Ⅳ FEASIBLITY STUDY

CHAPTER 7

PRELIMINARY ENGINEERING & DESIGN

CHAPTER 7 PRELIMINARY ENGINEERING AND DESIGN

7.1 Introduction

This chapter describes the preliminary design of the road and bridges for the improvement of Routes 14A and 16A, based on the results of the study as described in the previous chapter of Ⅳ Feasibility Study. Design drawings are compiled in Volume 3 in this report. The major design components are:

(a) Road and Intersection Plan
(b) Road Profile
(c) Road Cross Section / Pavement Structure
(d) Road Drainage Facility
(e) Bridge Structure Plan / Profile
(f) Bridge Protection
(g) Others (Guard Rail, Guard Post, Retaining Wall)

The improvement of Road **Route 14A** is from B. **Houay Phek to B. Sukhuma (59.301km)**. The improvement of Road **Route 16A** is from B. 1km mark east of **Paksong** on Route 16 to **B. Lak 52(64.138km).**

Table 7.1.1 and 7.1.2 summarize the Project Route 14A and 16A respectively.

Table 7.1.1 Summary of Route 14A

Route	**14 A**	**Road Length**	L = 59.301 km
Origin	Ban Houay Phek	**Destination**	Ban Sukhuma
Existing Road Surface Type : Earth / Gravel road : 31.601 km, (New Construction : 27.700 km)			
Terrain Conditions : This road runs through the flat terrain with paddy field.			
Socio-economic Conditions: This is the northern part of Route 14A and located in Phonthong, Champasack, and Sukhuma Districts of Champasack Province. The route goes through rice rich and densely populated area along the Mekong River. These three districts have considerable size of fork force in industrial and service sector. Wat Phou, a ruin of ancient Kumer civilization with World Heritage status, generate more traffic into this route.			
Traffic Demand Forecast : year 2020 North Section (B.Houay Phek-B.Phonngam 34.1km) 1,100VPD(incl. motorcycle 3,000) 2,250PCU South Section(B.Phonngam-B.Sukhuma 25.2km) 800VPD(incl. motorcycle 4,681) 2,400PCU			

Road Specification: **Pavement** : Asphalt Concrete, **Design Speed** : 80km/hour, **Carriageway** : 7.0m(3.5m*2-lane), **Paved Shoulder** : 1.0m (2.0m for populated section) **Pavement Area** : 450,000m2, **Embankment Volume** : 790,000m3, **Cutting Volume** : 89,000m3
Bridge Specification: **Effective Width** : 8m for 2-lane **Type and Nos.** : PC-I 22-50m length (11Nos.), RC-I 15m length (3Nos)

Table 7.1.2 Summary of Route 16A

Route	**16 A**	**Road Length**	L = 64.138 km
Origin	Junction of Route 16(East Paksong)	**Destination**	Junction of Route 1 I(Ban Lak52)
Existing Road Surface Type : Earth/Gravel road : 57.838 km, (New Construction : 6.300km)			
Terrain Conditions : This road runs through either a flat (31.7km), rolling (16.4 km) or mountainous (16.0 km) terrain mainly covered with copse. There are some small villages along the road.			
Socio-economic Conditions: This road link passes through the Boloven Plateau area located in Paksong District (Champasack Province) and Saysettha District (Attapeu Province). Ethnic minorities hold majority of the population and literacy rate of the district is 62.3% and student ratio is 22.5%. Cash crops like coffee are cultivated here rather than rice. Accessibility to the market is already secured with the connection to Thai border through Pakse. Route 16A rather contributes to the connection of Attapeu and Sekong province to the west part of the country. Upon the completion of Route 16 east and 18B that run to the Vietnamese border, Route 16A will contribute to transmit traffic from Vietnam to Pakse and to Thai.			
Traffic Demand Forecast : year 2020 Flat Section 1,300 VPD (incl. motorcycle 2,320) 1,950PCU Mountainous Section 3,950PCU			
Road Specification: **Pavement** : Asphalt Concrete, **Design Speed** : 80km/hour (40km/hour for mountainous), **Carriageway** : 7.0m (3.5m*2-lane), **Paved Shoulder** : 1.0m (2.0m for populated section) **Pavement Area** : 471,000m2, **Embankment Volume** : 398,000m3, **Cutting Volume** : 332,000m3(soil) 382,000(rock)			
Bridge Specification: **Effective Width** : 8m for 2-lane, 5m for 1-lane (1No. of PC-I type is 1-lane type, because an existing bridge can be utilized for another lane) **Type and Nos.** : PC-I 25-60m length (6Nos.), RC-I 15m length (1No.)			

Based on a review of design standards applied in previous projects financed by ADB and IDA, as well as the MCTPC Road Design Manual, AASHTO and Japanese Standards, criteria for the Project has been developed taking into account local conditions.

7.2 Road Design Criteria

7.2.1 Road Classification and Geometric Design Criteria

The major components of the geometric design applied for the Project roads are as shown in Table 7.2.1. The design criteria shown in the table modify some figures for the following items from those prescribed in the MCTPC Road Design Manual:

- Lane width : to be reduced on some road classes
- Paved shoulder width : to be reduced on some road classes
- Paved shoulder width : to be increased on some road classes
- Soft shoulder : 0.5m each side to be added 0.5m on both sides

The modified figures are shadowed in the table.

Table 7.2.1 Road Classification and Geometric Design Criteria

1	**Road Design Class**	I			II			III			IV			V			VI			VII		
2	**Traffic Volume (Veh./day)**	＞8000			3000 - 8000			1000 - 3000			300 - 1000			100 - 300			50 - 100			＜50		
3	**Terrain**	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
4	**Design Speed (Km/hr)**	100	80	60	100	80	60	80	60	40	80	60	40	60	40	20	60	40	20	40	30	20
5	**Formation Width (m)**	37.5	35.0	21.5	25.5	22.0	10.0	10.0	10.0	9.0	10.0	9.0	8.0	8.0	7.5	7.5	7.0	6.0	6.0	5.5		
	Number of Lanes	4			2			2			2			2			1			1		
	Lane Width (m)	3.75	3.5	3.5	3.75	3.5	3.5	3.5	3.5	3.0	3.5	3.0	3.0	3.0	2.75	2.75	5.0	4.0	4.0	3.5		
	Carriageway Width (m)	15.0	14.0	14.0	7.5	7.0	7.0	7.0	7.0	6.0	7.0	6.0	6.0	6.0	5.5	5.5	5.0	4.0	4.0	3.5		
	Median (m)	3.0		2.0	-			-			-			-			-			-		
	Paved Shoulder (m) (Outside)	2x2.5	2x1.75	2x1.75 (2x2.5)	2x2.5	2x1.0	2x1.0 (2x2.0)	2x1.0 (2x2.0)	2x1.0 (2x2.0)	2x1.0 (2x1.5)	2x1.0 (2x2.0)	2x1.0 (2x2.0)	2x0.5 (2x1.0)	2x0.5	2x0.5	2x0.5	-			-		
	Paved Shoulder (m) (Inside)	2x0.75	2x0.75	2x0.5	-			-			-			-			-			-		
	Lane of Low Traffic (m)	2x3.0	2x3.0	-	2x3.0	2x3.0	-	-			-			-			-			-		
	Island between Paved Shoulder and Low Traffic	2x3.0	2x3.0	-	2x3.0	2x3.0	-	-			-			-			-			-		
	Unpaved Shoulder (m) (Soft Shoulder)	2x0.5			2x0.5			2x0.5			2x0.5			2x0.5			2x1.0			2x1.0		
6	**Max. Gradient (%)**	5	6	7	5	6	7	6	7	8	6	7	8	7	8	10	7	8	10	8	9	10
7	**Min. Horizontal Curve (m)**	400	250	130	400	250	130	250	130	60	250	130	60	130	60	20	130	60	20	60	30	20
8	**Min. Vertical Curve**																					
	Crest (m)	10000	5000	2500	10000	5000	2500	5000	2500	1000	5000	2500	1000	2500	1000	500	2500	1000	500	1000	500	500
	Sug (m)	3000	2000	1500	3000	2000	1500	2000	1500	600	2000	1500	600	1500	600	200	1500	600	200	600	400	200
9	**Superelevation (%)**	3 - 10																				
10	**Crossfall**																					
	Paved (%)	2 - 3																				
	Unpaved (%)	3 - 4																				
	Paved Shoulder (%)	＞3																				
	Unpaved Shoulder (%)	＞4																				
11	**Road Reserve (m)**	60						40						30						20		

Note : Figures in bracket show the shoulder widths in urban and population area sections.

Road Reserve currently regulated by MCTPC is 50m.

In addition to the above, the following criteria are applied for the Project.

(1) Super-elevation & Radius of Horizontal Curve

Table 7.2.2 Super-elevation and Radius of Horizontal Curve

Radius (m)			Super-elevation (%)
80km/h	60km/h	40km/h	
250-270	130-150	60-70	10
270-340	150-190	70-80	9
340-430	190-240	80-100	8
430-560	240-300	100-130	7
560-740	300-400	130-180	6
740-1,030	400-540	180-240	5
1,030-1,450	540-770	240-350	4
1,450-2,220	770-1,200	350-530	3
2,220-3,200	1,200-1,800	530-800	2

(2) Widening of Curve (m)

(i) Flat (W = 2 x 3.5m): None

(ii) Rolling (W = 2 x 3.5m)

Table 7.2.3 Widening (Rolling Area)

Radius of Curve (m)	Widening (m)
90<R<160	2x0.25
160<R	None

(iii) Mountainous (W = 2 x 3.0m)

Table 7.2.4 Widening (Mountainous Area)

Radius of Curve (m)	Widening (m)
60<R<90	2x0.5
90<R<160	2x0.25
160<R	None

(3) Super-elevation & Widening for Transition Section

Clothoid Curve is applied to ensure smooth traffic flows.

Table 7.2.5 Values for Transition Curve

Design Speed (km/h)	Maximum Transition Rate (m/m)	Minimum Parameter of Clothoid 'A'	Minimum Radius to Omit Transition Section (m)
80	1/150	150	2,000
60	1/125	90	1,000
40	1/100	40	500

(4) Minimum Sight Distance

(i) Stopping Sight Distance

Table 7.2.6 Stopping Sight Distance

Design Speed (km/h)	Minimum Sight Distance (m)
80	100
60	70
40	40

(ii) Passing Sight Distance

Table 7.2.7 Passing Sight Distance

Design Speed (km/h)	Minimum (m)
80	325
60	225
40	160

(iii) Minimum Proportion of Road with Reduced Passing Sight Distance

Table 7.2.8 Minimum Proportion of Passing Sight Distance

Design Speed (km/h)	Class III
80	1/4
60	1/4
40	1/5

7.2.2 Pavement Design Criteria

The Road Design Manual (1996 version) describes two methods of flexible pavement design; namely asphalt concrete pavement for roads with relatively high traffic volume and double bituminous surface treatment (DBST) or gravelling for roads with lower traffic volume. However, the Manual allows the use of different design methods if the conditions require it, after taking into consideration the road category, design strategy, traffic volume, materials available, and environment. DBST has been applied for most current road projects in Lao PDR because of the relatively low traffic volume and its cost effectiveness.

The criteria for selecting pavement type based on traffic volume are as shown in Table 7.2.9. The criteria for design of pavement structures are based on ‘AASHTO Guide for Design of Pavement Structures’.

Table 7.2.9 Criteria for Selecting Pavement Type

Traffic Volume (PCU)	Recommended Pavement Type
PCU < 150	Earth
150 < PCU < 500	Gravel
500 < PCU < 2000	Double Bituminous Surface Treatment (DBST)
2000 < PCU	Asphalt Concrete

7.2.3 Drainage Design Criteria

(1) Return Period for Rainfall

The return period applied for design of road crossing drainage facilities and side ditches is an important factor. Table 7.2.10 shows the return period used for several projects.

Table 7.2.10 Comparison of Return Periods

Facilities	Road Design Manual (MCTPC)	Japanese Standard	ADB Project in Lao PDR
Crossing Facilities (Culverts)	2 – 50 years (Proposal: 20 years)	3 – 7 years (30 years)	20 years
Side Ditches	-	3 years	-

Note : Value in ( ) is for important facilities.

Some parts of national roads were scoured because of insufficient drainage capacity during heavy rain in 2002. MCTPC wishes to adopt a 20-year return period for design of road crossing facilities. The Study also recommends to adopt the following return periods:

Crossing facilities: 20 years

Side ditch: 5 years

(2) Velocity

Maximum velocity for drainage facilities should be regulated to prevent abrasion of the concrete pipe/culvert surface and erosion of culvert approaches. Also, a minimum velocity should be regulated to prevent the accumulation of debris. Table 7.2.11 shows the velocity range for the MCTPC and Japanese standards.

Table 7.2.11 Minimum and Maximum Velocities

	Road Design Manual (MCTPC)	Japanese Standard
Minimum Velocity	-	0.6 m/sec
Maximum Velocity	2.5 m/sec	3.0 m/sec

The velocity range applied for the preliminary design is 0.6 to 2.5 m/sec based on the construction quality in Lao PDR.

(3) Minimum Diameter for Pipe Culverts

Table 7.2.12 Minimum Diameter for Pipe Culverts

Road Design Manual (MCTPC)	Japanese Standard
D 0.80 m	D 0.60 m

The minimum diameter applied for the preliminary design is 0.80m based on the local conditions..

(4) Rainfall Intensity

Values for Route 14A are based on data in Pakse area, while values for Route 16A are based on data in Paksong area. Rainfall intensity for 5 and 20 year return periods is shown in Table 7.2.13.

Table 7.2.13 Rainfall Intensity

Return Period	Route 14A	Route 16A
5 years	120 mm/hr	120 mm/hr
20 years	150 mm/hr	170 mm/hr

(5) Minimum Earth-Cover

A 50cm minimum earth-cover is required to reduce the impact of live loads on culverts. In case minimum earth-cover cannot be ensured, a foundation type of culvert, such as a 360 degree concrete foundation, to ensure adequate culvert strength should be considered.

7.2.4 Earthwork Design Criteria

(1) Cutting Slope

Table 7.2.14 is applied for the grade for cutting slope for the Project based on soil and rock type assessed by the geological survey.

Table 7.2.14 Grade for Cutting Slope (1)

Soil and Rock Type	Slope Gradient
Soil	1：1
Weathered Rock	1：0.5
Sound Rock	1：0.3

However, if other type of soil and rock would be found in future survey or construction stages, Table 7.2.15 could be applied for.

Table 7.2.15 Grade for Cutting Slope (2)

Soil and Rock Type	Slope Gradient
Talus Deposit	1：1.2 ～ 1：1.5
Residual Soil (Clay)	1：1.2
Cracky and Weathered Rock	1：0.5 ～ 1：0.7

(2) Embankment Slope

As for the embankment slope, Table 7.2.16 is applied for the grade based on examination of embankment material assessed by geological and material survey.

Table 7.2.16 Grade for Embankment

Soil Type	Slope Gradient
Clayey Gravel (GC)	1：2

(3) CBR

The value of CBR for embankment and subgrade material is to be higher than the followings.

- Lower Filled Up Ground —
- Upper Filled Up Ground CBR > 2.5
- Subgrade CBR > 8

Note that the material having following conditions at the same time is unsuitable as upper subgrade.

- PI ≧10 (PI = plasticity Index)
- Weight percentage of sieve less than 75 μm ≧ 25%

7.3 Bridge Design Criteria

7.3.1 Review of Design Standards and Criteria

There is no design standard for bridges in Lao P.D.R. The Road Design Manual (1996 version) only designated the live load level for a bridge design according to the road class. Consequently, previous bridge construction projects have different design standards.

Given the immense problems resulting from bridge failure and the high cost of replacement, structural design should be treated with great care. With proper design, construction, and maintenance, a bridge can last for at least 50 years. Accordingly, when designing a bridge, it is necessary to consider not only the present conditions, but also 30 to 50 years in the future. Vehicles are being made larger to accommodate greater loads and the live load has increased

to 20 to 25 tons as a result. Moreover, the design standards and specifications should consider the level of importance and role of the road in the country. Although the Study routes are national roads, their level of importance will be little different from that of a first-grade trunk road such as Route 13.

