFT SIDE TOTAL				769	RIGHT SIDE TOTAL				866
TOTAL									1635

(L-SHAPED RC)

LEFT SIDE					RIGHT SIDE				
NO.	STATION		HEIGHT	LENGTH	NO.	STATION		HEIGHT	LENGTH
	START	END	H(m)	L(m)		START	END	H(m)	L(m)
1	0+565	0+586	3.5	21	1	1+065	1+085	3.5	20
2	0+905	0+935	3.5	30	2	1+115	1+125	3.5	10
3	1+170	1+230	4.0	60	3	1+125	1+165	5.0	40
4	1+280	1+330	4.0	50	4	1+350	1+390	3.5	40
5	1+330	1+375	3.5	45	5	1+390	1+430	4.5	40
6	1+375	1+405	4.5	30	6	1+430	1+530	4.0	100
7	1+405	1+560	4.0	155	7	1+530	1+590	4.5	60
8	1+560	1+585	5.0	25	8	1+590	1+725	4.0	135
9	1+585	1+635	4.5	50	9	1+725	1+775	3.5	50
10	1+670	1+710	4.5	40					
11	1+710	1+765	4.0	55					
12	1+785	1+830	3.5	45					
13	1+850	1+870	3.0	20					
14	1+870	1+915	4.0	45					
LEFT SIDE TOTAL				671	RIGHT SIDE TOTAL				495
TOTAL									1166

(2) Pavement Marking and Traffic Sign

Centerline, lane line, borderline and crosswalk are set up as pavement marking. Cat's-eye is set up every 25 m on the centerline. Center line, lane line and border line are set up at all sections of the road, and crosswalk is set up at school and hospital zone.

Traffic signs for traffic safety are set up. Speed limit sign as regulatory sign, chevron board and school zone as warning sign and informatory sign are set up.

(3) Guardrail and Guidepost

Guideposts are set up at the curved alignment sections where radius is under 500 m, culvert approaches and the road with embankment height of over 5 m. In addition, guardrails are set up at bridge approaches, bridges and culverts.

The guardrail and guidepost locations are shown in the Table 2.2.2.11-2. Total numbers of guidepost is 1,010, and total length of guardrail is 360 m.

(4) Truck Scale (Vehicle Weighing Machine)

Within the Cambodia, the damages of the roads and bridges caused by overloading vehicles is remarkable, and become the severe problems from the viewpoints of road maintenance and traffic safety control. Therefore, two (2) truck scales were installed at Sta. 7+000 (right side) and Sta. 52+000 (left side) to regulatory the overloading vehicles

Table 2.2.2.11-2 Location of Guidepost and Guardrail

(Guideposts)

Left Side						Right Side					
No.	Station		Length (m)	Nos. Pitch =5m	Remarks	No. Start	Station		Length (m)	Nos. Pitch =5m	Remarks
	Start	End					Start	End			
1	1+010	1+030	20.0	5	Embankment	1	2+955	2+985	30.0	7	Embankment
2	1+090	1+230	140.0	29	Embankment	2	12+340	12+616	276.0	56	Acute Curve
3	1+330	1+360	30.0	7	Embankment	3	12+720	12+755	35.0	8	Embankment
4	1+750	1+770	20.0	5	Embankment	4	12+800	12+825	25.0	6	Embankment
5	1+875	1+925	50.0	11	Embankment	5	12+875	12+885	10.0	3	Embankment
6	1+955	1+965	10.0	3	Embankment	6	13+110	13+125	15.0	4	Embankment
7	2+050	2+070	20.0	5	Embankment	7	14+222	14+236	14.0	4	Acute Curve
8	2+125	2+160	35.0	8	Embankment	8	16+300	16+448	148.0	31	Acute Curve
9	2+320	2+330	10.0	3	Embankment	9	32+396	32+416	20.0	5	Box Culvert
10	2+950	2+985	35.0	8	Embankment	10	32+424	32+444	20.0	5	Box Culvert
11	3+182	3+713	531.0	107	Acute Curve	11	32+490	32+520	30.0	7	Acute Curve
12	12+715	12+750	35.0	8	Embankment	12	32+980	33+040	60.0	13	Acute Curve
13	12+870	12+890	20.0	5	Embankment	13	36+856	36+876	20.0	5	Box Culvert
14	13+015	13+145	130.0	27	Embankment	14	36+888	36+908	20.0	5	Box Culvert
15	13+617	13+744	127.0	26	Acute Curve	15	40+982	41+006	24.0	6	Box Culvert
16	14+744	14+754	10.0	3	Acute Curve	16	41+010	41+030	20.0	5	Box Culvert
17	16+650	16+745	95.0	20	Acute Curve	17	41+955	42+125	170.0	35	Embankment
18	32+396	32+416	20.0	5	Box Culvert	18	42+255	42+310	55.0	12	Embankment
19	32+424	32+444	20.0	5	Box Culvert	19	42+500	42+710	210.0	43	Embankment
20	32+715	32+800	85.0	18	Acute Curve	20	42+875	43+075	200.0	41	Embankment
21	36+856	36+876	20.0	5	Box Culvert	21	44+326	44+346	20.0	5	Box Culvert
22	36+888	36+908	20.0	5	Box Culvert	22	44+354	44+374	20.0	5	Box Culvert
23	40+982	41+002	20.0	5	Box Culvert	23	46+906	46+926	20.0	5	Box Culvert
24	41+010	41+030	20.0	5	Box Culvert	24	46+934	46+954	20.0	5	Box Culvert
25	42+010	42+115	105.0	22	Embankment	25	46+954	46+980	26.0	6	Embankment
26	42+255	42+290	35.0	8	Embankment	26	47+040	47+075	35.0	8	Embankment
27	42+650	42+690	40.0	9	Embankment	27	48+005	48+310	305.0	62	Embankment
28	42+875	43+000	125.0	26	Embankment	28	48+670	48+750	80.0	17	Embankment
29	44+326	44+346	20.0	5	Box Culvert	29	48+716	48+736	20.0	5	Box Culvert
30	44+354	44+374	20.0	5	Box Culvert	30	48+744	48+764	20.0	5	Box Culvert
31	46+906	46+926	20.0	5	Box Culvert	31	49+971	49+991	20.0	5	Box Culvert
32	46+934	46+954	20.0	5	Box Culvert	32	49+999	50+019	20.0	5	Box Culvert
33	47+850	47+875	25.0	6	Embankment	33	53+565	53+945	380.0	77	Acute Curve
34	48+005	48+090	85.0	18	Embankment	34	53+980	54+050	70.0	15	Embankment
35	48+716	48+736	20.0	5	Box Culvert	35	54+435	54+530	95.0	20	Acute Curve
36	48+744	48+764	20.0	5	Box Culvert						
37	49+971	49+991	20.0	5	Box Culvert						
38	49+999	50+019	20.0	5	Box Culvert						
39	53+955	53+985	30.0	7	Embankment						
TOTAL			2128.0	464		TOTAL			2553.0	546	