The Study team developed design criteria suitable for Routes 14A and 16A improvement based on the review of design standards applied in previous projects and the AASHTO and Japanese standards, which have been applied in various bridge projects in Lao P.D.R. The design standard and criteria of previous bridge projects in Lao PDR is summarized in Table 7.3.1. From the table, it can be seen that in the main the AASHTO standard has been used for bridge projects in Lao P.D.R

7.3.2 Bridge Cross Section

Road Design Manual recommends only a minimum bridge width of 6m, between curb faces, for the road class III and IV. Accordingly, previous bridge projects have applied different bridge widths depending on the surrounding condition, which bridges are located. For example, some of them have only carriageway width without shoulder. The Study team observed it would result in the traffic safety issue particularly at night, although the traffic safety facility was installed near the bridge. On the other hand, it should be borne in mind that the bridge cost accounts for a high portion in a road project.

Table 7.3.1 Bridge Design Standards and Criteria in Previous Bridge Project

Project name	IDA	ADB-6	ADB-7
Project Road	-	Rt 16 &Rt 1I	Rt 13S
Section	-	Pakson-Attapeu	Pakse-Cambdian border
1.Bridge Width	-	8.0(10.0)m	7.0m(9.0m)
Carriageway	7.0m	7.0m	7.0m
Footpath	0.5m (each side in near village)	1.0m (More than 100m)	1.0m (in populated area)
2,Design Standard	AASHTO	AASHTO	AASHTO(1989)
Live Load	HS25-44	HS25-44	HS20-44*1.25
Design forces	-	no wind ld	
HWL Frequency	-	50 yrs	-
Freeboard	-	0.6m	-
3.Bridge Type			
RC	-	12-15m span	-
PC	-	18-25m span	-

Project name	Road 9/Eastern Section(ADB)	ADB-9	JICA
Project Road	Rt 9 Eastern	Rt 1I, Rt 16-4, Provincial	Rt 13S
Section	Mouan Phin- Vietnam bd.		Thakekh - Pakse
1.Bridge Width	8.0,7.0(10.0)m	6.0m	9.0(11.0)m
Carriageway	7.0m	6.0m	7.0m
Footpath	1.0m	-	0.5 or 1.0m (popurated area)
2,Design Standard		AASHTO(1992)	Japanese standard
Live Load	-	HS20-44*1.25	B type load (HS25 equivalent)
Design forces		Wind ld, braking ld	no wind ld, Kh=0.06
HWL Frequency	50yrs	50yrs	50yrs
Freeboard	0.5m	1.5m	0.75-1.2m (depending of discharge volume)
3.Bridge Type			
RC	-	-	10,15,18m span
PC	-	13,16,18,22,25m span	22,25,30m span

In consideration of the factors mentioned above, the Study team applied the following bridge widths depending on local condition. A one-meter footpath at each side of carriageway should be provided for bridges in the populated areas or their vicinity. (See Figure 7.3.1)

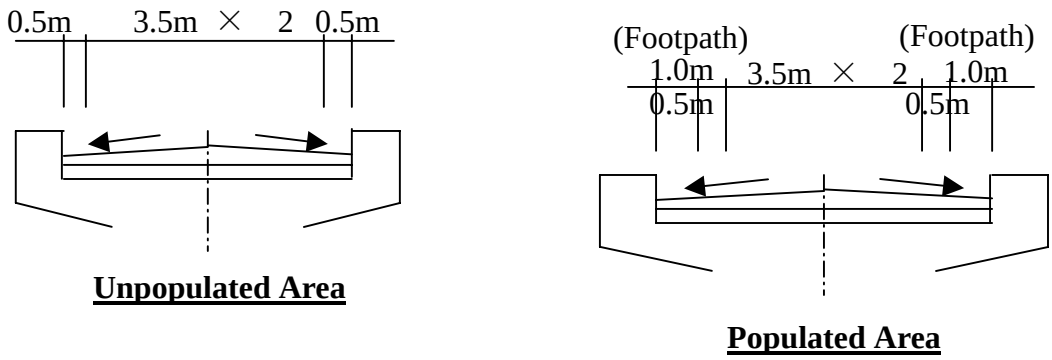


Figure 7.3.1 Bridge Widths for Rout 14A and 16A

7.3.3 Loading Criteria for Bridges

(1) Live Load

Classification

The Road Design Manual (1996 version) specified the live load level for bridge design according to road class. Design live loads to be applied are AASHTO HS-25-44 (equivalent to HS-20-44 * 125%) for the Class I to IV roads, and HS-20-44 for Class V to VII roads. Since the Study roads are classified as Class III, the HS-25-44 live load shall be applied for the bridge design for Rt. 14A and 16A, in consideration of current international tread of an increase in truck loading capacity.

Application of Live Load

Application and distribution of the live load on a bridge shall conform to Article 3.11 and 3.12 of AASHTO standard, respectively.

Impact

The live load shall be increased due to dynamic and vibration effects in accordance with Article 3.8 of AASHTO standard.

(2) Dead Load

The dead load is a main component in determining the weight of a bridge structure. The dead load can be calculated on the basis of the unit weights specified in the AASHTO and Japanese

standards. The major unit weights by material and member are as follows:

Steel material:	7.850 tf/m^3
Reinforced concrete:	2.500 tf/m^3
Prestressed concrete:	2.500 tf/m^3
Plain concrete:	2.350 tf/m^3
Asphalt concrete:	2.300 tf/m^3
Handrail:	0.050 tf/l.m each side

(3) Wind Load

The wind pattern in the Pakse area has been well analyzed in the feasibility study report on the Construction of the Mekong Bridge at Pakse, 1996, by using observatory data from 1957 to 1994. According to the report, 40.6m/sec is appropriate for a 50-year return period and 45.5m/sec for a 100-year return period.

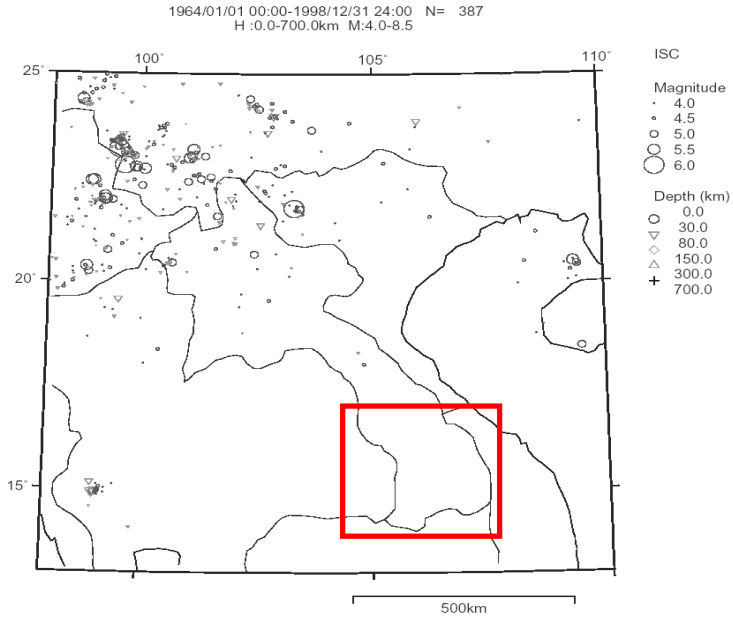
The Japanese standard recommends 40m/s velocity as the wind load for bridge structures, which is estimated as a 50-year return period. The wind velocity condition of the Pakse area can be regarded as the similar level to the basic date of the Japanese standard. Consequently, the Japanese standard is applied for the wind load in this preliminary design when required.

(4) Braking Force

Braking forces shall be taken as 25 percent of the axle weights of the design truck per lane placed in all design lanes in accordance with Article 3.6.1.1.1 of AASHTO, which has traffic headed in the same direction. It is assumed that the forces shall act horizontally at a height of 1.818 m from the roadway surface.

(5) Seismic Force

There has been no strong earthquake in the history of southern Laos according to the database on worldwide earthquakes developed by Tokuji UTSU (an honorary professor at Tokyo University). Furthermore, there has been no earthquake recorded in southern Laos between 1964 and 1998 according to the International Seismological Center, the UK. Accordingly, there is no need to consider seismic forces in bridge design. However, the minimum acceleration coefficient, 0.06, is applied to bridge design to ensure stability and safety in accordance with AASHTO and Japanese standards.



Source: International Seismological Center, the UK

Figure 7.3.2 Earthquake Records between 1964 and 1998 in the Study Area

(6) Thermal Effects

Differential temperature causes both longitudinal and transverse secondary load effects. Variation in average bridge temperature should be based on the locality in the Project area. According to temperature records collected from observations in the Project area, whereas it ranges from 10.1℃ to 40.0℃ in Pakse, and 2.3℃to 29.5℃ in Paksong. Furthermore, a lag between air temperature and internal temperature of massive concrete or steel members should be considered. Consequently, the average temperature range to be applied is as shown in Table 7.3.2.

Table 7.3.2 Range of Temperature Considered in Bridge Design

	Structure Type	Max. Temperature	Min. Temperature
Rt. 14A	Concrete Structure	+40℃	10 ℃
	Steel Structure	+55℃	10 ℃
Rt. 16A	Concrete Structure	+30℃	0 ℃
	Steel Structure	+45℃	0 ℃

(7) Hydrodynamic Force

Hydrodynamic force should be considered for piers, particularly when located in rapid river flows, and it shall be calculated by the following formula:

$$P=K * V^2 * A$$

Where,

P : Pressure intensity in kgf/m2

K : Resistant coefficient of pier according to its shape

V : Velocity of river flow in m/sec

A : Vertical projection area of a pier in square meter

7.3.4 Flood, Navigation and Other Clearances

(1) Frequency of Design Flood

It is important to select an appropriate frequency for design flooding in bridge planning because it has a large effect on construction cost and people's lives. In addition, the scale of a bridge, grade of a road and social and economical impact if the bridge collapses should be considered. As a result of a review of previous road and bridge projects on design frequency, a 50-year return period has been mainly applied to bridge design on national road (see Table 7.3.1).

In consideration of the above, a 50-year return period of flood is sufficient enough for the design water level analysis for bridges in this Project. The reasons in detail are described below.

- All previous bridge projects have applied a 50-year return period.
- Both Project roads have a detour route connecting with district centers. Accordingly, social and economic impacts induced by bridge failure due to flooding can be lessened.
- All bridges on both routes are categorized into small to medium size ones up to 60m in the bridge length and its importance is less than a large-scale bridge with more than 100m in length from the viewpoint of difficulty of replacement.
- For bridges on Rt. 14A, the water level of the Mekong mainly dominates the high water level of the branch rivers. Since water level data during approximately 100 years are available at the Pakse observation station, more accurate estimation of the water level at each return period can be obtained.

(2) Flood Clearance

Flooding clearance is determined in consideration of the presence of debris such as drifting timber in a river during flood. Previous bridge projects applied a clearance ranging from 0.5m to 1.5 m. On the other hand, Japanese standard determines clearance for flood discharge at the design return period. The clearance becomes higher according to an increase in discharge volume (See Table 7.3.3). In this Project, this standard is basically adopted because the value of the standard is similar level to ones in previous projects

Table 7.3.3 Flood Clearance by Design Flood Discharge

Design Flood Discharge Q(m3/s)	Q<200	200<= Q <500	500<= Q <2000	2000<= Q <5000	5000<= Q <1000	10000<= Q
Clearance (m)	0.6	0.8	1.0	1.2	1.5	2.0

However, since the No.2 to No.6 rivers on Rt. 16A run through mountainous area and a large size of drift timbers are observed in rainy season, the minimum clearance therefore it to be set as 1m.

Figure 7.3.3 Drift Timber in Xe Namnoy River in Rainy Season

(3) Navigation Clearance

There is no river that requires clearance for navigation on both Rt. 14A and 16A. Accordingly, the force of a ship collision is not considered in the bridge design.

7.4 Preliminary Design for Roads

The design must take into account the interdependence between geometric features and behavior of drives. The major objectives of design for the Study are as follows:

- To ensure minimum levels of safety and comfort for drivers by taking into consideration adequate sight distances, coefficients of frictions, and road space for vehicle maneuvering.
- To ensure uniformity of alignment
- To ensure that the road design is economical

7.4.1 Road Classification

Road design should be based on traffic volume. Route 14A, is designated as a ClassⅢ road with traffic volumes of 2,250PCU for the design year 2020.

Route 16A, a Class Ⅲ road would normally be recommended for level terrain(approx.1,950 PCU) and a Class Ⅱroad for the mountainous terrain(3,950PCU). However, given priority to economy, it is decided that a Class Ⅲroad has been applied for the entire route of Route 16A in the Study. These forecast traffic volumes are explained in ⅣChapter 11.

Table 7.4.1 Traffic Forecasts (Route 14A)

Part	PCU Year 2008	PCU Year 2020
STA.0+000 B.Houay Phek – STA.34.100 B.Phonngam	880	2250
STA.34+100 B.Phonngam– STA.59.300 Sukhuma	930	2400

Table 7.4.2 Traffic Forecasts (Route 16A)

Part	PCU Year 2008	PCU Year 2020
Mountainous (STA.42+000 – STA.58.000)	1550	3950
Flat (Others)	740	1950

7.4.2 Design Vehicle

The sizes and physical characteristics of vehicles using the road are positive controls in geometric design. The principal vehicle dimensions affecting design are:

- Minimum turning radius
- Path of inner rear tire, tread width and wheel base

The design elements affected are cross-section, road widening in horizontal curves and intersection layout. The design vehicles applied for the Project road are in conformity to the 'Road Design Manual, MCTPC' and its maximum size of vehicle type is the Trailer-truck Combination (WB12) as the following size:

Vehicle width : 2.6 m

Vehicle length : 16.7 m

7.4.3 Design Speed

The design speed should be determined taking into account correlation of the physical features of roads that influence vehicle operation. It is the maximum safe speed that can be maintained over a specified section of road when conditions are so favorable that design features of the roads govern. The following consideration should be taken for the selection of design speed:

- Classification and function of the road
- Nature of the terrain
- Density and character of the adjoining land use
- Traffic volumes expected to use the road

Both Routes 14A and 16A are expected to function as arterial roads and national road links. Most of the sections pass thorough less populated areas. The design speed applying for each project is based on the Road Class and terrain conditions as shown in Table 7.4.3.

Table 7.4.3 Design Speed for Each Route

Route No.	Road Class	Flat Section	Mountainous Section
Route 14A	Class III	80 km/hr	-
Route 16A	Class III	80 km/hr	40 km/hr

As density and character of the adjoining land use varies along a route of some length, the design speed does not have to be constant for the whole length of a road. Changes in the design speed are required in order to obtain proper correlation between the road layout and the above factors.

7.4.4 Cross Section Elements

The cross-section of the Project road is composed of the following element:

- Carriageway
- Paved Shoulder (hard shoulder)
- Unpaved Shoulder (soft shoulder)

The cross section elements for the Project road are shown in Figure 7.4.1 and Figure 7.4.2 for rural section and populated section respectively. The design concepts for deciding the elements of the cross-section are described below.

Carriageway

The lane width of the Project road is to be 3.5 meters, which can ensure a basic minimum level of safety and comfort for drivers, by taking into consideration adequate sight distance, coefficients of frictions and road space for vehicle maneuvering, under the maximum design speed of 80km/hour. The lane width for rural sections and populated sections is the same in order to ensure uniformity of alignment.

Paved Shoulder/Unpaved Shoulder

As for paved shoulder, a 2.0 m width is applied for populated section and a 1.0 m width is applied for rural section taking economic consideration. A 2.0 m paved shoulder in populated sections enables a pedestrian and a cyclist to pass while a 1.0 m one in rural section is passable for either a pedestrian or cyclist. A 0.5 m unpaved shoulder function to keep road pavement and road structures in maintainable conditions. A 2.5% cross fall is applied for asphalt pavement in the Project roads.

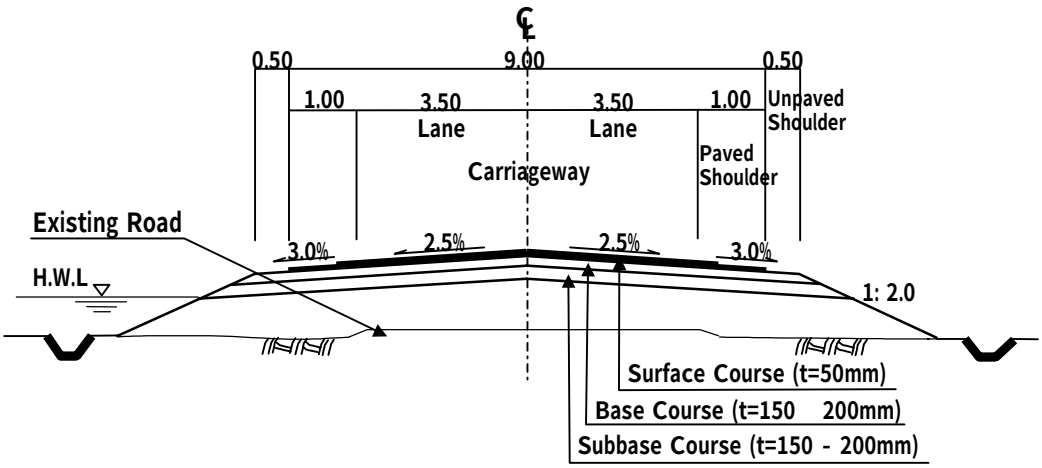


Figure 7.4.1 Typical Cross Section for Rural Section (Flat Area)

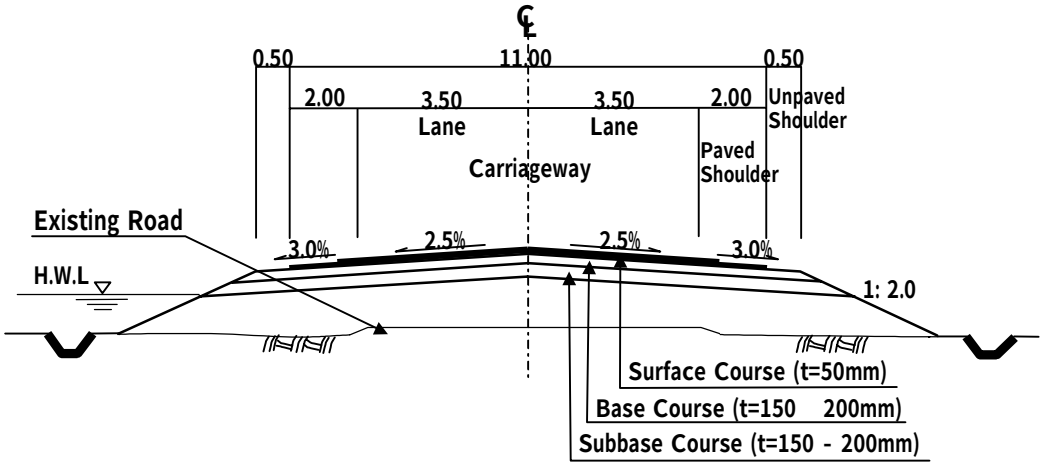


Figure 7.4.2 Typical Cross Section for Populated Section (Flat Area)

Based on the above basic concept, the populated sections requiring a 2.0 meters paved shoulder for Routes 14A and 16A are identified as shown in Tables 7.4.4 and 7.4.5 respectively.

Table 7.4.4 Sections with 2 m Shoulder for Route 14A

Station	Town or Village Name	Length (m)
STA.0+000 – STA.0+500	B. Houay Phek	500
STA.13+650 – STA.14+250	B. Houaypakho	600
STA.16+850 – STA.17+650	B. Khonken	800
STA.19+100 – STA.20+500	B. Khannheng	1,400
STA.21+350 – STA.22+500	B. Vatxay	1,150
STA.24+400 – STA.24+750	B. Phantakham	350
STA.26+900 – STA.28+700	B. Vatthong	1,800
STA.35+500 – STA.35+900	B. Maidonthangkhouay	400
STA.37+400 – STA.37+700	B. Nongnokkhian	300
STA.38+500 – STA.38+800	B. Tangbeng	300
STA.39+400 – STA.39+700	B. Nongnthon	300
STA.41+300 – STA.42+250	B. Dontalat	950
STA.45+750 – STA.47+600	B. Chikthanggo	1,850
STA.49+700 – STA50+050	B. Nongbouakhao	350
STA.51+650 – STA.52+000	B. Bak	350
STA.54+000 – STA.54+500	B. Samkha	500
STA.54+900 – STA.55+300	B. Samkha	400
STA.57+600 – STA.57+800	B. Phonpheng	200
STA.59+200 – STA.59+300	B. Sukhuma	100
Total		12,600

Table 7.4.5 Sections with 2 m Shoulder for Route 16A

Station	Town or Village Name	Length (m)
STA.0+500 – STA.0+500	B. Nongkhengkham	500
STA.8+000 – STA.9+300	B. Nongchan	1,300
STA.10+000 – STA.!11+150	B. Lak 11	1,150
STA.11+150 – STA. 12+900	B. Lak 12	1,750
STA.16+500 – STA.17+500	B. Chansavang	1,000
STA.19+800 – STA.20+800	B. Nonkhaung Noy	1,000
STA.21+400 – STA.22+500	B. Nonkhaung Nhay	1,100
STA.23+000 – STA.24+000	B. Nonkhaung Nhay	1,000
STA.24+900 – STA.25+400	B. Nongkine	500
STA.27+500 – STA.28+100	B. Lak 27	600
STA.31+800 – STA.34+000	B. Nong-E Oil	2,200
STA.60+300 – STA.60+700	B. Lak 56	400
Total		12,500

7.4.5 Alignment Setting

The road geometric form is a three-dimensional (3-D) alignment which is represented in horizontal and vertical alignment. The other elements are super-elevation and sight distance.

The basic concept for the determination of the horizontal alignment is described below.

- The alignment must take into account the control points such as temple, church, graveyards, cemetery, religious monument, school and hospital.
- The alignment must take into account connection with each existing road and configuration of intersection.
- Dividing villages must be avoided as much as possible.
- Due care must be taken to minimize the effects on non-inhabited areas by having the Project roads.
- The alignment must be such that the amount of cutting and filling can be minimized.

The basic concept for the determination of the vertical alignment is described below.

- The alignment must take into account connection with each existing road at grade crossing.
- Road surface height must be determined based on the hydrological analysis.
- Road surface height is increase by 0.6 meters from the existing road surface, even though there has been no sign of flood.
- The alignment must ensure the minimum earth cover overt the road crossing facilities.
- The gentlest gradient can be less than 0.5% while 2.5% is applied for cross fall for asphalt pavement road.
- The alignment must be such that the amount of cutting and filling can be minimized.

Based on the above basic concept, alignment setting for Routes 14A and 16A is executed as shown in Tables 7.4.6 and 7.4.7 respectively.

Table 7.4.6 Alignment Setting (Horizontal / Vertical) for Route 14A

Station	Control Points	Countermeasures
STA.0+150 – STA.0+450	Cemeteries	- Alignment avoids these areas.
Sta.5+000 – STA.34+000	Flooding from Mekong River	- Surface height is designed based on flooding water level of Mekong River (50-year return period).
STA.24+500 – STA.29+000 (STA.26+000 – STA.28+000)	Champasack Town, Three-leg intersection with access ways (11nos.) to farm road, (Houses, Temples and School)	- Alignment avoids this section. - The minimum access ways are connected. - Alignment runs a farm road. and retaining walls are built on the affected places.
STA.30+000 – STA.36+000	Wat Phou, Ancient City	- Alignment passes through a paddy field to avoid these areas.
STA.34+050	Historical Monument	- Alignment passes through 50 m away from the monument.
STA.34+100	Intersection with existing road :14A	- Grade crossing
STA.34+100 – STA.35+500	Populated area (B.Phonngam)	- Alignment passes through a paddy field to avoid houses.
STA.35+500	Meeting point with existing road	- Grade crossing
STA.41+000	Meeting point with existing road	- Grade crossing
STA.41+000 – STA.43+000	Populated area (B.Dontalat)	- Alignment passes through a paddy field to avoid houses.
STA.42+100	Intersection with existing road :14A1	- Grade crossing
STA.43+000	Meeting point with existing road	- Grade crossing
STA.40+035 STA.45+040	Existing bailey bridge	- Hydrological analysis applies taking account of rainfall and discharge water from upstream
STA.55+050	Intersection with existing road :14C1	- Grade crossing

Table 7.4.7 Alignment Setting (Horizontal / Vertical) for Route 16A

Station	Control Points	Countermeasures
STA. 0+750 STA. 14+650 STA. 24+650 STA. 31+700	Cemetery	- Alignment avoids these areas.
STA. 33+700	Intersection with existing road	- Grade crossing
STA. 41+950	Intersection with existing road	- Grade crossing
STA. 42+000 – STA 58+000	Mountainous section	- Apply for mountainous criteria
STA. 51+400 STA. 51+600 STA. 51+950	Existing steel I bridge	- Control of alignment in case the existing will be utilized.

7.4.6 Road Surface Elevation

Between the starting point and Ban Phonsao on Route 14A, the route runs along the Mekong , from which river water overflows during the rainy season. Accordingly, it is a major issue how to define the road surface elevation in this section. The road surface elevation should therefore consider the flooding levels of the Mekong at each return period. The return period adopted for this preliminary design is 50 years for the following reasons:

- 50 years is an appropriate return period from the viewpoint of historical flood levels, estimated return period and construction cost effectiveness.
- MCTPC also wish to apply a return period of 50 years.

(1) Flooding Level and Return Period

Table 7.4.8 shows the flood levels at Champasack and its return period examined by the Study Team.

Table 7.4.8 Estimated Flooding Level and Return Period at Champasack Observatory

Return Period	Flood Level	Remarks
20 Years	97.11 m	Recorded data in 2000
50 Years	97.41 m	
100 Years	97.61 m	
More than 500 Years	98.36 m	Recorded data in 1978

Two large floods were recorded in 1978 and in 2000. The flood in 1978 is the largest and this can be assumed to have a return period of more than 500 years.

(2) Road Surface Elevation

The minimum road surface height at flooding is 60cm higher than a water level at the 50-year return period, because the estimated pavement thickness is 60 cm, and the surface pavement should be protected from the flooding. As a result, the minimum road surface height near the Champasack town point is estimated to be 98.01m. Comparing this height with historic flood levels for other return periods, the following can be said:

- The surface height is 40cm higher than the flooding level (97.61m) for a return period of 100 years.
- The surface height is 35 cm lower than the flooding level (98.36m) recorded in 1978. However, emergency vehicles, such as pick-up trucks and other trucks could pass through. In this case, it is estimated that flooding of this scale would have an effect for less than 5 days.

Consequently, the Study team identifies that the 50-year return period is appropriate for the

Project Route 14A, and a minimum surface height of 98.01m is adopted for STA. 25+000 or Route 14A.

(3) Water Surface Gradient of Mekong

The following water surface gradient can be applied to estimate the design flood water level at various points on the Route 14A. The figure is estimated based on actual flood water level data at three observatories along the Mekong.

Table 7.4.9 Water Surface Gradient

Section	Water Surface Gradient
North Side from Champasack Observatory	0.011%
South Side from Champasack Observatory	0.008%

7.4.7 Pavement Structure

The pavement design has been carried out according to the following procedure.

(i) Set up time constraints (analysis and design period)
(ii) Estimate cumulative axle loads during analysis period
(iii) Identify flexible pavement structural number (SN) to withstand the axle load
(iv) Identify a set of pavement layer thickness corresponding SN
(v) Design pavement structure
(vi) Design overlay thickness

(1) Analysis and Design Period

The design period means service life of pavement without overlaying. Several road projects based on AASHTO realized that a 10 to 20 years design period is realistic for the analysis taking account of overall factors such as economic, construction and maintenance performance. Note after the design period, periodic maintenance work (i.e., overlaying) will be implemented. Basing on the above, the study applies 10 years (2008 – 2017) for the design period and 15 years (2008-2022) for analysis period in this preliminary design.

(2) Cumulative Axle Loads

The cumulative axle loads for the design period is estimated using '18-kip ESAL (**W18**)' which is equivalent to 8-tons single axle loads. The cumulative '18-kip ESAL (W18)' is obtained by converted figures from the traffic forecast (VPD: Motorized Four-wheeled Vehicles per Day) for the design period. The conversion factor is determined based on a size of damage. The cumulative axle load in design period and traffic volume forecasted on Route

14A and 16A for the 15-years period (i.e., analysis period 2008 – 2022) are described in Table 7.4.10 and Table 7.4.11 respectively. The Route 14A is divided into two sections, i.e., north (STA0-STA34km) and south (STA34-STA59), because of difference of traffic volumes.

Table 7.4.10 Forecast Cumulative '18-kip ESAL (W18)' per 1 lane (2008 – 2017)

Type of Vehicle		Light Vehicle	Bus	Heavy Truck.	Medium Truck	Total
Conversion (Damage) factor		0.383	0.383	2.598	1.276	
14A North	W18	197,206	155,095	174,180	287,442	813,923
14A South	W18	166,868	109,186	90,832	212,766	579,652
Rt. 16A	W18	290,410	67,177	182,271	395,963	935,821

Table 7.4.11 Traffic Volume Forecast VPD (2008 – 2022)

Route 14A North (0 - 34km)

	2008	2022
Light Vehicle	178	595
Bus	144	422
Medium Truck	77	212
Heavy Truck	24	66
Total	423	1295

Route 16A South (34 - 59.301km)

	2008	2022
Light Vehicle	142	475
Bus	93	273
Medium Truck	53	146
Heavy Truck	13	36
Total	301	930

Route 16A

	2008	2022
Light Vehicle	263	878
Bus	68	200
Medium Truck	142	390
Heavy Truck	21	58
Total	494	1526

(3) Structural Number (SN)

The structural design of pavement is based on identifying a flexible pavement structural number (SN) to withstand the predicted level of axle load traffic (**W18**).
The equation for identifying of SN is as follows.

$$\log_{10}(\mathbf{W18}) = Z_R \times S_0 + 9.36 \times \log_{10}(\mathbf{SN}+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(\mathbf{SN}+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Other required conditions are also determined by referring AASHTO standard.

i) Reliability (R) : 89.4 %
ii) Overall Standard Deviation (S_0) : 0.35
iii) Standard Normal Deviate (Z_R) : -1.282
iv) Resilient Modulus of Subgrade (M_R) : 12,000 psi (CBR x 1,500)
v) Design Serviceability Loss (Δ PSI) : 1.7

According to above equation and required conditions, SN of the project road routes for the design period (10 years) is obtained as shown in Table 7.4.12.

Table 7.4.12 Pavement Structural Number (SN)

Route	SN
Rt. 14A N	2.67
Rt. 14A S	2.53
Rt. 16A	2.74

(4) Layer Thickness

A set of pavement layer thickness is identified taking account of economic and local conditions. The following equation provides the basis of converting SN into actual thickness of layers namely surface course, base course and subbase.

$$SN = a1D1 + a2D2m2 + a3D3m3$$

where

a1, a2, a3 : Layer coefficients representative of surface, bas and subbase courses, respectively.
D1, D2, D3 : Actual thickness (in inches) of of surface, bas and subbase courses, respectively.
m2, m3 : Drainage coefficients for base and subbase courses respectively.

Required conditions are also determined by referring AASHTO standard.

	Layer	Material Characteristics	a	m	
1	Surface Course	Asphalt Concrete	0.400	-	
2	Base Course	Granular Base (CBR=80)	0.135	1.10(Rt.14AN&16A)	1.20(Rt. 14AS)
3	Subbase Course	Crushed Stone (CBR=30)	0.115	1.10(Rt.14A)	1.20(Rt. 14AS)

NOTE

Differences of drainage coefficient are determined taking account of flooding severity.

(5) Pavement Structure

As a result of a trial calculation using the above equation, the following pavement structure has been determined.

(i) Route 14A North (STA. 0 +000 – STA. 34+000): SN = 2.67

Layer	Thickness
Asphalt Concrete	50mm (1.97 inches)
Granular Base (CBR=80)	175mm (6.89 inches)
Crushed Stone (CBR=30)	175mm (6.89 inches)

SN = 0.400 x 1.97 + 0.135 x 6.89 x 1.10 + 0.115 x 6.89 x 1.10 = 2.68 > 2.67 – OK –

(ii) Route 14A South (STA. 34 +000 – STA. 59+301): SN = 2.53

Layer	Thickness
Asphalt Concrete	50mm (1.97 inches)
Granular Base (CBR=80)	150mm (5.91 inches)
Crushed Stone (CBR=30)	150mm (5.91 inches)

SN = 0.400 x 1.97 + 0.135 x 5.91 x 1.20 + 0.115 x 5.91 x 1.20 = 2.56 > 2.53 – OK –

(iii) Route 16A: SN = 2.74

Layer	Thickness
Asphalt Concrete	50mm (1.97 inches)
Granular Base (CBR=80)	200mm (7.87 inches)
Crushed Stone (CBR=30)	200mm (7.87 inches)

SN = 0.400 x 1.97 + 0.135 x 7.87 x 1.10 + 0.115 x 7.87 x 1.10 = 2.95 >2.74 – OK –

It is recommended that an alternative pavement structure will be re-examined in a detailed design stage taking economical material availability into consideration.