(Guardrails)

Left Side				Right Side			
No.	Station		Length (m)	NO.	Station		Length (m)
	Start	End			Start	End	
1	42+125	42+155	30	1	42+125	42+155	30
2	42+224	42+254	30	2	42+224	42+254	30
3	42+710	42+740	30	3	42+710	42+740	30
4	42+843	42+873	30	4	42+843	42+873	30
5	47+875	47+905	30	5	47+875	47+905	30
6	47+973	48+003	30	6	47+973	48+003	30
Sub Total			180m	Sub Total			180m
Total (L+R)				360m			

2.2.3 Basic Design Drawings

Basic Design Drawings are shown in Appendix 8.

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

The basic conditions for implementing the Project are as follows:

- This Project, if approved, will be implemented in accordance with the guidelines of Japan's Grant Aid after the signing of the Exchange of Notes between the Governments of Japan (GOJ) and the Kingdom of Cambodia.
- The Ministry of Public Works and Transport (MPWT) is responsible for implementing the Project.
- The detail design, assistance in tendering, and construction supervision of the Project will be undertaken by a Japanese consulting firm in accordance with a contract between the MPWT and the consultant.
- The construction will be undertaken by the successful Japanese tenderer in awarding the contract with the MPWT.

The basic concepts in the implementation plan and procurement plan are as follows:

- Materials and equipments and labors necessary for the Project will be procured in Cambodia as far as available. Items unavailable locally will be procured from Japan or third countries, which will be selected on the basis of cost, on condition that the quality and supplying capacity meet the requirements.
- Imported materials which are constantly available in the local market will be procured and regarded as local materials.
- Common equipment owned by local contractors will be leased from them.
- The construction method and schedule will be planned reflecting local conditions of climate, topography, geology etc.
- Easy and common construction methods which do not require the use of special equipment or new technology will be adopted as much as available.
- Organizations for construction management by the contractor and construction supervision by the consultant will be established meeting the standardized construction management requirements.
- The traffic shall be maintained during construction period and necessary measures for safety shall be taken.
- Full attention shall be paid to the environmental preservation, preventing the washing away of soil in the rainy season, pollution of river, minimizing the noise/vibration, impact against traffic in urbanized areas etc.

The Project is implemented under three (3) stages, taking into consideration the environmental and social aspects.

Stage-1 : Bridge No.2 and No.3

Stage-2 : Sta.13+100 ~ Neak Loueng

Stage-3 : Sta.0 ~ 13+100

2.2.4.2 Implementation Conditions

(1) Securing of safety for the road users and construction

1) During Road Construction

A space of at least one lane shall be opened to traffic which is controlled by alternate passing. Necessary safety facilities such as notice signs, detour signs, safety cones safety light and traffic control men shall be properly placed.

2) During Structure Construction

- The detour shall be provided for the existing traffic.
- The workers engaging in works at high place shall be prevented from falling down by putting proper equipment/facilities for going up and down, downfall prevention facilities etc.

(2) Environmental Considerations

- Measures to prevent the dust pollution during road construction shall be undertaken by sprinkling water etc.
- Proper maintenance shall be carried out for the existing road utilized in transporting the materials and equipment.
- The construction methods minimizing the noise/vibration are adopted in the populated areas: Sta. 0+000 - Sta.23+900 and Sta.53+400 - Sta.55+980.

(3) Considerations on Natural Condition

It shall be difficult to carry out the embankment, substructure, revetment and riverbed protection in the rainy season because the Mekong River covers the bed of road embankment from July to November. Therefore, those works shall be carried out in the dry season or when the Mekong River does not affect them from December to June.

2.2.4.3 Scope of Works

The undertakings of both governments of Japan and Cambodia are listed in Table 2.2.4.3-1.

Table 2.2.4.3-1 Undertakings of Both Governments

Items	Contents	Undertaking by		Remarks
		Japan	Cambodia	
Procurement of materials and equipment	Procurement & delivery	○		
	Tax exemption and customs clearance		○	
	Maintenance/improvement of delivery route		○	
Preparatory Works	Acquisition of lots for construction	○		Site office, stock yard, plant yard, working area, etc.
	Other preparatory works	○		
Removal/ relocation of obstructions	Removal of ground obstructions		○	Electric posts and wire, etc.
	Removal of underground obstructions		○	Optical cables, water pipes etc.
Demolition of existing bridges	2 Bailey bridges	○		
Construction works	Road improvement	○		
	Construction and improvement of structures: 3 bridges 9 culverts: 2 pipe culverts, 7 box culverts	○		
	Construction of revetments	○		

2.2.4.4 Consultant Supervision

A Japanese consultant will carry out the detailed design, assistance in tendering and construction supervision in accordance with the contract between the MPWT and the Consultant.

(1) Detailed Design

Major works in the detailed design to be carried out by the consultant are as follows:

- Review of road design, opening design, revetment design, and drawings prepared during the Basic Design Study;
- Review of the construction plan and materials/equipment procurement plan prepared during the Basic Design Study; and
- Review of the cost estimation prepared during the Basic Design Study.

The necessary time for the Detailed Design is one and half (1.5) month for Stage-1, three (3) months for Stage-2 and two (2) months for Stage-3.

(2) Assistance in Tendering

Major items of the services in the assistance in tendering are as follows:

- Preparation of tender documents (conducted simultaneously with the Detailed Design);
- Tender publication;
- Pre-qualification;
- Assistance in tendering;
- Tender evaluation; and
- Contract facilitation

The necessary time for the assistance in tendering is 3 months for Stage-1, Stage-2 and Stage-3, respectively.

(3) Construction Supervision

The Consultant will carry out the supervision of the construction works executed by the contractor. Major items of the construction supervision are as follows:

- Inspection and approval of site survey;
- Inspection and approval of construction plan;
- Quality control;
- Progress control;

- Measurement of work;
- Inspection of safety aspects; and
- Final inspection and turnover

The necessary construction periods are as follows:

Stage-1 (Bridge No.2 and No.3)	:	16 months
Stage-2 (from Sta. 13+100 to Sta.55+980)	:	28 months
Stage-3 (from Sta. 0+000 to Sta.13+100)	:	17 months

One (1) resident engineer would be in change of construction supervision during Stage-1, because the main component is to improve two (2) bridges only.

As for Stage-2, one (1) more engineer is required to fulfill the tasks because the improvement length is 44.98 km long. The main components involve significant scale of earth works, cement stabilization against sub-grade and subbase course, bridge, culverts and due to soft soil layer, the construction procedure base on monitoring is required. The construction tasks are more than that of ordinary project.

Although the improvement length is 13.10 km in Stage-3, this section is located on the soft soil layer which requires the same monitoring procedure as Stage-2. Many involuntary resettlements would be occurred due to the nature of this area is populous. A lot of detailed meetings with client and close attention to PAPs are required.
Therefore one (1) resident engineer and one (1) more engineer are stationed for Stage-3 as well.

2.2.4.5 Quality Control Plan

The quality control plan for concrete work is shown in the Table 2.2.4.5-1 and the quality control plan for earthwork and pavement work is shown in Table 2.2.4.5-2.

Table 2.2.4.5-1 Quality Control Plan for Concrete Work

Item	Test	Test Method (Specification)	Frequency of Test
Cement	Physical property test	JIS R 5201 - 3	Once before trial mix. Thereafter, once a month or when the material brand is changed.
Fine Aggregate	Physical property test	JIS A 1103	Once before trial mix. Thereafter, once a month or when the material source is changed.
	Sieve analysis	JIS A 1102	Once a month
Coarse Aggregate	Physical property test	JIS A 1110, 1121	Once before trial mix. Thereafter, once in every 1,500 m^3 or when the material resource is changed.
	Sieve analysis	JIS A 1102	Once a month
Water	Quality test	pH, Cl^+	Once before trial mix
Concrete	Slump test	JIS A 1101	Once in every 50m3 for each category
	Moisture content test	JIS A 1111	Once a day
	Compressive strength test	JIS A 1108	6 specimens per 100 m^3 in each category (3 specimens for 7 days strength test and 3 specimens for 28 days strength test)

Table 2.2.4.5-2 Quality Control Plan for Earthwork and Pavement Work

Work Item	Test	Test Method (Specification)	Frequency of Test
Embankment	Density in-situ	JIS A 1214	Once in every 5,000m^3 , 500 m^3 in subgrade.
Base course / subbase course	Sieve analysis	JIS A 1102	Once before placement and when the material source is changed.
	CBR	*Hosou-shiken hou 2-3-1*	Once before placement and when the material source is changed.
	Moisture-density relation	JIS A 1210	Once before placement and when the material source is changed.
	Density in-situ	*Hosou-shiken hou 2-5-3*	Once in every 1,000m^2
Asphalt concrete surface course	Temperature of asphalt mixture	-	As required
	Bulk specific gravity	*Hosou-shiken hou 2-5-3*	Once every 1,500 m^2

2.2.4.6 Procurement Plan

(1) Construction Materials

The construction materials available in Cambodia are sand, crashed stone, aggregate, asphalt concrete, ready mixed concrete (only in and around Phnom Penh), prefabricated concrete products and timbers. All others are imported.

Procurement plan of the major materials is shown in Table 2.2.4.6-1.