(6) Overlaying

After the initial design period (2008 – 2017) expires, overlay work will be executed as periodic maintenance to withstand cumulative axle load during remaining analysis period (2018 – 2022). The design is carried out according to the following procedure.

i) Estimate cumulative axle loads (W18') and required pavement structural number (SNy) during remaining analysis period

ii) Identify effective structural number (SNeff) of initial pavement structure at the end of design period (2017)

iii) Identify required structural number of the overlay and design its thickness.

The cumulative axle loads18-kip ESAL (W18') and required structural number (SNy) in this period are in Table 7.4.13.

Table 7.4.13 W18' & SNy (2018 – 2022)

Route	W18'	SNy
Rt. 14A N	725,595	2.62
Rt. 14A S	518,757	2.48
Rt. 16A	841,306	2.69

The condition of initial pavement layers namely surface course, base course and subbase courses should be surveyed to identify effective structural number (SNeff). In this design stage, these layers conditions are estimated using average pavement condition factor (Cx: 0.78) in AASHTO. According to Cx, coefficients of each layer are converted to as follows:

	Layer	Material Characteristics	a'	m'		
1	Surface Course	Asphalt Concrete	0.31	Rt.14A N	Rt. 14A S	Rt. 16A
2	Base Course	Granular Base (CBR=80)	0.105	0.85	0.93	0.85
3	Subbase Course	Crushed Stone (CBR=30)	0.09	0.85	0.93	0.85

Accordingly, SNeff of the projected routes are obtained as follows:

Route	**SNeff**
Rt. 14A N	: 1.75
Rt. 14A S	: 1.68
Rt. 16A	: 1.91

The following equations provide required structural number of the overlay (SN_{OL}) and its thickness (D_{OL}).

$$SN_{OL} = SNy - SNeff$$

$$D_{OL} = SN_{OL} / a1$$

NOTE
a1: Layer coefficient of asphalt surface (0.400)

It is therefore, D_{OL} (thickness for overlaying) are obtained as shown in Table 7.4.14.

Table 7.4.14 SN_{OL} & D_{OL} of the Projected Routes

Route	SN_{OL}	D_{OL} (mm)
Rt. 14A N	0.87	**60**
Rt. 14A S	0.80	**55**
Rt. 16A	0.78	**50**

7.5 Assessment of Existing Bridges on Route 16A

7.5.1 Necessity of Assessment

There are five existing bridges on Route 16A. Those bridges are all of a medium scaled one, ranging from 24m to 60 m in the total length. Regarding the bridge type, one is a Bailey type and others are of a steel-I beam type. These steel-I beam type bridges were constructed in the mid – 1990s by a Korean private company in the process of providing an access road to the construction site of a hydroelectric power plant. Accordingly, these bridges are relatively new, and those are confirmed that they have little structural damage during the bridge inventory survey. Since the design standard and criteria for these bridges are not available, it is necessary to examine whether or not these steel-I beam bridges have sufficient capacity against the live load designated for the project.

The Bailey type bridge is not considered because it is not appropriate as a permanent bridge due to lack of carriageway width and insufficient load capacity.

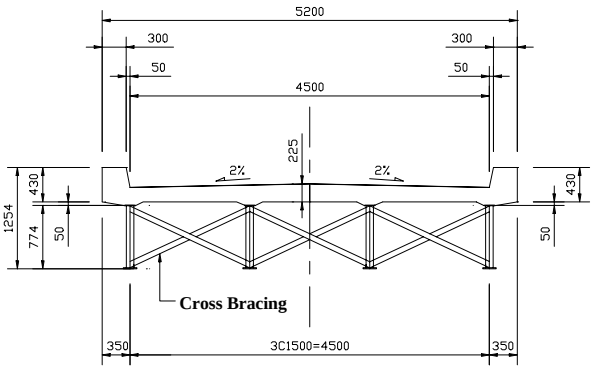
7.5.2 Existing Structures and Conditions

The Study Team obtained design drawings of existing steel-I beam bridges from the Energy Department, and confirmed that the existing bridges were built according to the drawings without modification. The major characteristics of these four bridges located on the Project Route 16A are briefly described in Table 7.5.1.

Table 7.5.1 Major Characteristics of Existing Steel-I Beam Bridges

Br. No	River Name	Br. Length (m)	Span Nos.	Span Length (m)	Beam Depth (m)	Beam Nos.
3	Xe Katam	48.00	4	12.04@4	0.80	4
4	Xe Namnoy	60.13	4	12.04+18.04@2+12.04	0.80,0.80	4,6
5	Xe Namnoy	24.07	2	12.04@2	0.80	4
6	Houay Katak-Tok	24.07	2	12.04@2	0.80	4

To summarize, these steel-I bridges are characterized by utilization of a simple beam and only two types of span length, 12m and 18m, with same girder depth of 0.8m. The typical cross-sections of the steel-I bridges by span length are shown in Figure 7.5.1.



(Span=12.0m) **(Span=18.0m)**

Figure 7.5.1Typical Cross-section of Steel-I Bridge

7.5.3 Structural Examination of Retaining of Existing Bridges

(1) Examination Methodology

1) Structural Components to be Diagnosed

In this examination, only the superstructure of the existing bridges is subject to be diagnosed as to its structural safety for the following reasons:

- The live load is a dominant factor to determine the dimension of superstructure. However, the design live load for the existing bridge is not available.
- All foundations of the bridges are situated on firm layers such as rock or boulders and the layer supporting the foundation is observed to have sufficient bearing capacity from the site observation.
- Since the seismic force is a minor factor to check the stability of substructure and foundation of the existing bridges. (No large earthquake in history)

2) Span Length

From the result of the inventory survey and the design drawings obtained, a simple beam with only two types of span length, 12m and 18m, are to be examined for their safety.

3) Check Items of Structural Members

The following items of structural members are to be checked in order to confirm its structural safety in service status.

Main beams: exterior beam or interior one

- Safety against the bending moment induced by dead and live loads at the span center
- Safety against the share forces induced by dead and live loads
- Safety against deflection limit of the beams

Deck slab

- Safety against a bending moment induced by the wheel load and dead one.

The length of overhang is relatively short, 300mm for the 12m span and 600mm for the18m span, so that it receive no effect from the live load. Therefore, the overhang shall be excluded from this examination.

(2) Examination Results

As a result of the examination, both types have sufficient capacity against the live load by AASHTO standard applied for this project. The results are shown in Table 7.5.2. The appropriateness of the results is also confirmed by comparing with the results obtained by using a bridge design software applying the live load of Japanese standard.

Table 7.5.2 Examination Results

Member	Items	Unit	Span 12m	Span 18m	Allowable Value	
					12m	18m
Girder	Bending Stress	kgf/cm^2	778	1089	1400	
	Shear Force	kgf/cm^2	78	45	800	
	Deflection	mm	2.5	12	14mm	22mm
Slab	Compressive Stress on Concrete	kgf/cm^2	24	18	80	
	Bending Stress on Re-bar	kgf/cm^2	540	454	1200	

7.5.4 Conclusion on Retaining Study Bridges

Although it is confirmed that all existing steel-I bridges can be utilized as permanent bridges for this project from the structural point of view, two other factors should be considered to determine their retaining i.e. road alignment and hydrology. Regarding the former, alignment of each access road to a bridge should fulfill the road design criteria on the basis of the road class at reasonable cost. The bridges should have sufficient clearance against high water level for a 50-year return period based on the hydrological analysis.

(1) Requirement from Road Alignment

As a result of the preliminary design of the road, only access roads to the Xe Katam Bridge (No.3 bridge) should be improved in alignment to satisfy the road design criteria. It results in requiring a bridge alignment with a skew angle against the river direction. Accordingly, the Study Team concluded that it is difficult to restore the existing bridge as the project bridge. However, since the alignment setting was only undertaken by using 1/5000 topographic maps, it is recommended to review the suitability of the existing Xe Katam Bridge for new alignment in the detailed design stage.

(2) Requirement from Hydrological Analysis

There is no information on design conditions of the existing bridges, particularly design high water level and its probability. The Study Team examined whether or not the existing bridges have sufficient clearance against the high water level at 50-year probability.

As a result of the analysis, Xe Namnoy 1 Bridge (No.4) and Houay Ho Bridge (No.6) have insufficient clearance against the estimated HWL. It is assumed that both bridges shall be safe against the HWL of approximately a 15-year probability and a 25-year probability respectively. Consequently, it is judged in this preliminary design that both bridges should be replaced by new bridges with sufficient clearance against the HWL of a 50-year probability, although, further consideration should be given at the detailed design stage.

(3) Evaluation of Retaining Study Bridges

As a result of the analysis on requirements from three aspects mentioned above, only the Xe Namnoy 2 Bridge should be retained for the Project. It is recommended to replace the other three bridges with sufficient clearance against the design HWL set.

Table 7.5.3 Result of Examination of Retaining Existing Steel-I Bridges

Bridge Name	Structural Requirement	Alignment Requirement	Hydrological Requirement	Comprehensive Evaluation
Xe Katam	O	X	O	X
Xe Namnoy 1	O	O	X	X
Xe Namnoy 2	O	O	O	O
Houay Ho	O	O	X	X

(4) Recommendations

1) Recommendations for Bridges to be Restored

The following some repair works will be recommended to bridges retained to extend their life and ensure the traffic safety:

- Re-painting of steel girders to prevent girders from rusting
- Extension of drainage pipes to the position where spray of drained water does not affect girders.
- Replacement of the existing railings to ensure the safety against vehicle collision.

2) Recommendations for Bridges to be Replaced

Since steel girders of bridges to be replaced still keep sound condition, it is recommended to re-utilize those girders to other crossing points. Piers of bridges to be replaced may give an adverse effect on a new bridge at flooding. Accordingly, it is recommended to demolish piers in rivers after taking girders.

7.6 Preliminary Design for Bridges

There are 14 bridges on Route 14A and 7 bridges on Route 16A involved in the improvement Project. It is found that these bridges' size is not more than 60m bridge length, as a result of the bridge inventory survey. Consequently, to standardize a bridge type by span or height is an effective way to minimize construction cost.

In this section, descriptions of bridge types are introduced i.e., a superstructure type by span and a substructure by height these should be designed taking into consideration their standardization.

7.6.1 Selection of Bridge Types

(1) Superstructure

The superstructures of new bridges on Route 14A and 16A are designed to meet the following general requirement.

1) Structural Requirements

The general relationship between span length and bridge type is shown in Table 7.6.1. The minimum span length of a bridge is generally determined by the nature of the river over

which the bridge is required to pass: the soil condition, and factors relating to the surrounding. The span length is one of the most important factors in determining the bridge type. Once the span length is fixed then the choice of bridge type is limited.

A beam or girder has a desirable ratio of girder depth (height) to the length of span, which will result in minimum construction cost, and this depth ratio has been generally adopted. However, for the main span of a bridge where the depth is critical for determining the vertical alignment of the road, which will affect the total cost of the structure, the bridge type having minimum allowable girder depth is to be selected.

2) Environmental Requirements

Attentive considerations are necessary to preserve the existing environment of man-made facilities (e.g., irrigation canals, public facilities such as road net works) and to avoid adverse effect to existing rivers.

From the aesthetic point of view, a bridge type, which harmonizes with the surrounding environment, should be adopted.

Table 7.6.1 Standard Applicable Span

TYPE		SPAN										Girder Height/ Span ratio
		10m		20m		30m		40m		50m		
RC Bridge	R.C Simple I Girder											1/10
	R.C Slab											1/12
	R.C Rigid Frame											1/15
PC Bridge	Pretensio Girder											1/15
	Hollow slab											1/22
	Simple Post-tension I girder											1/17
	Simple composite girder											1/15
	Connected Continuous Composite girder											1/15
	Continuous Composite girder											1/16
	Simple box girder											1/20

3) Construction Requirement

The pre-cast method is an effective way to shorten the construction period. If the construction period is limited, the type of bridges is determined by taking into account the speed of construction.

4) Construction Economy

The most economical type of a bridge will ultimately be selected from the alternatives which satisfy the conditions mentioned above. To compare the costs of various bridge type, the total construction costs of the superstructure, substructure and approaches are considered.

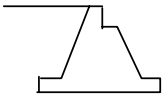
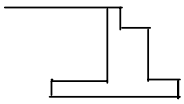
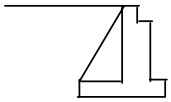
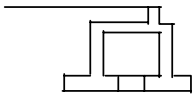
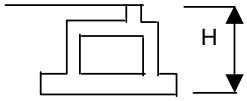
(4) Substructure

The substructure of new bridges is designed to meet the following general requirements.

1) Abutment

Reinforced concrete is used for abutment. The type of abutment is determined based on the relationship between height and the suitability of abutment type as shown in Table 7.6.2.

Table 7.6.2 Range of Heights for Type of Abutment

Tape and Shape		Applicable H (m)	Characteristic
Gravity-type		H<= 5	- Simple structure - Easy construction - Heavier weight
Reversed T Type		5< H <=12	- Cost effective - Easy construction
Counterforted Buttresseds type		10 <= H	- Intricate constrution - Difficulty in back filling
Rigid-framed Type		10<= H <= 15	- Complicated structure - High cost
Box Type		12<= H	- Complicated structure - Intricate construction - High cost

2) Pier

Reinforced concrete piers is used unless special conditions must be met. A Wall-type pier with round faces against flow is recommended for river/canal pier to provide smooth flow of water.

3) Type of Foundation

The foundation type is determined mainly by subsoil conditions, the loading to be supported, and economic criteria. A spread foundation is utilized where the depth of the supporting strata is less than 5m, whereas a piled foundation is employed for depths more than 5m.

7.6.2 Design of Bridge Structure

(1) Determination of Total Bridge Length and Span Arrangement

The following policy is applied when determining the bridge length and span arrangement.

- The bridge length over the rivers on Route 14A, where frequently overflow to the surrounding area, is determined taking into account the river width of upstream or downstream side.
- Bridge length of river crossing with no dike is determined to take the river width in flooding condition into account bridges on Route 16A.
- The minimum span length of bridges is determined to limit obstruction by piers during flooding to approximately 5% of the sectional area of the river. Also from an aesthetic point of view, all span lengths should be as constant as possible.

(2) Superstructure Design

1) Basic Bridge Type

A concrete bridge type is applied to the Project bridges because of the following reasons:

- Most of materials except for a PC cable are locally available. Accordingly, cost effectiveness can be achieved comparing with a steel type bridge.
- A concrete bridge type is a major bridge type in previous bridge projects in Lao PDR, and local contractors have also some experience to build it.
- Maintenance burden on the road agency is less than one of a steel type, which is periodically required re-painting at least.

2) Bridge Type by Span Length

Since there is no requirement of navigation clearance for any rivers on both Rt. 14A and 16A,

a pre-cast type with less than 30m in span length is appropriate from the view point of cost effectiveness, workability of construction and minimizing construction time. Based on a relationship between span length and standard type of bridge mentioned before and current practice in Lao PDR and neighboring countries, the Study team selected the following superstructure types by various span lengths. (See Table 7.6.3)

Table 7.6.3 Superstructure Types by Span Length

Span Length (m)	Superstructure Types	Remark
L<=10	RC Slab	Supporting required
10< L<18	RC I – Girder	Supporting not required
18=<L<=33	PC I - Girder	Supporting not required

Furthermore, in order to ease of maintenance burden on expansion joints, a connected continuous girder is designed.

(3) Substructure Design

1) Abutments

The height of abutments is ranging from 5m to 15m. Based on this fact and considering the current construction practices in Lao PDR, the adoption of the following types of abutment is made (See Table 7.6.4).

Wing walls and approach slabs are required in most of the locations. The wing wall length is limited to about 8m, and approach slabs are required when embankment height of back side of abutment is more than 5m.

Table 7.6.4 Abutment Type by Its Height

Abutment Height (m)	Abutment Type
H <= 5	Concrete Gravity Type
6 <= H <=12	RC Reversed T - Type
13<H	RC Boxed Type

2) Piers

There are many failure cases of a pile-bent type by scouring, particularly in rapid flow rivers in developing countries. Accordingly, the Study Team adopts the wall type with round faces against flow for piers in rivers to provide smooth flow of water.

3) Minimum Cover Depth of Footings

Pier and abutment footings are provided with appropriate soil covers depending on their situations. In the case of piers in rivers, a minimum cover depth of two (2) meters is designed to be sufficient to take account of possible scouring.

(4) Foundation Design

1) Foundation Type

The geological survey clarified the location of the bearing strata suitable for bridge foundation. At rivers on Route 14A, approximately 7-8m of the alluvial soil generally covers on the sand stone or mudstone. Accordingly, some abutments and piers are required to be supported by piles. On the one hand, all foundations are to be a spread footing type when a bearing strata consisting of gravel, boulder or rock is situated at shallow depth.

2) Types of Pile

Pre-cast RC square piles (40cm x 40cm) is appropriate for economic reasons and in light of current construction practice in Lao PDR, if piles are required from the viewpoint of cost effectiveness.

7.6.3 Bridge Protection Work

Protection work is required to protect substructures and embankment from scouring and erosion, particularly where a rapid flow is expected at flooding. For bridge sites on Route 14A, since inflow velocity from the Mekong or velocity of the river itself are assumed to be less than 3m/s at maximum, a gabion protection around abutment is sufficient.

At bridge sites on Route 16A, the maximum flow velocity is assumed to reach 5 to 10 m/s, confirmed by the river velocity survey. Accordingly, a solid protection work is required. Since large boulders or stones are available in the riverbed around the bridge sites, a wet masonry with large stones are recommended to protect abutments from rapid flow. In addition gabion protection is recommended around piers.

The standard structures for the protection work are shown in Volume 3 of 4: Preliminary Drawings.

7.6.4 Results of Preliminary Design of Bridges

(1) General

Based on the design policies described above, preliminary design of bridges were undertaken and, results are summarized in Table 7.6.5, Table 7.6.6 and drawings of Bridge General View in Volume 3 of Preliminary Drawings.

(2) Bridges on Route 14A

Table 7.6.5 Preliminary Design Results of Bridges on Route 14A

			Superstructure							Substructure								
										A1Abutment			P1 Pier			A2Abutment		
No	River Name	Km post	Br. L (m)	Nos. Span	Span (m)	Br. Type	Effective W(m)	HWL (1/50)	Clear-ance	Type	Hight (m)	Founda. Type	Type	Hight (m)	Founda. Type	Type	Hight (m)	Founda. Type
1	Huay Thok	5+330	25	1	25	PC-I	8.0	99.60	0.6	Rev.-T	9.0	Spread	-	-	-	Rev.-T	10.0	Spread
8	Huay Imet	11+140	15	1	15	RC-I	8.0	99.70	0.6	Rev.-T	6.0	Spread	-	-	-	Rev.-T	6.0	Spread
11	Huay Thakhong	13+420	25	1	22	PC-I	8.0	98.80	0.6	Rev.-T	11.5	Pile	-	-	-	Rev.-T	9.0	Pile
12	Huay Tabxan	14+325	30	1	30	PC-I	8.0	98.70	0.6	Box	16.0	Spread	-	-	-	Box	16.0	Spread
14	Huay Khonken	16+810	25	1	25	PC-I	8.0	98.40	0.6	Rev.-T	10.5	Pile	-	-	-	Rev.-T	8.5	Pile
15	Huay Hong	18+075	25	1	25	PC-I	8.0	98.20	0.6	Rev.-T	11.0	Pile	-	-	-	Rev.-T	10.0	Pile
16	Huay He	18+760	30	1	30	PC-I	8.0	98.10	0.6	Rev.-T	10.5	Pile	-	-	-	Rev.-T	11.0	Pile
18	Huay Sai	21+160	44	2	22	PC-I	8.0	97.70	0.6	Rev.-T	6.5	Pile	Wall	12.5	Spread	Rev.-T	13.0	Spread
19	Huay Phaphin	24+010	22	1	22	PC-I	8.0	97.50	0.6	Rev.-T	11.5	Pile	-	-	-	Rev.-T	11.5	Pile
20	Huay Phabang	29+020	50	2	25	PC-I	8.0	97.00	0.6	Rev.-T	8.5	Pile	Wall	15.0	Spread	Rev.-T	9.5	Pile
21	Huay Sahoua	31+715	30	1	30	PC-I	8.0	96.80	0.6	Rev.-T	11.0	Spread	-	-	-	Rev.-T	11.0	Spread
22	Huay Kok	32+140	15	1	15	RC-I	8.0	96.80	0.6	Rev.-T	10.5	Spread	-	-	-	Rev.-T	10.5	Spread
24	Huay Thateng	40+035	15	1	15	RC-I	8.0	100.50	0.6	Rev.-T	7.5	Spread	-	-	-	Rev.-T	7.0	Spread
25	Huay Manpha	45+040	22	1	22	PC-I	8.0	98.40	0.6	Rev.-T	5.0	Spread	-	-	-	Rev.-T	5.0	Spread

(2) Bridges on Route 16A

Table 7.6.6 Preliminary Design Results of Bridges on Route 16A

No	River Name	Km post	Superstructure							Substructure								
										A1Abutment			P1 Pier			A2Abutment		
			Br. L(m)	Nos Span	Span L(m)	Br.Type	Effective W(m)	HWL (1/50)	Clear-ance	Type	Hight (m)	Founda. Type	Type	Hight (m)	Founda. Type	Type	Hight (m)	Founda. Type
1	Huay Mckchan-Gunai	17+580	25	1	25	PC-I	8.0	1143.30	0.6	Rev.-T	5.0	Spread	-	-	-	Rev.-T	6.5	Spread
2	Huay Namtang	35+530	30	1	30	PC-I	8.0	818.70	1.0	Rev.-T	10.0	Spread	-	-	-	Rev.-T	9.0	Spread
3	Xe Katam	45+740	50	2	25	PC-I	8.0	496.40	1.0	Rev.-T	11.5	Spread	Wall	13.0	Spread	Rev.-T	11.5	Spread
4	Xe Namnoy 1	51+390	60	2	30	PC-I	8.0	262.50	1.2	Rev.-T	8.0	Spread	Wall	13.5	Spread	Rev.-T	12.5	Spread
5	Xe Namnoy 2	51+585	25	1	25	PC-I	5.0	257.60	1.0	Rev.-T	11.5	Spread	-	-	-	Rev.-T	11.5	Spread
6	Huay Ho	51+935	30	1	30	PC-I	8.0	266.80	1.0	Rev.-T	8.0	Spread	-	-	-	Rev.-T	8.0	Spread
7	No name	61+560	15	1	1	RC-I	8.0	187.60	1.0	Rev.-T	7.0	Spread	-	-	-	Rev.-T	7.0	Spread

CHAPTER 8

CONSTRUCTION PLANNING

CHAPTER 8 CONSTRUCTION PLANNING

8.1 Introduction

This chapter describes the proposed construction plan for the road improvement project of Routes14A and 16A. It includes a note on the construction method for major works, construction resources for materials and equipment, construction procedure and schedule, on the basis of site conditions, including topography, geology, hydrology and meteorology, and the structural scale and work quantities, as described in previous chapters.

The improvement work can be divided into road work and bridge work, which are discussion is made separately. There is a considerable difference in the site conditions and the scope of work between Routes 14A and 16A. These results serve cost estimation and establishing an implementation plan for the project.

8.2 Pre-Construction Stage

There are major five pre-construction activities. These are:

-Land Acquisition and Resettlement
-Archeological Remains Survey for the New Construction Section
-Forest Resource Survey
-UXO Survey and Clearance
-Relocation of Utilities (e.g. electric poles)

These activities must be completed in the pre-construction stage; otherwise the implementation schedule will be affected and result in a possible delay in road opening. The procedure and time schedule for these activities is discussed in detail in Ⅳ Chapter 10 Implementation Schedule.

8.3 Construction Plan for Route 14A Improvement

8.3.1 Construction Conditions

(1) General

After preparation work such as establishment of contractor camp and provision of temporary road, construction work will commence. There are some characteristics of construction

conditions, which determine the road construction plan. These are described below.

(2) Scope of Work

Road improvement work can be divided into road work and bridge work. For the road work, by construction section should be applied for this project. The characteristics of each section are described in Table 8.3.1 and the typical cross-section of the road is also shown in Figure 8.3.1.

Table 8.3.1 Major Features of Construction by Section

Section	Length (Km)	Type of Improvement	Features of Road Structure	Quantities of Major Works (m3)
Section 1: (Sta. 0-24+500)	24.5	New construction	- Relatively High embankment - Asphalt concrete pavement	**BM:** 299,000 **CS:** 51,300 **GM:** 46,700 **AC:** 9,310
Section 2 (Sta.24+500 -35+500)	11.0	Improvement of existing road & new construction	- High embankment (up to 4m) -Asphalt concrete pavement	**BM:** 305,800 **CS:** 22,600 **GM:** 18,200 **AC** 4,180
Section (Sta.35+500 -59+301)	23.801	Improvement of existing road	- Low embankment -Asphalt concrete pavement	**BM:** 95,800 **CS:** 43,100 **GM:** 39,300 **AC** 9,040

Note: BM: Borrow Material, CS: Crushed Stone for sub-base, GM: Granular Material for base-course, AM: Asphalt Concrete for surface course

Large volume of embankment materials is required and should be supplied from borrow pits, because there is almost no cut section.

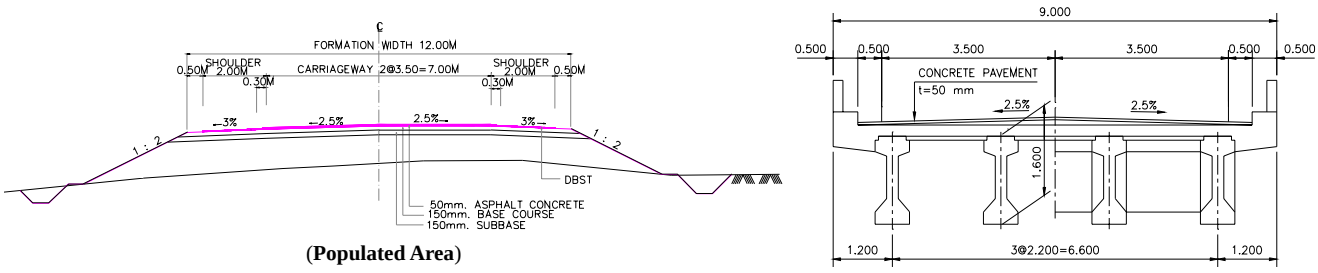


Figure 8.3.1 Typical Cross-section of Rt.14A

For bridge work, the major characteristics of bridge construction are as follows. The typical bridge cross-section is shown in Figure 8.3.1.

- All 14 bridges are small to medium scale, ranging from 15m to 50m in bridge length, with span length from 15m to 30m.

- A pre-cast girder type should be adopted for all bridges.
- Six bridges require a pile foundation of 6-12m pile length.

(3) Site Condition

There are two major site condition features affecting the construction plan for Route14A.

- **Only Dry Season Construction**: Major construction work should be undertaken only in the dry season between October and June, due to the high rise in the water level in rivers, inundation in paddy fields in the missing link area and the ancient city area, and the large number of rainy days in the rainy season.
- **No Access Road for Construction Vehicles in Missing Section:** There is no access road for construction vehicles in the missing section and the ancient city area. Accordingly, site work in these sections is limited for the first one or two months until a temporary access road can be provided.

(4) Procurement Conditions

Major construction equipment for road and bridge works and their procurement condition are indicated in Table 8.3.2. Major equipment for pavement work and girder erection work for bridge construction should be procured from foreign countries. Major materials for road works such as borrow materials, cement, aggregate, sand and re-bar can be procured in Lao P.D.R., but bitumen for asphalt concrete, PC cables and fittings for bridges such as bearing and expansion joint should be procured abroad. From satisfactory past experience, such materials have been supplied.

Table 8.3.2 Procurement Conditions for Major Construction Machinery

Work	Items	Specification	Procured from
Common	Excavator	0.6-0.8m3	Lao PDR
Road	Damp Truck	10 ton	Ditto
	Bulldozer	15 ton	Foreign country
	Motor Grader	3.1 m	Ditto
	Tire Roller	8-20 ton	Ditto
	Macadam Roller	10-12 ton	Ditto
	Asphalt Distributor		Ditto
	Asphalt Mixing Plant	60 ton/h	Ditto
	Asphalt Finisher	2.4- 4.5m	Ditto
Bridge	Pile driver	Ram weigh 2.5ton	Ditto
	Truck Crane	25 ton	Lao PDR
	Erection Girder	For 30m span	Foreign country
	Girder Fabrication Facility	Portal crane, rails etc.	Ditto
	Trailer	For segment Transportation	Lao PDR

(5) Key issues to be considered

Most work should be done in the dry season. Consequently, to reduce construction time is a key issue for project construction planning.

8.3.2 Road Construction Plan

This section discusses the construction method of earthworks and pavement work, the construction procedures and schedule for each section.

(1) Basic Construction Method

In order to ensure major construction works is undertaken in the dry season and to achieve cost effectiveness, an equipment intensive construction method should be applied.

(2) Earthwork

Work Volumes

The required quantity of borrow materials for each section is shown in Table 8.3.1. The table shows that the relatively large volume of borrow material, a total of 700,000 cubic m., is required for embankment.

Source of Borrow Materials

It is important to select good materials for embankments. The quality of borrow material determines the quality of the road. From observation, relatively good borrow material is available in southern Lao.

Six existing borrow pits were identified and investigated during the borrow pit survey by the Study Team geologist. It was found that useful borrow materials are situated 0.5-2.0m beneath the top-soil, and that approximately 140,000 cubic m. are available. Consequently, new borrow pits are also needed. Investigation of potential borrow pits shows that the volume of borrow material will be available from mainly the foot of mountains along the Mekong. However, it is recommended not to have any borrow pits near the preservation area of Wat Phou. The potential areas for borrow pits are indicated in Figure 8.3.2.

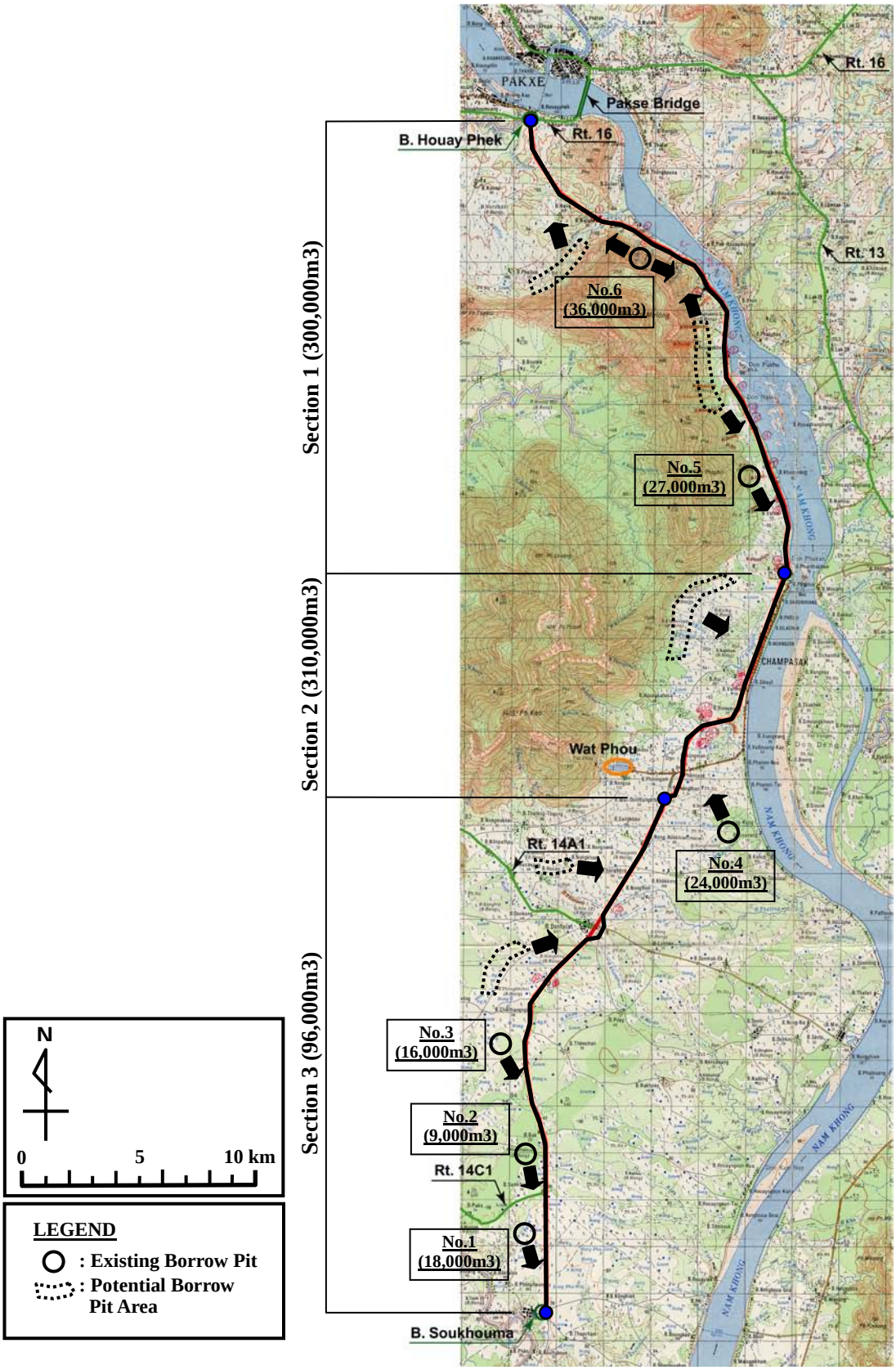


Figure 8.3.2 Existing & Potential Borrow Pit Area & Haulage Plan (Rt.14A)

Haulage Plan of Borrow Materials

Table 8.3.3 shows the outline of a haulage plan for borrow materials to each section.