Table 2.2.4.6-1 Material Procurement Plan

Item	Procurement Source			Remarks
	Cambodia	Japan	Third Country	
Construction Materials				
Crusher-run (Foundation, roadbed)	○			
Cement	○			
Sand	○			
Crusher-run (Coarse Aggregate)	○			
Reinforcing Bar : D6 - D32	○			
Concrete Admixture		○		Japan
PC Strand Wire			○	Thailand
Bridge Shoe		○		Japan
Non Shrinkage Mortar	○			
Expansion Device 4 PC Girder		○		Japan
Boulder (Wet Stone Masonry)	○			
Reinforced Concrete Pipe	○			
Straight Asphalt			○	Singapore
Mattress Gabion		○	○	Japan, Thailand
Cylinder Gabion		○	○	Japan, Thailand
Concrete Curb Block	○			
Verge Block	○			
Interlocking Block	○			
Concrete Pile	○			
Wooden Pile	○			
Planting Tree	○			
Steel Sheet Pile	○			
Water Stop Plate	○			
Timber	○			
Expansion Joint		○	○	Japan, Thailand
Guardrail		○	○	

(2) Equipment

There is no equipment lease company in Cambodia while equipments owned by local contractors are possible to be leased. The common equipments owned by local contractors are of old model and quantity is not enough for this Project. Special equipments such as large crane, reverse circulation drill, vibration hammer, erection girder facilities, etc. are not locally available and to be procured from the third countries or Japan. Procurement plan of the major equipment is shown in Table 2.2.4.6-2.

Table 2.2.4.6-2 Procurement Plan of Major Equipment

Item	Type	Procurement Source				Remarks
		Cambodia		Third Country	Japan	
		Lease from Local Contractor	Lease near NR1			
Backhoe	0.27m^3				○	
Backhoe	0.5m^3	○		○		Thailand
Backhoe	0.8m^3	○				
Backhoe	1.4m^3				○	
Bulldozer	3 t			○		Thailand
Bulldozer	15 t	○		○		Thailand
Bulldozer	21 t				○	
Motor Grader	3.1m	○		○		Thailand
Road Roller	10～12 t	○				
Pneumatic Tire Roller	8-20t	○			○	Left-hand-drive
Vibration Roller	0.8～1.1 t	○				
Vibration Roller	3～4 t	○				
Vibration Roller	15～18 t				○	
Road Stabilizer	1.2m				○	
Road Stabilizer	2.0m				○	
Water Tanker	6m^3	○				
Dump Truck	10 t	○			○	Left-hand-drive
Agitator Truck	4.5m^3				○	Left-hand-drive
Asphalt Finisher		○				
Asphalt Distributor		○				
Truck	2t、4t	○				
Concrete Mixing Plant				○		Thailand
Sub-base Mixing Plant	105m^3/h				○	
Portable Impact Crusher	53t/h				○	
Crawler Crane	50t	○				
Vibration Hammer	60KW			○		Thailand
Truck Crane	20t			○		Thailand
Reverse Circulation Drill				○		Thailand
Trailer	20～40t	○				

2.2.4.7 Implementation Schedule

At the beginning, the Project was planned to be implemented in two (2) phases as follows:

Phase 1 : Sta.23+900～55+980
Phase 2 : Sta.0+000～23+900

However, it is necessary to take cautious and flexible countermeasures in cope with environmental and social considerations. Following three (3) stages are planned for implementation of the Project considering the progress and result of involuntary resettlement.

Stage	Scope	Budget
Stage-1 :	Construction of No.2 and No.3 Bridge	(by single year government budget)
Stage-2 :	Improvement from Sta.13+100 to Sta.55+980	(by three years government bonds)
Stage-3 :	Improvement from Sta.0+000 to Sta.13+100	(by two years government bonds)

These stagings make taking cautious and flexible countermeasures available in cope with the progress of obtaining the PAPs' agreement.

Moreover, the scoping of Stage-2 and Stage-3 are variable subject to the progress of obtaining the PAPs' agreement (attention must be paid that the implementation schedule would be divided into more stages subject to the progress of agreement been by the Cambodian side).

The Cambodian side shall report the progress of agreement as follows;

Stage-1 : End of March, 2005
Stage-2 : End of October, 2005
Stage-3 : End of October, 2006

Table 2.2.4.7-1 Implementation Schedule

Stage	Work Item			Month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Stage 1	Rehabilitation of 2 Bridges	Detail Design	Site Survey																																
			Work in Japan																																
			Finalization			(Total 1.5 months)																													
		Construction	Preparatory Work																																
			Bridge																																
			Approach Road																																
			Road Facility																	(Total 16.0 months)															
Stage 2	Sta.13+100 ~ Sta.55+980 Rehabilitation of 1 Bridge, 9 Culverts and Road Improvement (L=42.88km)	Detail Design	Site Survey																																
			Work in Japan																																
			Finalization				(Total 3.0 months)																													
		Construction	Preparatory Work																																
			Bridge																																
			Culvert																																
			Road																																
			Road Facility																													(Total 28.0 months)			
Stage 3	Sta.0+000 ~ Sta.13+100 Road Improvement (L=13.1km)	Detail Design	Site Survey																																
			Work in Japan																																
			Finalization			(Total 2.0 months)																													
		Construction	Road																																
			Road Facility																																
			Demobilization																		(Total 17.0 months)														

2.3 Obligations of the Royal Government of Cambodia

The following measures should be undertaken by the Royal Government of Cambodia on condition that the Grant Aid by the Government of Japan is extended to the Project.

- To provide data and information necessary for the Project.
- To relocate existing utilities such as power poles, power cable, optical cable and water pipes, etc.
- To bear commissions to the bank in Japan for its banking services based upon the Banking Arrangement, namely the advising commission of the "Authorization to Pay" and payment commission.
- To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation in Cambodia and prompt internal transportation of the materials and equipment for the Project.
- To exempt Japanese nationals engaged in the Project from customs duties, internal taxes and other fiscal levies, which may be imposed in Cambodia with respect to the supply of the products and services under the verified contracts.
- To accord Japanese nationals, whose services may be required in connection with the supply of the products and the services under the verified contract, such facilities as may be necessary for their entry into Cambodia and stay therein for the performance of their work.
- To provide necessary permission, licenses and other authorizations for implementing the Project.
- To maintain and use properly and effectively the facilities constructed under the Project.
- To coordinate and solve any issues related to the Project which may be raised form third parties or inhabitants in the Project area during implementation of the Project.
- To bear all the expenses, other than those covered by the Japan's Grant Aid, necessary for the Project.