Table 8.3.3 Haulage Plan for Borrow Materials

Section	Haulage Plan
Section 1: (Sta. 0-24+500)	- 300 thousand of borrow material is required for this section. - Supply of borrow materials are made mainly from new borrow pits at the foot of mountains in the section 1 and partially from the existing pit No.4. Accordingly, the average hauling distance shall range from 1-10km.
Section 2 (Sta.24+500 -35+500)	- 310 thousand of borrow material is required. - Supply of borrow materials is made from the existing 5 & 6 borrow pits and new pits located at the foot of mountains. Accordingly, the average hauling distance shall range from 5-20km.
Section (Sta.35+500 -59+301)	- 96 thousand of borrow material is required. - Borrow materials shall be supplied from the adjacent existing and new borrow pits along the route. Accordingly, the average hauling distance shall be around 5km.

Construction Method and Procedure for Earthworks

The earthworks should be carried out with the following procedure and the composition of machinery and equipment described in Table 8.3.4.

Table 8.3.4 Construction Method of Earthworks

Sub-work Items	Composition of Equipment	
	Hauling Distance: less than 100m	Hauling Distance: more than 100m
Clearing	Bulldozer	
Excavation Loading Hauling	Bulldozer - Bulldozer	Tractor Shovel Tractor Shovel/ Payloader Dump Truck
Spreading Compaction	Bulldozer/ Motor Grader Tamping Roller/ Tire Roller	

Restoration Plan of Borrow Pits

After excavation of borrow material at pits, these areas should be restored to avoid an adverse impact on surrounding area and to keep natural the aesthetics. The restoration work should be generally undertaken with the following manner:

- Right after removing all borrow material, all wastes are buried and finish graded;
- Spread topsoil that was stockpiled at the start of excavation at the pit area; and
- Seed or plant trees on the area loosened the topsoil.

The restored pit areas should be monitored periodically by the implementation agency.

(3) Pavement Work

Work Volumes

Pavement work can be divided into three sub-work items: sub-base, base course and surface course work. The required quantity of each sub-work by section is shown in Table 8.3.1. The table shows 2,200 cubic-m of total crushed stone and granular materials are required for sub-base and base-course work. In addition, 2,2000 cubic-m (52,000 tons) of asphalt mix is necessary for surface course work.

A quite large volume of aggregates will be required for construction.

Source of Pavement Material

There are two sources of crushed stone and granular material: one is the Mekong and the other is from land or mountains. There are several quarry sites near the project road and the required volume is available from these sites. The location of these quarry sites is indicated in Figure 8.3.2. Bitumen to make the asphalt mix should be imported from Thailand.

Construction Method and Procedure for Pavement Work

Since there is no supplier of asphalt hot mix in southern Lao, a contractor should setup an asphalt concrete mixing plant near the site, possibly in Champasack Town. Pavement work should be carried out according to the following procedures and the composition of machinery and equipment described in Table 8.3.5.

Table 8.3.5 Construction Method for Pavement Work

Procedure	Sub-work Item	Composition of Equipment
1	Sub-grade preparation	Motor Grader, Tire Roller, Macadam Roller
2	Sub-base work	ditto
3	Base-course work	ditto
4	Spray of prime/ tack coat	Asphalt Distributor
5	Surface course work	Asphalt Mixing Plant, Asphalt Finisher, Macadam Roller, Tire Roller

(4) Drainage Work

Drainage work should be undertaken in parallel with earthworks. All sizes of pipe culvert can be procured from local factories near Pakse, box culverts should be built at the site by procuring the necessary materials. A side ditch will also be built at site, and rock and stones obtained in the excavation process should be utilized if possible.

(5) Temporary Works and Safety Measures for Traffic

At the beginning of construction, when a temporary road for construction vehicles will be provided, a detour road during construction should be set parallel to the existing roads in other

section in order to ensure safety for normal traffic. The temporary road should be of 5m minimum width. At intersections of the existing road and the detour or temporary road, a spotter should be arranged to control and guide normal traffic and construction vehicles.

8.3.3 Bridge Construction Plan

This construction plan includes a note on the construction method for superstructure, substructure and foundation, construction procedures and the construction schedule of each bridge.

(1) Construction Plan for Superstructure

1) Construction Method

Girder Fabrication Method

A pre-cast segment method is recommended for girder fabrication in order to shorten construction time, to save costs as well as to ensure quality of girders. This method has already been applied in the bridge project for Route 13 north funded by the Swedish Government. In this method, firstly, a girder segment, which is divided into three parts from the total girder length, is fabricated and stored in one place with a large yard. Secondly, segments stored are transported to each bridge site and combined as one-girder. Finally, these girders are erected and placed at designated position on the substructures. This method is applied for the works where those bridge construction sites are closed each other.

There are some advantages of this method compared to the site-fabrication method at each bridge site.

- It is possible to fabricate segments in the rainy season and start erection work right after the rainy season is over. Accordingly, construction time at site can be minimized;
- The number of frame sets for girder fabrication can be reduced because of the rainy season work;
- There is no need for a large fabrication yard near the bridge site; and
- Standardized work and procedure for segment fabrication will ensure girder quality

The segment fabrication yard should be in or near Champasack Town from the viewpoint of accessibility to the bridge sites.

Girder Erection Method

Erection utilizing an erection girder is appropriate, considering site conditions and availability of a crane with large lifting capacity in Lao P.D.R. To place a 30m-girder, two cranes with 120 tons lifting capacity will be required, and it is difficult to procure such cranes in Lao PDR at the moment.

2) Construction Procedure

The standard construction procedure for the superstructure is shown in Figure 8.3.3.

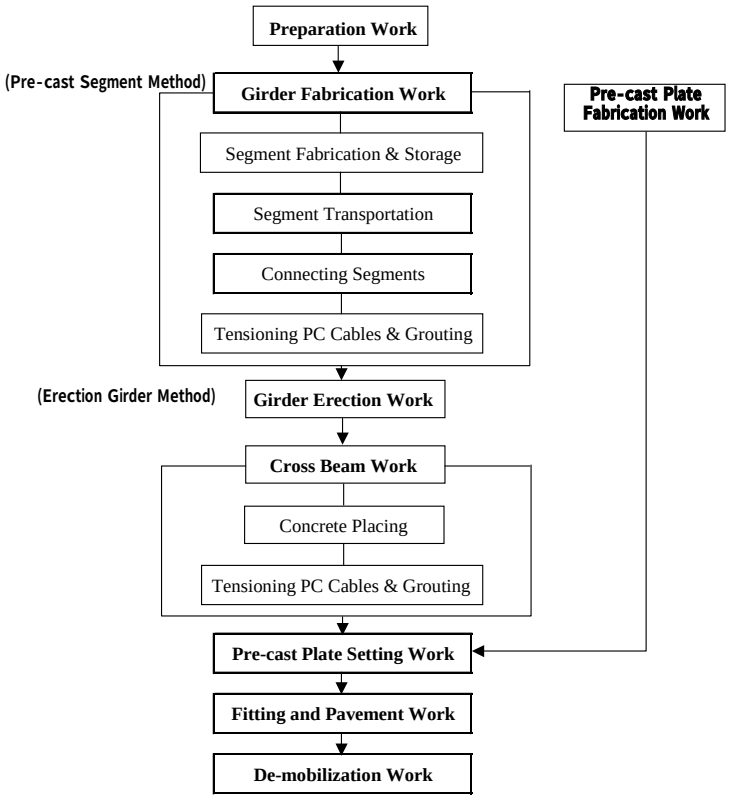


Figure 8.3.3 Construction Procedure of Superstructure

(2) Construction Plan for Substructure and Foundation

1) Construction Method for Pile Foundation

There are seven bridges supported by pile foundation on Route 14A. According to the preliminary design, the scale of a typical pile foundation can be assumed to be as follows:

Pile length: 6-12 m

Feature of subsoil: Silty clay with N value ranging from 6 to18

Surrounding condition: few houses near the site

Pile type: RC pile (40cm x 40cm)

In consideration of these conditions, pile driving by hammer is the most appropriate method. It does not cause a serious impact on houses nearby, with vibration and noise induced by pile driving, because this is located away from the construction site.

2) Construction Procedure for Substructure and Foundation

The construction of the foundation and substructure should be undertaken with the following procedure, shown in Figure 8.3.4.

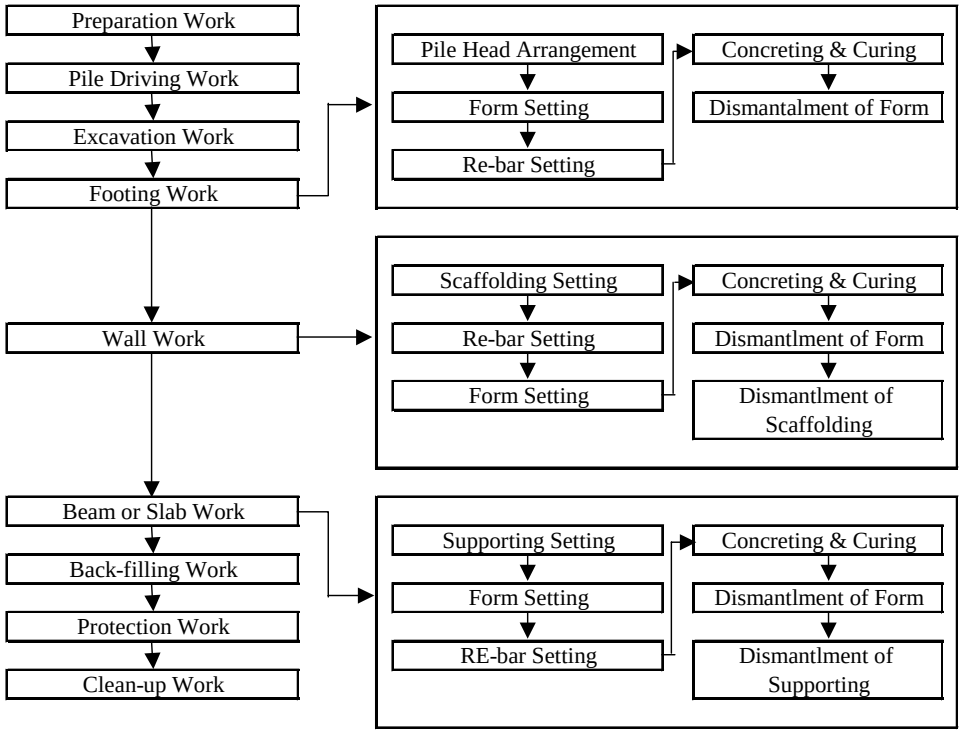


Figure 8.3.4 Construction Procedure of Substructure & Foundation

8.4 Construction Plan for Route 16A Improvement

8.4.1 Construction Conditions

(1) General

The site conditions, characteristics and scope of work which determine the construction plan for Route 16A are described below.

(2) Scope of Work

For the road works, the whole route will be divided into four sections due to the characteristics of the work. The features of the sections are described briefly in Table 8.4.1 and the typical cross-section is indicated in Figure 8.4.1.

Table 8.4.1 Major Features of Construction by Section for Rt. 16A

Section	Length (Km)	Type of Improvement	Features of Road Structure	Quantities of Major Works (m3)	
Section 1: (Sta. 0-34+000)	34.0	Improvement of existing road	- Low embankment -Asphalt concrete pavement	**BM:** **CM:** **CS:** **GM:** **AC:**	142,100 44,800 83,700 76,400 12,900
Section 2 (Sta.34+000 -42+000)	8.0	New construction / Improvement of existing road	- Site clearance - High cut & low embankment -Asphalt concrete pavement	**BM:** **CM:** **CS:** **GM:** **AC:**	57,400 193,900 (179,800) 18,600 16,800 3,000
Section (Sta.42+000 -58+000)	16.0	Improvement of existing road	- High cut, many slope protection works, and steep gradient -Asphalt concrete pavement	**BM:** **CM:** **CS:** **GM:** **AC:**	168,000 452,200 (202,400) 33,900 30,500 5,300
Section (Sta.58+000 -64+138)	6.138	Improvement of existing road	- Low embankment -Asphalt concrete pavement	**BM:** **CM:** **CS:** **GM:** **AC:**	30,400 23,500 (25,600) 14,400 13,090 2,300

Note:1. BM: Borrow Material, CM: Cut Material, CS: Crushed Stone for sub-base, GM: Granular Material for base-course, AM: Asphalt Mix for surface course
Note2: The figures in parentheses show the volume of rock excavation within the cut materials.

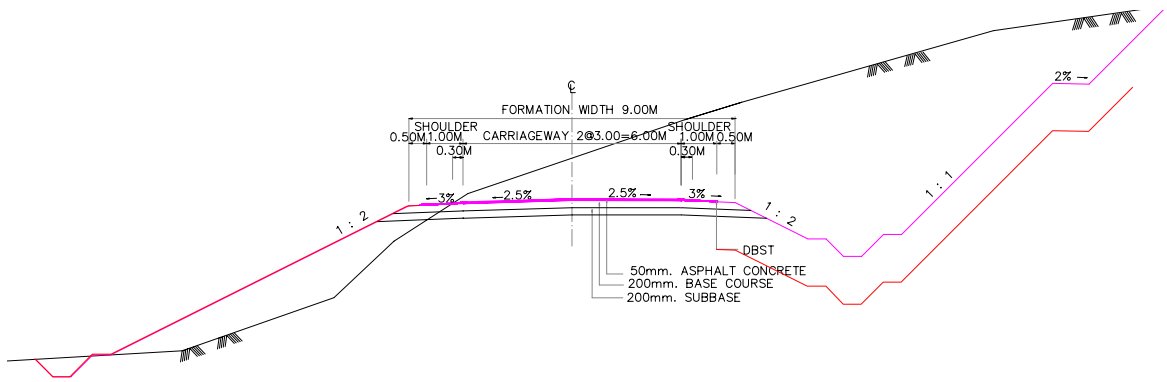


Figure 8.4.1 Typical Cross-section for Mountainous Sections

The construction work requires a large volume of excavation, particularly rock excavation and slope protection work in section 2 and 3. There is some imbalance between cut and borrow materials, with 70,000 cubic m. of borrow materials are required.

For bridge work, the major bridge construction characteristics for Route 16A are summarized as follows. Typical bridge cross-section is the same as for Route 14A.

- All seven bridges are small to medium scale, ranging from 15m to 60m in bridge length, with span length from 15m to 30m.
- A pre-cast girder type should be adopted for all bridges.
- All substructures are supported by spread foundation with high walls of more than 10m
- Protection work with stone masonry is required beside abutments.

(3) Site Conditions

There are three major characteristics of site condition:

- **Only Dry Season Construction**: Major construction works should be undertaken in the dry season between October and June, due to the rise in water level with rapid flow in rivers, and a large number of rainy days in the rainy season.
- **Difficulty of providing a Detour Road for Normal Traffic in Section 3 during Construction:** Since the existing road is mainly located on valley slopes of limited space, closing of the road to normal traffic may be required at some time, depending on work conditions.
- **Difficulty of Access to Bridge Sites:** Most bridge sites are located far away from Paksong. In addition, it is difficult to transport longer materials such as girder due to the existing road conditions, with sharp curves and steep gradient. Houay Namtang Bridge is located in the new construction section, it can be accessed after earthworks (excavation work) is done in the first few months.

(4) Procurement Conditions

Procurement conditions for major equipment and materials are almost the same as for Route 14A improvement, shown in Table 8.3.2, with the addition of a large rock-breaker and of explosive materials. These will be procured from Thailand or other countries

(5) Key Issues to be Considered

Most of the work will be undertaken with a limited site area, conditions and within a limited

time period. Accordingly, ensuring access for construction especially on the mountainous section, shortening construction time and utilizing excavated materials, will be key issues for construction planning.

8.4.2 Road Construction Plan

This section deals with the construction method for earthworks and pavement, which are major components of the road work, and construction procedures and schedules for each section.

(1) Basic Construction Method

In order to shorten the construction time, as well as to achieve cost effectiveness, equipment intensive construction method should be applied.

(2) Earthwork

Work Volumes

The quantities of major works by section are shown in Table 8.4.1. The table shows that the large volume of excavation work including rock excavation, the total of 710,000 cubic- m, is required to be excavated. Rock excavation work significantly affects the construction time, due to its low work volume per day.

Source of Borrow Materials

It is important to select good materials for embankment. For this project, only 65,000 cubic-m of borrow material is required because suitable materials for embankment can be supplied from the cut sections.

Six borrow pits has been identified near the route during the geological investigation by the Study Team. The location of the existing borrow pits is shown in Figure 8.4.2. It is estimated that 155,000 cubic-m of borrow materials is available from these pits. This is sufficient to the project.

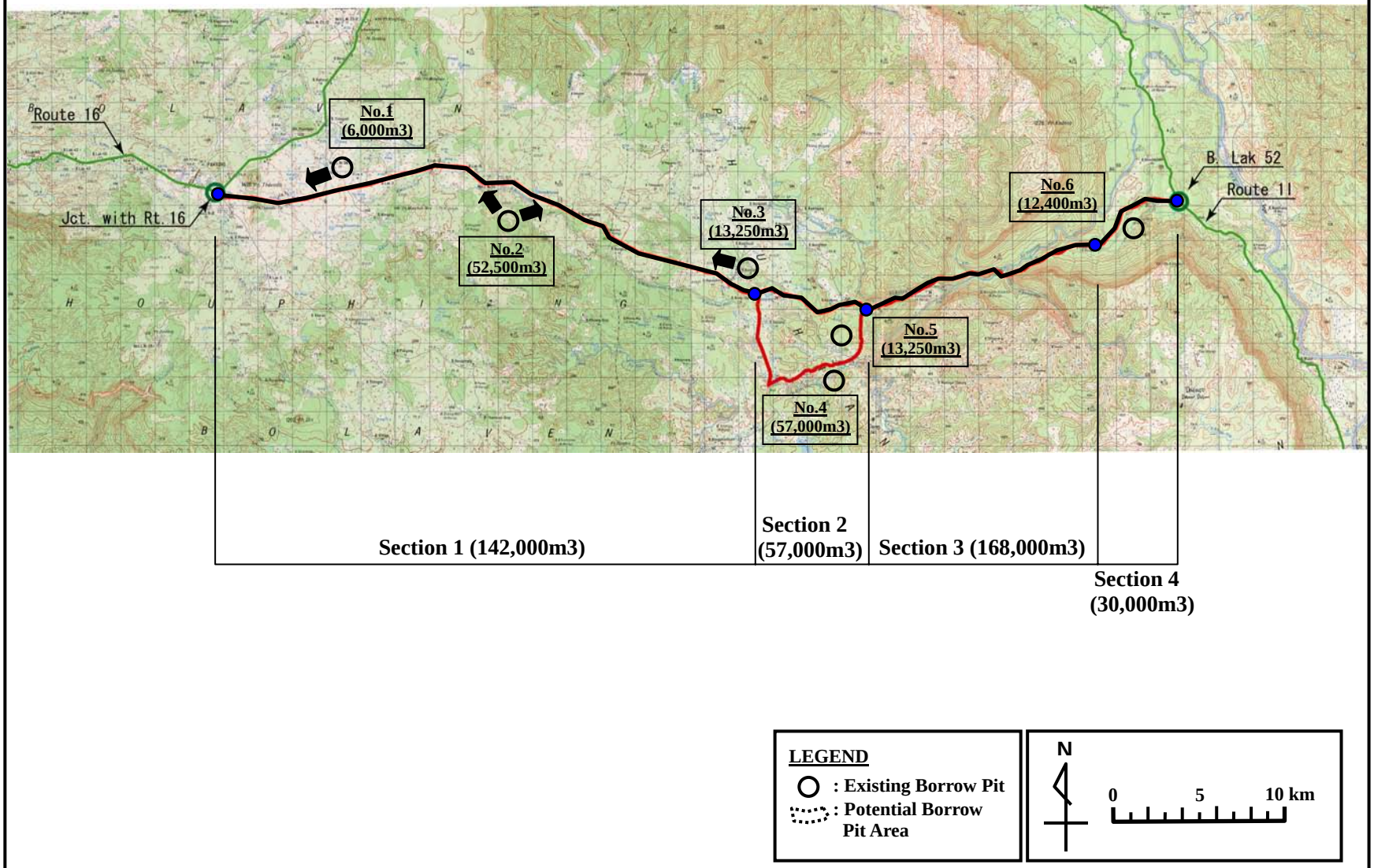


Figure 8.4.2 Existing & Potential Borrow Pit Area & Haulage Plan (Rt.16A)

Haulage Plan for Borrow Material

Table 8.4.2 shows the draft haulage plan for borrow material to each section. This is also indicated in Figure 8.4.2

Table 8.4.2 Haulage Plan for Borrow Materials

Section	Haulage Plan
Section 1: (Sta. 0-34+000)	- 142 thousand m3 of borrow materials is required. - 45 thousand m3 from the cutting part within the section, 30 thousand m3 from the section 3 and the rest from the nearest pits of No.1, 2 and 3. - Haulage distance shall range from 1-20km
Section 2 (Sta.34+000 -42+000)	- 57 thousand m3 of borrow materials is required. -14 thousand m3 from the cutting part within the section, 43 thousand m3 from the section 3. Accordingly, no need for borrow pits. - Haulage distance shall range from 1-10 km.
Section 3 (Sta.42+000 -58+000)	- 168 thousand m3 of borrow materials is required. - All materials shall be supplied from cut materials within the section. Accordingly, no need for borrow pits. - Haulage distance shall be 1-3 km.
Section 4 (Sta.58+000 -64+138)	- 30 thousand m3 of borrow materials is required. - 23 thousand m3 from the cutting part within the section, 7 thousand m3 from the section 3. Accordingly, no need for borrow pits. - Haulage distance shall range from 1-10 km.

Construction Method and Procedure of Earthworks

The earthworks will be carried out with the following procedure and the composition of machinery and equipment described in Table 8.4.3.

Table 8.4.3 Construction Method of Earthworks

Sub-work Items	Composition of Equipment	
	Hauling Distance: less than 100m	Hauling Distance: more than 100m
Clearing	Bulldozer	
Excavation (soil) Loading Hauling	Bulldozer - Bulldozer	Tractor Shovel Tractor Shovel/ Payloader Dump Truck
Excavation (rock) Loading Hauling	Explosives/Giant Breaker/ Ripper with Bulldozer Excavator/ Tractor Shovel Dump Truck	
Spreading Compaction	Bulldozer/ Motor Grader Tamping Roller/ Tire Roller	

Restoration Plan for Borrow Pits

There is no need to find a new borrow pit. The required borrow material will be supplied from existing pits. However, restoration of borrow pits is recommended.

Maximum Utilization of Residual Rocks

Approximately 380,000 cubic-m of rocks are estimated to excavate in the cut sections. This

volume is approximately equivalent to the required volume of aggregate for the whole works. Accordingly, the utilization of excavated materials should be maximized for this project such as aggregate for sub-base and base materials or concrete, materials for masonry and side ditch.

(3) Pavement Work

Work Volumes

Pavement work can be divided into three sub-works: sub-base, base course and surface course work. The required quantity of each sub-work by section is shown in Table 8.4.1. The table shows approximately 29,000 cubic-m of total aggregate is required for sub-base and base-course works. In addition, 2,400 cubic-m (54,000 tons) of asphalt concrete is needed for the surface course work. A fairly large volume of aggregate will need to be supplied for construction.

Source of Pavement Material

Although there is one quarry site 14km away Paksong on Route16 toward Sekong, basalt rocks excavated during the cut works should be utilized as pavement material where possible to achieve cost effectiveness and reduce residual material. Setting-up a crushing plant near section 3 is an alternative. Bitumen to make the asphalt mix should be imported from Thailand

Construction Method and Procedure for Pavement Work

Since there is no supplier of asphalt hot mix in southern Lao, a contractor should assemble an asphalt concrete mixing plant near the proposed route. After that, pavement work should be carried out according to the procedure and the composition of machinery and equipment described in Table 8.3.5.

(4) Drainage Works

Drainage work shall be undertaken in parallel with earthworks. Whereas all size of pipe culvert can be procured from local factories near Pakse, box culverts should be built at site by procuring the necessary materials. A side ditch is also built at site and rock and stones obtained in the excavation process should be utilized if possible.

(5) Temporary Works and Safety Measures for Traffic

At the beginning of construction, when a temporary road for construction vehicles will need to be provided in section 2(new construction section), a detour road during construction

should be built parallel to the existing road in other section if possible, to ensure safety for normal traffic. The road width shall be 5m minimum.

However, it is difficult to build a temporary detour road in section 3 because the existing road is located mainly on valley slopes. Road closure to normal traffic may be required at times depending on work, to ensure traffic safety. The adverse impact may not be significant, because only a few people live along section 3.

8.4.3 Bridge Construction Plan

The construction planning includes a note on the construction method for superstructure, substructure and foundations, construction procedures and schedule for each bridge.

(1) Construction Plan for Superstructure

1) Construction Method

Girder Fabrication Method

Due to the difficulty of transporting longer materials to the site, girder fabrication work should be conducted adjacent to the bridge site.

Girder Erection Method

Erection utilizing an erection girder is appropriate, considering site conditions, girder type and length, and unavailability of a crane with large lifting capacity in Lao P.D.R.

2) Construction Procedure

The standard construction procedure for a superstructure is shown in Figure 8.4.3.

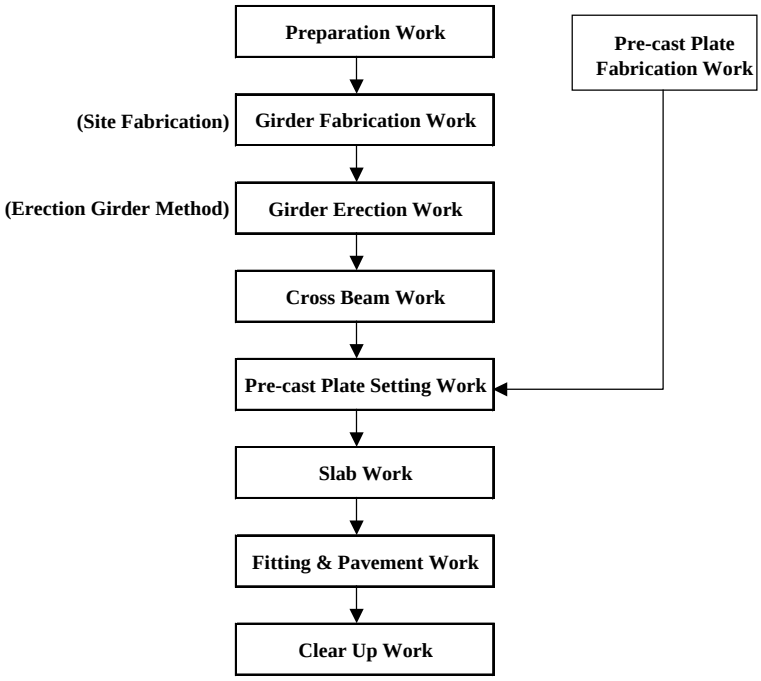


Figure 8.4.3 Construction Procedure for Superstructure for Route 16A

(2) Construction Plan for Substructure and Foundations

1) Construction Method

After providing an access road to each substructure, substructure work will start. A main issue on the substructure work is drainage of water during the footing work. Since subsoil includes boulders and big stones, it is difficult to drive a sheet pile to stop water coming in. An appropriate capacity drainage pump is required to drain water. Other work items can follow common practice.

2) Construction Procedure for Substructure and Foundation

The construction procedure shall be undertaken as indicated in Figure 8.3.4 for Route 14A, except for pile driving work.

8.5 Construction Schedule

8.5.1 Estimated Construction Time

(1) Introduction

In order to estimate construction time, it is necessary to consider local conditions on the study routes such, as workable time or duration, labor regulations, skill level etc. For both of Route 14A and 16A, the following assumptions have been made.

(2) Limited Working Period

Based on previous project experience and climate conditions in southern Lao, major works such as earthworks, pavement works and bridge works are assumed to be undertaken only in the dry season from, October to June. However, minor works can be conducted in the rainy season.

(3) Rate of Operation

The rate of operation in the dry season has been estimated based on the following factors:

- Sundays
- National Holidays: 9 days from October to June
- Rainy days : 10 % of working days (based on meteorological data in Pakse and Paksong for the last 10 years)
- Others: Paid holidays (15 days)

The ratio of operation for Routes 14A and 16A is estimated to be 0.75.

(4) Standard Work Volumes per Day

A standard work volume for each work item need to be defined to estimate construction time. Since there is no standard data in Lao P.D.R., the Study Team made estimates for local conditions. Table 8.5.1 shows the standard work volume per day for major road works.

Table 8.5.1 Standard work Volume per day for Major Road Works

Work Item	Standard Work Volume/day.one team
Embankment Work	250 m3
Sub-base & Base course Work	1300 m2
Surface Course Work	200 tons

8.5.2 Construction Schedule for Route 14A Improvement

(1) Construction Schedule for Road Works

The construction time for each major work can be estimated on the basis of the above assumptions. Further requirements to realize smooth completion are as follows:

- Earthworks in the new construction sections (1 & 2) shall be prioritized to finish settlement of embankment before pavement work and be completed within the first dry season.
- Surfacing work shall be concentrated in the second dry season to minimize the operation time of the asphalt mixing plant.

The construction schedule for road works by section is estimated in Figure 8.5.1. The construction period is 30 months, including preparation work and de-mobilization.