The Royal Government of Cambodia should execute the resettlement of the Project affected people (PAPs) including the followings.

- Agreement on compensation consent from PAPs;
- Confirmation to budgetary arrangement for resettlement compensation
- Compensation payment to PAPs; and
- Rehabilitation of life on PAPs

2.4 Project Operation Plan

(1) Operation and Maintenance System

Maintenance of the Project road after completion will be undertaken by MPWT and Departments of Public Works and Transport of the Municipality/Provinces and those obliged to maintain the Project road. The demarcation of maintaining the Project road is as follows:

Sta.0+000 - Sta.5+000 : Phnom Penh Municipality
Sta.5+000 - Sta.55+980 : Kandal Province

Jurisdictionally, Departments of Public Works and Transport of Municipality/Provinces belong to both MPWT and Municipal/Provincial governments. Demarcation of tasks related to maintenance of roads between the Municipal/Provincial Departments and the MPWT is as follows:

- Daily maintenance works such as cleaning of road surface ditch and culverts, slope vegetation management, maintenance of lighting, etc. are executed by the Municipal/Provincial Departments using the maintenance budgets of Municipal/Provincial governments.
- Repair/rehabilitation works such as crack sealing and pothole patching of pavement, repair of bridge revetment and riverbed protection, etc. are executed by the Municipal/Provincial Departments in some cases and by the MPWT in other cases.

In the former case, the necessary budget for specific tasks is requested to the MPWT and the work is executed using the budget when approved. The inspection to assess the necessity of the works, decide the scope of works and estimate the budget is usually conducted jointly with the MPWT and the Ministry of Economy and Finance.

In the latter case, the Maintenance Management Office set up in the General Directorate of Public Works is in charge.

(2) Maintenance Works to be Done

Necessary maintenance works for the Project road are as follows:

- Daily Maintenance : Routine inspection, cleaning of road surface ditch/culverts, maintenance of slope planting, cleaning of bridge ancillary facilities and maintenance of lighting, etc.
- Repair/Rehabilitation : Sealing of pavement crack, repair of pothole, repair of guidepost, repair of wet masonry (revetment, retaining wall), repair of slope damage, patching of

bridge surface pavement, reconstruction of bridge surface pavement, repair of hand rail, repair of revetment/riverbed protection, repair of older damages, etc.

The daily maintenance and the repair will be done by the Municipal/Provincial Departments of Public Works and Transport and by the MPWT respectively.

Although the road, bridges and culverts to be improved/constructed in this Project have high durability and weather resistance, the repair works of riverbed protection may possibly be necessary after the floods. Since the repair works of riverbed protection and revetment have been carried out frequently in Cambodia, no technical difficulty is expected in executing those repair works. Extensive repairs will not be required for a fairly long time for other structures. No technical difficulty is expected in executing daily maintenance works as well. It is considered possible for the road to be properly operated and maintained under the present system.

2.5 Rough Project Cost

2.5.1 Rough Estimate of Project Cost

The total project cost necessary to implement this Project is estimated at 8,194 Million Yen. The costs to be borne by both governments, Japan and Cambodia based on the scope of works for both governments as previously stated and respective details are estimated as follows on the conditions shown in (3) below.

This cost estimate is provisional and would be further examined by the Government of Japan for the approval of the Grant.

(1) Cost Borne by the Government of Japan

Total Cost	Stage 1	approximately 796 Million Yen
	Stage 2	approximately 4,696 Million Yen
	Stage 3	approximately 2,070 Million Yen
	Total	approximately 7,562 Million Yen

Improvement of National Road No.1, Phnom Penh – Neak Loueng Section (about 56km long)

Item		Roughly Estimated Cost (Million Yen)						
		Stage 1		Stage 2		Stage 3		Total
Facility	Roadway	97	730	3,185	4,473	1,313	1,972	7,175
	Bridge	458		169		-		
	Ancillary Facilities	175		1,119		659		
Detailed Design /Construction & Supervision		66		223		98		387

(2) Cost Borne by the Royal Government of Cambodia

Total Cost approximately 23,160 Million Riel (equivalent to 632 Million Yen)

Item	Roughly Estimated Cost	
	Riel in Million	Equivalent JPN Yen in Million
Compensation to PAPs	8,610	235
Relocation of Power Line	4,180	114
Relocation of Fiber Optical Cable	10,260	280
Relocation of Water Pipe	110	3
Total	23,160	632

(3) Conditions in Cost Estimate

- Time of Cost Estimate: June 2004
- Exchange Rate : 1US Dollar =109.17 Yen
  1,000 Riel = 27.293 Yen
- Construction Period : as shown in the Implementation Schedule
- Others : This Project is implemented in accordance with the system of Japan's Grant Aid.

2.5.2 Estimated Maintenance Cost

The annual costs of the maintenance works are roughly estimated at US$ 21,970 as detailed in Table 2.5.2-1.

When the Project is completed, both routine inspection and daily maintenance work are undertaken by the Department of Public Works and Transport those belong to Municipality and Province. And repair and rehabilitation are undertaken by MPWT.