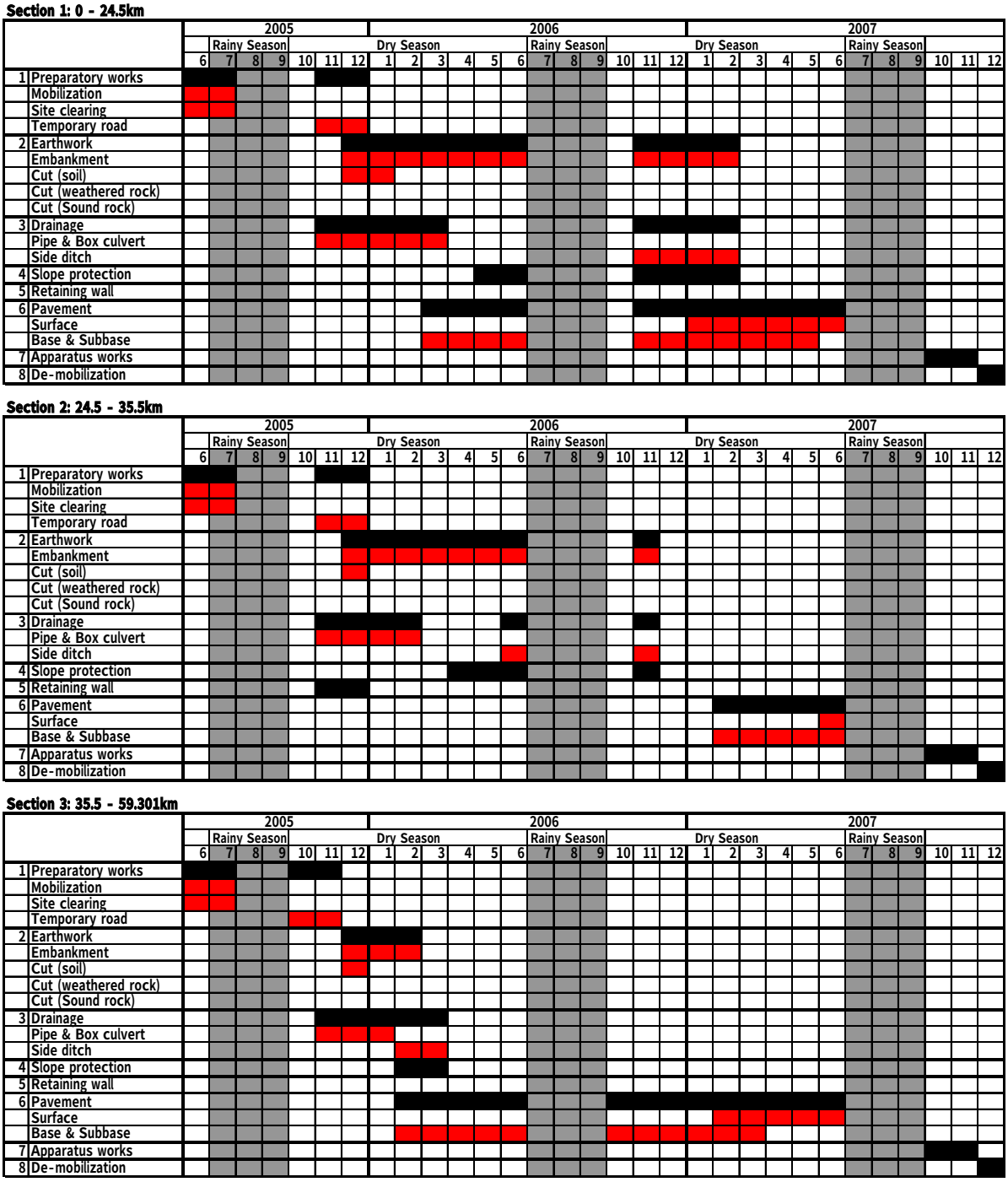


Figure 8.5.1 Construction Schedule for Road Works: Route 14A

(2) Construction Schedule for Bridge Work

1) Construction Schedule for Typical Superstructure Work

The assumed typical bridge is as follows:

Bridge Type: PC-I girder type

Bridge Length: 25m (one span)

Girder Fabrication: Pre-cast segment method

Nos. of Girder: 4

It takes approximately 3.3 month to complete a typical PC-I girder superstructure work., excluding preparation, girder fabrication and clean-up works (see detail ANNEX F-14).

2) Construction Schedule for Typical Substructure and Foundation Work

A construction schedule for typical substructure and foundation work on Route 14A is indicated in Table 8.5.4. The assumed typical substructures are as follows:

Substructure Type: Two Reversed T Abutments with 10m height

Foundation Type: RC pile (40cm x 40cm), L=9m(54 nos.), 11m (35 nos.)

It takes approximately 3.5 months to complete substructure (see detail ANNEX F-14).

3) Construction Schedule for All Bridge Works

On the basis of a study on construction time for a typical bridge, a schedule for all bridge works on Route 14A is provided in Figure 8.5.2, on the following assumption:

(Substructure and Foundation works)

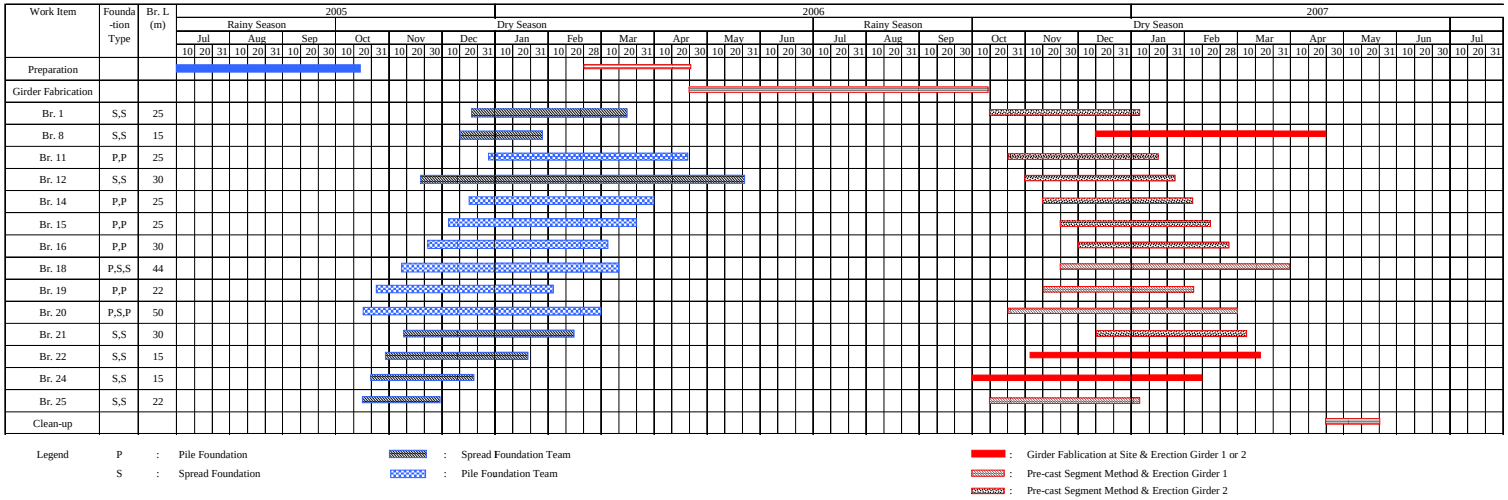
- Utilization of one-pile driving machine

(Superstructure Works)

- Utilization of a pre-cast segment method for PC girders but a site girder fabrication method for RC girders
- Utilization of two sets of the erection girder facility

The total construction time is estimated to be 23 months.

Rt.14A



Rt.16A

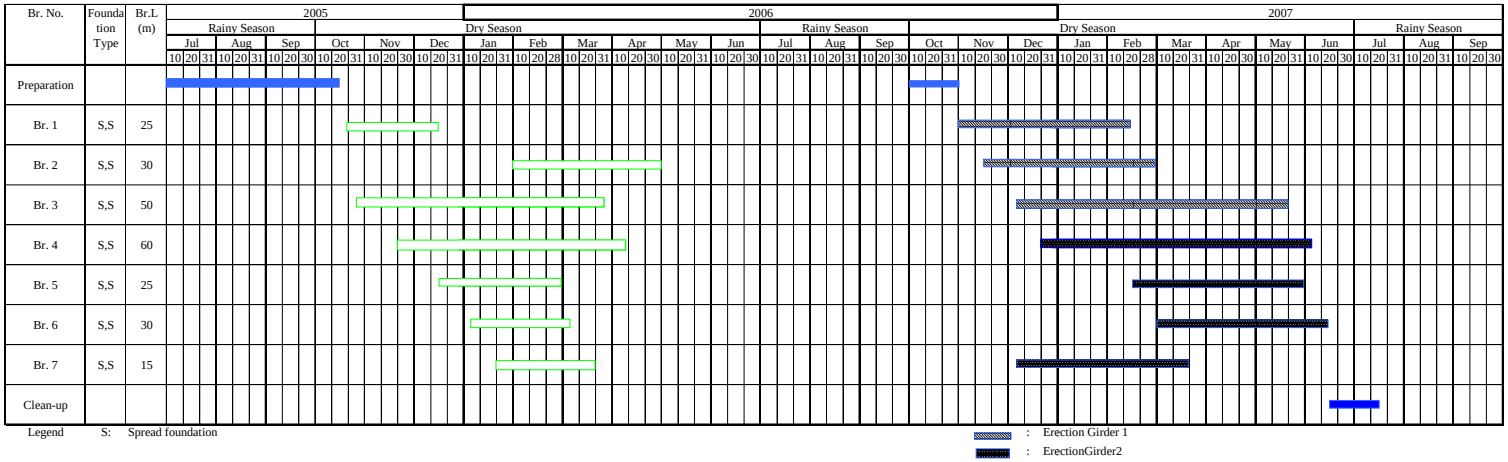


Figure 8.5.2 Construction Schedule for All Bridge Works for Route 14A and 16A

8.5.3 Construction Schedule for Route 16A Improvement

(1) Construction Schedule for Road Work

The construction time for each major work can be estimated on the basis of the above assumptions. Further requirements to realize smooth completion are as follows:

- Earthworks, particularly rock and soil excavation work in the sections 2 & 3, shall be prioritized to supply borrow materials and aggregate to other sections and be completed within the first dry season.
- Surfacing work shall be concentrated in the second dry season to minimize the operation time of the asphalt mixing plant.

The construction schedule for roads work by section is estimated in Figure 8.5.3.

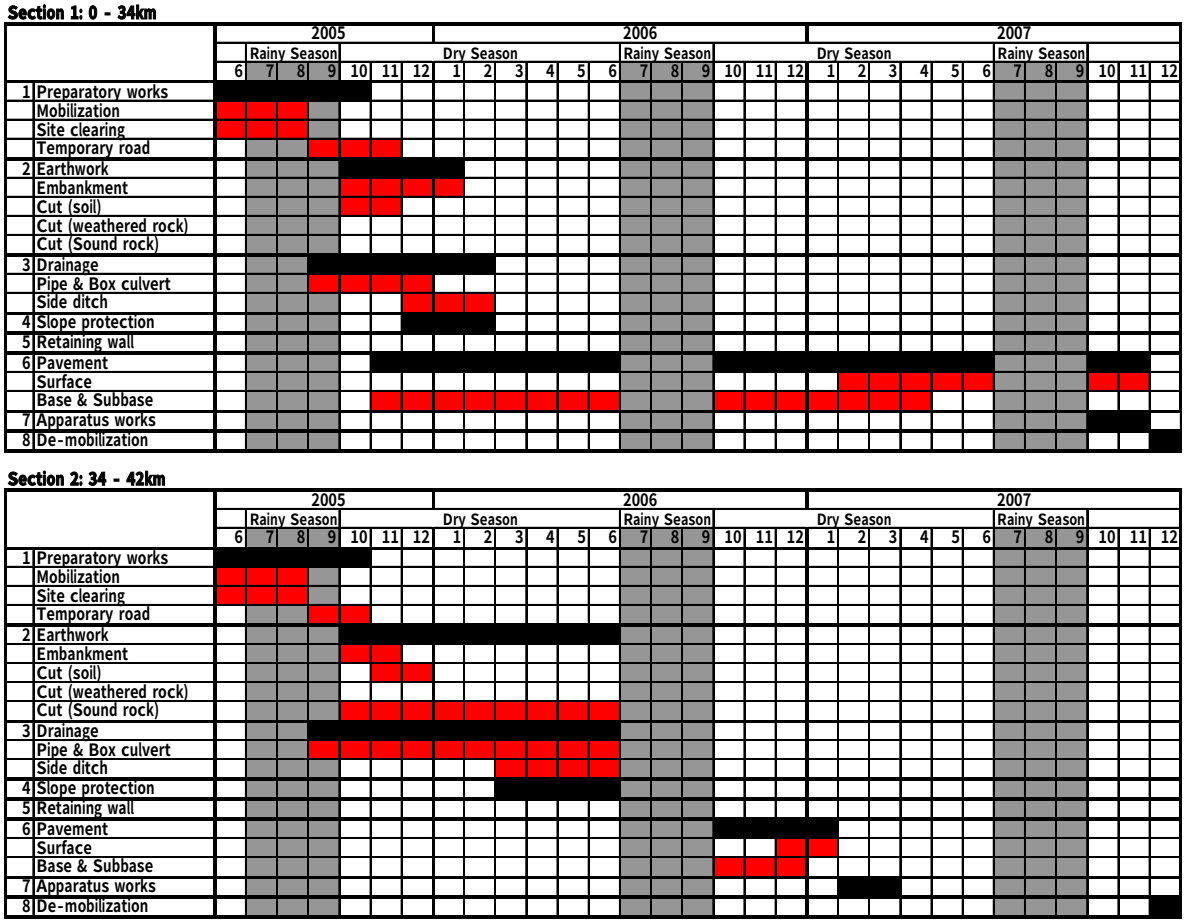


Figure 8.5.3 Construction Schedule for Works: Route 16A (1/2)

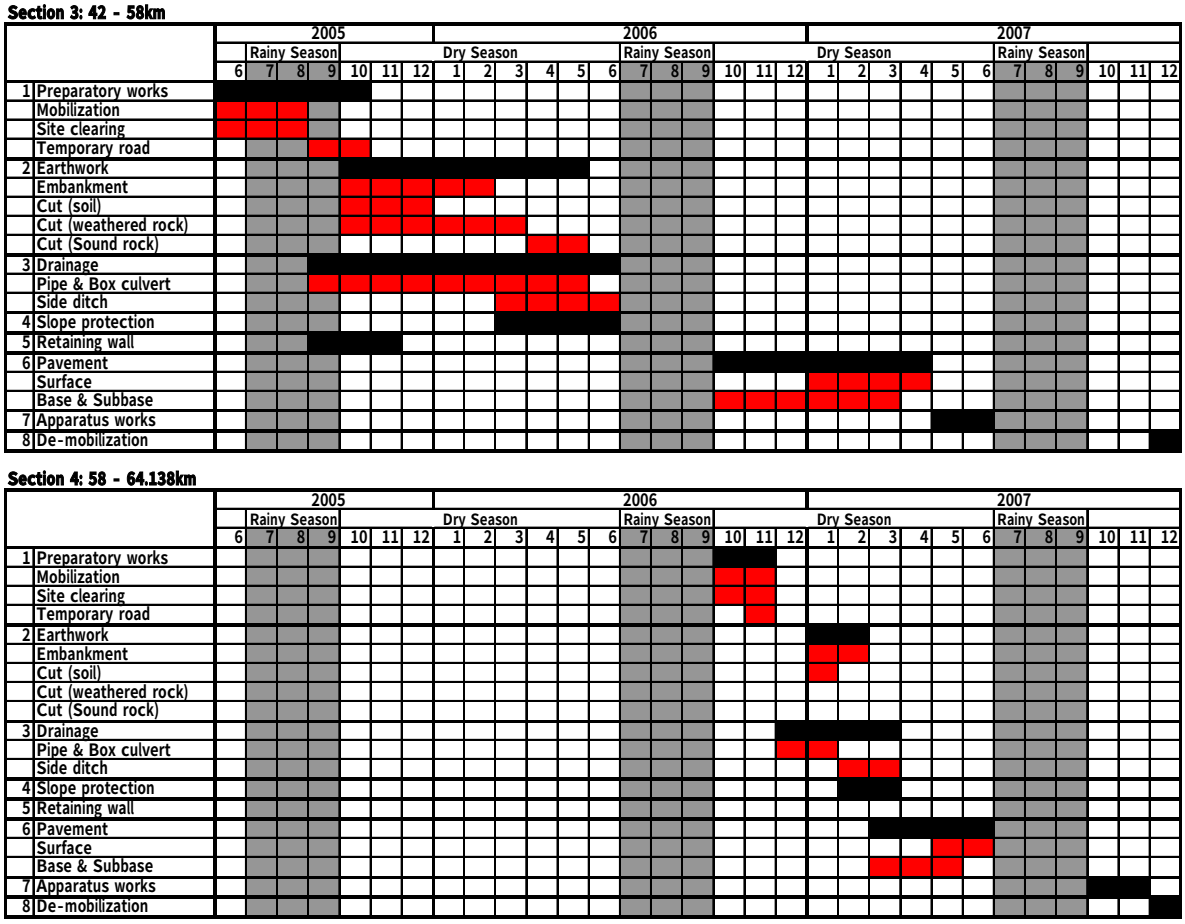


Figure 8.5.3 Construction Schedule for Works: Route 16A (2/2)

(2) Construction Schedule for Bridge Work

1) Construction Schedule for Typical Superstructure Work

The assumed typical superstructure is as follows:

Superstructure Type : PC-I girder

Bridge Length : 25m (1 span)

Girder Fabrication : at site

Girder Erection : Erection girder method (4 nos. of girders)

It will take approximately 3.8 month to complete the work, excluding preparation and clean-up works.

2) Construction Schedule for Typical Substructure and Foundation Work

The construction schedule for typical substructure and foundation work for Route 16A is similar to that Route 14A, without pile foundation work. It will take approximately 2 to 3.4 months to complete the work, excluding preparation and clean-up works.

3) Construction Schedule for All Bridge Works

The schedule for all bridge works on Route 16A is given in Figure 8.5.2 on the following assumptions:

- Utilization of one-set of erection girder equipment
- Girder fabrication to be undertaken on site

The total construction time is estimated at approximately 25 months.