Table 2.5.2-1 Maintenance Plan and Cost Estimate

1. Routine Inspection (Undertaken by the Departments of Public Works and Transport of Municipality/Province)

Facility	Inspection Item	Frequency	Number of Staff	Equipment	Quantity	Cost (US$/year)
Road		12 times a year (4 days/time)	2 persons	scoop, hammer, sickle, barricade, pick-up truck	Worker: 96 man-day /year	480
Pavement	crack, deformation, pothole, etc.					
Sholder/slope	erosion, collapse, etc.					
Pavement marking	injury, deformation, stain, splitting					
Guide post	damage				Pick-up: 48 veh-day /year	1,680
Revetment	crack, damage, collapse, etc.					
Bridge						
Pavement	crack, deformation, pothole, etc.					
Drainage	existence of soil, obstacles					
Pavement marking	injury, deformation, stain, splitting					
Structure	damage on bridge surface/ abutment/ pier					
Revetment/ Riverbed protection	crack, damage, collapse, etc.					
Ancillary facilities	damage of lighting, apparatus to attach utilities, handrail etc.					
Culvert						
Structure	displacement, damage					
Revetment/ Riverbed protection	crack, damage, collapse, etc.					
					Subtotal	2,160

2. Daily maintenance work (Undertaken by the Departments of Public Works and Transport of Municipality/Province)

Facility	Work Item	Frequency	Number of Staff	Equipment/ Materials	Quantity	Cost (US$/year)
Road		12 times a year (4 days/time)	5 persons	scoop, barricade, mowing machine, broom, tools, pick-up truck, bulb	Worker: 240 man-day /year	1,200
Pavement	cleaning					
Sholder/slope	cleaning, cutting grass					
Pavement marking	cleaning				Pick-up: 48 veh-day /year	1,680
Bridge						
Pavement	cleaning					
Drainage	clearance of soil, obstacles					
Pavement marking	cleaning					
Lighting	cleaning, replacement of bulb					
					Subtotal	2,880
				Subtotal of routine inspection and daily maintenance		5,040

3. Repair/Rehabilitation (Undertaken by the MPWT)

Facility	Work Item	Frequency	Number of Staff	Equipment/ Materials	Quantity	Cost (US$/year)
Road		2 times a year (20 days/time)	8 persons		Worker: 320 man-day /year	1,600
Pavement	crack sealing, patching of potholes,					
Sholder/slope	repair of damages					
Pavement marking	re-marking			Plate tamper	40 unit-day /year	280
Guide post	repair of damages, replacement					
Revetment	repair of damages			Pick-up truck	80 veh-day /year	2,800
Bridge						
Pavement	crack sealing, patching of potholes,					
Drainage	repair of damages			Base course	100 m^3/year	1,000
Pavement marking	re-marking			Asphalt concrete	10 t/year	600
Structure	repair of damages			Cement	100 bags/year	350
Revetment/ Riverbed protection	repair of damages			Boulder	50 m3/year	300
Ancillary facilities	repair of damages, repainting			Road marking paint	1,000 m/year	10,000
Culvert						
Structure	repair of damages					
Revetment/ Riverbed protection	repair of damages					
					Subtotal	16,930
					Total	21,970

The total budgets appropriated for the road maintenance by office in charge in the last three years are shown in Table 2.5.2-2.

Table 2.5.2-2 Total Maintenance Budgets in the Last Three Years

(Unit : US$)

Year		2001	2002	2003
MPWT		2,134,700	1,116,800	1,997,200
Municipality and Province	DPWT of Phnom Penh	715,500	2,027,200	1,052,200
	DPWT of Kandal Province	N/A	143,000	280,000
	Total of Municipality and Province	2,850,200	2,170,200	1,332,200

Note: N/A means not available

The required costs for the routine inspection and daily maintenance of the Project road are 5,040 US$/yr accounting for about 0.4% of the total budgets of the two (2) concerned Municipal/Provincial DPWTs in 2004 appropriated for the road maintenance and the required costs for repair works of the Project road is 16,930 US$/yr accounting for about 0.8% to 1.5% of the budget of the MPWT for the road maintenance. No financial problem in budgets is expected.

Chapter 3 Project Evaluation and Recommendations

3.1 Project Effect

The aim of the Project is to improve the damages and deteriorated pavement observed all through the road, by implementing the road improvement of about 56 km in between Phnom Penh and Neak Loueng, to restore the function and capacity of the Trunk National Road, by widening the road and replacing temporary bridges which are the bottleneck at present, and smoothen the flow of goods and peoples.

The direct beneficial are the residents of Phnom Penh in which the Project located and of Kandal Province, and the indirect beneficial are all the population of 242 million (estimated population in 2003) in Cambodia.

The direct and indirect positive effects under the Project implementation are described on Table 3.1-1, and Table 3.1-2 as below, the negative effects are on the table 3.1-3 and Table 3.1-4.

Table 3.1-1 Direct Positive Effects by the Implementation of the Project

Present Conditions and Issues	Counter Measure under the Project	Effect and its Degree of the Project Improvement
1. Function as Arterial National Road - Road is narrow; - Congested with vehicles and motorcycles being mixed; and - Bridges with one lane The above is causing lower efficiency of traffic flow, and congestion, that is, significantly disturbing the function of as a trunk road.	To widen the road width by separating 4-wheel lane and motorbike lane, and replace or newly construct the bridges. - 4-wheel lane section: 1.8 km (Beginning - Sta. 1+800) - Motorbike lane section: 54.18 km (Sta. 1+800 - Ending) - Bridge replacement/construction: 3 nos.	- To expect the improvement of traffic capacity, reduction of travel time, upgrading of traffic ability and traffic safety. - To upgrade the function of the National Road
2. Function as Lifeline Regarding the market area, bus stop/emergency evacuation space, and schools/hospitals, inconvenience caused by the issues below. - There are no roadside service facilities; and - Restricted or without parking space and sidewalk	To install the roadside service facilities as below along the connecting roads from the rural community or village center. - Small-scale market area: 3 nos. - Bus stop: 20 nos. - School/hospital area: 40 nos.	Marketing activities become active and evacuation space for the livestock can be ensured at the time of flood with securing the smooth traffic flow through the solution on the traffic congestion around the market area, bus stop/emergency evacuation space.
3. Travel Time - Average speed is 30 kph now from Phnom Penh to Neak Loueng about 55.98 km long - Travel time is 1 hour and 50 minutes	- To construct the economic and durable road structure and pavement with high traffic ability.	- Vehicle travel speed becomes 80kph. - Travel time can be shortened as 45 - 50 minutes.

Present Conditions and Issues	Counter Measure under the Project	Effect and its Degree of the Project Improvement
4. Heavy Cargo Traffic Two bridges to be replaced are temporary Bailey bridges with one lane only, and limited to the vehicle loads of 15 tons.	- To replace as the bridges with design active loads by HS20-44.	- To enable heavy cargoes to pass through; and - To promote the efficiency of cargo service.
5. Flood Countermeasures (1) Stage of the Mekong river - There exist two (2) pipe culverts and two (2) box culverts in the opening before 2000 flood. However, each one culvert among these four culverts cannot respectively work. - Two (2) openings were excavated because Phnom Penh municipality was on the edge of submerge riskiness due to the stage of the Mekong River was going up to 10.16 m. Two Bailey bridge were built on both places. - Flood countermeasures are still no sufficient due to the poor conveyance, even four (4) box culverts were newly installed.	Place the additional openings: - Newly construction of one bridge; - Replacement of two (2) bridges; - Newly installation of seven (7) box culverts; and - Newly installation of two (2) pipe culverts.	- To reduce the flood riskiness by lowering the water level of about 11 cm in the Mekong river near the Phnom Penh Municipality.
(2) Road Elevation The difference between the present road surface elevation and flood level in 2000 is only 30 cm on average. Consequently, overflow occurred on three (3) places (total length: 1.1 km) in 2000 flood.	- To raise the road surface elevation by 70 cm on average	- No more overflow occurs at the time of flood; - To enhance the travel safety; and - To improve the durability of road structures.
(3) Slope Damages At the time of flood, damages on bank slopes occurred frequently by the flow especially around the road curves, bridge peripheral parts and water colliding fronts.	- Revetment works will be done for the bank slopes where are easily destroyed so as to mitigate the flow attack; and - To install greenbelt around the said three bridges.	- To sustain the stable embankment with the slope protection of road embankment by installing greenbelt; and - To expect the additional affects as environmental protection.
(4) Refuge Space No refuge space is provided, at the time of flood residents retire to road space and cause at the malfunction of the road.	- Shoulder is widened as bus stop / refuge space at the twenty (20) intersections at connection road.	- At the time of flood, 3,000 residents are available to retire at its maximum.
6. Drainage Facilities - No rainwater drainage facilities within the urbanization areas such as Chbar Ampov, Kokir Market, and Neal Loueng. - To cause the degradation of traffic function and limiting of traffic safety because the rainwater is discharged into the roads during raining.	Installation of road drainage facilities as below: - U-shaped side ditch: L=2,230m (both sides) - Drainage channel: L=5,045m	- To secure the smooth traffic flow and improve the traffic safety by installing the road drainage facilities.

Present Conditions and Issues	Counter Measure under the Project	Effect and its Degree of the Project Improvement
7. Traffic Safety - Road width is almost 6.5m on an average; - High riskiness of traffic accident occurrence due to the traffic is mixed with 4-wheel vehicles and motorbikes without separation.	To improve traffic safety by separating the traffic between vehicle and motorbikes. The following traffic safety facilities were installed. - road marking: centerline, lane, sidetrack, pedestrian crossing - traffic sign: regulatory signs (speed limit), warning signs (sharp turn, school), guide signs - guardrails/guideposts: bridge's or culvert's circumference, fill with height more than 5 m.	- To expect the reduction of traffic accidents by traffic facilitation based on the separation between 4-wheel vehicles and motorbikes - To install the various traffic safety facilities to assure the safety of increasing and speeding-up passing vehicles.

Table 3.1-2 Indirect Positive Effects by the Implementation of the Project

Present conditions and Issues	Counter Measure under the Project	Effect and its Degree of the Project Improvement
1. Smooth Flow of Goods and Peoples Present narrow road width and the structure that is easily damaged by flood, lower the function of national trunk road and limit the smooth flow of goods and peoples.	To upgrade the road structures and improve the function of the national roads.	Improvement of national trunk road function by reducing the transport time and costs will encourage the flow of goods and peoples.
2. Socio-Economic Activities Socio-Economic activities are not activated enough due to inadequate distribution of goods and association of peoples.	To improve the function of national trunk road and upgrade the lifeline function.	To promote socio-economic activities due to the increment of exchange of goods and peoples.
3. Upgrade of Residents' Living Standards along the Road Transport cost is high due to the long transport time of agricultural goods, and poor access to the schools/hospitals and urban facilities.	To improve the traffic ability by larger traffic capacity, and install roadside service facilities	To transport easily agricultural goods, and improve the access to schools/hospitals and urban facilities.

Table 3.1-3 Direct Negative Effects by the Implementation of the Project

Issues	Counter Measures (Counter Measures under/over and above the Project)
1. Increase of Traffic Accident NR1 is functioning as a life road for the residents those stay along the road. There is a possibility of increasing the traffic accident due to the high speed driving after the improvement.	To enlighten all road users' traffic safety consciousness/knowledge, by holding a traffic safety education to the pupil/students and residents, and promote the driving moral through the traffic safety campaign/maintain control of driving speed.
2. Effect by New Opening Water flows into Colmatage through the new openings and erode the agricultural land or residential area. Moreover, there is a possibility to affect fauna and flora.	I.R.C would compensate for the damage when it is confirmed by PAP and MoRAM. It is very difficult to forecast the effect to ecosystem, therefore the Environmental Baseline Survey was conducted in March 2005, and follow up Survey will be conducted to confirm the presence or magnitude of effect.
3. Overloaded Vehicle When the function as arterial road is improved number of car will increase and at the same time illegal overloaded vehicles increase. There is a possibility that overloaded vehicle will damage the pavement and cause the traffic accident.	The truck scales are planned and shall provided through the Project. Cambodian side shall maintain the control of overloaded vehicle by utilizing the provided facility to prevent the road damage or traffic accident due to the overloaded vehicle.

Table 3.1-4 Indirect Negative Effects by the Implementation of the Project

Issues	Counter Measures (Counter Measures under/over and above the Project)
1. Increase of HIV/AIDS Road improvement will activate the human interchange and spread HIV/AIDS.	To enlight all Project employees the fundamental knowledge and prevention means though the safety meeting opportunity during the construction stage.

3.2 Recommendations

The Royal Government of Cambodia is expected to fulfill the following items, issues and recommendations, in order to execute the project satisfactory and maintain the sustainability of the effect of the Project:

(1) Issues

- As for the agreement related to the in voluntary resettlement, Cambodian side should proceed reasonable schedule subject to the appropriate milestone which was agreed with Japanese side and carry out a necessary report to Japanese side.
- To keep good maintenance. It is important, especially to maintain the road pavement and opening structures such as bridges and culverts for the road maintenance. Road maintenance is not only for comfortable driving, but also for prolonging the durability (periods until the maintenance required). To secure adequate budget to have good road maintenance, which is inevitable. It is also important to keep drainage structures and bearings clean, to repair the revetment and riverbed protection, and to maintain the slope vegetation and thus to prolong working life.
- With regard to the Colmatage side, of which influence might come up in the form of water intake into the area, as a result of additional new openings, the attention should be paid to the impact to the social and natural conditions. Especially, within the parts without waterway on the Colmatage side, careful observation should be done to prevent the reverse impact to the existing farmlands and inhabited area from scouring. Therefore, establishment of countermeasure system is required by establishing the information system from the residents to grasp the flooding and disaster etc. information as soon as possible together with the thorough monitoring during the rainy season.

- As a result of road improvement, it is predictable that the traffic speed will be increased. Therefore, it is important to maintain traffic safety by the implementation of traffic safety education, improvement of traffic manner and observance of traffic regulations etc.

- It is indispensable to check whether the resettlement especially those livelihoods of the socially weak are already reintegrated or not. In addition, it is recommended that adoption of those affected inhabitants shall be employed as workers during construction stage, and for the maintenance jobs such as clearing and the crossing guard/guides within the areas of markets/schools/hospitals, to assist the reintegration of livelihood of the said peoples.

- It is recommended that Cambodian side shall utilize the results of Environmental Baseline Survey conducted March 2005, and proceed the monitoring after completion of the Project appropriately.

- To increase the traffic capacity by the improvement of the Monivong Bridge. Moreover, the maintenance of those roads connect with National Road No.1 as much as possible is desirable. Therefore, the expanding effects by the Project can be expected.

(2) Recommendation

Technical assistance on the maintenance and traffic safety measures to be implemented is recommended to ensure the maintenance and traffic safety, and secure manifestation/sustainment of the Project effects. Specifically, system formulation and establishment of guidelines are indispensable.

3.3 Project Adequacy

It is reasonable to judge, upon the reason mentioned below, that the project is adequate to implement under the grant aid program of the Government of Japan:

① It contributes to the improvement of living standard of residents by improving as a life road, reduction of traffic accidents, provision of countermeasure against flood, activation of social and economic activities, as an effects of the project implementation.

② Domestic funds and man-power and technology would be suit for the administration and maintenance, since it doesn't require highly sophisticated technology.

③ The Royal Government of Cambodia has targeted in "the Second 5 years Socio-Economic Development Plan (2001~2005)", to improve trunk roads as an aim of road improvement, in this connection, the present project is worthy to attain the goal of the plan, and in addition, the present project is incorporated in the course of "Asian Highway".

④ Apart from the involuntary resettlement, in terms of negative impacts of the project in aspect of environment social considerations, it is very possible to overcome significantly the impacts, by studying the contents of the present report and reflect the result of it on the design. After completion of the Project, to carry out monitoring is recommended considering the results of Environmental Baseline Survey.

For the involuntary resettlement, careful consideration is due to affected residents, to have approval and concurrence from them., so that based upon the suggestion of the "JICA Advisory Council of Environmental and Social Consideration Reviews", the Basic Study has been carried out from in January to March, 2005, and others, such as Supplemental Study, Baseline Study and Preliminary Study Ⅱ (Second Environmental Social Consideration Supporting Study) have been taken place, for the study of adequacy of the resettlement, of which needs occurred in the Phase-1 portion, to be established under the responsibility of the Government of Cambodia. The result of it has been presented as a suggestion in this detailed design stage, to minimize the negative impacts to PAPs.

3.4 Conclusion

The Implementation of the project is expected to have enormous positive effects, as mentioned above, on condition that the Royal Government of Cambodia shall take an appropriate countermeasures against involuntary resettlement, and contributes to the residents in improving their living standards, it is, therefore, quite adequate to execute the project under the grant aid program of the Government of Japan. Further, in terms of the administration and maintenance after the completion of the project, it is very much likely that the Government of the Cambodia has no problem in arranging the funds and manpower.